September 2026

Everett Link Extension

Draft Environmental Impact Statement

GEOLOGY AND SOILS TECHNICAL REPORT

Appendix G.12

SOUNDTRANSIT
U.S. Department of Transportation
Federal Transit Administration

Table of Contents

Figures

Tables

Acronyms

AIR	SR 99/Airport Road
ALD	West Alderwood
ASH	Ash Way
BI	Broadway/I-5
BMP	best management practice
CY	cubic yards
DNR	Washington State Department of Natural Resources
EGN	SR 526/Evergreen
EIS	Environmental Impact Statement
EMC	Everett Municipal Code
EVLE	Everett Link Extension
EVT	Everett Station
I-5	Interstate 5
LMC	Lynnwood Municipal Code
MAR	Mariner
NEPA	National Environmental Policy Act
NEHRP	National Earthquake Hazards Reduction Program
OMF	operations and maintenance facility
RCW	Revised Code of Washington
SCC	Snohomish County Code
SR	State Route
SWI	SW Everett Industrial Center
SWIF	Southern Whidbey Island Fault
WAC	Washington Administrative Code
WSDOT	Washington State Department of Transportation

1 INTRODUCTION

1.1 Overview

The Central Puget Sound Regional Transit Authority (Sound Transit) is proposing to expand Link light rail transit service northward from the Lynnwood City Center Station to the Everett Station area in Snohomish County, Washington (Figure 1-1). The Everett Link Extension (EVLE) Project would provide fast, reliable light rail service to regional residential and job centers in Snohomish County's growing urban areas. The proposed project is part of the Sound Transit 3 (ST3) Plan of regional transit system investments, funding for which was approved by voters in the region in 2016.

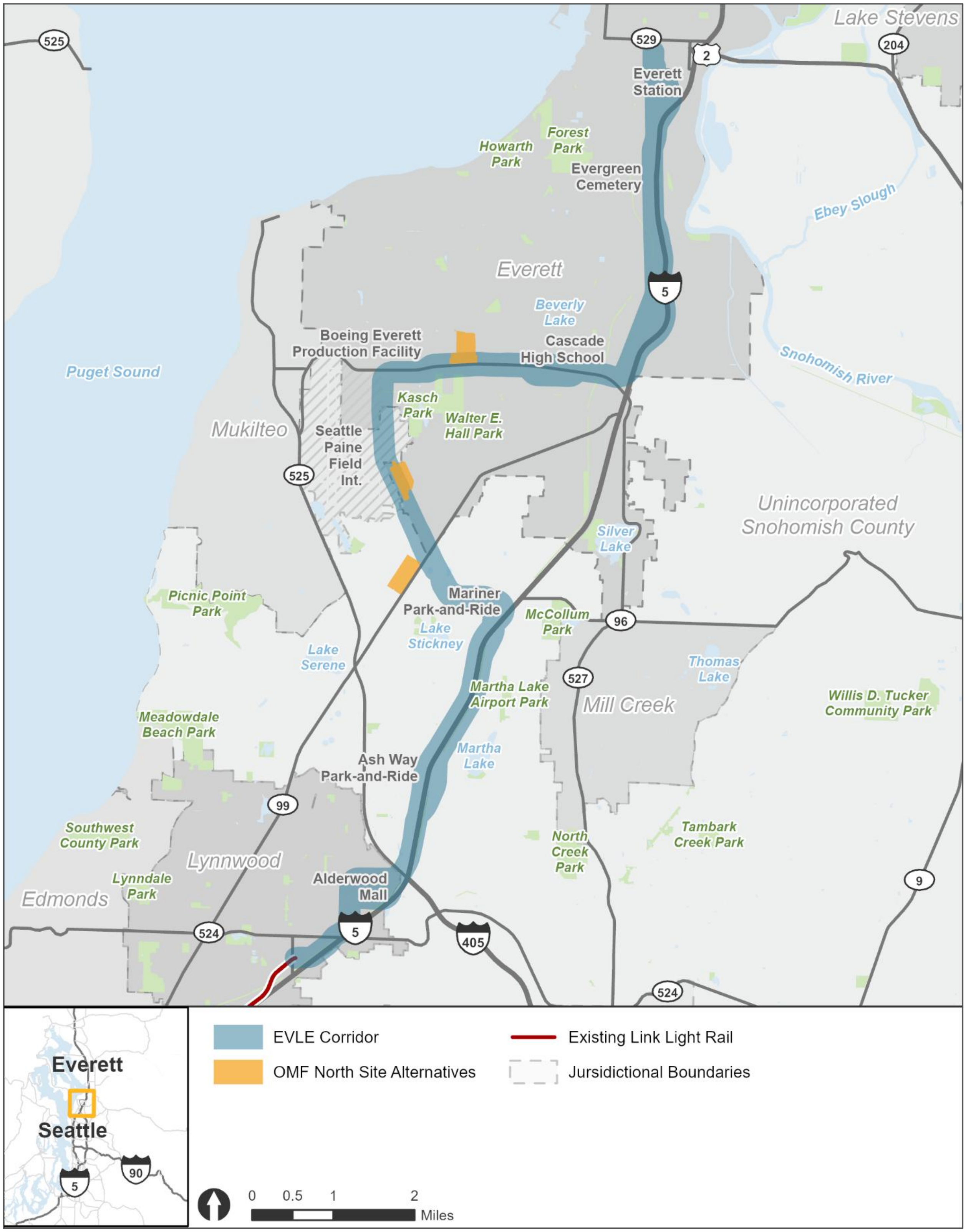
For this analysis, the EVLE Project consists of approximately 16 miles of light rail guideway, seven light rail stations, two parking facilities, and an operations and maintenance facility (OMF North). Sound Transit proposes to begin construction of the project in 2030. The current schedule for opening light rail service from the Lynnwood City Center Station to Everett Station is 2041. A shorter route connecting Lynnwood City Center to the SW Everett Industrial Center Station would open first in 2037 as the initial phase. OMF North would open by 2034, prior to opening of the light rail extension, as the facility is necessary for storing rail cars and supporting service for not only the extension to Everett, but also other parts of the regional system.[1] Parking facilities at the Mariner and Everett Stations would open by 2046.

One station, State Route (SR) 99/Airport Road Station, is currently considered provisional since planning, preliminary engineering, and environmental review are funded, but final design and construction are not. However, for purposes of this evaluation, all seven stations are assumed to be funded and open according to the schedule described above to capture all locations where impacts could occur. The station would be fully constructed and open for service when additional funding is identified.

The initial phase is not discussed in this analysis because it would not have additional potential impacts when compared with the fully built alternatives (i.e., the impacts would be the same in the West Alderwood, Ash Way, Mariner, SR 99/Airport Road, and SW Everett Industrial Center Segments, and for the OMF sites, but the impacts in the SR 526/Evergreen, Broadway/I-5, and Everett Station Segments would not occur until construction on those segments begins). All potential impacts are described in Section 4.

[1] Construction of light rail projects is typically divided into sections, and construction would occur across different parts of the corridor between 2030 and 2046. For more information on the construction approach, see Draft EIS Appendix B.

Figure 1-1 EVLE Project Corridor



For planning and engineering purposes, the project is organized into eight geographic segments, discussed in this document from south to north. Within those segments, a total of 17 alignment alternatives and 18 station location alternatives are under consideration. These alignment and station alternatives are combined into Build Alternatives for analysis as shown in Table 1-1 and Figure 1-2.

Table 1-1 describes the alignment and station alternatives as follows:

- **Segments:** The eight alignment segments and corresponding abbreviations are:
  - West Alderwood (ALD).
  - Ash Way (ASH).
  - Mariner (MAR).
  - SR 99/Airport Road (AIR).
  - SW Everett Industrial Center (SWI).
  - SR 526/Evergreen (EGN).
  - Broadway/I-5 (BI).
  - Everett Station (EVT).
- **Alignment Alternatives:** Alignment alternatives in each segment are identified with numbers (e.g., ALD-1).
- **Station Alternatives:** Station alternatives in each segment are identified with letters (e.g., ALD-B).[2]
- **Build Alternatives:** Alignments and stations are combined to create the Build Alternative name (e.g., Station ALD-B is located on Alignment ALD-1, so this pairing is referred to as Alternative ALD-1B). If a preferred Build Alternative has been identified by the Sound Transit Board of Directors, it is indicated with an asterisk.
- **Design Options:** A design option is an alternate design for a portion of a Build Alternative. It could be a different route or profile along a portion of an alignment, a different station configuration, or a different parking location. For example, in the West Alderwood Segment, the Alderwood Mall Boulevard Design Option is being considered for all three Build Alternatives.

[2] Letters identifying station alternatives are non-sequential in some segments; missing letters denote alternatives that did not perform as well as alternatives considered in the Draft EIS. For more information on the Alternatives Development process, see Draft EIS Chapter 2.

Table 1-1 Alignment and Station Build Alternatives by Segment

Segment	Alignment Alternatives	Station Alternatives	Build Alternatives (Combined Alignment and Station)	Build Alternative Design Options Also Considered
West Alderwood	ALD-1	ALD-B	ALD-1B	Alderwood Mall Boulevard
	ALD-2	ALD-D	ALD-2D*	Alderwood Mall Boulevard
		ALD-F	ALD-2F	Alderwood Mall Boulevard
Ash Way	ASH-1	ASH-A	ASH-1A	None
	ASH-2	ASH-D	ASH-2D	None
Mariner	MAR-1	MAR-B	MAR-1B	Surface Parking
	MAR-2	MAR-D	MAR-2D	Surface Parking
SR 99/ Airport Road	AIR-1	AIR-A	AIR-1A	None
	AIR-2	AIR-B	AIR-2B	None
SW Everett Industrial Center	SWI-1	SWI-A	SWI-1A*	Lower
		SWI-B	SWI-1B	None
		SWI-C	SWI-1C	None
SR 526/ Evergreen	EGN-1	EGN-A	EGN-1A	None
	EGN-2	EGN-B	EGN-2B	North Side of SR 526
	EGN-3	EGN-E	EGN-3E	North Side of SR 526
Broadway/I-5	BI-1	None	BI-1*	None
	BI-2	None	BI-2	None
Everett Station	EVT-1	EVT-A	EVT-1A	None
	EVT-2	EVT-C	EVT-2C*	None
	EVT-3	EVT-D	EVT-3D*	None

* Denotes preferred alternative

There are also three OMF North site alternatives under consideration as shown in Table 1-2 and Figure 1-2.

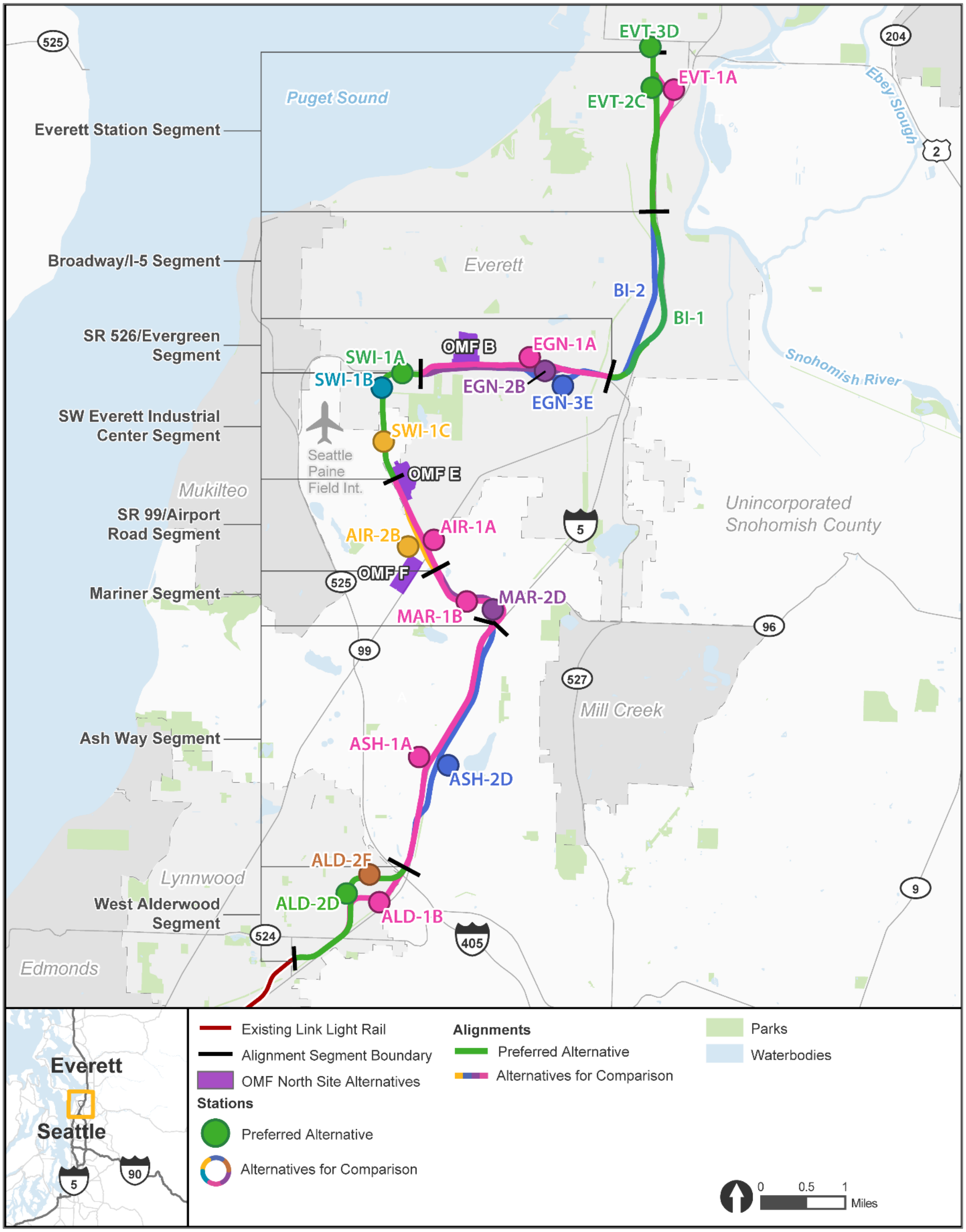
Table 1-2 OMF North Site Alternatives

Build Alternative	Build Alternative Design Options Also Considered
OMF Site F	Lead Tracks to West Side of Airport Road
OMF Site E	None
OMF Site B	Lead Tracks to South Side of SR 526

Analysis of the Build Alternatives was based on the conceptual design drawings included in the Draft Environmental Impact Statement (EIS) Appendix F.

The No Build Alternative describes the environment, including the transportation system, as it would exist in 2046 without the proposed project. The No Build Alternative uses 2046 as the year of analysis to align with the target date for completion of all EVLE Project components and the full buildout of the light rail capital projects included in the ST3 Plan.

Figure 1-2 EVLE Project Alternatives



1.2 Potential Design Refinements

In addition to the alternatives described above, the Draft EIS provides a qualitative evaluation of potential design refinements that could reduce overall project cost if applied to the alignment and station alternatives (for more information, see Draft EIS Chapter 2). The potential design refinements identified to date that could be considered in each segment, along with potential changes in impacts, are described in Draft EIS Chapter 4. Sound Transit has not identified any change in geology and soils impacts as a result of the potential design refinements (see quantitative analysis methodology in Draft EIS Appendix I). If Sound Transit decides to include these refinements as part of the project prior to the Final EIS, they would be reflected in the conceptual design plans and evaluated in the Final EIS.

1.3 Purpose of Report

The purpose of this report is to describe the geology and soil resources present within the study area and document the impacts associated with the Build Alternatives. This report also describes measures intended to avoid, minimize, and mitigate impacts to the described geology and soil resources.

2 REGULATORY CONTEXT AND METHODOLOGY

2.1 Applicable Laws, Regulations, and Guidelines

Federal, state, and local regulations, policies, and guidance apply to geology and soils. In Washington, the Growth Management Act (Chapter 36.70A Revised Code of Washington [RCW]) requires all cities and counties to identify critical areas within their jurisdiction and develop regulations to protect them. The following list of regulations and guidance applies to the geologic features and soils present within the study area.

2.1.1 State

- Agricultural Resource Lands (Washington Administrative Code [WAC] Chapter 365-190-050).
- Mineral Resource Lands (WAC Chapter 365-190-070).
- Critical Aquifer Recharge Areas (WAC Chapter 365-190-100).
- Geologically Hazardous Areas (WAC Chapter 365-190-120).
- Roadside Policy Manual (Washington State Department of Transportation [WSDOT] 2022).

2.1.2 Local

- Critical Area Ordinances
  - City of Everett Municipal Code (EMC) Chapter 19.37, Geologically Hazardous Areas.
  - City of Lynnwood Municipal Code (LMC) Chapter 17.10, Geologically Hazardous Areas and Critical Aquifer Recharge Areas.

  - Snohomish County Code (SCC) Chapter 30.62B, Geologically Hazardous Areas and Chapter 30.62C, Critical Aquifer Recharge Areas.
- Sound Transit Requirements Manual – Set 701 Geotechnical Engineering (2023).

2.2 Methodology

This analysis evaluated the potential impacts of the No Build Alternative and the Build Alternatives on geology and soils within the study area. National Environmental Policy Act (NEPA) regulations require that an EIS disclose impacts (i.e., effects) of a proposed action on the environment. NEPA requires an EIS to evaluate and disclose the "reasonably foreseeable environmental effects of the proposed agency action" (42 USC Section 4332). Reasonably foreseeable environmental effects are those that are sufficiently likely to occur during operation (long-term) or construction (short-term). Reasonably foreseeable environmental effects do not include effects that are speculative in nature or remote in time or place, or that are the result of a lengthy causal chain. For this analysis, reasonably foreseeable effects include all effects that are considered likely to result from the project over its operational lifetime within the study area of each resource.

The study area does not contain any designated agricultural resource lands or mineral resource lands. Therefore, those resource lands are not discussed further. The study area for each alternative extends 100 feet beyond the project limits (the permanent project improvements and areas needed for project construction), in the context of local jurisdictions and/or the region, for an understanding of broader geologic processes and to understand mechanisms related to site geology and sensitive and critical areas.

A glossary of helpful definitions is provided below in Table 2-1.

Table 2-1 Helpful Technical Definitions

Term	Definition
Alluvial fan	Triangle or cone shaped deposit of coarse sediment
Differential ground movements	Uneven settling and movement of the ground
Dip	Angle between inclined surface and horizontal surface
Fault rupture	Physical displacement of rock along fault line
Geologic contacts	Surface or boundary where one rock touches another
Permeable	Ability of a porous solid (rock, sediment, or soil) that allows transmission of fluids
Pore pressure	Pressure of fluids in the pore space of rocks or soils
Mass movement	The downslope movement of soil and rock debris
Shear strength	The maximum shear stress that a soil can sustain without experiencing failure
Tectonics	Study concerning the structure and deformation of rocks that make up the Earth's crust

2.2.1 Geologic Hazards

In Washington, geologically hazardous areas are those defined as being susceptible to erosion, landslides, earthquake-induced hazards (liquefaction, ground rupture, etc.), and which may require mitigation to reduce geologic hazard risks to be suitable for siting of commercial, residential, or industrial development (WAC 365-190-120).

While the ordinances (Section 2.1.2) of each jurisdiction in the study area include different criteria to define geologically hazardous areas, there are overall similarities. A discussion of the hazard types in the study area is presented in the following sections.

2.2.1.1 Steep Slope and Erosion Hazards

Steep slopes and other areas susceptible to erosion can pose a geologic hazard. Steep slopes may be susceptible to landslides during wet weather, seismic events, or may be susceptible to high to severe erosion.

Spatial data obtained from Snohomish County identifies potential steep slope hazard areas and erosion hazard areas throughout the study area. Slopes identified as “steep slopes” (or “landslide hazards” as discussed in Section 2.2.1.2) were considered to pose a relatively high risk for erosion, and potentially slope instability with development of the project.

2.2.1.2 Landslide Hazards

Landslide hazard areas are defined by each of the city and county regulations that the project occurs within. Geographic information system data aggregated by the Washington State Department of Natural Resources (DNR) was used to assess landslide hazards in the study area. The city and county landslide hazard areas are based on the following criteria:

- City of Lynnwood landslide hazard areas (LMC 17.10.100) are defined as:
  - Areas with slopes steeper than 40%.
  - Areas with slopes between 15% and 40% that are underlain by soils largely consisting of silt and clay.
  - Areas with slopes steeper than 15% with zones of emergent water such as groundwater seepage or springs.
  - Areas of landslide deposits regardless of slope inclination.
- City of Everett landslide hazard areas are defined by Dames and Moore Methodology for the Inventory, Classification and Designation of Geologically Hazardous Areas (EMC 19.37.080) as:
  - Very high/severe hazard – slopes greater than 15% in Qtb, Qw, and Qls[3] geologic units (defined and described in Section 3.1.1) and slopes greater than 15% with uncontrolled fill.
  - High hazard – slopes greater than 40% in all other geologic units (not Qtb, Qw, and Qls or uncontrolled fill).

[3] Qtb – Transitional Beds; Qw – Whidbey Formation; and Qls – Landslide Deposits.

- Snohomish County landslide hazard areas (SCC 30.91L.040) are defined as those potentially subject to mass movement with a vertical height of 10 feet or more including:
  - Areas of historic landslides and areas susceptible to basal undercutting by streams, rivers, or waves.
  - Areas with slopes steeper than 33%, which intersect geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment.
  - Areas located in a canyon or an active alluvial fan.

2.2.1.3 Seismic Hazards

Seismic hazard areas include areas that are susceptible to earthquake-induced ground shaking, fault rupture, liquefaction, and landslides.

Fault Zones

Fault zones are approximately linear features of varying width in which multiple traces associated with a single fault have been mapped as having previously experienced fault rupture. Potential impacts of fault rupture include abrupt, large, differential ground movements and damage to structures that straddle a fault. Figure 3-28 and Figure 3-30 show examples of fault zones.

Liquefaction

Soil liquefaction is a phenomenon in which ground shaking causes the pore pressure in loose, saturated, granular soil to increase to a level near the initial effective stress of the soil. This results in a reduction of shear strength in the soil, and this shear strength reduction can result in settlement, lateral spreading (lateral ground movement on gentle slopes), and landsliding. Due to the reduced soil strengths, lateral and vertical foundation restraint may also be significantly reduced.

Soft-Soil Ground Motion Amplification

The type of near-surface soils can affect the level of earthquake ground shaking in an area. Earthquake ground motion amplification at various frequencies (i.e., greater ground displacement and longer duration shaking, causing increased potential for structural damage) may occur for areas underlain by extensive deposits of relatively soft, cohesive soils. Soil frequency is evaluated using soil site classifications. The National Earthquake Hazards Reduction Program (NEHRP) Seismic Site Class data, available from the DNR, was used to complete a preliminary review of site classes, defined in Table 2-2, that may occur within the study area. The NEHRP data provides generalized maps of soils that are estimated to be Site Classes A through E. Areas mapped as Site Classes C-D, D, D-E, and E have a relatively high potential for ground motion amplification.

Table 2-2 Seismic Site Class Description

Site Class	Site Profile Name
A	Hard rock
B	Rock
C	Very dense soil and soft rock
D	Stiff soil
E	Soft clay soil
F	Soil requires site response analysis

SOURCE: DNR (2022).

3 AFFECTED ENVIRONMENT

The following sections summarize the geology and soil resources within the study area, as mapped by local jurisdictions.

3.1 Geology and Soils

The EVLE Project is in the central Puget Lowland (see Figure 3-1), an elongated topographic and structural depression filled with a complex sequence of glacial and nonglacial sediments that overlie bedrock. The area has been glaciated six or more times in the past two million years. Ice for these glacial events originated in the mountains of British Columbia. The maximum southward advance of the ice was about halfway between Olympia and Centralia.

The distribution of the sediments in the Puget Lowland is complex because each glacial advance deposited new sediments and partially eroded previous sediments. Between glacial episodes, the complete or partial erosion or the reworking of deposits, as well as the local deposition of other sediments, took place. During the last glacial advance, known as the Vashon Stade of the Fraser Glaciation, the lobe of the Cordilleran Ice Sheet that covered the Puget Lowland was locally over 3,000 feet thick. When the glacial ice sheet receded from the area about 13,500 years ago, it left behind topography characterized by low-rolling relief about 500 feet above sea level with some deeply cut ravines and broad valleys. Since then, present-day geologic processes, such as erosion and deposition by streams and landslides, as well as human activity, have modified the ground surface and further complicated the geology. Most of the study area extends across this rolling, elevated platform of glacial material. This includes the West Alderwood Segment through the SR 526/Evergreen Segment and all OMF North site alternatives. However, the northern section of the alignment adjacent to I-5, including the Broadway/I-5 and Everett Station Segments, lies along the border of the glacial upland and the valley wall of the Snohomish River.

The Puget Lowland is near the Cascadia Subduction Zone (see Figure 3-1). The tectonics and seismicity of the region are the result of the relative northeastward subduction of the Juan de Fuca Plate beneath the North American Plate. North-south compression is accommodated beneath the Puget Lowland by a series of west- and northwest-trending faults that extend to depths of about 12 miles.

Figure 3-1 Project Location

3.1.1 Geologic Units and Surficial Geology

Figure 3-2 through Figure 3-13 show the mapped surficial geology in the study area. Surficial geology is the mapped extents of geologic units found at the ground surface. A mapped geologic unit is an area of soil or rock defined by characteristics that are distinct from other geologic units. Section 3.1.1.1 presents summary descriptions for geologic units that are mapped in the study area and their engineering properties. While these geologic units are mapped within the study area vicinity as shown in the below figures, not all of these geologic units may be present within the study area. The geologic units shown in the figures are based on surficial geologic mapping from the DNR Geological Survey (DNR 2019a and 2019b).

Current geologic maps from DNR indicate that the surficial geologic deposits present along the study area were deposited during the Vashon Stade of the Fraser glaciation. Some surficial deposits within the Broadway/I-5 and Everett Station Segments may be Pre-Vashon sediments. Pre-Vashon sediments may be encountered in excavations for deep foundations throughout the study area.

3.1.1.1 Geologic Units

The following is a discussion of the mapped geologic units within the study area.

The youngest deposits along the alignment are fill in the form of modified land. Fill is soil placed by humans. Its properties can vary significantly depending on the origin of the material and whether the fill was placed in an engineered or nonengineered fashion. Most of the fill along the alignment is composed of silty to gravelly sand placed during the construction of I-5, SR 526/Evergreen Way, and Airport Road. While often unmapped, fill may be present across the entire study area. Fill is expected to be encountered under and adjacent to roadways and highways and may be present where the EVLE Project alignment crosses highway and roadway alignments.

Peat deposits (Qp) are present in isolated areas within the study area and generally coincide with local wetlands, recessional outwash channels, and kettle features. In addition to peat, these deposits may include woody debris, interbeds of silt and clay, and fine-grained alluvium. Peat deposits are present northwest of the SR 525 and I-5 interchange near the boundary of the West Alderwood and Ash Way Segments (Figure 3-2, Figure 3-3, and Figure 3-4).

Vashon glacial till (Qvt) is mapped throughout the study area (Figure 3-2 through Figure 3-13). Till or "hardpan" is typically composed of an unsorted mixture of silt, sand, and gravel with scattered cobbles and boulders. It is very dense and relatively impervious. Water infiltrating through overlying deposits normally perches on top of the till. However, some groundwater may be encountered in more pervious granular lenses within the till.

Advance outwash (Qva) is mapped as underlying portions of the north and central sections of the SR 526/Evergreen, Broadway/I-5, and Everett Station Segments and throughout the study area (Figure 3-8 through Figure 3-13). Advance outwash was deposited in outwash channels emanating from the Vashon glacier during its southward advance. The deposit is composed of stratified sand with gravel and some cobbles, which generally coarsens upward. The fines content is relatively low compared to adjacent deposits, and fines most commonly occur at the base of the deposit. The unit is noted as a principal aquifer of the region containing water perched on top of the underlying glaciolacustrine deposits (Thomas and others 1997).

Transitional Beds (Qtb) are present along portions of the north section of the Broadway/I-5 and Everett Station Segments and east of I-5 outside of the study area (Figure 3-10 through Figure 3-13). These deposits consist of clay, silt, and fine sand. The fine-grained material is derived from glacial flour deposited in proglacial lakes in the Puget Lowland. These fines are often interbedded with silt and fine sand, which may be locally laminated. Scattered organic fragments, peat, and gravel may be found near the base of the deposit. The material is relatively impervious.

3.1.1.2 Surficial Geology

The surface geology of the study area is generally composed of glacial overridden soils with areas of unmapped fill. Glacial till is the primary surficial geologic unit from the West Alderwood Segment to the Broadway/I-5 Segment (Figure 3-2 through Figure 3-11). The surficial geology of the Broadway/I-5 Segment is composed of a mix of glacial till and glacial outwash transitioning north to a mix of glacial outwash and transitional beds in the Everett Station Segment (Figure 3-10 through Figure 3-13). These soils are generally considered favorable for foundations with limited settlement and good bearing capacity. However, several areas with limited extent are less favorable for foundations. These areas include the following:

The Ash Way Segment within the Swamp Creek subbasin, northwest of the SR 525 and I-5 interchange, which is mapped as peat at the surface. The peat deposits are mapped as being adjacent to the proposed alignment surrounding Maple Road near the SR 525 and I-5 interchange and adjacent to Alder Way east of I-5 (Figure 3-3).

The Mariner Segment within the Swamp Creek subbasin, where the creek crosses under Airport Road near the boundary of the SR 99/Airport Road and Mariner Segments (Figure 3-5). While mapped as glacial till, young alluvium, peat, or swamp deposits may be present.

Merrill and Ring Creek crosses south to north across the study area in the SR 526/ Evergreen Segment and northeast of OMF Site B (Figure 3-8). While mapped as glacial outwash, young alluvium, peat, or swamp deposits may be present.

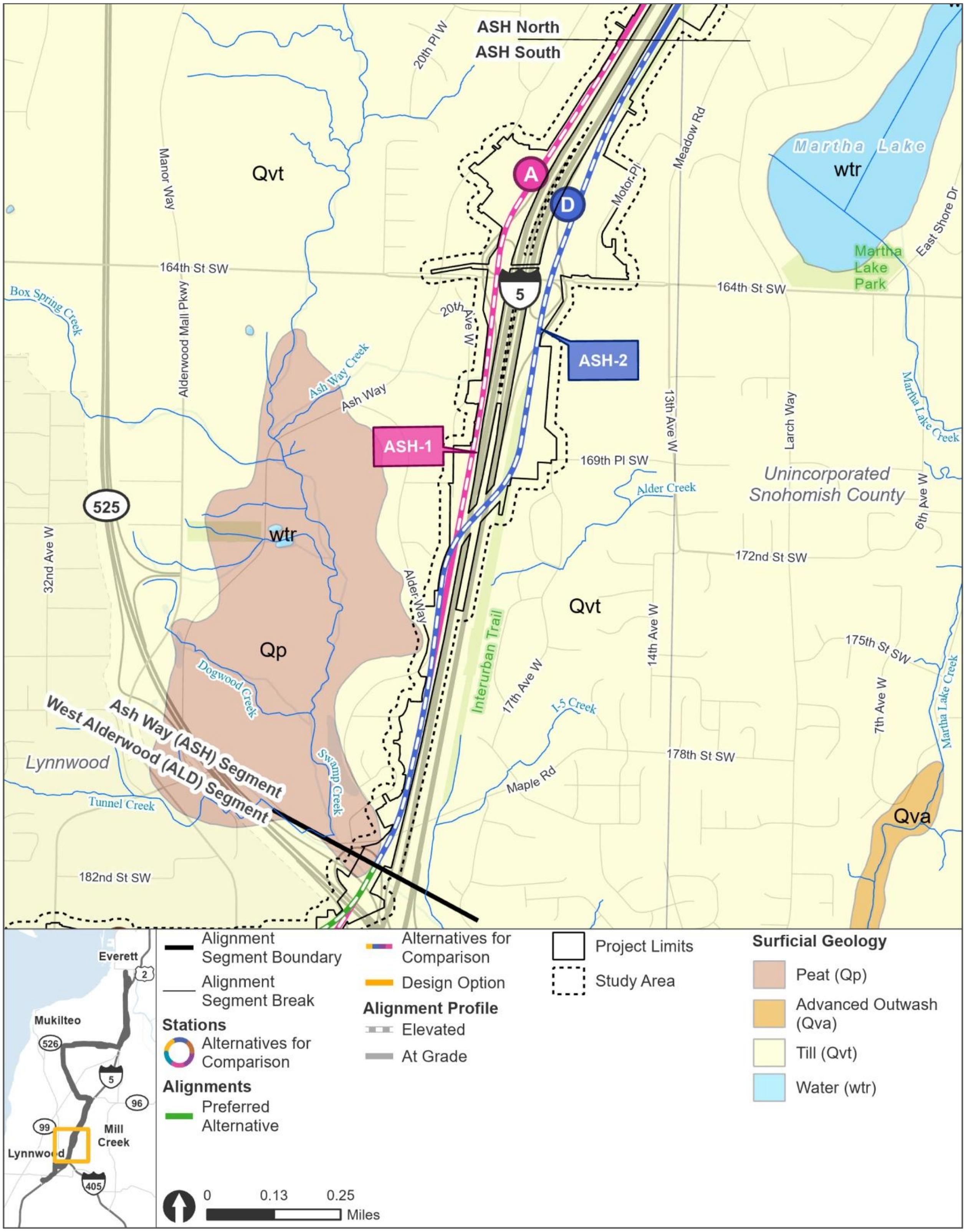
Wood Creek parallels the southern section of the Broadway/I-5 Segment to the east and crosses the segment northwest to southeast from near the intersection of 78th Place SE and Broadway (Figure 3-10 and Figure 3-11). While mapped as glacial outwash, young alluvium, peat, or swamp deposits may be present in those areas associated with Wood Creek.

Additional mapped or unmapped streams, drainages, or wetlands in the study area may contain young alluvium, peat, or swamp deposits.

Figure 3-2 Surficial Geology – West Alderwood Segment

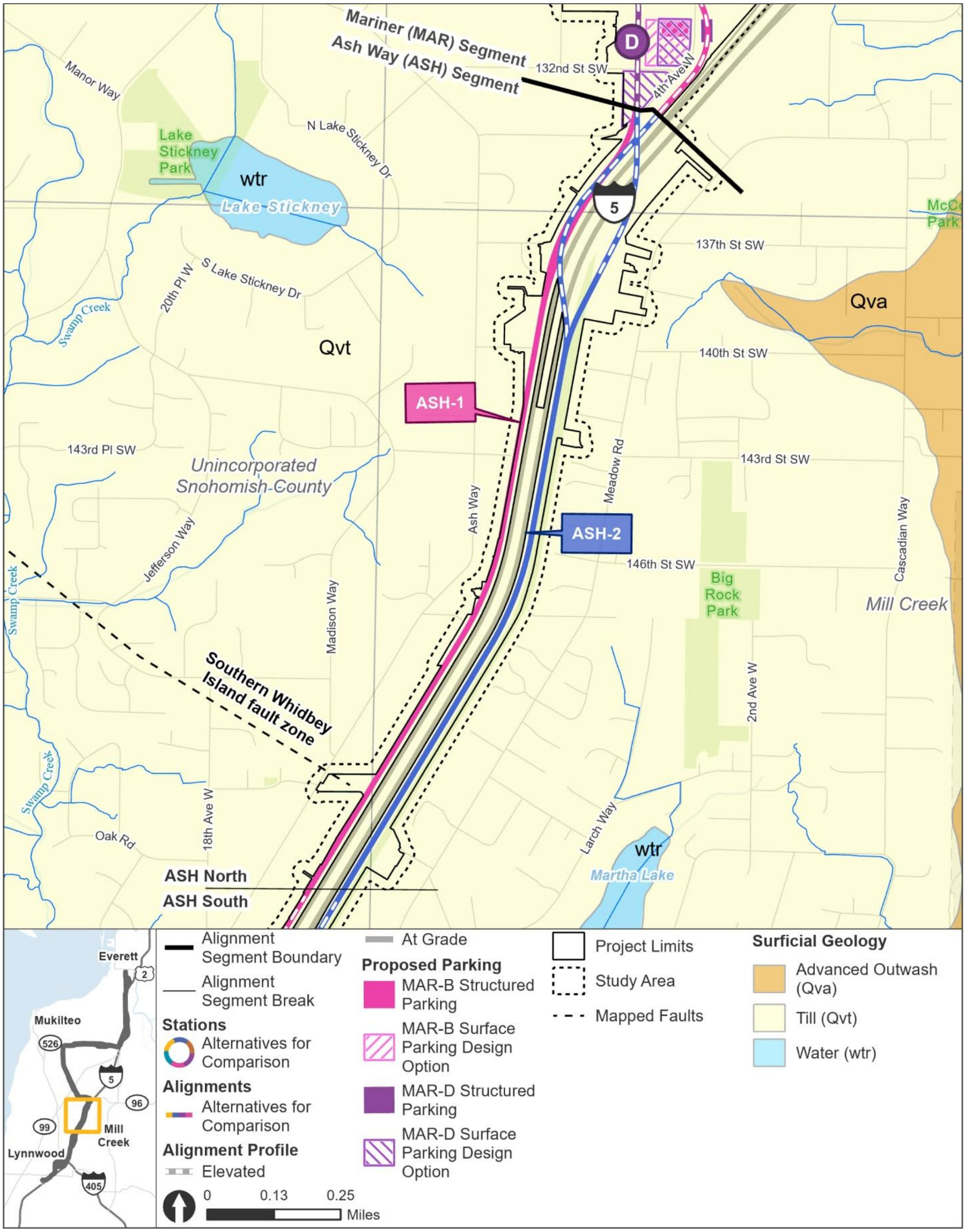
SOURCE: DNR (2019a) and Snohomish County (2024).

Figure 3-3 Surficial Geology – Ash Way Segment (South)



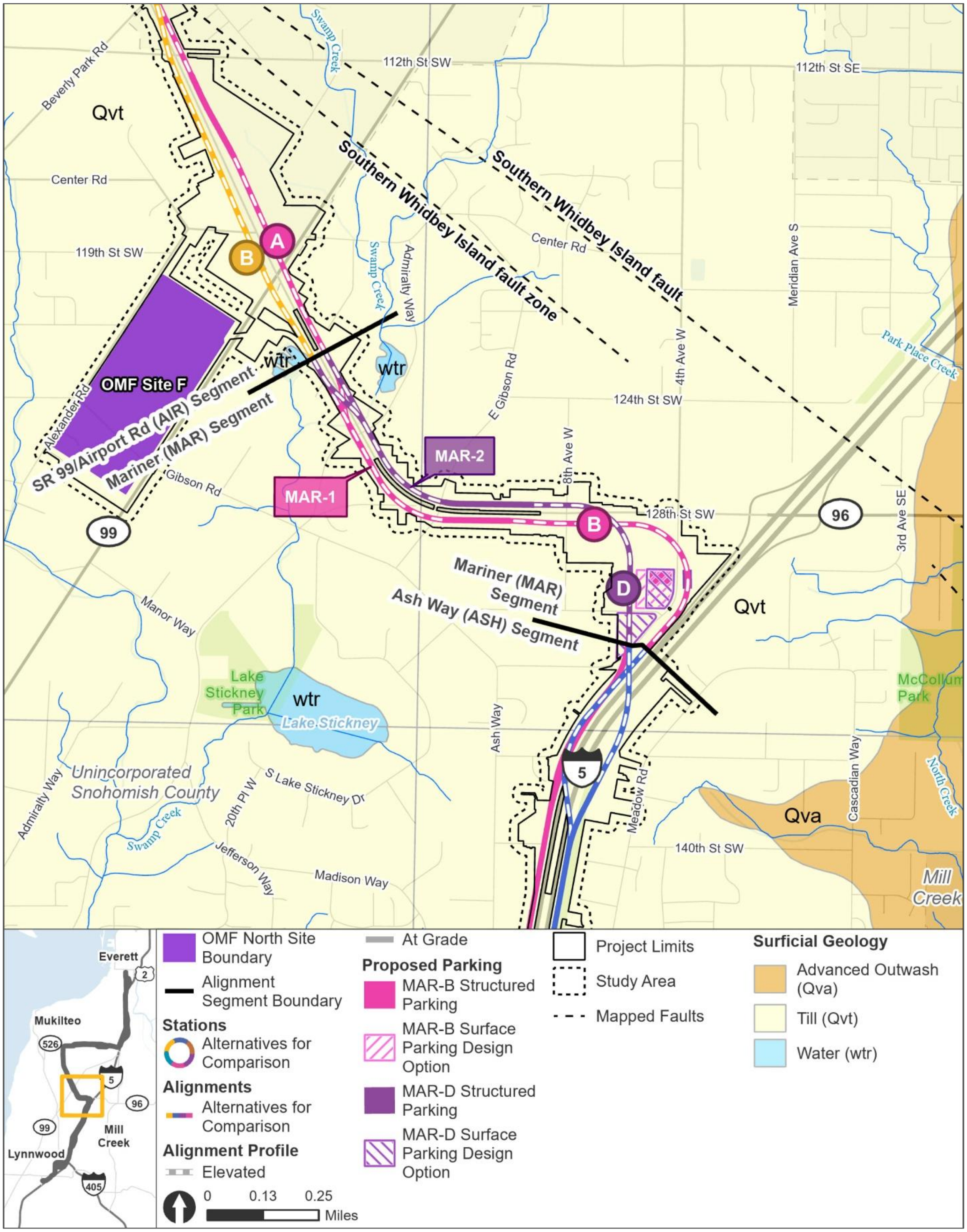
SOURCE: DNR (2019a) and Snohomish County (2024).

Figure 3-4 Surficial Geology – Ash Way Segment (North)



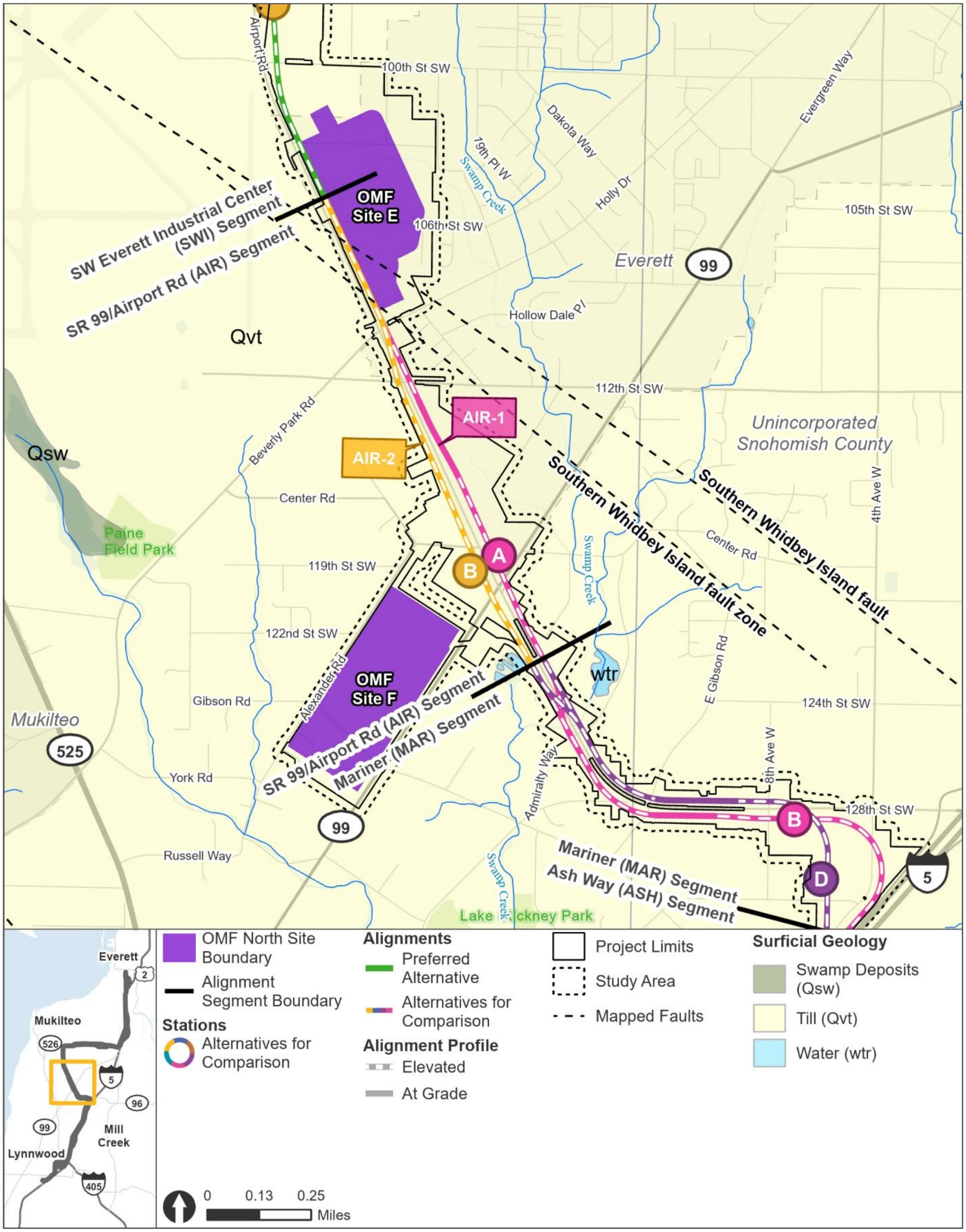
SOURCE: DNR (2019a) and Snohomish County (2024).

Figure 3-5 Surficial Geology – Mariner Segment



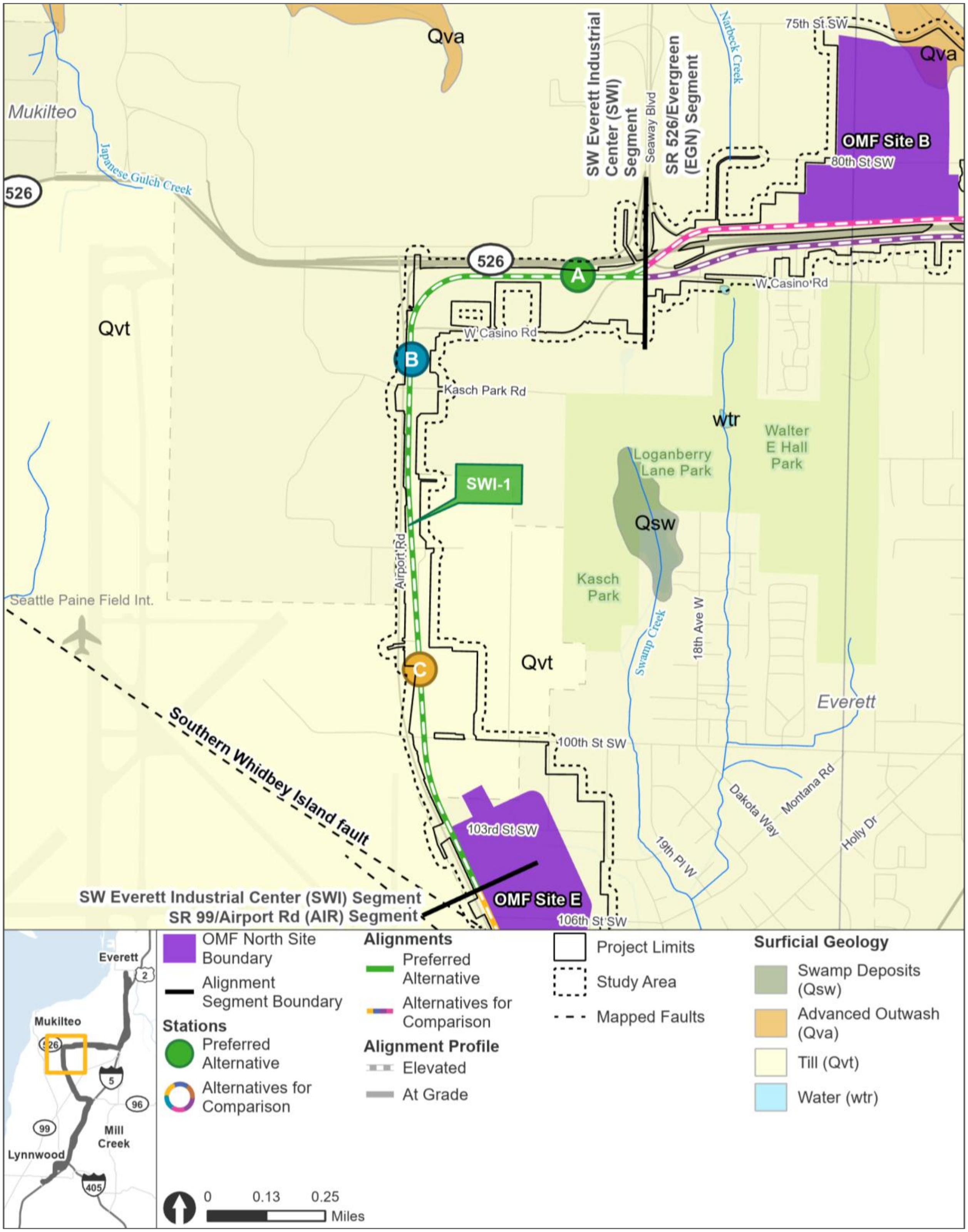
SOURCE: DNR (2019b) and Snohomish County (2024).

Figure 3-6 Surficial Geology – SR 99/Airport Road Segment and OMF Sites F and E



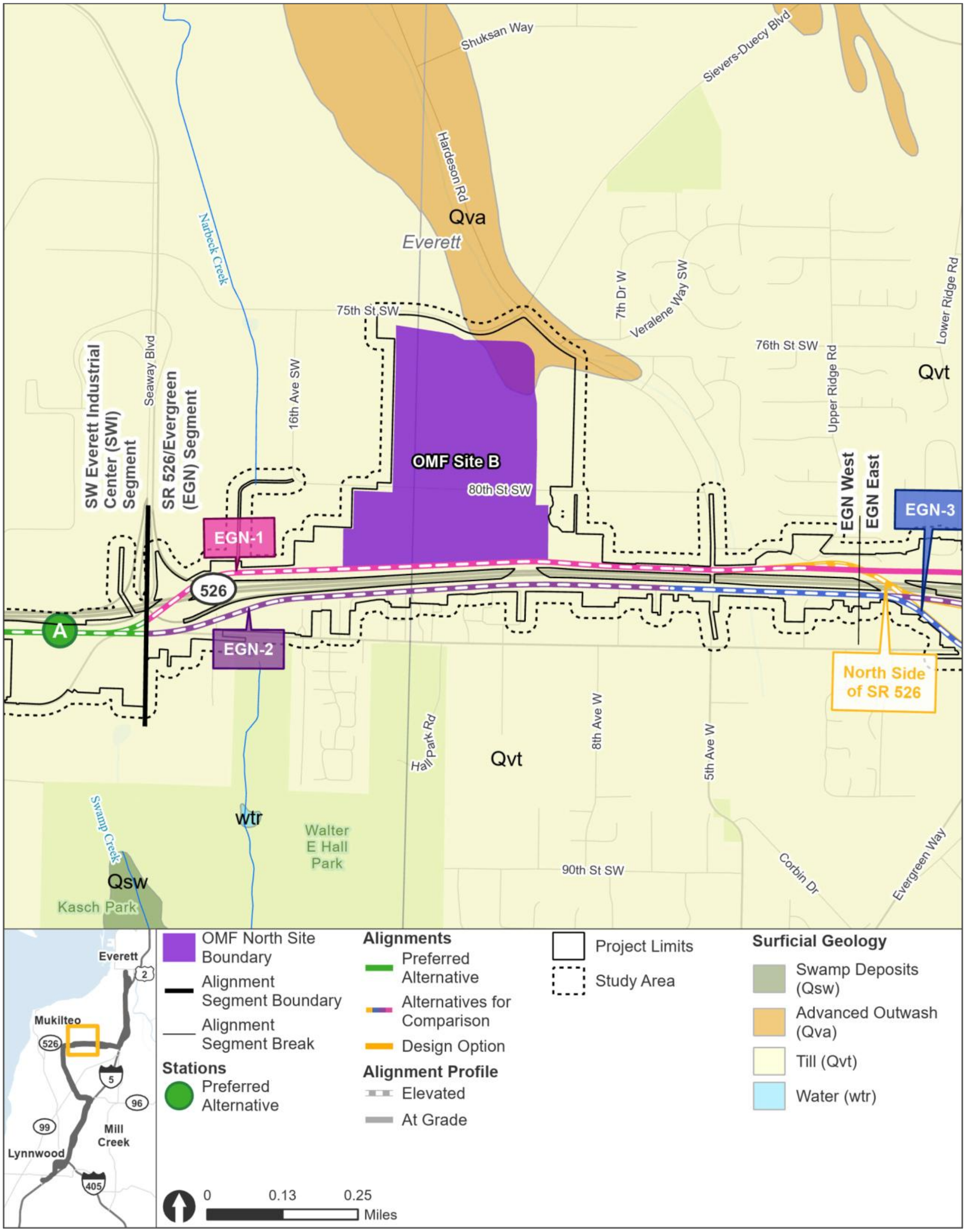
SOURCE: DNR (2019b) and Snohomish County (2024).

Figure 3-7 Surficial Geology – SW Everett Industrial Center Segment and OMF Site E



SOURCE: DNR (2019b) and Snohomish County (2024).

Figure 3-8 Surficial Geology – SR 526/Evergreen Segment (West) and OMF Site B

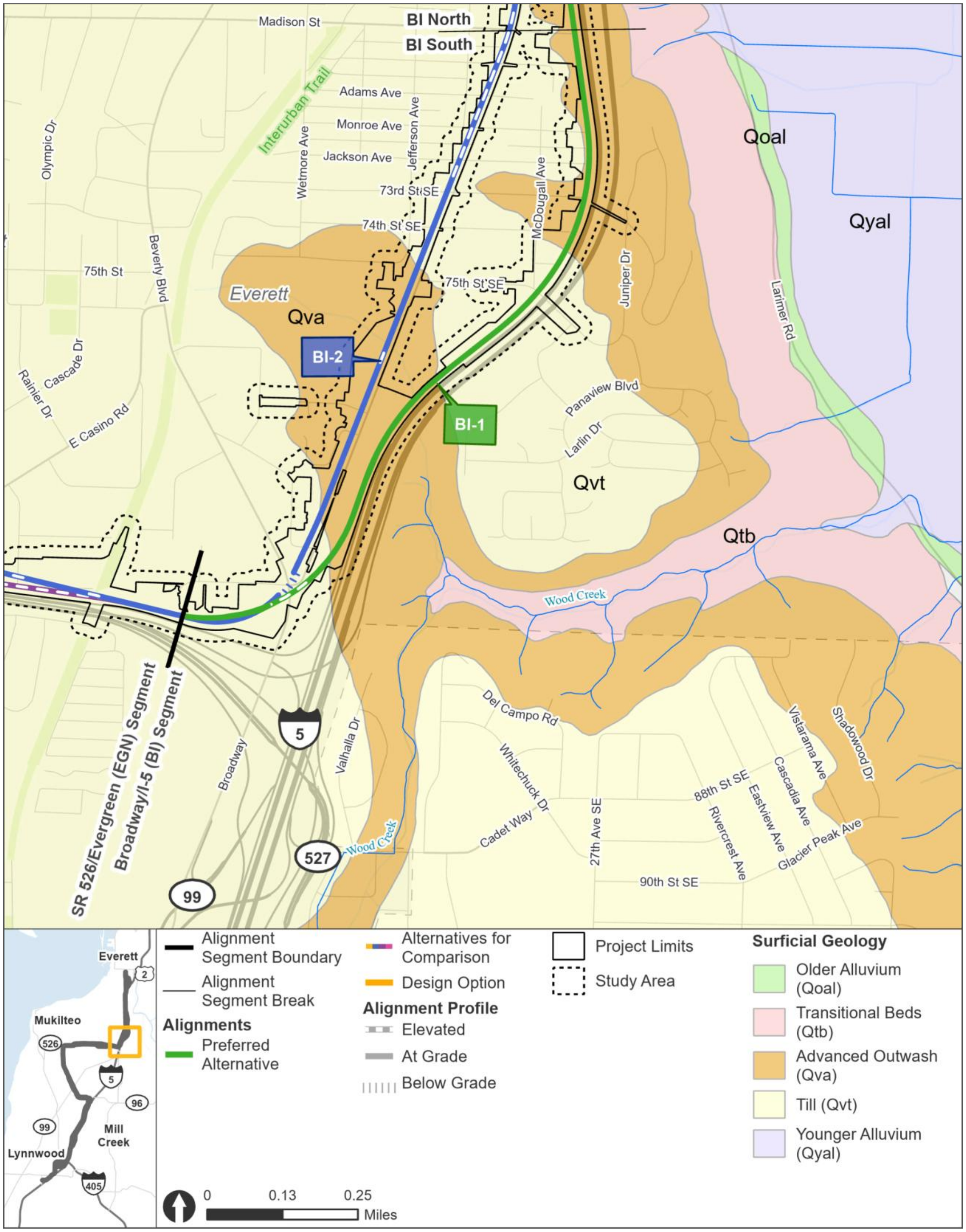


SOURCE: DNR (2019b) and Snohomish County (2024).

Figure 3-9 Surficial Geology – SR 526/Evergreen Segment (East)

SOURCE: DNR (2019b) and Snohomish County (2024).

Figure 3-10 Surficial Geology – Broadway/I-5 Segment (South)

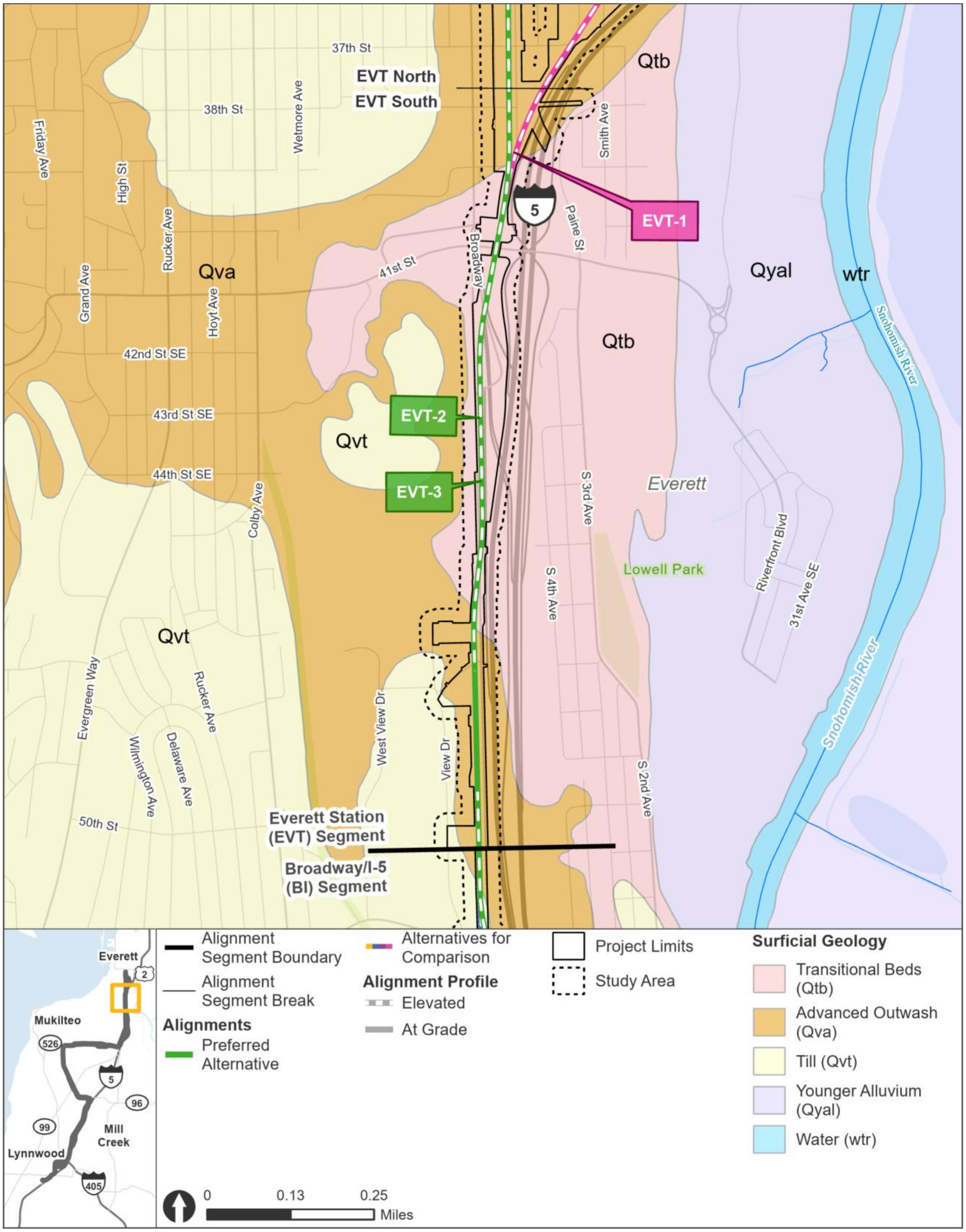


SOURCE: DNR (2019b) and Snohomish County (2024).

Figure 3-11 Surficial Geology – Broadway/I-5 Segment (North)

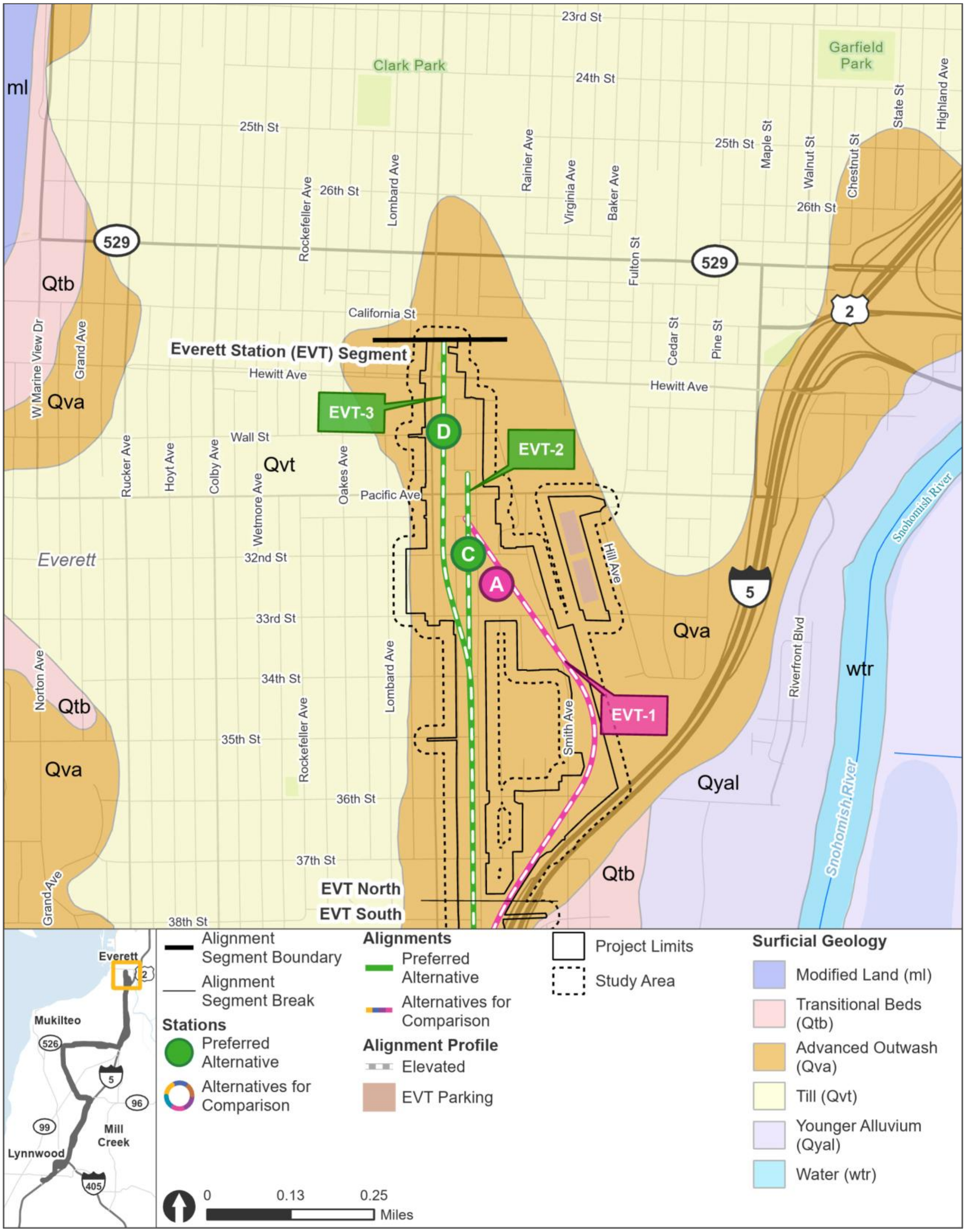
SOURCE: DNR (2019b) and Snohomish County (2024).

Figure 3-12 Surficial Geology – Everett Station Segment (South)



SOURCE: DNR (2019b) and Snohomish County (2024).

Figure 3-13 Surficial Geology – Everett Station Segment (North)



SOURCE: DNR (2019b) and Snohomish County (2024).

3.2 Geologic Hazards

3.2.1 Steep Slopes and Erosion Hazards

Steep slopes are mapped throughout the study area, as shown in Figure 3-14 through Figure 3-25. These mapped steep slopes include smaller, localized steep slopes as well as areas of laterally extensive steep slopes as described below.

Those mapped steep slopes that are smaller and localized in nature are typically limited in height and extent, are often adjacent to roads and highways, and may be associated with roadway embankments and other human-made cut slopes.

Mapped areas with laterally extensive steep slopes are located:

- In the Ash Way Segment, adjacent to the east side of I-5 south of the Ash Way and Mariner Segment boundary, and near a North Creek tributary (Figure 3-15 through Figure 3-17).
- In the SR 526/Evergreen Segment, near the Merrill and Ring Creek crossing under SR 526 within the northeast and northern portions of OMF Site B (Figure 3-20), and under SR 526 near the Interurban Trail (Figure 3-21).
- In the Broadway/I-5 Segment, the Wood Creek subbasin east of the I-5 and SR 526 interchange and extending north parallel to I-5 for approximately 2,000 feet (Figure 3-22).
- Along the eastern extents of the Broadway/I-5 and Everett Station Segments associated with the bluff above the Snohomish River Valley that is located east of I-5 from approximately the I-5 and SR 526 interchange to the 41st Street exit on I-5 (Figure 3-22 through Figure 3-24).

As shown in Figure 3-14 through Figure 3-25, most of the study area has been mapped as not being in an erosion hazard area. Areas within the study area or immediately adjacent to the study area that have been mapped as being within an erosion hazard area are:

- In the Ash Way Segment, at a previously described area of peat soils northwest of the SR 525/I-5 intersection through which Swamp Creek flows (Figure 3-15).
- In the Broadway/I-5 Segment, within the Wood Creek subbasin east of the I-5 and SR 526 interchange and extending north parallel to I-5 for approximately 2,000 feet (Figure 3-22).
- Along the eastern extents of the Broadway/I-5 and Everett Station Segments associated with the bluff above the Snohomish River Valley east of I-5 from approximately the I-5 and SR 526 interchange to the 41st Street exit on I-5 (Figure 3-22 through Figure 3-24).

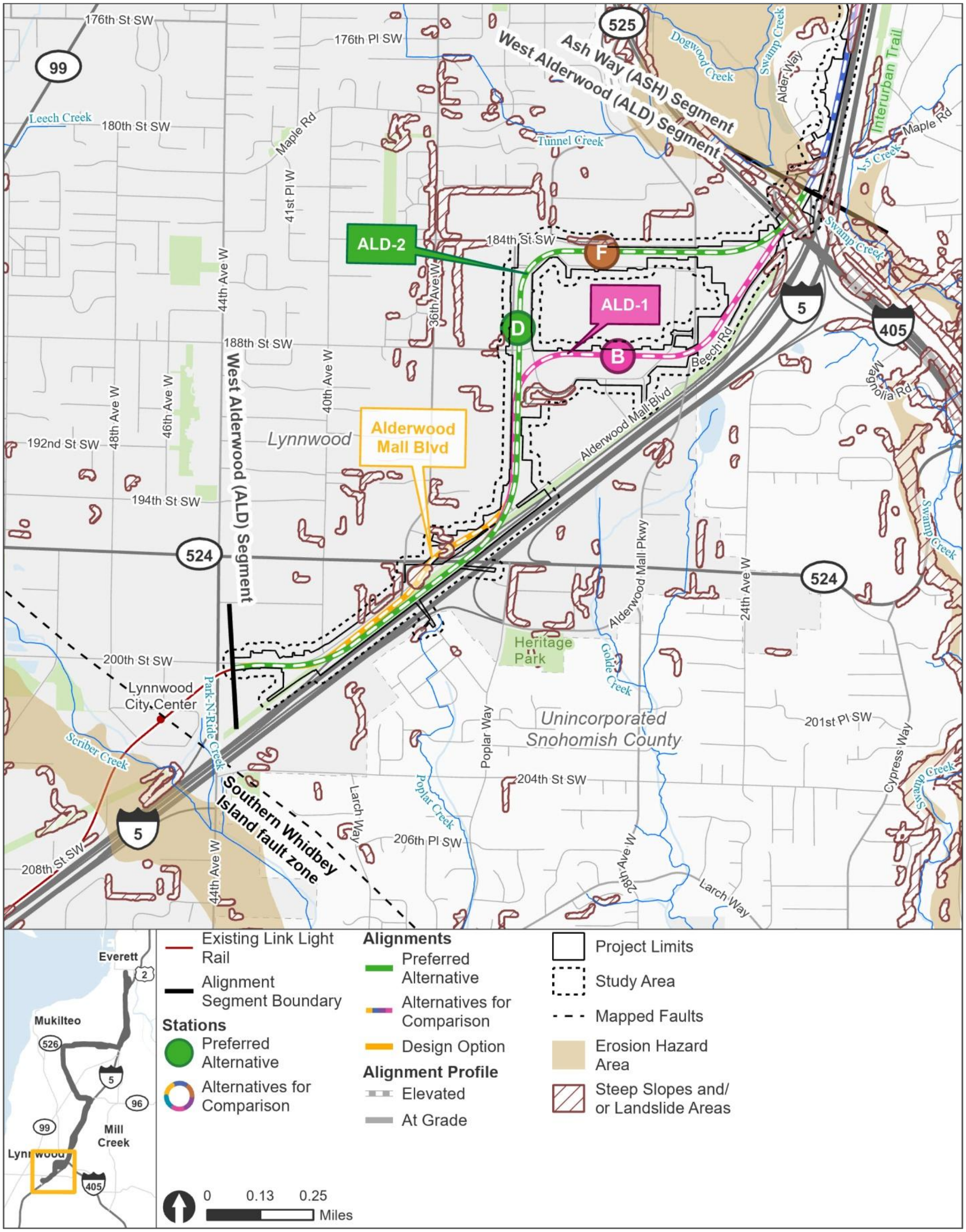
3.2.2 Landslides

Historic landslides have been mapped within the following areas, as shown in Figure 3-14 through Figure 3-25:

- In the Broadway/I-5 Segment, within the Wood Creek subbasin east of the I-5 and SR 526 interchange and extending north parallel to I-5 for approximately 2,000 feet (Figure 3-22).

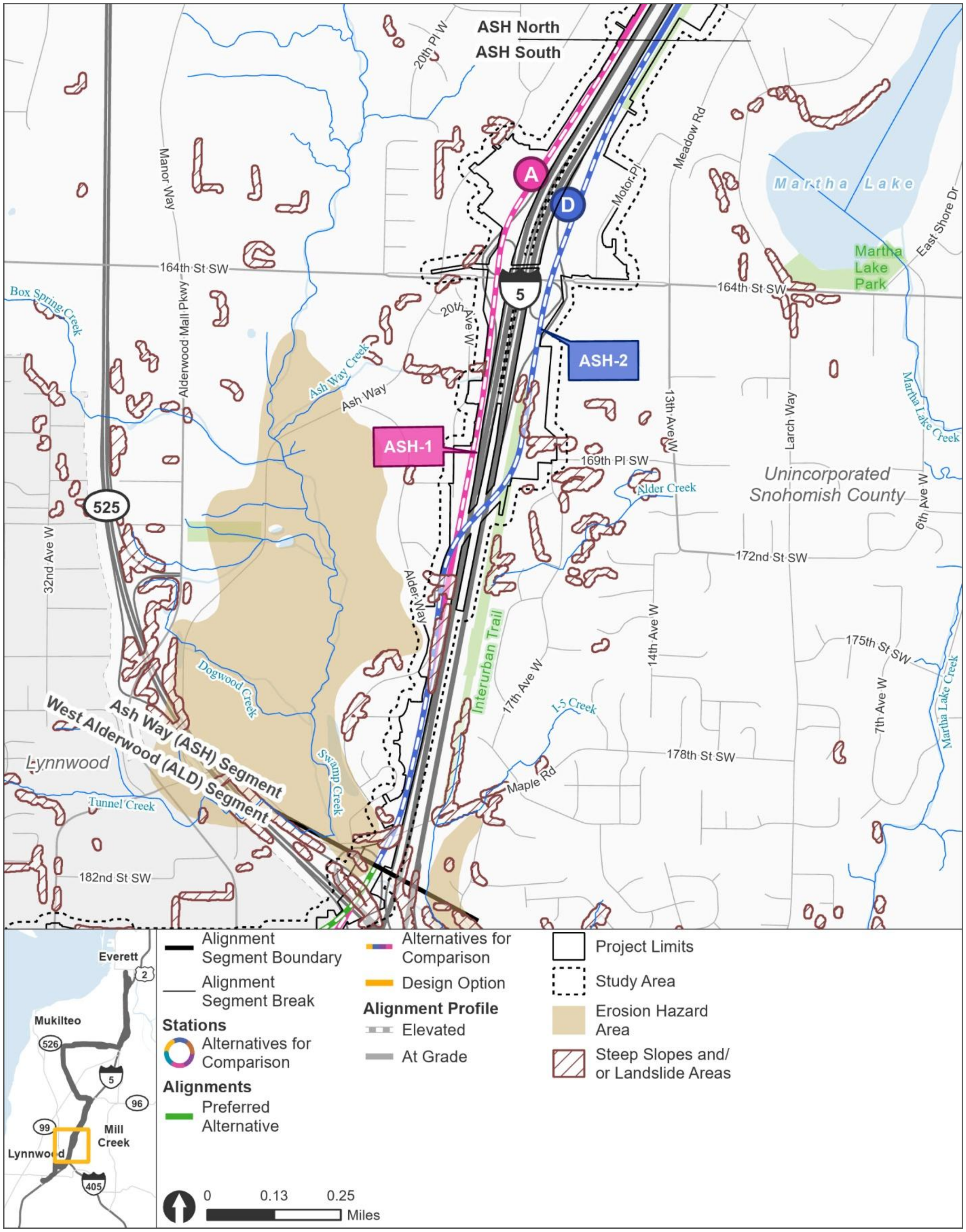
- Along the eastern extents of the Broadway/I-5 and Everett Station Segments associated with the bluff above the Snohomish River Valley east of I-5 from approximately the I-5 and SR 526 interchange to the 41st Street exit on I-5 (Figure 3-22 through Figure 3-24).

Figure 3-14 Erosion, Steep Slope, and Landslide Hazards – West Alderwood Segment



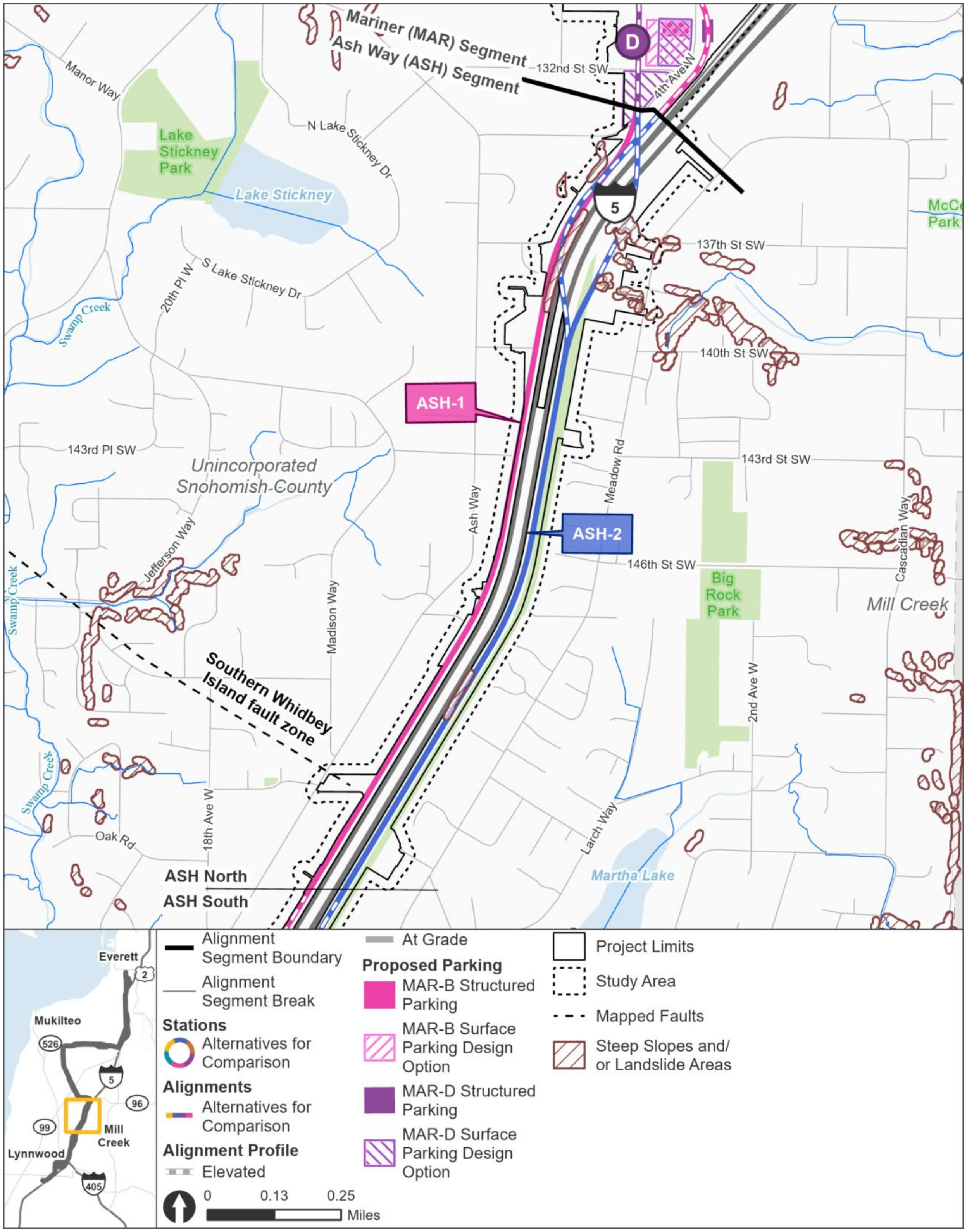
SOURCE: DNR (2024) and Snohomish County (2024).

Figure 3-15 Erosion, Steep Slope, and Landslide Hazards – Ash Way Segment (South)



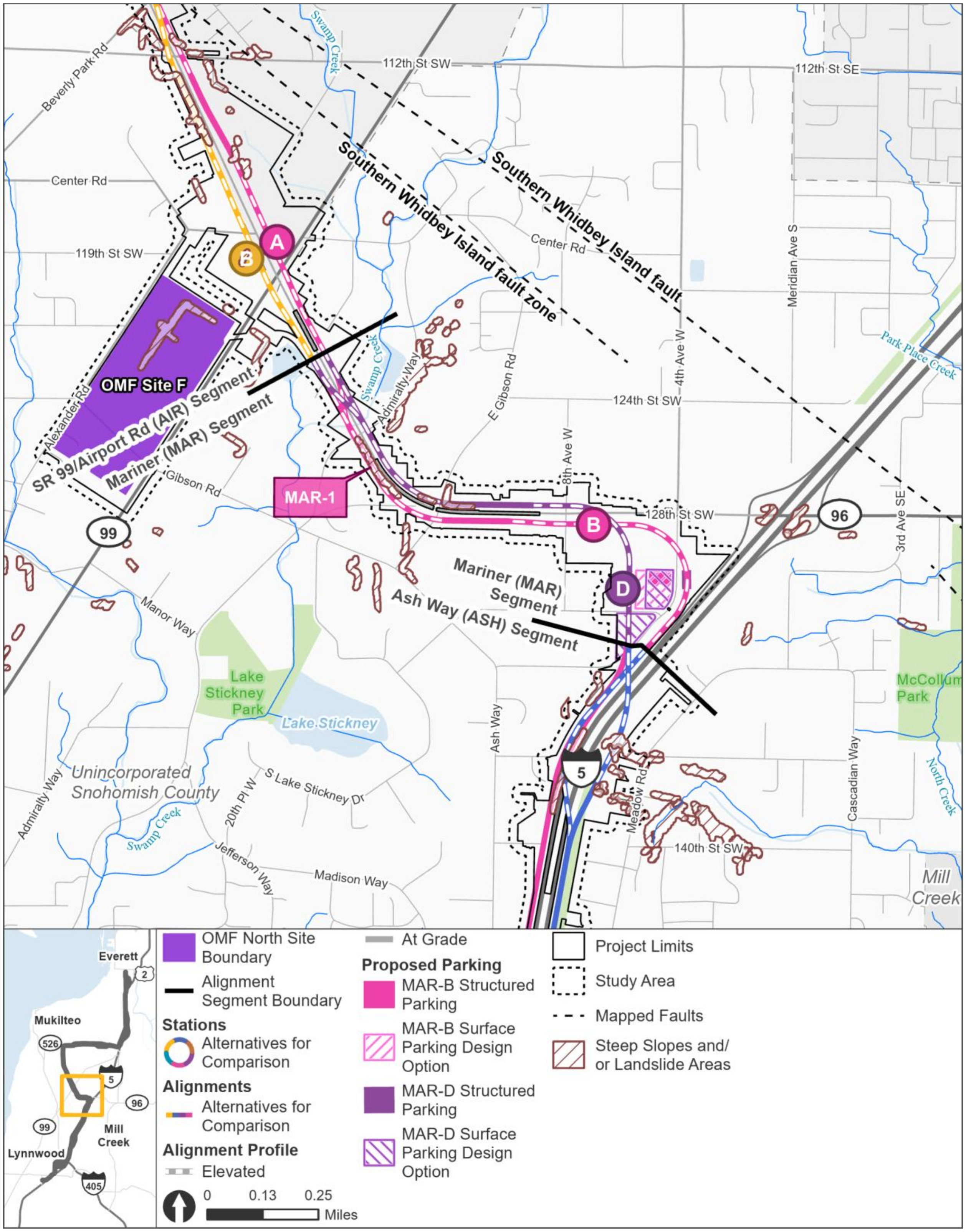
SOURCE: DNR (2024) and Snohomish County (2024).

Figure 3-16 Erosion, Steep Slope, and Landslide Hazards – Ash Way Segment (North)



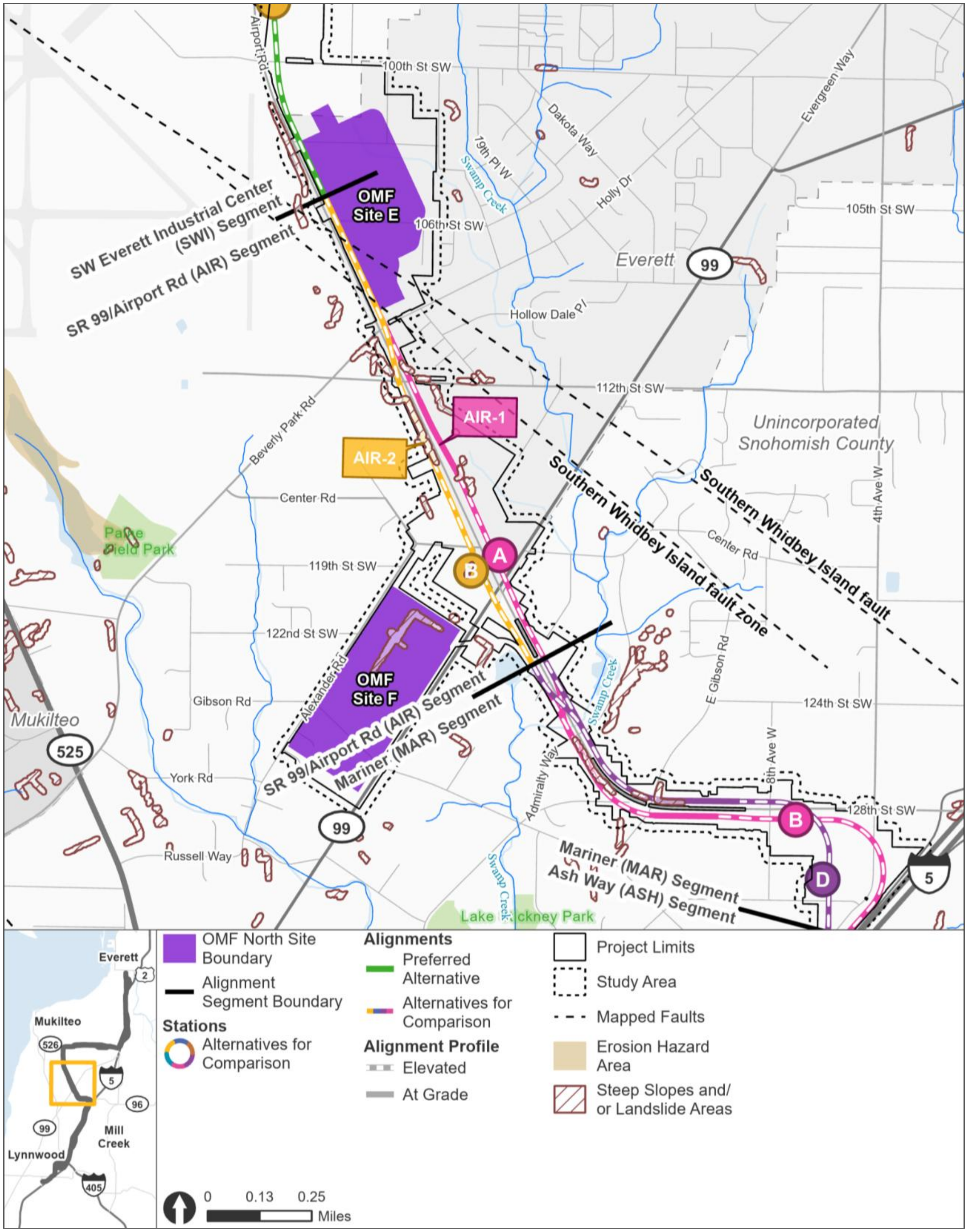
SOURCE: DNR (2024) and Snohomish County (2024).

Figure 3-17 Erosion, Steep Slope, and Landslide Hazards – Mariner Segment



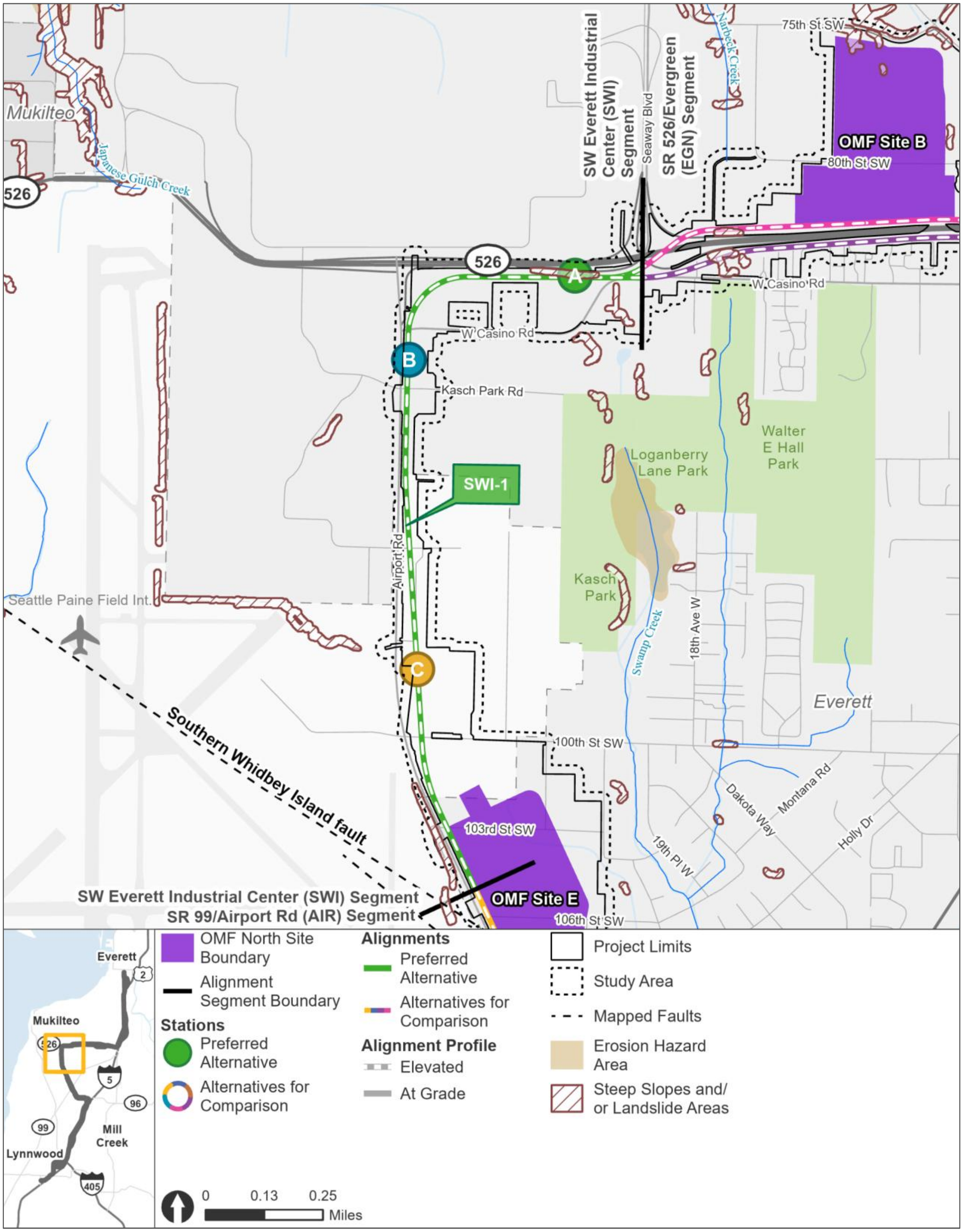
SOURCE: DNR (2024) and Snohomish County (2024).

Figure 3-18 Erosion, Steep Slope, and Landslide Hazards – SR 99/Airport Road Segment and OMF Sites F and E



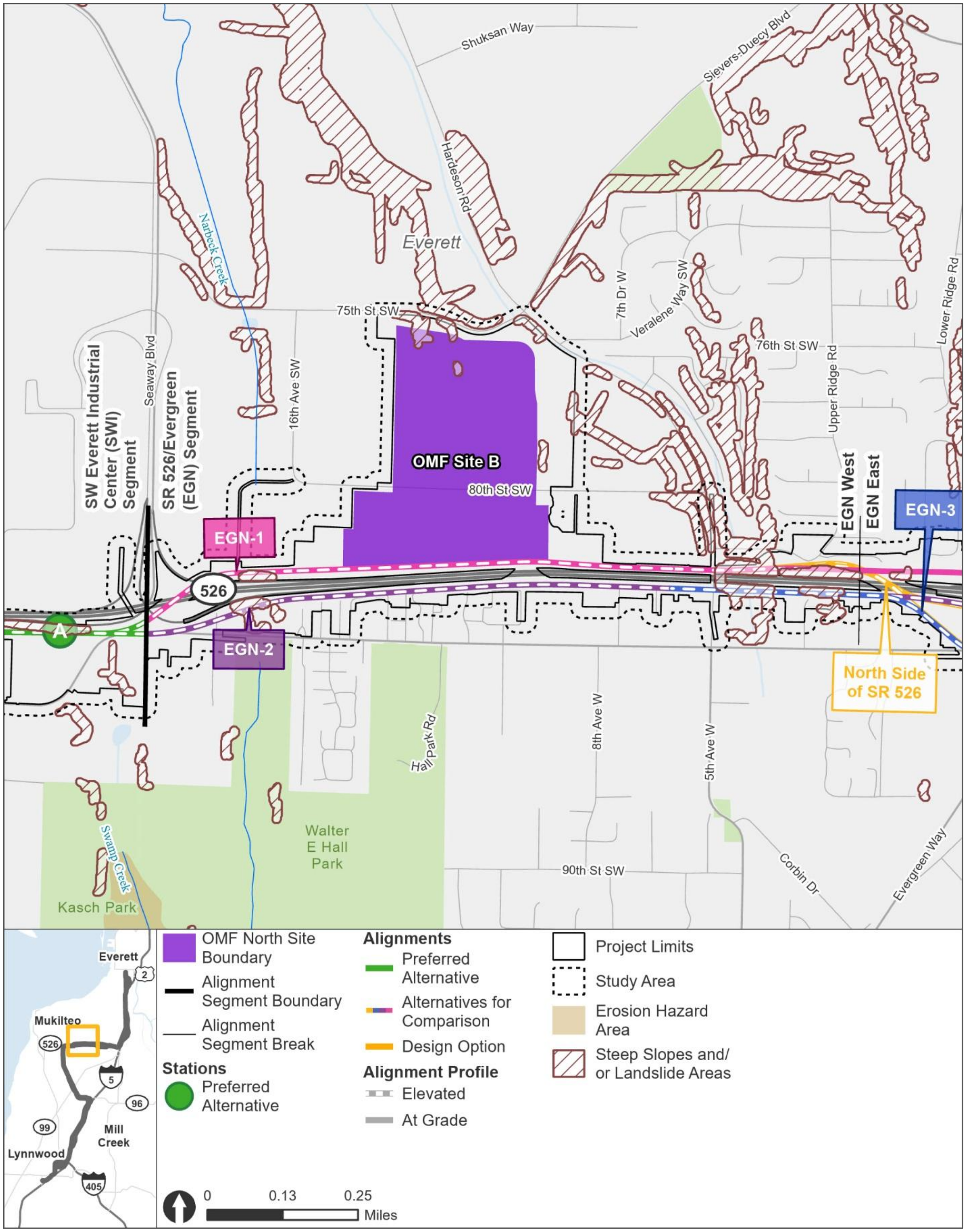
SOURCE: DNR (2024) and Snohomish County (2024).

Figure 3-19 Erosion, Steep Slope, and Landslide Hazards – SW Everett Industrial Center Segment and OMF Site E



SOURCE: DNR (2024) and Snohomish County (2024).

Figure 3-20 Erosion, Steep Slope, and Landslide Hazards – SR 526/Evergreen Segment (West) and OMF Site B

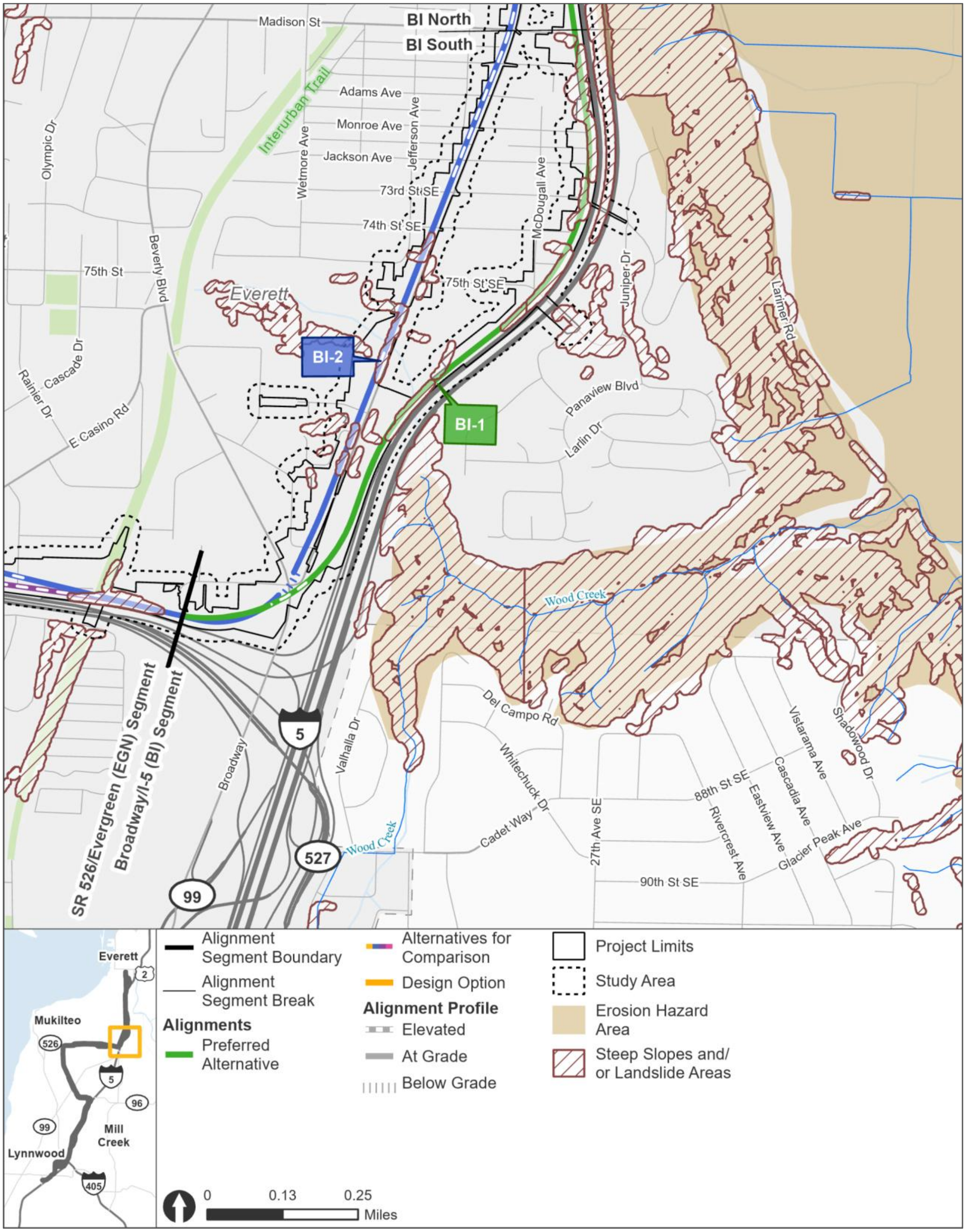


SOURCE: DNR (2024) and Snohomish County (2024).

Figure 3-21 Erosion, Steep Slope, and Landslide Hazards – SR 526/Evergreen Segment (East)

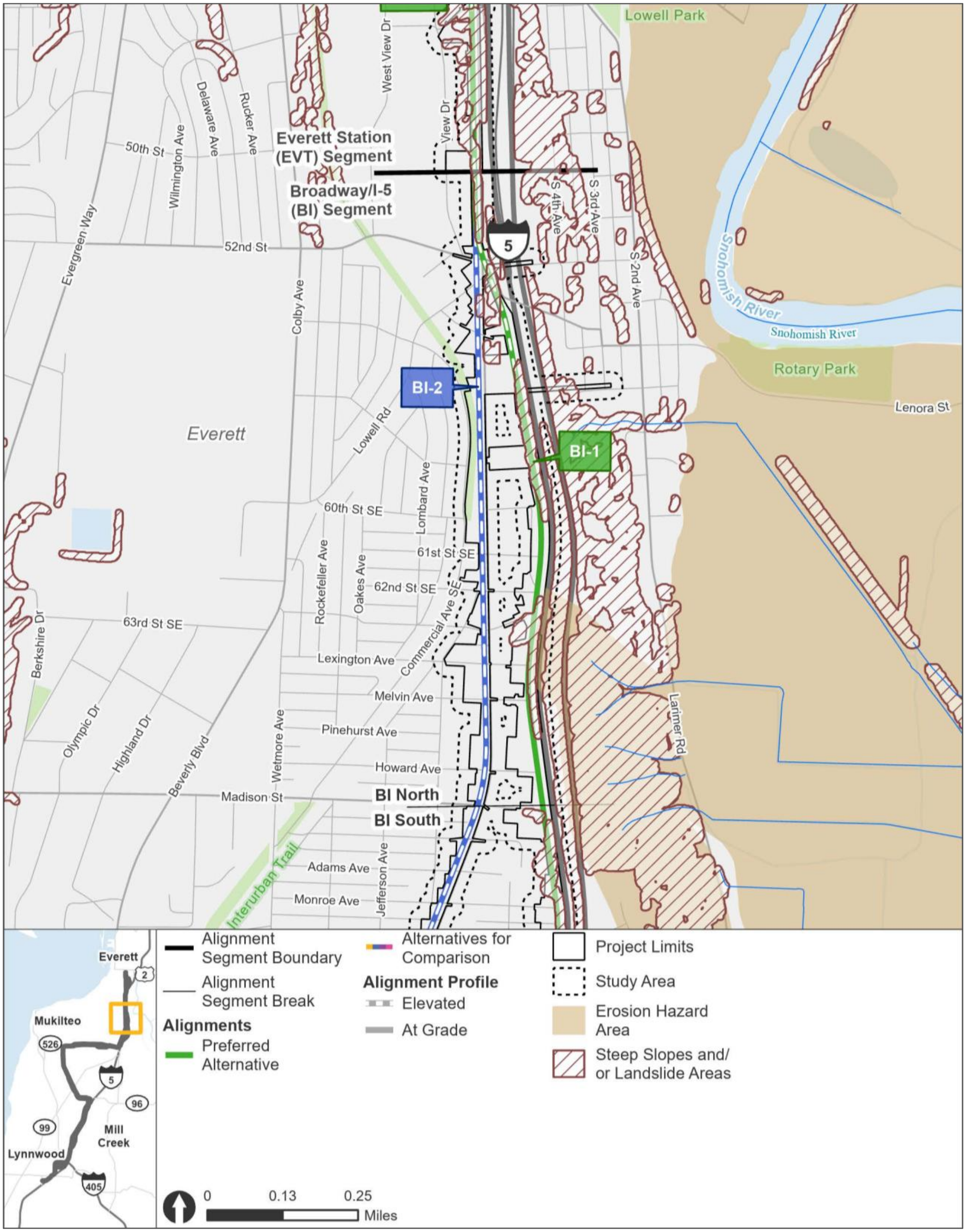
SOURCE: DNR (2024) and Snohomish County (2024).

Figure 3-22 Erosion, Steep Slope, and Landslide Hazards – Broadway/I-5 Segment (South)



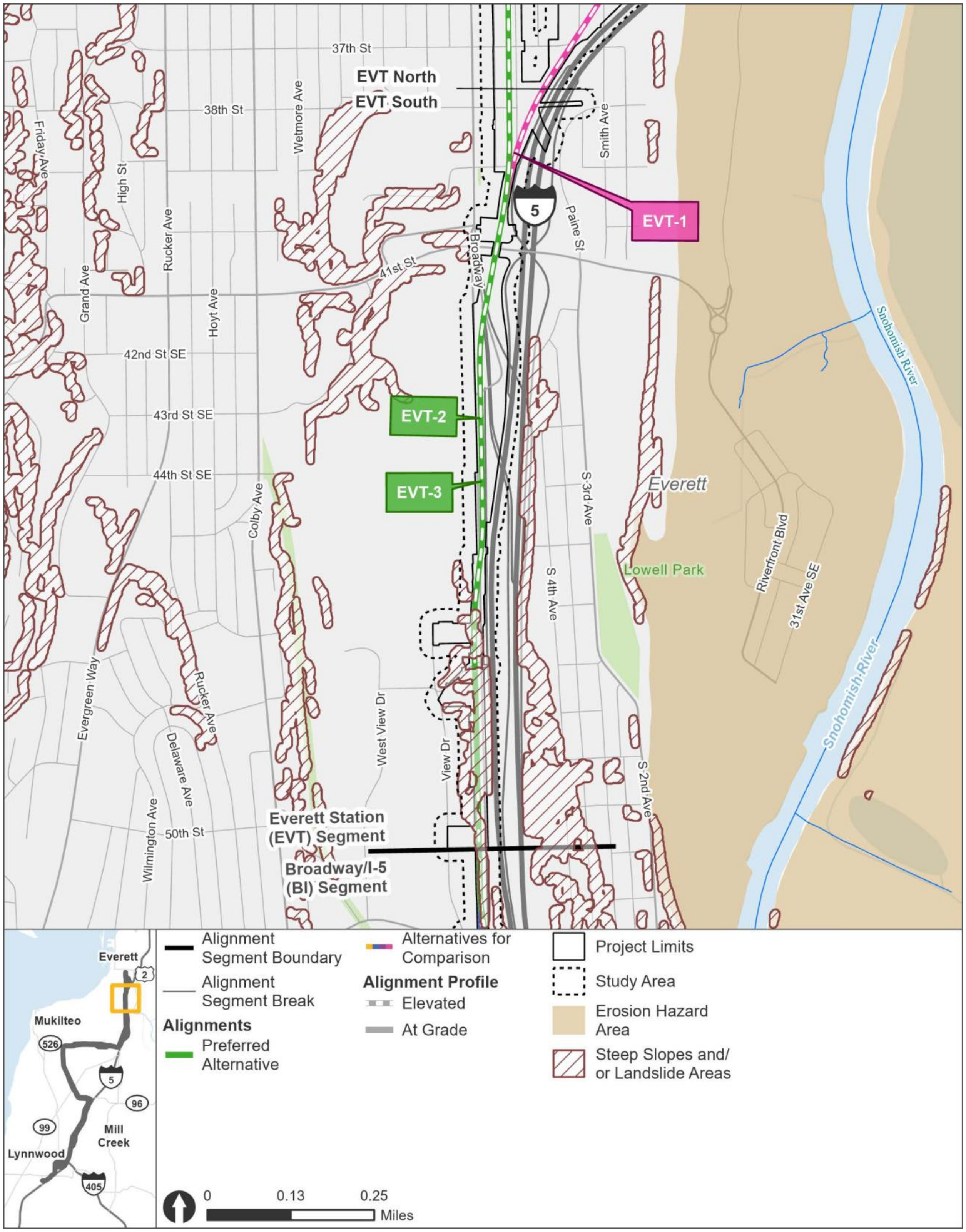
SOURCE: DNR (2024) and Snohomish County (2024).

Figure 3-23 Erosion, Steep Slope, and Landslide Hazards – Broadway/I-5 Segment (North)



SOURCE: DNR (2024) and Snohomish County (2024).

Figure 3-24 Erosion, Steep Slope, and Landslide Hazards – Everett Station Segment (South)



SOURCE: DNR (2024) and Snohomish County (2024).

Figure 3-25 Erosion, Steep Slope, and Landslide Hazards – Everett Station Segment (North)

SOURCE: DNR (2024) and Snohomish County (2024).

3.2.3 Seismic Hazards

3.2.3.1 Fault Zones

Maps from U.S. Geological Survey and DNR show a fault zone in the vicinity of the alignment (DNR 2022). The notable mapped active fault zone within the study area is summarized below and shown in Figure 3-26 through Figure 3-37.

- **Southern Whidbey Island Fault (SWIF) Zone:** The nearest potentially active fault zone to the project is the SWIF, a north-dipping fault zone trending northwest from Woodinville, Washington, to Victoria, Canada. The fault zone is approximately 4 to 7 miles wide between Lynnwood and Everett, crossing through the study area through the Ash Way (Figure 3-28) and SR 99/Airport Road (Figure 3-30) Segments. Geologic evidence discovered in the 2000s indicates that ground surface deformation from movement on this fault zone occurred as recently as about 3,000 years before present. It is estimated that the SWIF can produce earthquakes on the order of 7.0 magnitude (Sherrod and others 2008). This fault and fault zone pass through the southeastern portion of OMF Site E and underneath the alignment in the SR 99/Airport Road Segment. Additional detail on specific issues potentially associated with seismic activity is provided in the following subsections.

3.2.3.2 Liquefaction

Maps created by Snohomish County Emergency Management show areas with moderate to high susceptibility for liquefaction throughout the study area as shown in Figure 3-26 through Figure 3-37.

Mapped areas with moderate to high susceptibility for liquefaction are located:

- South of the study area in the West Alderwood Segment (Figure 3-26).
- A small area along the western boundary at the south end of the Ash Way Segment from approximately the boundary with the West Alderwood Segment to the intersection of Ash Way and Alder Way (Figure 3-27).
- Along the eastern extents of the Broadway/I-5 and Everett Station Segments associated with the Snohomish River Valley that is located east of I-5 from approximately the I-5 and SR 526 interchange to the 41st Street exit on I-5 (Figure 3-34 through Figure 3-37).

3.2.3.3 Soft-Soil Ground Motion Amplification

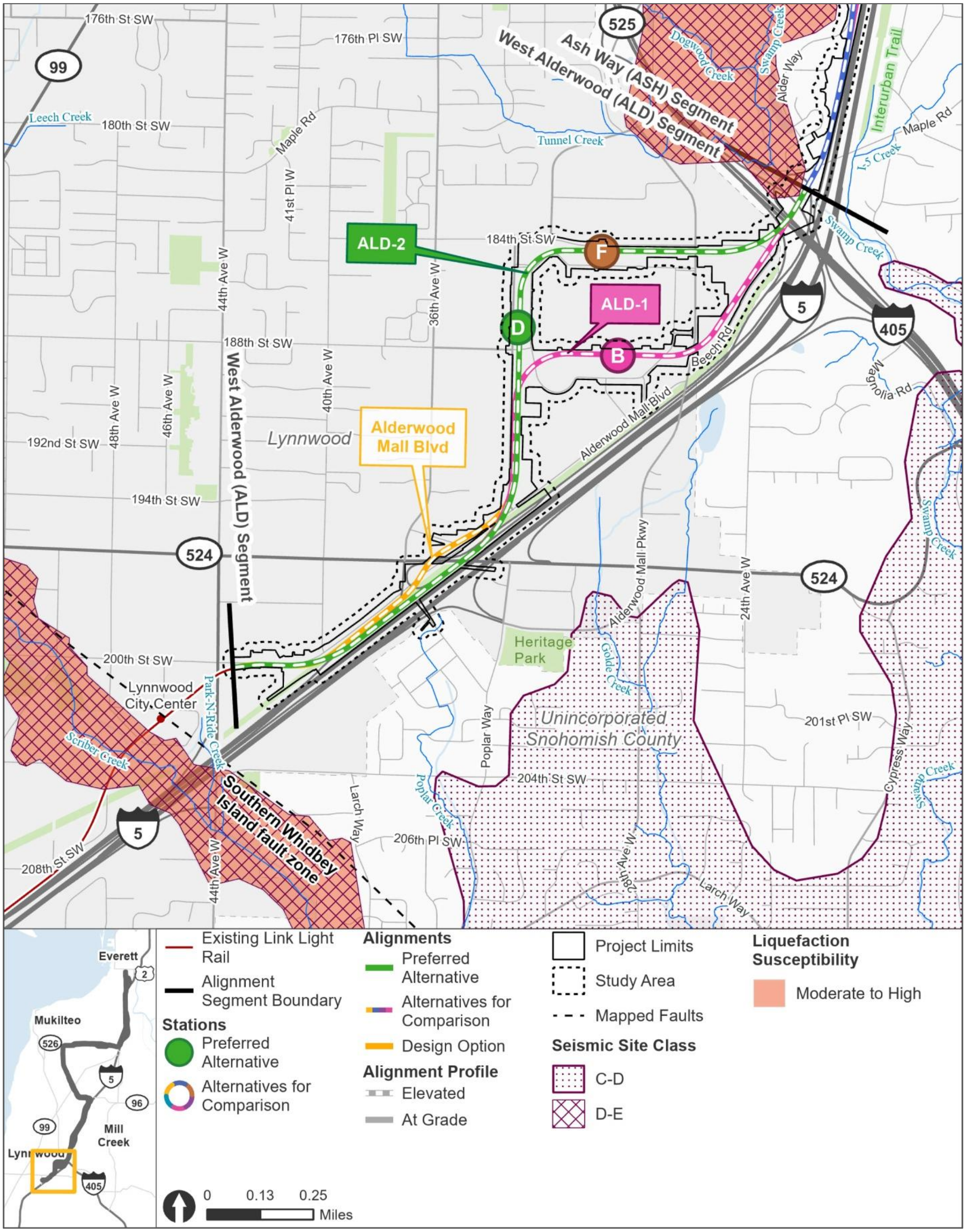
Maps created by the DNR show areas mapped as Seismic Site Classes C-D, D, D-E, and E, which have relatively high potential for ground motion amplification, within the study area as shown in Figure 3-26 through Figure 3-37.

Mapped areas with relatively high potential for ground motion amplification are located:

- South of the West Alderwood Segment study area (Figure 3-26).
- On the western boundary of the Ash Way Segment from approximately the boundary with the West Alderwood Segment to the intersection of Ash Way and Alder Way (Figure 3-27).
- In the northeast corner of OMF Site B in the SR 526/Evergreen Segment (Figure 3-32).

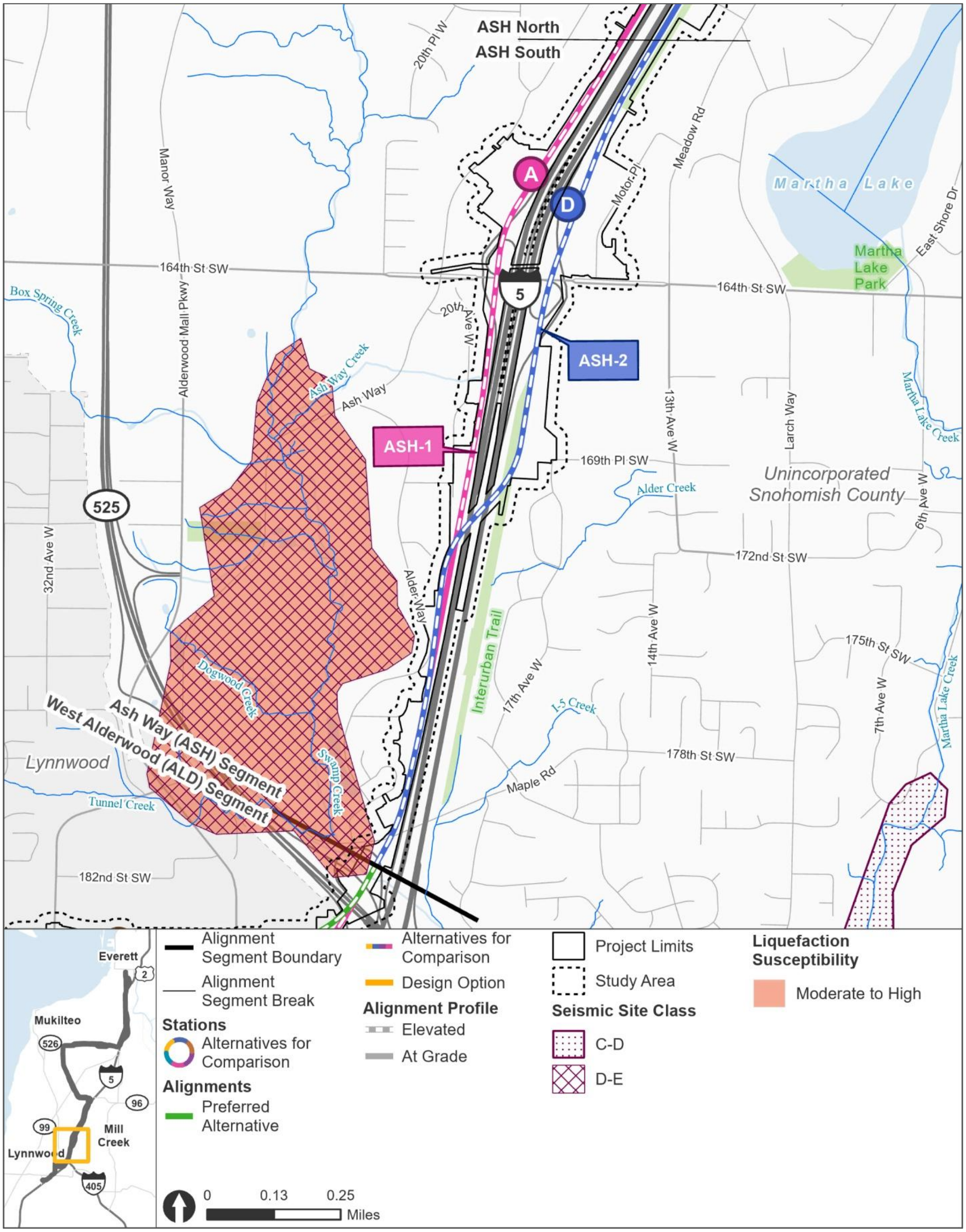
- Crossing Alternative BI-1 in the southern portion of Broadway/I-5 Segment near the intersection of 78th Place SE and Broadway, crossing both Alternatives BI-1 and BI-2 farther south, and adjacent to or underneath both alignment alternatives in the entire northern portion of this segment (Figure 3-34 through Figure 3-37).
- Throughout the Everett Station Segment (Figure 3-36 and Figure 3-37).

Figure 3-26 Seismic Hazards – West Alderwood Segment



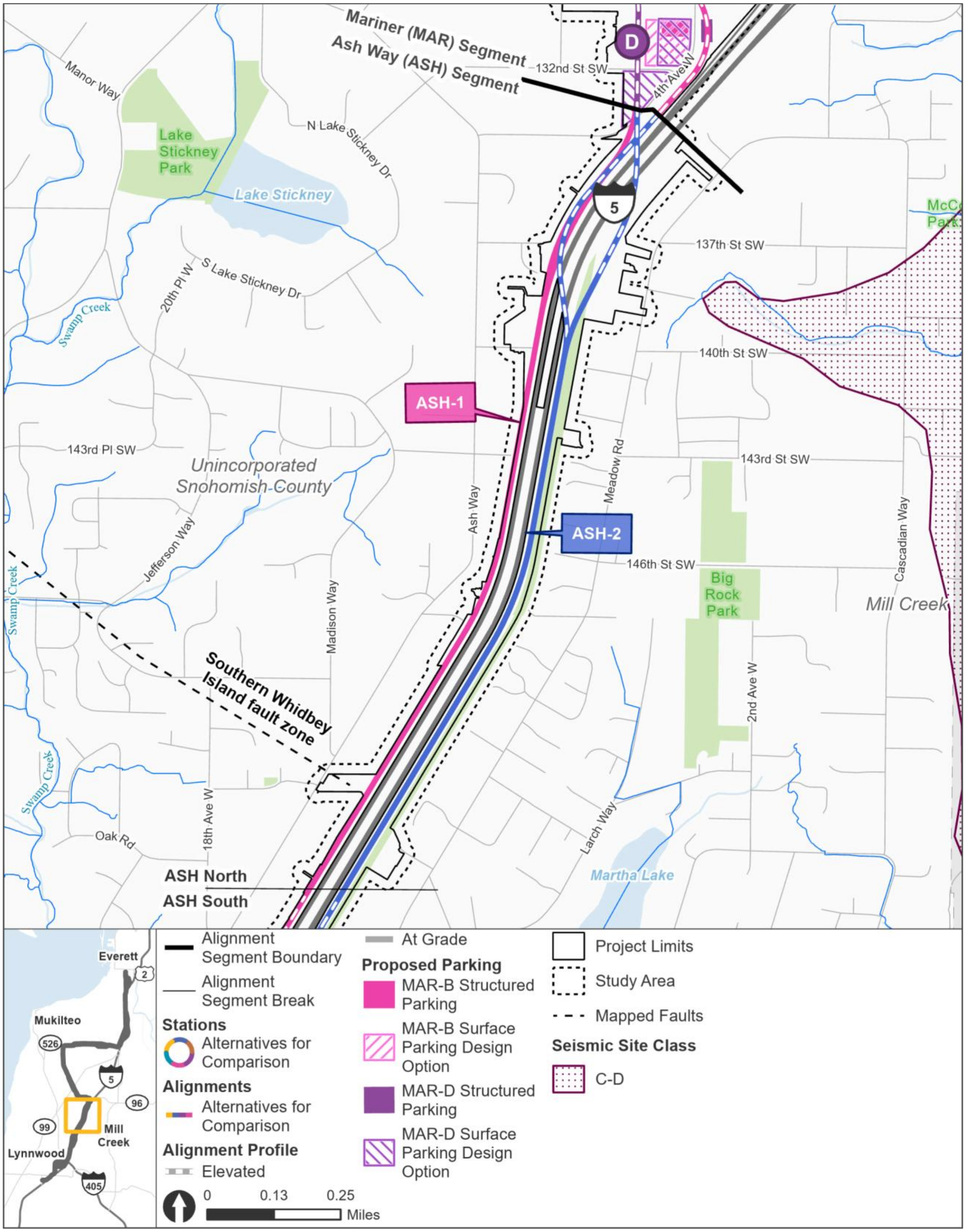
SOURCE: DNR (2022 and 2024) and Snohomish County (2024).

Figure 3-27 Seismic Hazards – Ash Way Segment (South)



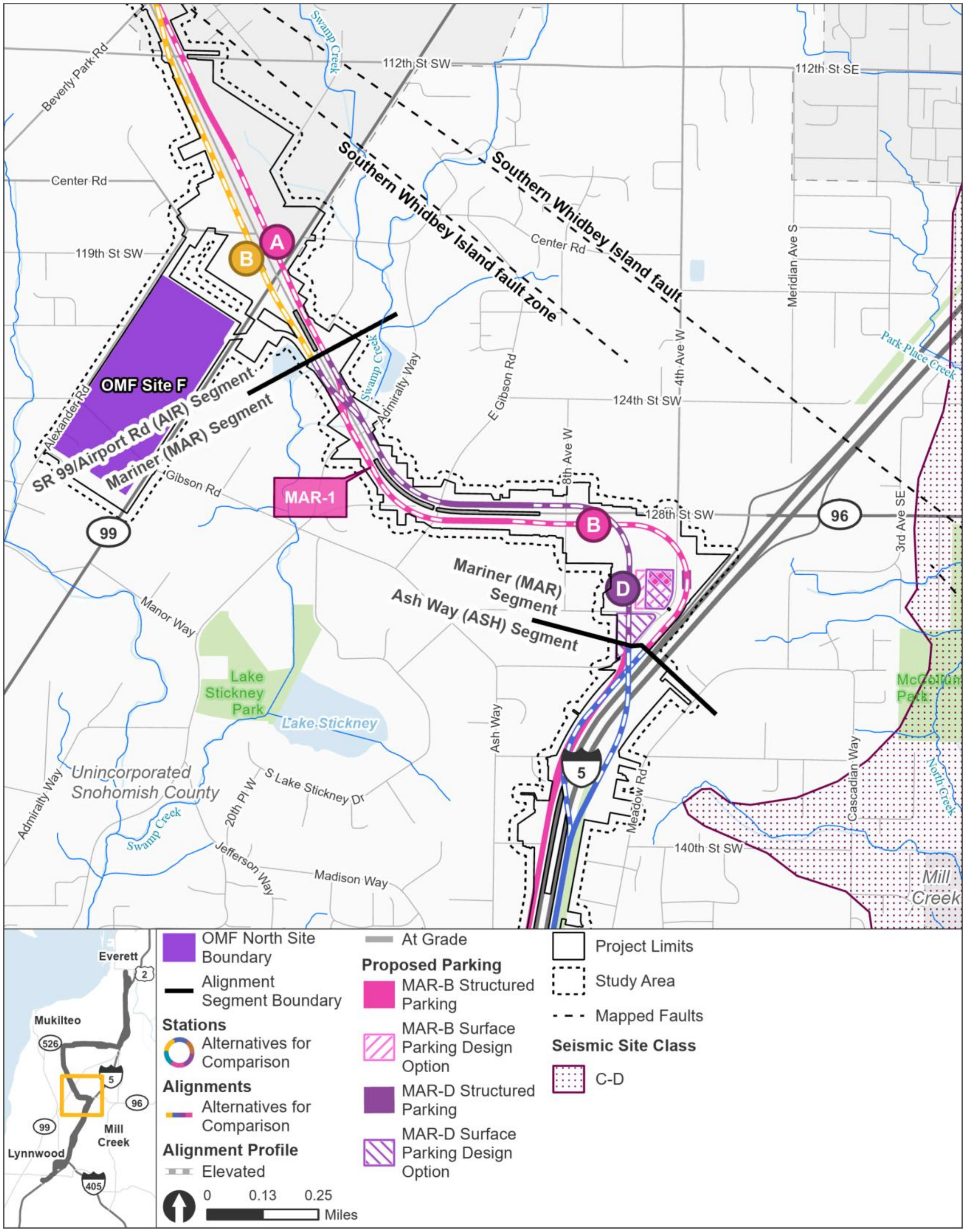
SOURCE: DNR (2022 and 2024) and Snohomish County (2024).

Figure 3-28 Seismic Hazards – Ash Way Segment (North)



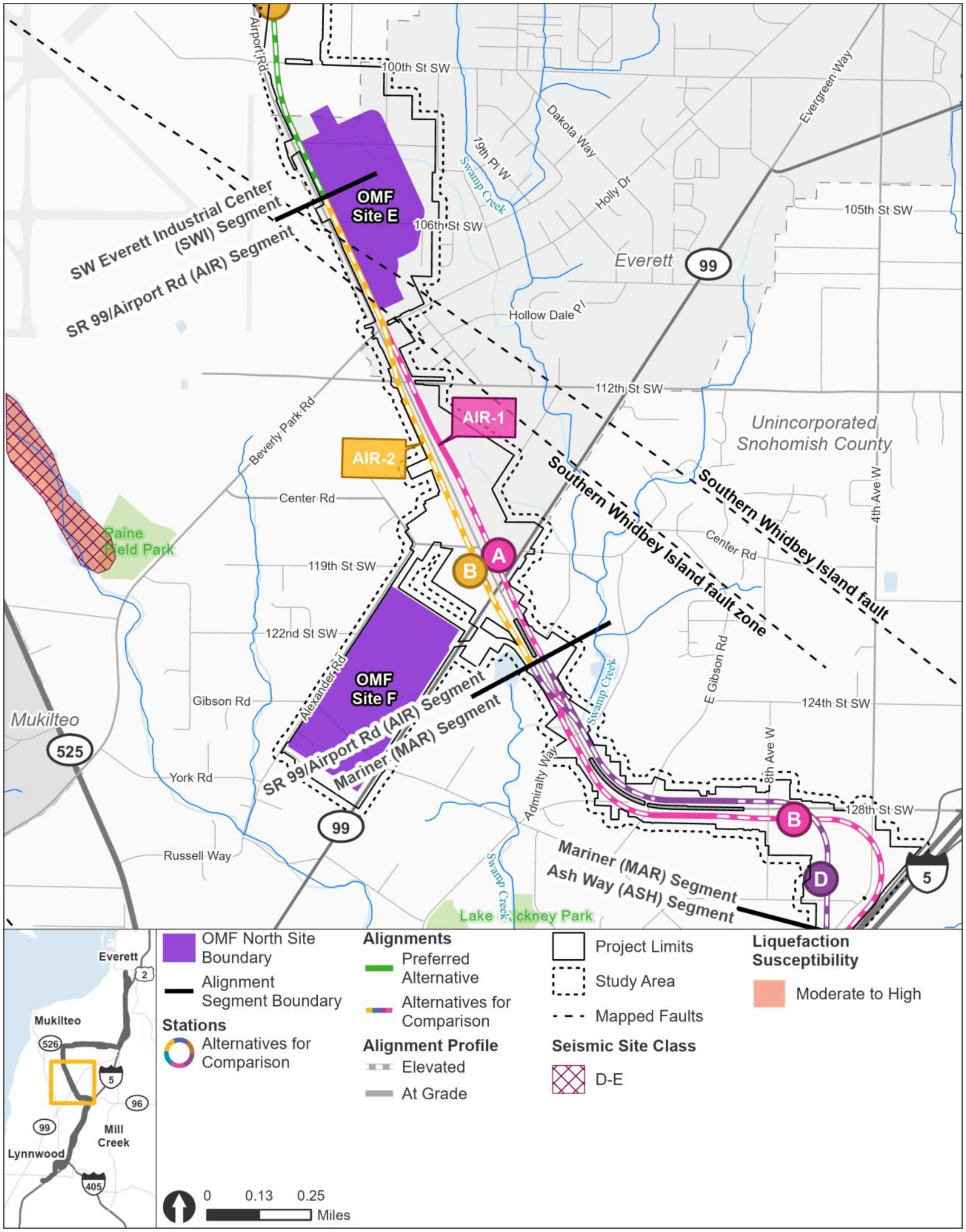
SOURCE: DNR (2022 and 2024) and Snohomish County (2024).

Figure 3-29 Seismic Hazards – Mariner Segment



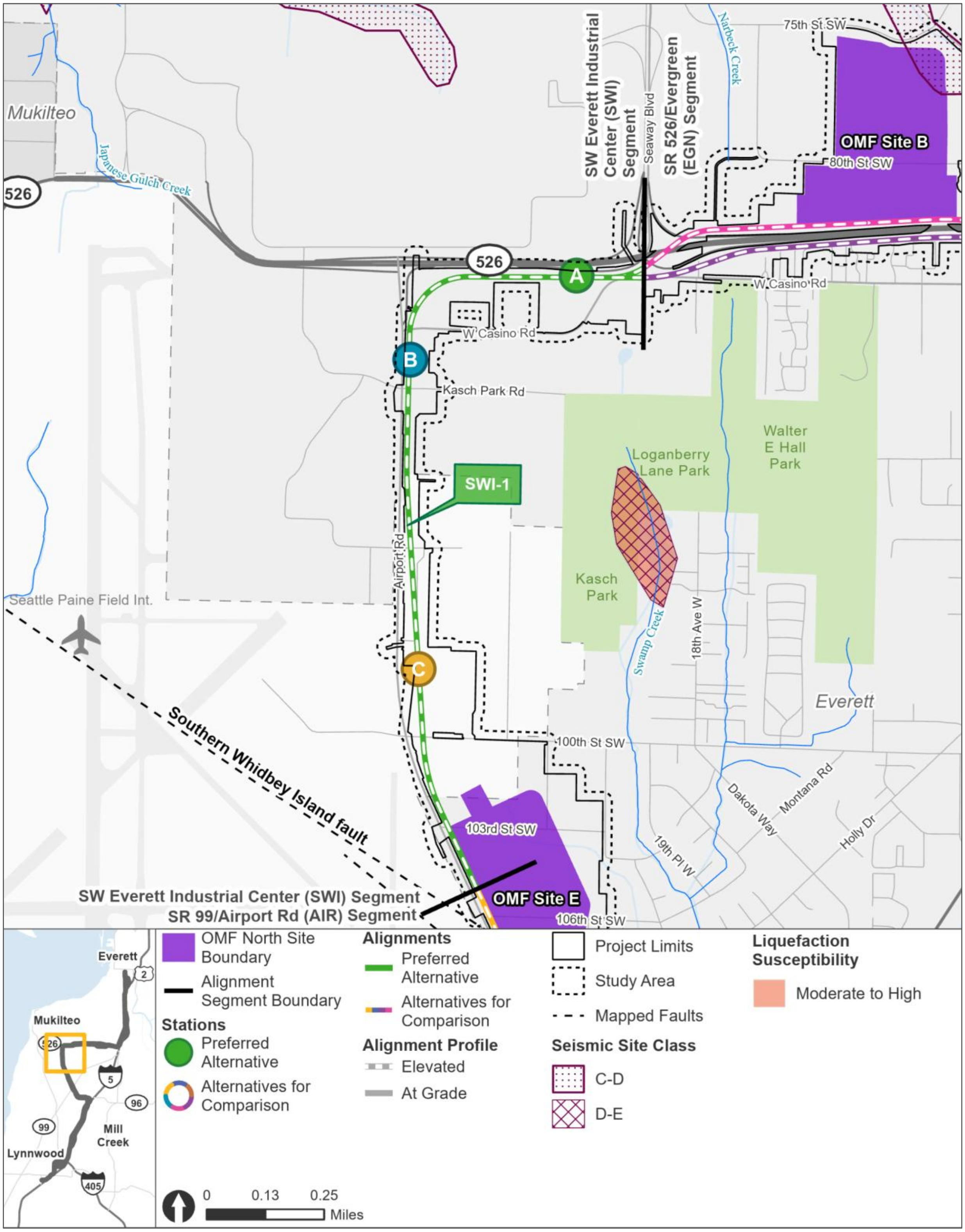
SOURCE: DNR (2022 and 2024) and Snohomish County (2024).

Figure 3-30 Seismic Hazards – SR 99/Airport Road Segment and OMF Sites F and E



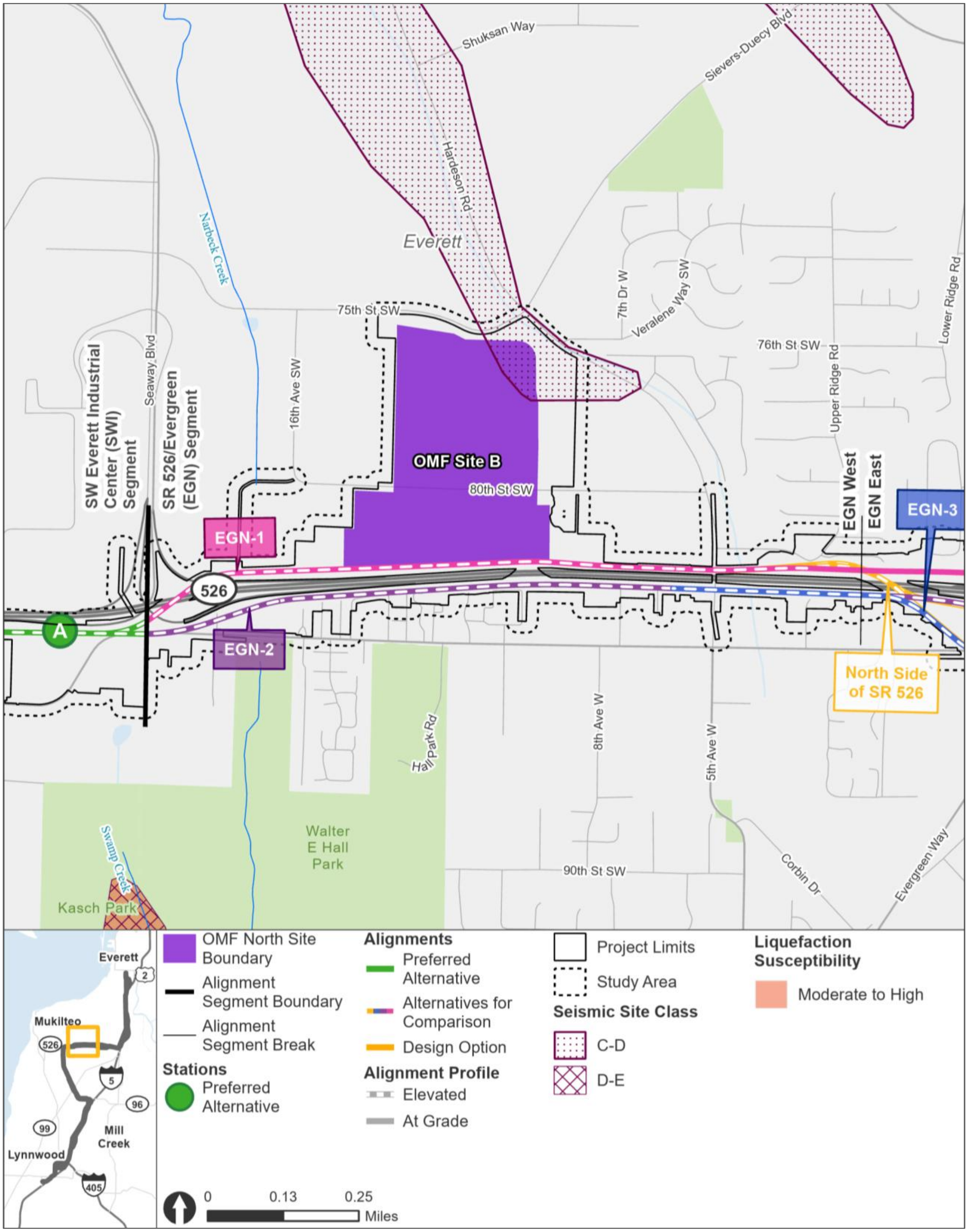
SOURCE: DNR (2022 and 2024) and Snohomish County (2024).

Figure 3-31 Seismic Hazards – SW Everett Industrial Center Segment and OMF Site E



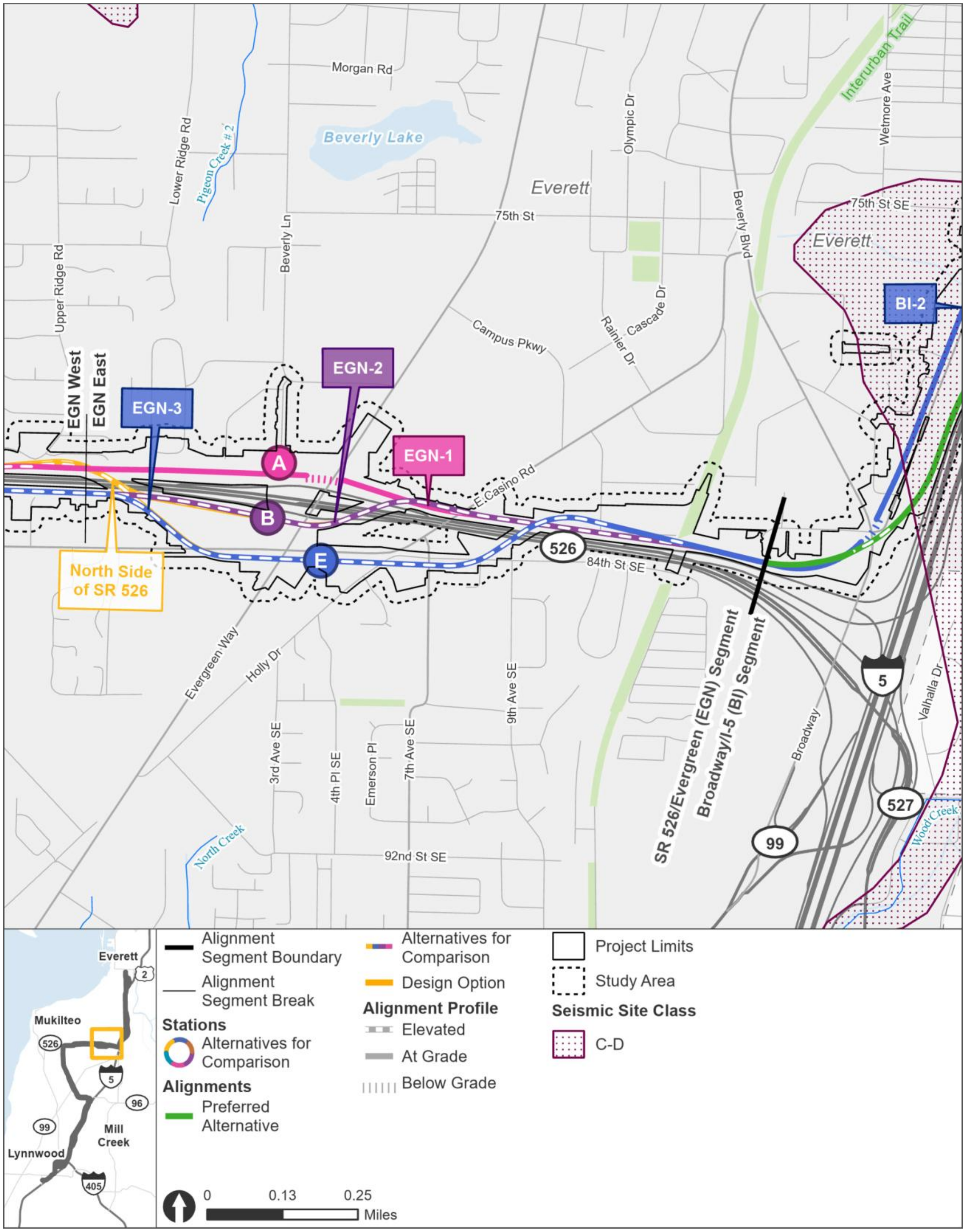
SOURCE: DNR (2022 and 2024) and Snohomish County (2024).

Figure 3-32 Seismic Hazards – SR 526/Evergreen Segment (West) and OMF Site B



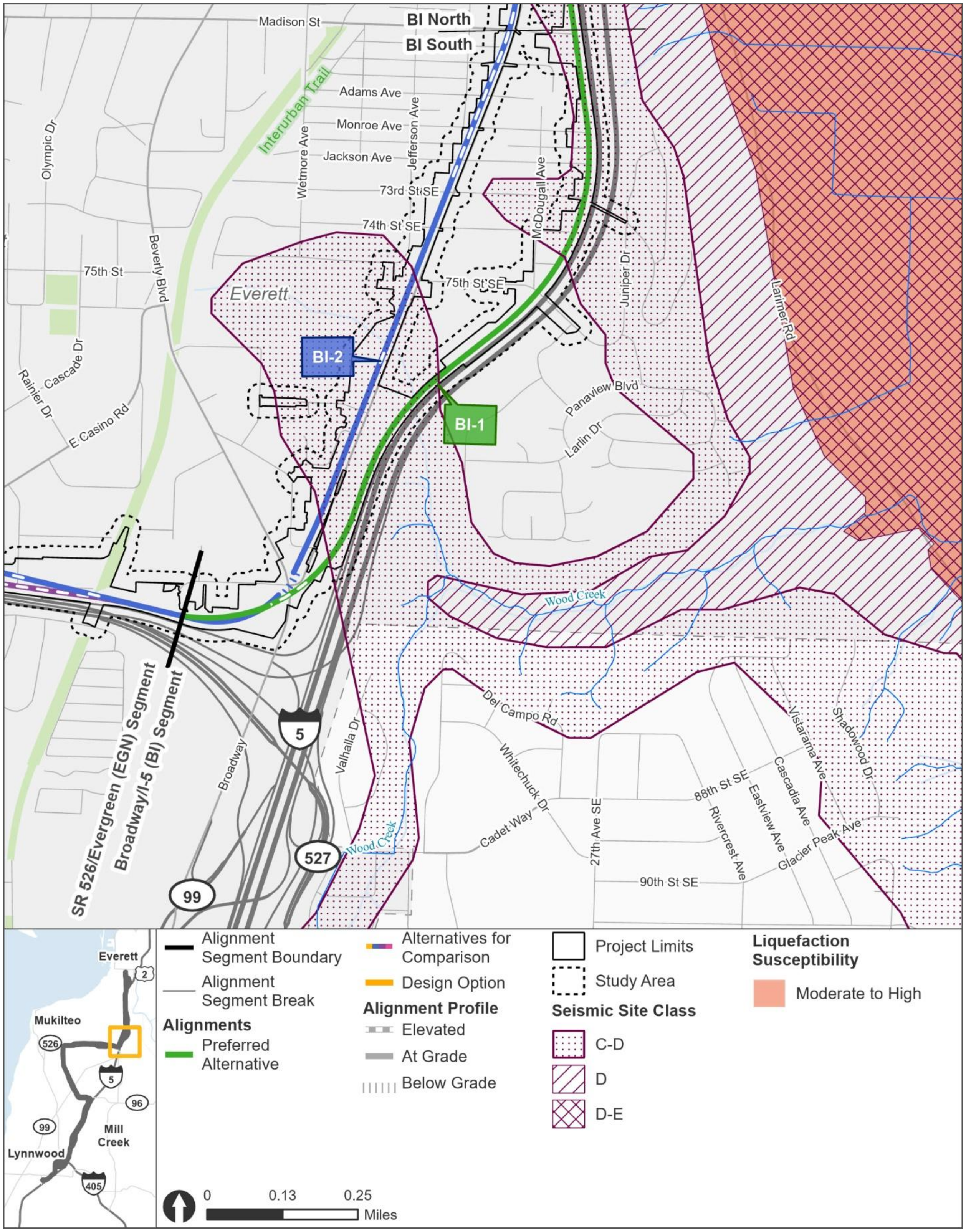
SOURCE: DNR (2022 and 2024) and Snohomish County (2024).

Figure 3-33 Seismic Hazards – SR 526/Evergreen Segment (East)



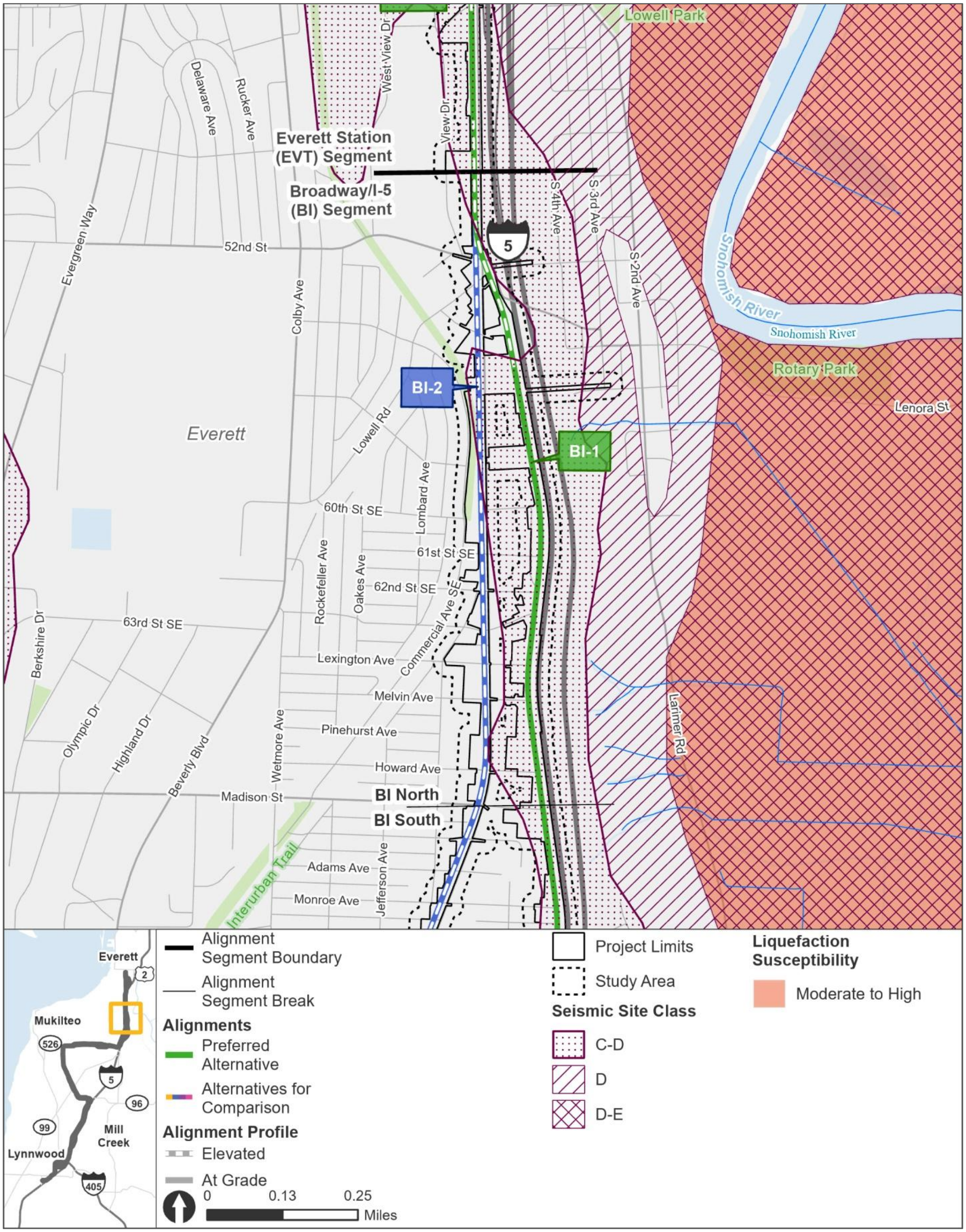
SOURCE: DNR (2022 and 2024) and Snohomish County (2024).

Figure 3-34 Seismic Hazards – Broadway/I-5 Segment (South)



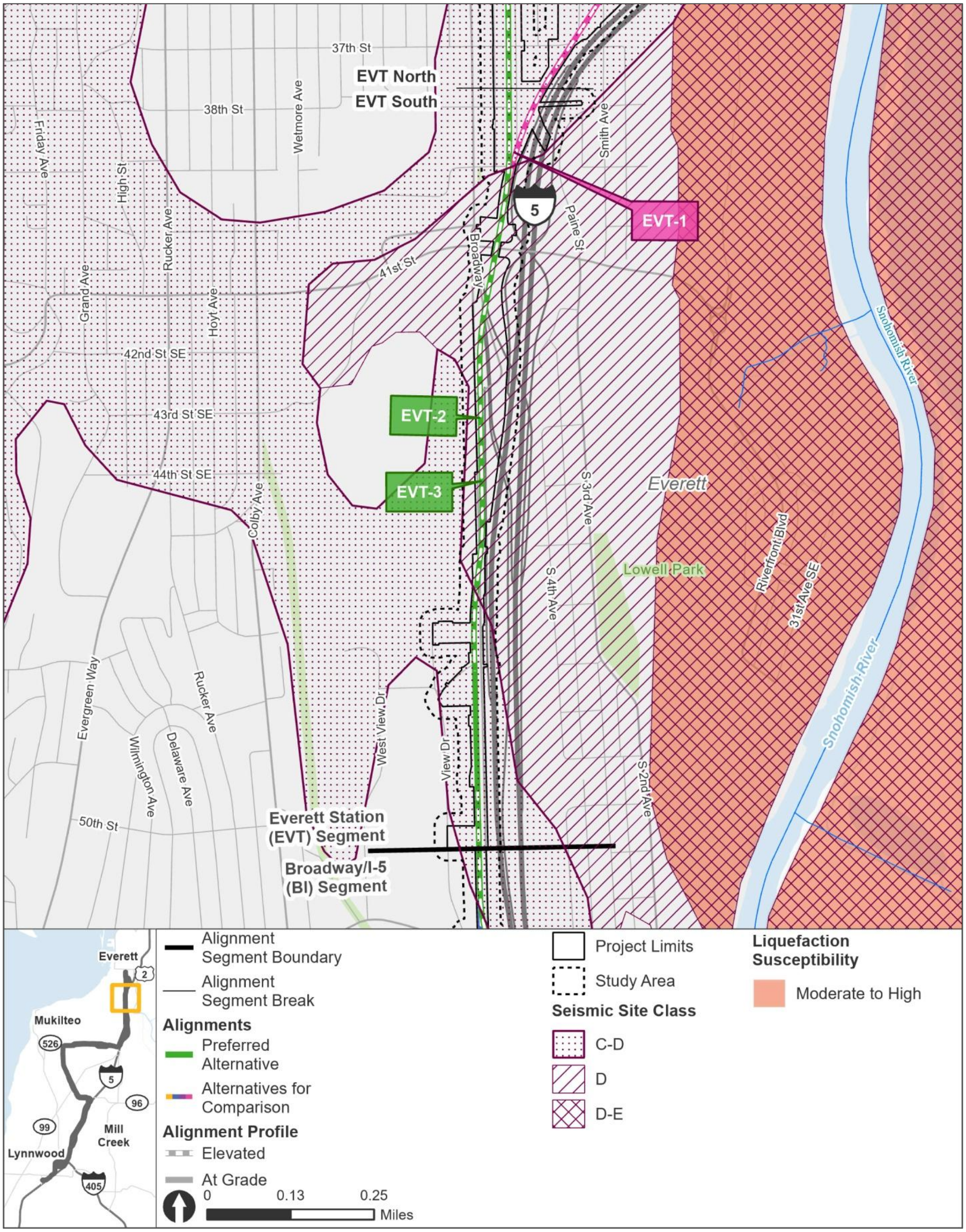
SOURCE: DNR (2022 and 2024) and Snohomish County (2024).

Figure 3-35 Seismic Hazards – Broadway/I-5 Segment (North)



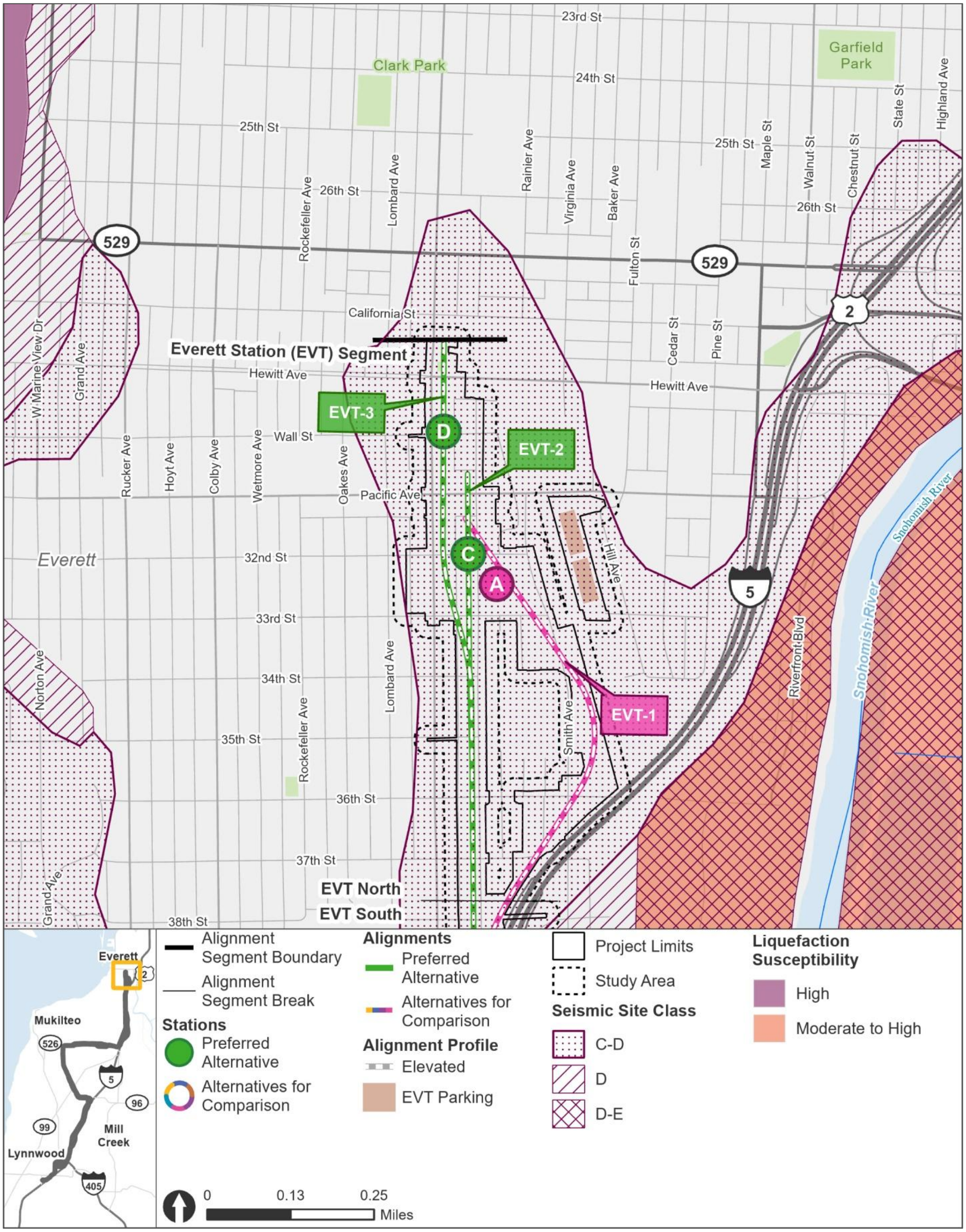
SOURCE: DNR (2022 and 2024) and Snohomish County (2024).

Figure 3-36 Seismic Hazards – Everett Station Segment (South)



SOURCE: DNR (2022 and 2024) and Snohomish County (2024).

Figure 3-37 Seismic Hazards – Everett Station Segment (North)



SOURCE: DNR (2022 and 2024) and Snohomish County (2024).

4 ENVIRONMENTAL IMPACTS

4.1 Build Alternatives

The Build Alternatives' conceptual designs avoid impacts to critical areas where feasible to reduce the inherent risk of construction or operational risks over time in these areas. Geotechnical investigations have begun and will be ongoing as design advances to further evaluate soil types and geologic hazards, including those due to soil type, steep slopes, and seismic events. Qualified geotechnical engineers are included in the design team to help determine the most appropriate design measures to satisfy safety and performance requirements in accordance with the governing design codes.

Some impacts to geology and soils have the potential to occur as described below.

4.1.1 Operational Impacts

4.1.1.1 Impacts Common to All Build Alternatives

All alignment and station alternatives and all OMF North site alternatives would have some degree of operational impacts, with all crossing or occurring near some type of geologic hazard. For example, OMF Site B would require substantial permanent cut slopes and tall permanent fills requiring retaining structures up to 59 feet tall, and OMF Site F would require similar permanent cuts and fills up to 40 feet tall. The potential operational impacts for all alternatives are described below, including greater detail found in Table 4-1.

Slope Stability, Retaining Structures, and Landslides

Unstable slopes could pose a hazard to the community in the event that the ground were to slump, slide, or otherwise fail. Unstable slopes could be those already in existence, slopes that might be steepened by the project, and embankment fills installed for the light rail alignment or OMF North site. Instability could damage structures in the path of moving soil or reduce the soil's support for nearby structures, especially during a large seismic event. During final design, appropriate geotechnical investigations and design studies will be conducted to avoid creating unstable slopes, and appropriate slope stability improvement measures would be implemented as needed for the project to manage potential slope stability risks and impacts.

Seismic Hazards

The primary seismic hazard is ground shaking from a seismic event, which may: affect the guideway structures supporting the light rail system; cause ground movement and slope failure where Build Alternatives might be constructed on sloping ground; and cause liquefaction of loose, saturated soils, potentially causing ground settlement and soil strength reduction. Sound Transit would design the light rail system and associated structures to withstand seismic events. The design objective of all structures would be to maintain intermediate life safety and no-collapse performance levels and to reduce the likelihood of substantial impacts to other structures. The Build Alternative design would mitigate seismic hazards in areas with liquefaction-prone soils by use of more robust foundation elements or ground improvements, such as installation of stone columns, jet grouting, deep soil mixing, or a combination thereof.

Settlement and Earth Fills

Retained fills used in areas where project facilities would be above the existing grade would increase loads on the existing soil, causing compression and uneven settlement of soft soils. If this type of settlement were to occur, it could damage light rail structures and nearby structures, roadways, and utilities. However, the project design would incorporate measures to improve soils where potential for settlement is identified, use lightweight fills to limit settlement, or allow tolerances for anticipated settlement.

4.1.2 Construction Impacts

4.1.2.1 Impacts Common to All Build Alternatives

The amount of earthwork required for each Build Alternative would depend on the location-specific topography, planned site elevations, and soil composition. Some excavated soils could be reused as structural fill for construction purposes, if determined that this can be done safely and comply with regulatory requirements. Soils that are not appropriate to be reused as structural fill may be used on-site for other purposes. Although each alignment and station alternative is on relatively flat terrain, regrading would occur at all sites. Where slopes exist or are created, retaining walls would likely be needed in some areas. This is particularly true for the OMF North site alternatives, which are large areas that would need to be graded to a uniform elevation and require retaining structures as a result. OMF Site B would require substantially more grading than OMF Sites E or F. Table 4-1 and Table 4-2 show approximate cut and fill volumes in cubic yards (CY) for each of the alignment/station and OMF North site alternatives, respectively.

Table 4-1 Approximate Cut and Fill Volumes of the Alignment and Station Alternatives

Segment	Alternative	Potential Hazard Crossings	Cut (CY)	Fill (CY)	Net (CY)	Net Result
ALD	ALD-1B	Partially crosses mapped steep slope/landslide hazard(s)	47,000	13,000	34,000	Cut
	ALD-1B with Alderwood Mall Boulevard Design Option		31,000	9,000	22,000	Cut
	ALD-2D		48,000	9,000	39,000	Cut
	ALD-2D with Alderwood Mall Boulevard Design Option		32,000	5,000	27,000	Cut
	ALD-2F		44,000	9,000	35,000	Cut
	ALD-2F with Alderwood Mall Boulevard Design Option		23,000	5,000	18,000	Cut
ASH	ASH-1A	Partially crosses mapped steep slope/landslide hazard(s); Southern Whidbey Island Fault Zone	59,000	106,000	47,000	Fill
	ASH-2D		87,000	156,000	69,000	Fill

Segment	Alternative	Potential Hazard Crossings	Cut (CY)	Fill (CY)	Net (CY)	Net Result
MAR[a]	MAR-1B	Partially crosses mapped steep slope/landslide hazard(s)	65,000	43,000	22,000	Cut
	MAR-1B with Surface Parking Design Option		65,000	43,000	22,000	Cut
	MAR-2D		62,000	35,000	27,000	Cut
	MAR-2D with Surface Parking Design Option		62,000	35,000	27,000	Cut
AIR	AIR-1A	Partially crosses mapped steep slope/landslide hazard(s); Southern Whidbey Island Fault Zone and crossed by Southern Whidbey Island Fault	49,000	51,000	2,000	Fill
	AIR-2B		113,000	8,000	105,000	Cut
SWI	SWI-1A	Partially crosses mapped steep slope/landslide hazard(s)	45,000	36,000	9,000	Cut
	SWI-1A with Lower Design Option		81,000	41,000	40,000	Cut
	SWI-1B		47,000	8,000	39,000	Cut
	SWI-1C		37,000	15,000	22,000	Cut
EGN	EGN-1A	Partially crosses mapped steep slope/landslide hazard(s)	116,000	42,000	74,000	Cut
	EGN-2B		39,000	50,000	11,000	Fill
	EGN-2B with North Side of SR 526 Design Option		39,000	38,000	1,000	Cut
	EGN-3E		39,000	65,000	26,000	Fill
	EGN-3E with North Side of SR 526 Design Option		53,000	48,000	5,000	Cut
BI	BI-1	Partially crosses mapped steep slope/landslide hazard(s) as well as a Seismic Site Class C-D	65,000	99,000	34,000	Fill
	BI-2		87,000	31,000	56,000	Cut
EVT[a]	EVT-1A	Partially crosses mapped steep slope/landslide hazard(s) as well as Seismic Site Class C-D and Class D	30,000	12,000	18,000	Cut
	EVT-2C		25,000	45,000	20,000	Fill
	EVT-3D		30,000	45,000	15,000	Fill

NOTES:

a) Earthwork for parking has not been calculated as part of the conceptual design.

Table 4-2 Approximate Cut and Fill Volumes of the OMF North Site Alternatives

Alternative	Potential Hazard Crossings	Cut (CY)	Fill (CY)	Net (CY)	Net Result
OMF Site F	Partially crosses mapped steep slope/landslide hazard(s)	886,000	382,000	504,000	Cut
OMF Site F with Lead Tracks to West Side of Airport Road Design Option[a]		886,000	382,000	504,000	Cut
OMF Site E	Crossed by the Southern Whidbey Island Fault	221,000	679,000	458,000	Fill
OMF Site B	Partially crosses mapped steep slope/landslide hazard(s) as well as a Seismic Site Class C-D	1,433,900	1,318,150	115,750	Cut
OMF Site B with Lead Tracks to South Side of SR 526 Design Option[a]		1,433,900	1,318,150	115,750	Cut

NOTES:

a) Differences in earthwork for the lead track design options have not been calculated as part of the conceptual design.

Construction activities may cause short-term geology and soil environmental impacts as described in the following sections.

Slope Stability, Retaining Structures, and Landslides

Slope stability evaluations would be performed during design and would be used to develop methods for slope stabilization during construction where necessary. Methods to improve slope stability hazards include, but are not limited to, retaining structures (e.g., soldier pile wall, secant pile wall, permanent ground anchors) and lowering the groundwater level within the slope (e.g., horizontal drains, excavated trench drains).

Erosion Hazards

During construction, activities like clearing vegetation, placing fill, and grading can lead to soil erosion. The risk of erosion depends on factors such as exposed soil area, rainfall intensity, soil characteristics, and stockpiled soil volume. Best management practices (BMPs) would be implemented in accordance with the Washington State Department of Ecology (Ecology) *Stormwater Management Manual for Western Washington* (2024), such as maintaining vegetation, using silt fences, and implementing erosion control measures like straw or mulch coverings to minimize erosion hazards. Moreover, erosion hazards would be avoided due to adherence to requirements of Ecology stormwater permits and National Pollutant Discharge Elimination System permits (as administered by Ecology). A Construction Stormwater Pollution Prevention Plan would be developed to prevent erosion and sediment discharge into receiving waters. At a minimum, the plan would meet each of the 13 elements described in the *Stormwater Management Manual for Western Washington* (Ecology 2024).

Settlement

Project elements, such as embankment fills, structures bearing on shallow foundations, site dewatering, retained cuts, and other features, could cause settlement. Depending on subsurface conditions, settlement could be limited to the immediate vicinity of the project element, could extend a short distance beyond the element, or could extend a considerable distance from the element, potentially causing settlement or damage to structures or landforms beyond the project limits. Geotechnical design studies during advanced design will evaluate settlement potential and its likely magnitude and extent, and appropriate mitigation measures will be incorporated into the design. Mitigation measures could include, but are not limited to, ground improvement (e.g., stone columns, soil-cement columns, over-excavation and replacement with suitable soil). In the case of potential dewatering-induced settlement, mitigation measures such as cutoff walls (e.g., steel sheet pile wall, cement-bentonite wall), injection wells, and other methods could be employed to limit the settlement extents.

Seismic Hazards

During project construction, the risk of seismic hazards is generally low due to the low probability of an earthquake occurring during the construction period (Petersen et al. 2024). However, if a large earthquake were to happen, the built environment, including any ongoing project construction activities, could be significantly impacted. Work schedules might be delayed while damaged components are repaired, and utilities or nearby structures could experience disruptions. Project construction would not increase or decrease the risk of seismic hazards, and project elements would be appropriately designed to withstand the design seismic events and meet the performance requirements specified in the *Sound Transit Requirements Manual*.

Dewatering

Sound Transit does not anticipate the need for extensive dewatering during construction at this time. The primary project element that would extend below the groundwater table is drilled shaft foundations for the guideway, and potentially, for structures associated with OMF sites. These shafts would likely be completed without dewatering and might require addition of water into bore holes (“water heading”) during installation to prevent heaving conditions at depth. If dewatering were found necessary, Sound Transit would consider the potential for dewatering-induced settlement on nearby structures and would employ measures, such as monitoring settlement of surrounding areas and limiting the area affected by dewatering by using cutoff elements such as sheet piles or cement-bentonite cutoff walls, to minimize the settlement extents.

4.2 No Build Alternative

Under the No Build Alternative, impacts to geology and soil resources from construction or operation of the EVLE Project would not occur. The existing risk from seismic hazards would still exist. New development would continue to take place in existing steep slope, erosion, and seismic hazard areas as allowed by local codes.

5 POTENTIAL MITIGATION MEASURES

Sound Transit is committed to complying with all applicable federal, state, and local environmental regulations, following best management practices (BMPs), and designing the EVLE Project in a way that mitigates adverse impacts. As a result, mitigation measures are reflected in the design of Build Alternatives. Final mitigation measures will be based on advanced design and will be included in the Final EIS and in FTA’s Record of Decision as environmental commitments for the project.

The project alternatives' location and design have been affected to date by the location of geologic resources and hazards. An effort was made to minimize impacts to areas identified as geologic hazards by properly siting project components and reconfiguring the design if necessary. Additional geotechnical and soil characterization will occur as design progresses to help address geologic hazards and engineering challenges in the study area.

Sound Transit would implement BMPs to mitigate impacts during the construction process. These BMPs are indicated, but not limited to those provided in, Section 4.1.2. With appropriate use of engineering design standards and BMPs as described above, no adverse geological or soils impacts are expected.

6 REFERENCES

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