Geology and Soils

Studies and Coordination

Information for this section was obtained through field reviews in 2007 that involved a geologic investigation of the project site and a geologic reconnaissance of the surrounding areas, and evaluations of federal, state, and local agency documents and maps. These documents included:

- *Preliminary Geotechnical Recommendations*, HWA Geosciences, Inc., August 10, 2007.
- *Soil Survey of Snohomish County Area, Washington*, United States Department of Agriculture, Natural Resources Conservation Service (formerly Soil Conservation Service), 1983.
- *Geologic Map of the Lake Stevens Quadrangle*, Snohomish County, Washington, Minard 1985.

Affected Environment

Geology

The project site covers two distinct topographical areas. Between the US 2 Trestle and Cavalero Road, the change in elevation ranges from 18 feet at the base of Cavalero Hill to 248 feet at its crest, resulting in an approximate 14% slope. In contrast, the area between Cavalero Road and 91st Avenue SE can be characterized as flat to gently rolling.

The project site is located within the Puget Sound Lowland Physiographic Province, which covers most of Snohomish County. This north-south trending structural and topographic depression is bordered on its west side by the Olympic Mountains, and to the east by the Cascade Mountain foothills. The Puget Lowland is underlain by Tertiary volcanic and sedimentary bedrock, and has been filled to the present day land surface with Pleistocene glacial and non-glacial sediments. Repeated advances and retreats of the continental glaciers that flowed through the area out of Canada more than 10,000 years ago created the low undulating plains that are characteristic of the Puget Lowland. Current land surfaces reflect the changes that are directly related to the most recent glacial advance and retreat through Snohomish County. Known as the Vashon Stade of the Fraser Glaciation, it took place between 13,000 and 20,000 years ago.

Soils in the area have been formed primarily through glacial till and glacial meltwater deposition processes. Glacial till is unstratified glacial drift material consisting of clay, silt, sand and boulders, and is transported by moving glacial ice. Glacial meltwater soil materials are stratified, and are moved initially by glaciers and then deposited by streams flowing from the ice. These deposits occur in the study area in outwash plains, which are usually smooth landforms of mainly sandy or coarsely textured material. Glacial outwash and glacial till were formed during the Vashon Stade period. Transitional beds were deposited during the retreat just prior to the

Vashon Stade glacial advance into the area, while after that time river valleys and low lying areas subject to periodic flooding were filled in with younger alluvium and alluvial fan deposits.

Five geologic units are found in the project area: Younger Alluvium is found on the Snohomish River floodplain at the western end of the project area. Between the US 2 Trestle and the crest of Cavalero Hill, scattered areas of Vashon Glacial Till is underlain by Vashon Advance Outwash, which is itself underlain by Pre-Vashon Transitional Beds. The primary geologic unit for the remainder of the project area from Cavalero Hill to 91st Avenue SE is Vashon Glacial Till. This is crossed by a small area of Vashon Advance Outwash between 79th and 83rd Avenues SE, and two areas of Vashon Recessional Outwash east of 83rd Avenue SE and west of 91st Avenue SE. These units and their locations in the project area are shown in Figure 19.

Younger Alluvium

Younger Alluvium is the youngest surficial geologic unit in the project vicinity. These deposits result from seasonal flooding of the Snohomish River and consist primarily of normally consolidated silts, clays, and fine sands with abundant organics. Generally, these deposits, which can range from three to more than sixty feet in depth, are poorly drained and highly compressible.

Pre-Vashon Transitional Beds

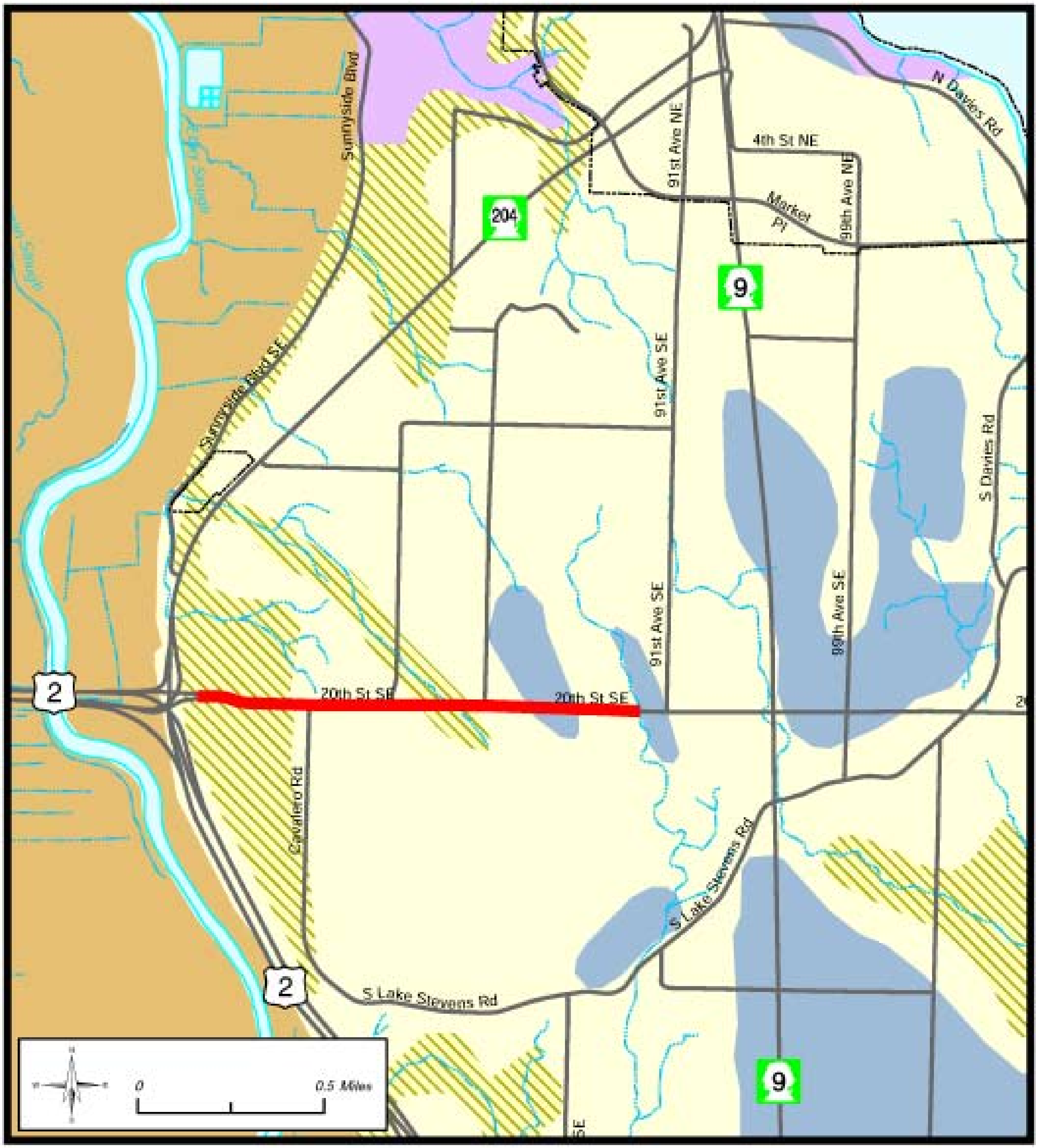
The oldest geologic unit in the project area is the Pre-Vashon Transitional Beds. These deposits consist of clay, silt, and very fine to fine sand. Sediments were mostly deposited in still to slowly moving water, and then over-ridden by the ice sheet during the Vashon glaciation. These deposits are typically low in permeability and exhibit low compressibility.

Vashon Glacial Till

Vashon Glacial Till consists of very dense deposits of silty sand to sandy silt, with varying amounts of gravels. Due to its compact, dense nature, Glacial Till is often referred to as hardpan, whose soil characteristics limit the movement of ground water through it. Limited amounts of ground water may be found within the upper three feet of Glacial Till during extended periods of wet weather. In general, this “perched” ground water will be topographically controlled and will flow or follow surficial topography towards a point of discharge into a stream or wetland area. Glacial Till is an excellent bearing soil for foundations of all kinds, but due to its high silt content is difficult to use and place as structural fill. It is also not considered suitable for infiltration of stormwater because of its high density and very low infiltration rates at shallow depths. Recent experience has shown that in many instances stormwater detention ponds located within Glacial Till need to be lined to limit infiltration into the ponds by perched ground water during extended periods of wet weather.

Vashon Advance Outwash

Vashon Advance Outwash deposits typically exist as stratified sand, gravelly sand, and sandy gravel, and are typically thinner when they underlie till. These deposits exhibit excellent engineering characteristics for foundation support and cut slope stability, and they are generally suitable for structural fill as long as groundwater seepage is not present. The sands and gravels are highly permeable and generally contain significant amounts of groundwater.



Key to Features:

			Project Corridor		Arterial Roads
	Streams		Waterbodies		City of Lake Stevens
	PreFraser Nonglacial		Alluvium		Vashon Till
	Vashon advance outwash		Vashon Recessional Outwash		

Source: *Division of Geology and Earth Resources, WA Department of Natural Resources, 2002.*

Figure 19: Geology

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Vashon Recessional Outwash

Recessional Outwash is found along the alignment at a slightly higher topographic elevation, overlying Glacial Till. It consists of stratified deposits of sands and gravels that are typically quite shallow. While the soil characteristics of this geologic unit are very good for the lateral and vertical transmission of ground water, generally rain and runoff will percolate downward to the underlying Glacial Till where it will flow laterally toward a local low area or a point of discharge into a stream or wetland. Recessional Outwash soils would be suitable for use as structural fill along the alignment, behind retaining walls, within embankment fills, or below roadway sections. Due to their overall gradation and low silt content, these soils provide excellent drainage and are also suitable for infiltration of treated stormwater.

Soils

The Natural Resources Conservation Service (formerly known as the Soil Conservation Service) identifies four soil series in the project area in the Soil Survey for Snohomish County: Tokul Gravelly Loam 0 to 8 percent slopes (the primary soil series in the project area), Tokul Gravelly Loam 8 to 15 percent slopes, Pastik Silt Loam 0 to 8 percent slopes, and Pastik Silt Loam 8 to 25 percent slopes (at Cavalero Hill). These soils and their locations are shown in Figure 20.

Tokul Soils

Tokul soils are moderately deep, moderately well-drained soils found on till plains. Tokul soils formed in glacial till and volcanic ash. Tokul 0 to 8 percent slopes has a moderate permeability above hardpan; while Tokul 8 to 15 slopes has a moderate permeability to hardpan. Permeability for both soil series is very slow through hardpan. Runoff is slow and the hazard of water erosion is slight.

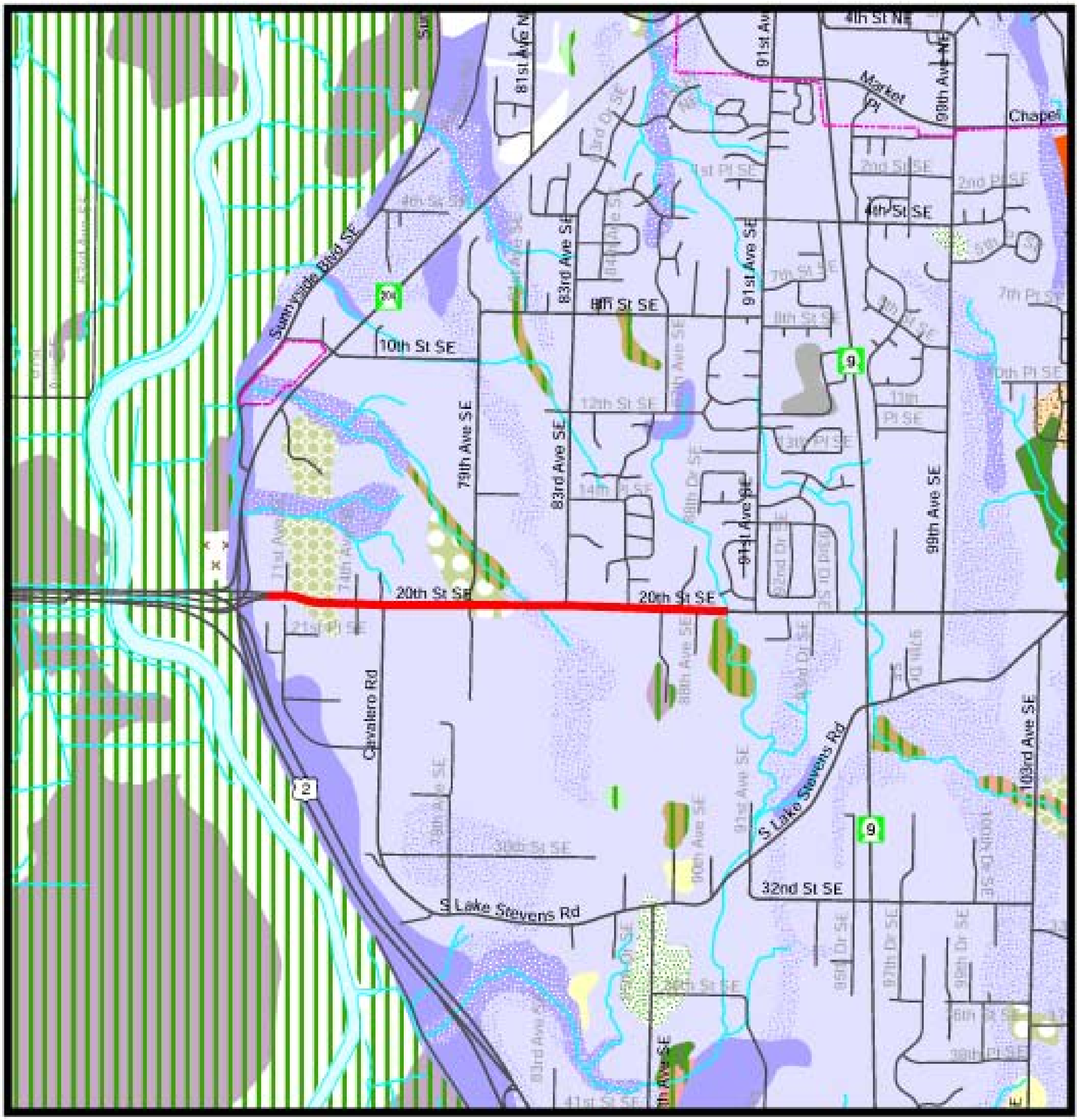
Pastik Soils

Pastik soils are very deep and moderately well-drained soils found on terraces. Pastik soils formed in lake sediment and volcanic ash. Permeability is slow. For Pastik 0 to 8 percent slopes, runoff is slow and the hazard of water erosion is slight. For Pastik 8 to 25 percent slopes, runoff is medium and the hazard of water erosion is moderate.

Site Explorations

The County's geotechnical consultant conducted field explorations to determine the geologic composition of the project area, and the suitability of specific areas for retaining walls, stormwater quantity and water quality treatment facilities, and signal pole foundations. It was not possible to evaluate all areas as rights-of-entry could not be obtained for some properties. The explorations that did take place included a surface reconnaissance of the alignment and the advancement of four boreholes. The locations of these boreholes are:

- BH-1, 300 feet west of 83rd Avenue SE
- BH-2, in intersection of Cavalero Road and 20th Street SE
- BH-3, south side of Cavalero Road at intersection with 20th Street SE
- BH-4, in the southwest corner of intersection of 83rd Avenue SE and 20th Street SE



Key to Features:

- Project Location
- Bellingham Silty Clay Loam
- Everett Gravelly Sandy Loam, 8-15% Slopes
- Kitsap Silt Loam, 8-25% Slopes
- Lynnwood Loamy Sand, 0-3% Slopes
- Mckenna Gravelly Silt Loam, 0-8% Slopes
- Mukilteo Muck
- Norma Loam
- Pastik Silt Loam, 0-8% Slopes
- Pastik Silt Loam, 8-25% Slopes
- Ragnar Fine Sandy Loam, 0-8% Slopes
- Terric Medisaprists, Nearly Level
- Urban Land
- Xerorthents, Nearly Level
- Tokul Gravelly Loam, 0-8% Slopes
- Tokul Gravelly Loam, 8-15% Slopes
- Tokul Gravelly Loam, 15-25% Slopes
- Tokul-winston Gravelly Loams, 25-65% Slopes
- Winston Gravelly Loam, 0-3% Slopes
- Winston Gravelly Loam, 3-30% Slopes
- Hydric Soils Overlay

Source: *Natural Resources Conservation Service, United States Department of Agriculture (USDA), December 1999.*

Figure 20: Soils

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The two borings at the intersection of Cavalero Road and 20th Street SE were drilled in support of two proposed walls, using a truck mounted, hollow stem auger drill rig. The explorations revealed that the topsoil horizon had been altered or modified in most areas of the alignment. An area of instability was identified south of 20th Street SE between 79th and 83rd Avenues SE. The location is underlain by road fill and soft organic material, and the roadway here appears to still be settling. The BH-4 exploration encountered loose and potentially liquefiable soil extending to a depth of approximately five to seven feet below ground surface. A perched groundwater table is present just below the ground surface.

Impacts – Geology and Soils

During Construction

Preferred Alternative

Under the Preferred Alternative, the existing ground surface will be extensively modified during construction. The Preferred Alternative would require clearing of trees and vegetative cover, clearing, grubbing and removal of topsoil, excavation for retaining walls and installation of stormwater facilities and drainage pipes, filling for embankments along the roadway, and paving all new sections of the proposed roadway alignment. The natural soils will be permanently disrupted, and there will be a net soil loss due to the proposed cuts and associated excavation. The project will require approximately 51,700 cubic yards of excavation. The excavation (cut) is necessary to achieve the proposed road grade and remove existing unsuitable soils. Approximately 19,500 cubic yards of fill will be required to construct the road at the proposed grade (an additional 22,750 cubic yards of fill would be required if CSBC, CSTC and HMA were used).

Soil disturbance activities have the potential to lead to erosion and decreased slope stability. The disturbance and exposure of soils during roadway construction, particularly during rainfall and storm events, could increase the amount of sediment entering Fox Creek and area wetlands. In addition, the BH-4 exploration encountered loose and potentially liquefiable soil extending to a depth of approximately five to seven feet below ground surface. The high level of the perched groundwater table present just below the ground surface may make excavation of the loose surface soil layers more difficult.

No Action Alternative

There will be no impacts under the No Action Alternative as there will be no road construction that will result in an increase in impervious surface area, and no vegetation clearing will occur. Soils will remain in their existing natural condition.

During Operation

Preferred Alternative

A direct impact of the road widening would be the permanent disruption of soils, and a net loss of soils due to the removal of topsoil and excavation activities. The removal of high moisture content topsoil and its replacement with well-drained fill material overlain with impervious pavement would increase the velocity and volume of surface water runoff. This would result in a corresponding decrease in groundwater recharge through infiltration. Increased stormwater runoff and velocities can accelerate the erosion of undisturbed areas, particularly on slopes. Earthquake hazards during operation include liquefaction, landsliding, and round surface rupture. The potential for liquefaction was found at the BH-4 exploration.

No Action Alternative

Under this alternative, no project-related land clearing, grubbing, excavation, filling or impervious surface would occur to impact soils and lead to potential soil erosion and slope instability.

Mitigation – Geology and Soils

During Construction

Preferred Alternative

Mitigation will occur through implementation of a Temporary Erosion and Sedimentation Control Plan and a Stormwater Pollution Prevention Plan that outline effective erosion control and slope stabilization methods, and construction Best Management Practices (BMPs) that meet local, state, and federal standards. These BMPs would be properly implemented, monitored, and maintained during construction.

BMPs would be used to provide erosion control and control surface water runoff, and would include proper construction staging, barrier berms, filter fabric fences, and temporary sediment detention basins. The use of slope coverings to contain sediment on site will be effective in protecting Fox Creek and area wetlands, and minimizing erosion in areas with cuts or fills. The engineering design will determine the type of retaining wall that would be appropriate in some areas where the project proposes to excavate (cut) or fill slope areas. It is anticipated that the road widening project will require approximately 18 retaining walls. The walls are required to keep the newly expanded roadway within right-of-way, and minimize impacts to adjacent properties in areas where the cuts and fills will be large. The walls will be constructed on both sides of 20th Street SE, and will range in height from four to nine feet (Figure 21). The walls will be both cut and fill walls. The cut walls may be in the form of rockeries, particularly if soils at the wall locations are stable. The fill walls will probably be mechanically-stabilized earth (MSE) walls. In areas where there is a high water table, the wall may be constructed as a soldier pile and lagging wall.

Undertaking grading activities during the dry season, particularly on moisture-sensitive soils, will help reduce the potential for erosion. Unstable soils that are not suitable for construction would be removed and replaced with imported fill brought from off-site sources. This includes the loose and potentially liquefiable soil found at BH-4 that would need to be replaced with good quality structural backfill. To avoid differential settling of the roadway south of 20th Street SE between 79th and 83rd Avenues SE, the existing loose soils would be removed and a standard mechanically-stabilized earth (MSE) wall configuration could be used here. If the soils are not removed, a cantilevered soldier pile fill wall could be used.

Construction of unsupported cuts would be scheduled during the late summer and early fall when groundwater levels are typically lowest. Potential methods for reducing slope instability risks

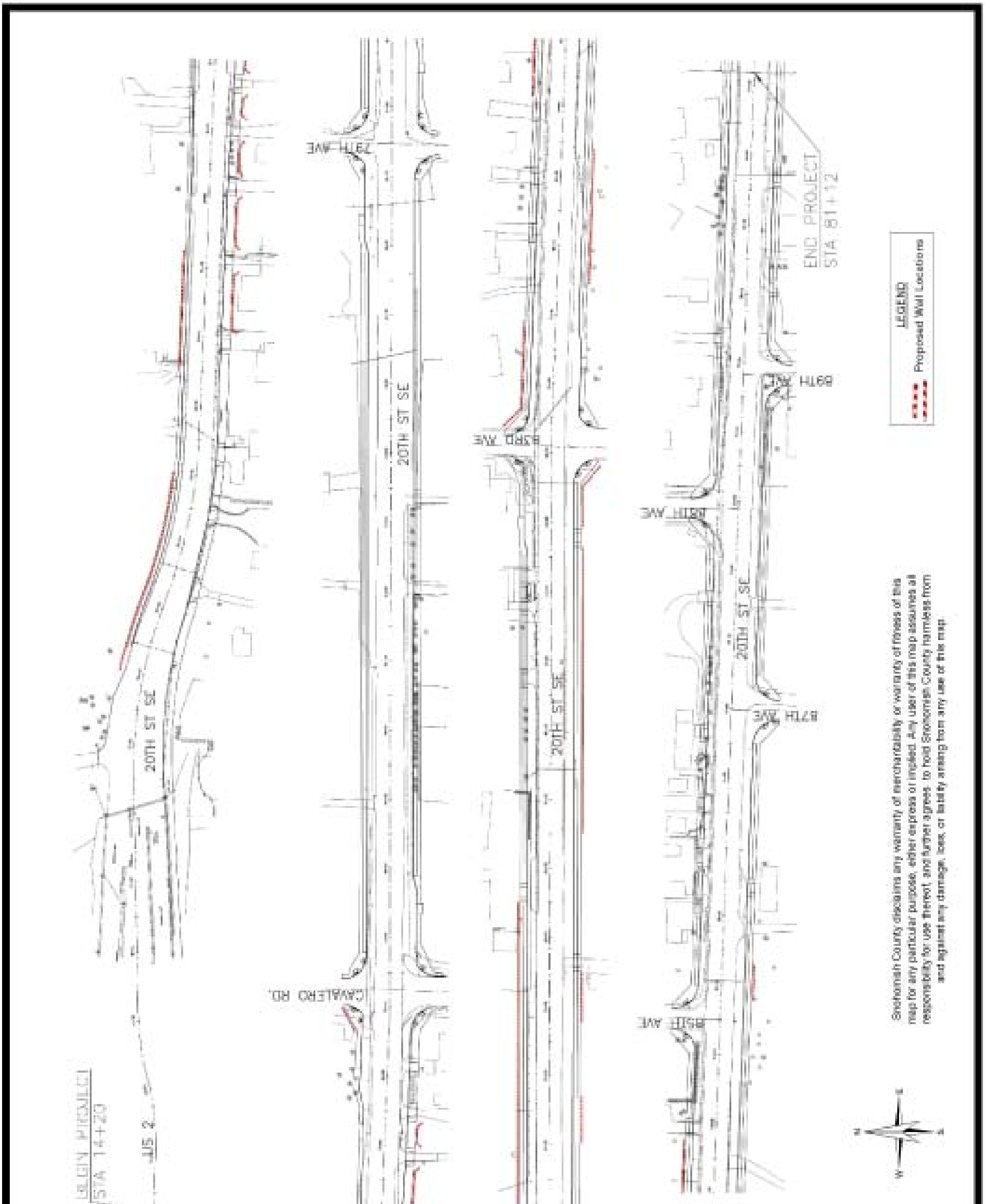

Figure 21: Potential Retaining Wall Locations

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could include dewatering near surface soils prior to making excavations. During the winter wet season, earth-moving activities would be reduced, access limited to the site, and tires and tracks on heavy equipment cleaned before leaving the site to assist in retaining sediment on-site. Any exposed surfaces would be protected with mulch, erosion-control fabrics, or plastic sheeting.

Exposed soils will be revegetated after final grading is completed to minimize sedimentation to nearby streams and wetlands. Erosion control blankets will be among the measures considered to accelerate the revegetation process. Suitable topsoil that has been removed and stockpiled would be used in these areas.

All materials used will meet the requirements of the American Association of State Highway and Transportation Officials (AASHTO), and county, state, federal and all other applicable standards. The project will be designed to withstand earthquakes using AASHTO standards.

No Action Alternative

Under this alternative, no construction activities will occur and mitigation will not be required.

During Operation

Preferred Alternative

Mitigation will occur through appropriate project design that considers onsite conditions, including the engineering characteristics of soils found along the alignment, and the suitability of these soils for different design features such as placement of retaining walls and re-use of soils for fill. The maximum slope ratio would be 2:1 where proposed right-of-way allows, but retaining walls would be constructed to maintain stability where the right-of-way does not provide ample room. Potential methods for reducing slope instability risks after construction could include designing retaining walls for at-rest soil conditions so that groundwater movement is minimized and, if full-height retaining walls are used, wall types such as tie-back walls or cylinder-pile walls can be constructed with little or no unsupported soil.

Permanent erosion control features will be integrated into the design of the overall project. These features will include a stormwater collection, detention and treatment system to prevent runoff that could erode vulnerable areas and to regulate stormwater discharge to project area streams and wetlands. The drainage system would also prevent water from contributing to slope instability and undermining the roadbed in areas that are susceptible to groundwater flow.

No Action Alternative

Under this alternative, the roadway improvement project will not take place, no impacts to geology and soils will occur, and mitigation will not be required.

Significant Unavoidable Adverse Impacts

The project would contribute to the cumulative increase of impervious surface in the project area. The existing ground surface will be extensively modified and approximately 51,700 cubic yards of excavation and 19,500 cubic yards of will be required to expand 20th Street SE. An additional 22,750 cubic yards of fill will be necessary if CSBC, CSTC and HMA are used, which will increase the project's impacts.