REVISED REPORT
FLOOD HAZARD ANALYSIS, CHANNEL MIGRATION POTENTIAL, AND SLOPE STABILITY EVALUATION
EVERETT RIVERFRONT REDEVELOPMENT PROJECT
EVERETT, WASHINGTON

NOVEMBER 16, 2007

FOR
OLIVERMCMILLAN EVERETT LLC

GEOENGINEERS

File No. 06191-002-03

Revised Report
Flood Hazard Analysis, Channel Migration Potential, and Slope Stability Evaluation
Everett Riverfront Redevelopment Project
Everett, Washington
File No. 06191-002-03

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REVISED REPORT
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INTRODUCTION AND PROJECT UNDERSTANDING

GeoEngineers, Inc. (GeoEngineers) was contracted by OliverMcMillan Everett LLC to perform a flood hazard analysis, channel migration and avulsion potential assessment, and a qualitative slope stability for the property proposed for the Everett Riverfront Master Plan and Redevelopment project (referred to herein as "project site"). The project site is located in Sections 29 and 32 of Township 29 North, Range 5 East of the Willamette Meridian, east of Interstate 5, south of Pacific Avenue and north of Lowell-Snohomish River Road in Everett, Washington. The proposed project is located adjacent to the western shoreline of the Snohomish River within the Snohomish River Estuary sub-basin (Figures 1 and 2). The total project site acreage comprises approximately 270 acres with 211 acres proposed for redevelopment.

PROJECT AREA

The Everett Riverfront Redevelopment Project Area comprises five distinct parcels along the Snohomish River, generally identified as:

1) **Tire Fire/Landfill Site:** This area is bordered on the north by 36th Street; on the west by the Burlington Northern Santa Fe (BNSF) mainline/right-of-way; and on the east and south by the diagonal created by the former Milwaukee Road railroad right-of-way.

2) **Simpson Pad:** This area is generally south and west of the area described below as the Simpson Category 1 Wetlands and Riparian corridor, and to the north of the area described below as the South Simpson Site. This area is identified in the Everett General Plan and related documents as the "Developable Portion of Simpson Site".

3) **Simpson Category 1 Wetlands and Riparian Corridor:** This area lies between the Tire Fire/Landfill site, the BNSF Mainline on the east, and between the Snohomish River and the upland area known as the Simpson Pad or the "Developable Portion of the Simpson Site". This area is comprised entirely of aquatic and riparian habitats planned for future public access.

4) **South Simpson Site:** This area lies between the BNSF Mainline on the west, the Snohomish River on the east, the Washington State Department of Transportation (WSDOT) water treatment property on the south and the Simpson Pad on the north. This area is also comprised entirely of aquatic and riparian habitats planned for future public access.

5) **Eclipse Mill/Port of Everett Site:** This area lies north of the easterly extension of 36th Street, east of the BNSF 'C'-line track and right-of-way, west of the Snohomish River and south of Pacific Avenue. The Port of Everett also owns properties in this area that are proposed to be included in the proposed redevelopment.

PROJECT PURPOSE

The primary purpose of the study was threefold. A geomorphic characterization was completed to evaluate the potential for lateral migration of the Snohomish River within the vicinity of the planned Everett Riverfront Plan and Development Project. The Migration Potential Assessment was conducted in general accordance with the recommended approach provided in the preliminary draft of the Snohomish County Critical Areas Regulation 30.62B Geologically Hazardous Areas (CAR), dated June 2005; and is consistent with the 2006 updated CAR (released for public review in July 2006), which utilizes the Forest Practices Board Manual, Section 2, Standard Methods for Identifying Bankfull Features and Channel Migration Zones, p. M2-20, 1994. The City of Everett has adopted an updated Critical Areas Ordinance (City of Everett, Ordinance 2909-06, 2006a) but has not yet codified the ordinance into Title 19 of the Everett Municipal Code. Geologically hazardous areas include erosion hazards, landslide hazards and seismic (liquefaction) hazards. Channel Migration Zones are not currently regulated by the City of Everett.

A flood hazard analysis was completed to determine the extent of potential flooding the site may experience under the 10-, 50-, 100-, and 500-year peak floods. The site was evaluated for flooding based on current conditions. Additional studies may be required to predict any impact that site modification may have on flood inundation areas. The primary factor that determines the extent of flooding across the site is the height and condition of the flood control levees.

We completed a qualitative stability evaluation of all embankments and slopes in the vicinity of the riverfront properties, including those of the levee systems, access road embankments, BNSF railroad embankments, fill pads, and banks of adjacent streams (including Bigelow Creek). These slopes and embankments were assessed for their potential to fail or erode based on their overall geometry and character.

FIELD RECONNAISSANCE

GeoEngineers conducted a field reconnaissance on January 22, 2007 to assess current geomorphic conditions and to evaluate the potential for channel migration within the project reach. Prior to the field reconnaissance, we collected and evaluated historical Government Land Office (GLO) maps, selected aerial photographs, available reports on local geology, topographic and geologic maps, and tidal conditions. A boat-assisted reconnaissance extended along the Snohomish River from the confluence of Steamboat Slough to the confluence of Ebey Slough. We documented areas of visible bank erosion, sediment production, areas subject to deposition, and levee conditions.

A surface reconnaissance was completed on January 22, 2007 and January 30, 2007 to evaluate the general nature of all inland embankments and slopes in the project area and to identify areas of existing or potential instability. Portions of all slopes and banks in the project area were traversed and periodically characterized by height, steepness, vegetative cover, ground material, proximity to flowing water, general condition, and overall likelihood as potential critical areas hazards. We continuously observed surface conditions and made periodic measurements where conditions remained consistent along the levees and embankments, but more detailed measurements and characterization were conducted in areas that were of possible concern.

EXISTING CONDITIONS

REGIONAL SETTING

The Snohomish River Basin, encompassing 1,856 mi^2, is the second largest river basin draining to the Puget Sound (Pentec, 1999). The basin is drained by three major rivers, the Skykomish, the Snoqualmie,

and the Snohomish. The Snohomish River flows through broad low-land glaciated valleys, entering Possession Sound near Everett. The upper portion of the Snohomish River basin encompasses the mountainous river systems of the Western Cascades (Snohomish Basin Salmonid Recovery Technical Committee, 1999). This sub-basin provides significant sediment production and the rivers gradient is generally high. The lower portion of the Snohomish River basin, which the project reach is part of, encompasses wetlands, sloughs, delta and forested transition zone (Snohomish Basin Salmonid Recovery Technical Committee, 1999). The Snohomish River Estuary has been heavily influenced by farming and levees.

The Snohomish River delta is drained by numerous drainage channels and freshwater tributary creeks that join with the mainstem Snohomish River and sloughs. This section of the Snohomish River has a relatively low gradient and typically develops a channel bottom composed of fine sands and silts (WRIA 7).

LOCAL SETTING

The project site is located in Snohomish River Estuary within the Snohomish River delta, approximately three miles upstream of the Puget Sound. The project site is bounded to the west by erosion-resistant uplands and by the Snohomish River to the east. The elevation of flows in the river are heavily influenced by diurnal tides; the diurnal tidal fluctuation (difference in mean higher high and mean lower low tide levels) measured in Everett (Station 9447659) is about 11 feet (NOAA, 2007). The project site includes the five distinct sites mentioned in the Project Area section.

Modifications of the site began in the 1930s with the addition of levees. The site became the location for many industries including a log mill, a paper mill, sand and gravel pit, and a landfill. The existing levee system along the left and right banks were installed in the 1930s and are no longer maintained. The only documented dredging that occurred on the Snohomish River near the project site was conducted approximately 1 mile downstream (US Army Corps of Engineers, 1997). Undocumented dredging likely occurred, as the on-site fill material consists of reworked river bank material. Because of the undocumented nature of the dredged material, the source of the material and when the dredging occurred cannot be determined.

GEOLOGY AND SOILS

Based on the geologic information obtained from maps prepared by Minard (1985), the project area is underlain by near-surface materials consisting of fill, Holocene-aged alluvium (12,000 years ago to present), and glacial deposits. The Holocene-aged alluvium consists of unconsolidated deposits of clay, silt and very fine sand, with abundant organic material and peat deposits. The glacial deposits typically are those derived from the advance and retreat of the last glacial occurrence, the Vashon stade of the Fraser Glaciation, which ended roughly 10,000 to 14,000 years ago. The glacial deposits consist of advance outwash sands and gravels, which preceded the glacial front and subsequently were overridden by the glacier and overlain by associated deposits of glacial till. Sediment overridden by the glacier was densely compacted. As the glaciers retreated, recessional sands and gravels were deposited in and around outwash streams. During the 10,000 years since the full retreat of the glacier, a relatively thick unit of younger alluvium and estuarine sediments has been deposited on the delta surface.

The project site consists of an average of three to 20 feet of fill placed on site from river dredging projects, previous grading activities or from surrounding area highway projects. The younger alluvium on the former Eclipse Mill site is overlain by fill consisting of wood debris, silt, sand and gravel ranging in thickness from 5 to 19 feet (GeoEngineers, 2003). The alluvium on the Simpson site is overlain by 6.5 to 16 feet of fill consisting of silt, sand, silty sand, peat, crushed rock and gravel (HWA, 2003). At the

Simpson site, a 10-foot-thick peat layer was encountered at a depth of approximately 6.5 feet below the ground surface (bgs).

HYDROLOGY

The Snohomish River at the confluence of the Snoqualmie and Skykomish Rivers has an average annual runoff of 6,973,000 acre feet (ac-ft) and an average annual discharge of 9,625 cubic feet per second (cfs). The extremes recorded for the period of record (water years 1964-1998) are a maximum of 150,000 cfs on November 25, 1990 and a low of 763 cfs on October 30, 1987 (USGS gage # 12150800). The mean annual hydrograph of the Snohomish River is characterized by a dual peak; one occurs during late fall or early winter, driven by fall rains and rain-on-snow events, and the other is in late spring or early summer, driven primarily by snowmelt in the upper watershed. Low flows occur in late summer through early fall.

FLUVIAL GEOMORPHIC CHARACTERIZATION AND CHANNEL MIGRATION POTENTIAL ASSESSMENT

This section of the report summarizes the results of the fluvial geomorphic characterization conducted for this study. The summary is based on the results of conclusions drawn from a comparison of historic (1938 and 1967) and recent (2002) aerial photographs, review of the GLO survey map dated 1869 (Figures 2 through 4), and observations made during the field reconnaissance (Figure 5). Comparison of the GLO map dated 1869 and the most current aerial photograph (2002) indicates no appreciable change in channel pattern or location have occurred (Figures 2 through 4). Selected photographs taken during the field reconnaissance are shown on Photograph Sheets 1 through 4. The field reconnaissance was conducted by boat on January 22, 2007. The reconnaissance was conducted through the rise and fall of a single tide recorded in Everett as a -3-foot low tide.

In the project area, the Snohomish River is a single-thread channel with a nearly 90 degree meandering bend at the upstream end of the project reach and a gently curving and through the remainder of the project reach. Channel dimensions documented during the reconnaissance at four transects throughout the project area were measured with respect to the Ordinary High Water Mark (OHWM); the channel width varies from approximately 360 to 450 feet, and the channel depth varies from approximately 12 to 20 feet below the OHWM at the thalweg.

BANK CONDITIONS AND LEVEES/REVETMENT/PILINGS

Figure 5 depicts the project reach, bank conditions and features and structures that were observed during the site reconnaissance. Photograph Sheets 1 through 4 include selected photographs of representative features along the left and right banks.

The banks generally consist of laminated, silty sand and sandy silt overlain by fill and levee materials consisting of reworked silty sand with occasional gravel (Photograph Sheet 1). The contact between the native soils and fill is consistently observed at the OHWM, which also identifies the former floodplain. Throughout the project reach, native deposits occupy the banks. The abundance of sand in the native soils along the banks increases through the central part of the project reach and decreases downstream near the northern section of the project reach. The cohesive soils observed below the OHWM are moderately resistant to erosion. Buried stumps in growth position and woody debris also are exposed along the contact between the original floodplain and overlying fill material.

On the left bank, a well-defined levee extends north and south of the Bigelow Creek outfall (Figure 5). A small, poorly-defined levee structure extends along the south end of the South Simpson site. Detailed information on the condition of the levees is provided in the slope stability sections of the report.

Culverts, pipes and small drainages from the wetlands complex located along the left bank were observed during the field reconnaissance. The wetland complex, which is located north and south of the Simpson Pad, is hydraulically restricted to the mainstem Snohomish River by two culverts, numerous small pipes and two small surface drainages (Figure 5). Bigelow Creek enters the Snohomish River from the left bank just north of the Simpson Pad (Figure 5 and Photograph Sheet 2). A tidegate at the mouth of Bigelow Creek previously impaired access into the creek, but has been removed (Haring, 2002).

Erosion control devices along the left bank consist of occasional boulder rip-rap, asphalt/concrete rip-rap and sections of wood pile revetment (Photograph Sheets 1 through 3). The asphalt/concrete rip-rap is present over short lengths of the river bank, but most significantly along the former Eclipse Mill site (Photograph Sheets 1 and 2). Boulder rip-rap was observed along a railroad embankment just south of the Eclipse Mill site (Photograph Sheet 2) and wood piling revetments extend along the north end of the Simpson Pad and along the South Simpson site (Figure 5 and Photograph Sheet 3). Based on our review of historical aerial photographs, many wood pilings along the right and left banks appear to be remnants of old, in-water log cribs and not installed for the purpose of erosion control.

In general, minor bank erosion was observed on both sides of the bank. Both channel banks appear to be equally subject to erosion at and above the OHWM. However, there was no evidence of channel widening or extensive bank erosion within the native soils. Minor erosion was observed behind some of the wood piling revetments along the left bank.

We observed 4 to 6 feet of fill overlying cohesive laminated sandy silt on the left bank near the sharp 90 degree bend upstream of the project area. At this site there was evidence of minor bank erosion (Photograph Sheets 3). Bank erosion was also observed along both banks downstream of the bend. Throughout the project area, erosion is typically concentrated at the OHWM, at the interface between the alluvial and wetland soils, causing undercutting and sloughing of levee material and loss of vegetation. The process appears to be caused by localized erosion of sandy laminae, resulting in undercutting blocks of cohesive bank sediment. This sloughing has resulted in 2 to 6 feet of bank recession of fill material along sections of the project reach.

CHANNEL GEOMETRY

Channel depth was measured along four transects within the site project during our reconnaissance. The channel floor transects indicate that the floor of the river typically is irregular, especially in the areas with gentle slopes on both sides of the banks. The channel thalweg is situated close to the left bank near the 90 degree meander bend. No depositional bars were observed on the channel floor or along the inside banks of bends at the time of the site visit.

RESULTS

Results of the aerial photo review and project reach reconnaissance indicate that channel migration is not likely to occur at the site location. This assessment is based primarily on the long-term stability of the channel throughout the project reach and the absence of bar building.

The most likely type of migration that could take place in a low gradient environment such as this is meander bend migration. Meander bend migration involves erosion of the outside bank of the river bend coupled with concurrent deposition of sediment along the inside bank of the bend. The area of most pronounced migration usually occurs where flow converges against the outer bank near the downstream end of a bend. This type of migration is neither present nor expected in the project area.

Minor erosion along both channel banks, as well as the sloughing of coherent clumps of cohesive soil is occurring along both banks of the river. This may indicate that some channel sections are widening;

however, the process driving this erosion is not consistent with, nor is it capable of driving, lateral migration of the entire channel.

Observed channel conditions also suggest that channel avulsion is highly unlikely. This assessment is based on the geomorphic conditions of the channel. The primary factor for this conclusion is the cohesive native deposits are erosion-resistant and unlikely to form a new channel through the project area.

CHANNEL MIGRATION ANALYSIS UNDER SNOHOMISH COUNTY CRITICAL AREAS REGULATION

In compliance with the draft Snohomish County CAR, the Forest Practices Board Manual approach was applied to the project area. Conditions specified in Board Manual approach are assessed below (in bold) and briefly discussed relative to conditions observed in the project area:

- **Valley confinement. If the valley floor is generally less than two bankfull widths, there is no channel migration zone (CMZ).** This element does not apply to Snohomish River in the strictest sense. Throughout the project area the channel is set in a low-salinity estuary environment influenced by diurnal tides and low relief landforms (delta/floodplain). Although levees confine high flows to the channel area, the levees play no role (in this geomorphic environment) in preventing channel forming processes from occurring. By this criteria alone there could be a CMZ.
- **Lateral activity. If there is no lateral movement possible because of bedrock or erosion-resistant bed and banks, there is no CMZ.** Significant focused bank erosion in native cohesive deposits was not observed. There also was no evidence of depositional bar building, which is a crucial driver of lateral movement. By this criteria, no CMZ is required.
- **Vegetation. If there are old growth trees or stumps down to the channel, there is no CMZ.** Buried roots and stumps in growth position at the former floodplain elevation are observed in the channel banks. Therefore, we interpreted no CMZ.
- **Secondary channels. If secondary channels on the floodplain are all above the bankfull elevation of the main channel, then proceed to a historical migration zone (HMZ) delineation to determine if there is a CMZ.** Tributary channels on the floodplain are at or below the elevation of the OHWM, which is lower than the bankfull elevation of the levee-confined channel (Bigelow Creek). Therefore, we interpreted no CMZ.

Based on the Snohomish County criteria for CMZ delineations, the Snohomish River channel through the project area is not subject to migration.

To complete the Forest Practices Board Manual approach regarding whether the channel may possibly migrate, the HMZ was assessed qualitatively by a comparison of the 1869 GLO map and historic aerial photographs from 1938 with recent aerial photographs from 2002 relative to the current channel configuration in the project area. The comparison of the GLO, 1938 and 1967 historical aerial photographs and the 2002 orthophoto clearly indicates that the basic channel pattern or configuration has not changed appreciably, and there has been no observable channel migration.

It is our opinion that the potential for future migration of the channel is very low. Based on our review of aerial photographs, soil conditions and our field observations, undercutting levee and native material will continue to erode both banks during flood events and tidal influence. In our opinion, any future loss of levee or other bank fill material will not increase in the risk of channel migration or avulsion based on the geomorphic characteristic of the channel.

QUALITATIVE SLOPE STABILITY EVALUATION

GENERAL

We completed a surface reconnaissance of slopes and streambanks in the project area and qualitatively evaluated their stability, taking into consideration how they may be impacted by future site development and/or flood flows. The primary criteria considered for stability of the slopes were slope inclination, slope height, soil type, vegetative cover, and proximity to flowing water. We also evaluated the stability of the slopes based on the City of Everett Critical Areas Ordinance criteria.

APPLICABLE REGULATORY CODES

The City of Everett has adopted updated Critical Areas Ordinance (City of Everett, Ordinance 2909-06, 2006a) but has not yet codified the ordinance into Title 19 of the Everett Municipal Code. Geologically hazardous areas include erosion hazards, landslide hazards and seismic (liquefaction) hazards. This study evaluated the slopes and streambanks relative to landslide and erosion hazards. According to Ordinance 2909-06, landslide hazard areas are defined as:

a. Those areas defined as high, and very high/severe risk of landslide hazard in the Dames and Moore Methodology for the Inventory, Classification and Designation of Geologically Hazardous Areas City of Everett, Washington: July 1, 1991:

> *i. Very High/Severe – Slopes greater than 15% in the Qtb, Qw, and Qls geologic units; and slopes greater than 15% with uncontrolled fill.*
>
> *ii. High – Slopes greater than 40% in all other geologic units (not Qtb, Qw, Qls or uncontrolled fill).*

b. Those areas defined as medium risk of landslide hazard in the Dames and Moore Methodology for the Inventory, Classification and Designation of Geologically Hazardous Areas City of Everett, Washington. July 1, 1991, when combined with springs seeps, immature vegetation, and/or no vegetation:

> *i. Slopes less than 15% for Qtb, Qw, Qls geologic units and uncontrolled fill*
>
> *ii. Slopes of 25% - 40% in all other geologic units*

c. Any areas with all three of the following characteristics:

> *i. Slopes greater than fifteen percent [sic]; and*
>
> *ii. Hillsides intersecting geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock; and*
>
> *iii. Springs, groundwater seepage, or saturated soils.*

d. Any area which has shown movement during the Holocene epoch (from ten thousand years ago to the present) or which is underlain or covered by mass wastage debris of that epoch.

e. Any area potentially unstable as a result of rapid stream incision, stream bank erosion, or undercutting by wave action.

f. Areas of historic failures, including areas of unstable, old and recent landslides or landslide debris within a head scarp, and areas exhibiting geomorphologic features indicative of past slope failure, such as hummocky ground, slumps, earthflows, mudflows, etc.

g. Any area with a slope of 40% or steeper and with a vertical relief of 15 or more feet, except those manmade slopes created under the design and inspection of a geotechnical professional, or those slopes composed of consolidated rock.

h. Areas that are at risk of landslide due to high seismic hazard.

i. Areas that are at risk of landslides or mass movement due to severe erosion hazards.

Erosion hazard areas are described in City of Everett Ordinance 2909-06 as:

a. Those areas defined as high and very high/severe risk of erosion in the Dames and Moore Methodology for the Inventory, Classification and Designation of Geologically Hazardous Areas City of Everett, Washington: July 1, 1991:

> *i. High erosion hazard areas include slopes of 25 – 40% in Qva and Qal geologic units; and slopes of >40% in other (not Qva or Qal) geologic units.*
>
> *ii. Very high/severe erosion hazard areas include slopes of >40% in Qva and Qal geologic units.*

b. Those areas defined as medium risk of erosion in the Dames and Moore Methodology for the Inventory, Classification and Designation of Geologically Hazardous Areas City of Everett, Washington: July 1, 1991 when they contain debris and mud flows, gullying or rilling, immature vegetation, or no vegetation:

> *i. slopes of 25-40% in other (not Qva or Qal) geologic units*

RESULTS

There are no landslide hazard areas mapped in the project area according to the City of Everett (2006b). A very high/severe erosion hazard is identified on the erosion hazard map prepared by the City of Everett (2006c) at the upstream (southern limits) of our study area, on the outside of a sharp bend in the Snohomish River. Erosion hazards, as they relate to fluvial processes, are discussed in the Fluvial Geomorphic Characterization section, under the subheading titled "Bank Conditions and Levees Revetments/Pilings".

Our slope stability evaluation in the project area is divided into four general areas based on our site reconnaissance:

1. River Banks, Levees, and River-Facing Embankments,
2. the Simpson Pad,
3. Stream Banks of Bigelow Creek, and
4. Road and Railroad Embankments.

Generally, most slopes observed in the study area were less than 10 to 12 feet high and were inclined to gradients of 10 to 100 percent. Most of the levee, road prism, and fill pad slopes were inclined to gradients of approximately 40 to 65 percent. However, banks along the Snohomish River and Bigelow

Creek were often steeply inclined (steeper than 70 percent) and/or undercut. The materials exposed in most embankments in the study area were silty sand or sand with silt and gravel, and were vegetated with blackberries, alders, ferns, grasses, holly bushes, and other shrubs and hardwoods.

River Bank, Levees, and River-Facing Embankments

There is a discontinuous system of fill embankments subparalleling the left bank of the Snohomish River in the project area and are potentially subject to flows from the Snohomish River. Review of the topographic map of the area (U.S. Geological Survey, 1973) shows a levee being present along the east (right) bank of the Snohomish River across from the project property, but no levee is shown on the west (left) bank. The topographic map shows paved and/or unpaved roads along the left Snohomish River bank in the southern and central portions of the study area and a railroad line that extended south along the river bank in the northern portion of the study area. Although the embankments were not necessarily constructed as levees, they do appear to protect landward properties wholly or partially from flood flows of the Snohomish River.

The river bank, levees and river-facing embankments are described below from south (upstream) to north (downstream). The southern part of the levee/embankment system diverges inland from the left river bank in the southern quarter of the project area and joins the east side of Simpson Pad. The east-facing slope of the Simpson Pad faces and is subparallel to the Snohomish River. Since this portion of the Simpson Pad is subject to flood flows and the potential for erosion as the result of the high flows, we discuss it here in conjunction with other slopes potentially affected by river flood flows. A gap exists between the northeast corner of the Simpson Pad and the northern segment of embankments that allows overbank flows to enter into the wetlands north of the Simpson Pad. Several hundred feet north of the Simpson Pad, a levee/embankment is located along the river bank. This embankment eventually merges with the present-day BNSF mainline railroad embankment. The embankments appear to vary in age and character; some segments have sharp edges and features, are well-defined, and are consistent in dimension, while others are discontinuous and considerably more degraded. Station sites described in the following text refer to periodic levee characterization locations and are depicted in Figure 6.

South Levee/Embankment System

The south levee/embankment system originates just north of Lowell Riverfront Park, and consists of the river-facing embankment of a recently constructed detention pond in the south wetland complex. The embankment joins the paved river-side footpath at the pond's northeast corner. The embankment diverges inland from the river-side footpath just north of a culvert crossing under the path and continues northward, where it connects with the southeastern corner of Simpson Pad. For the purpose of this discussion, the south levee/embankment system has been divided into two segments, from south to north: 1) the beginning or our traverse at the south end of the detention pond embankment (approximate Station 30+00) to the culvert crossing under the footpath (Station 40+00) and 2) the culvert crossing under the footpath (approximate Station 40+00) to the southeast corner of Simpson Pad (approximate Station 52+00) (Figure 6).

The southern portion (approximate Stations 30+00 to 40+00) of the southern levee/embankment system is generally 10 to 12 feet wide at the top, 5 to 6 feet high above the adjacent grade, and has banks that range in inclination at gradients from 30 to 60 percent, approximately 3.3H:1V to 1.67H:1V (horizontal:vertical). The ground surface is at approximate Elevation 20+ feet, based on review of a map by Reid-Middleton (1995). The embankment is surfaced with asphalt pavement and grass on the bank slopes. Longitudinal cracks in the pavement with up to 0.5 inches of vertical offset and other potential indications of slumping were evident in a few localized areas along the banks of the embankment.

The northern portion (approximate Stations 40+00 to 52+00) of the southern levee/embankment system is well-defined, symmetrical in cross section, and is of relatively consistent dimension throughout. The slopes on both sides of the levee are inclined at gradients of 55 to 65 percent (approximately 1.8H:1V to 1.5H:1V). The levee is typically 6 to 7 feet wide at the top, 4 feet high on the river side and up to 6 feet high on the landward side. The top surface is flat and in overall good condition. The levee is composed of silty-sand with gravel and is heavily vegetated with blackberries, alder, grasses, ferns, holly, and other shrubs. Large trees consisting predominantly of alders and occasional cottonwoods up to 18 inches diameter at breast height (DBH) are common on the embankment slopes. In places, large trees have toppled, with root wads pulling blocks of earth from the banks and leaving exposed, oversteepened bank soils. We observed evidence of possible soil creep and/or surface sloughing along both sides of the embankment.

East Simpson Pad Fill Slope

As mentioned above, the east-facing fill slopes of Simpson Pad are potentially exposed to high flood flows of the Snohomish River. The embankment consists of two distinct terraces. These slopes are generally inclined to 45 to 70 percent (approximately 2.2H:1V to 1.4H:1V) with a total vertical relief of 10 to 11 feet high towards the south, and decreasing to 8 to 10 feet high towards the north. Although steep in isolated places, there were generally observed no signs of instability along this side of the pad. However, there is a drainage swale near approximate Station 59+00 and approximately 700 feet north of the southeast corner of the pad where the embankment is 10 to 12 feet high, with slightly convergent slopes inclined at gradients greater than 65 percent slopes. This small swale may therefore be susceptible to erosion from concentrated runoff from the Simpson Pad.

Wood pilings are present along the left bank of the Snohomish River adjacent to the Simpson Pad. The bank slopes were best observed during our boat reconnaissance when the water was low during an ebb tide. It appears that the piles are the remnants of a timber pile and timber lagging revetment located along the water front. Most of the lagging has rotted or washed away, exposing the river bank to erosion. Localized areas of scour were observed along the bank; in general the bank slopes appear to be steep and subject to erosion. The ground surface between the river bank and the Simpson pad appears to be slightly backsloped (sloping down to the west). While it appears that railroad tracks and/or roads occupied this area in the past, we did not see any clear indication that a formal levee was present in this area.

North Levee/Embankment System

The north levee system includes the area adjacent to the left bank of the Snohomish River beginning at the northeast corner of Simpson Pad (station 75+00), continuing northward to the convergence of the BNSF railroad bed with the river bank (station 103+00). For the purpose of this discussion, the north levee system has been divided into three segments, from south to north: 1) approximate Station 75+00 to a small inlet at approximate Station 82+10, 2) approximate Station 82+10 to Bigelow Creek at approximate Station 87+50, and 3) approximate Station 87+50 to the BNSF railroad bed at approximate Station 103+00 (see Figure 6).

The first segment consists of relatively flat ground with no discernable levee or embankment. .The topographic map of the area (U.S. Geological Survey, 1973) shows the ground surface at or slightly above Elevation 10 feet in this area. The embankment in the second segment is better defined, but is generally irregular and undulating, and is interrupted by occasional breaches and swales. The embankment ranges in height from 3 to 9 feet above the surrounding grade, is 10 to 20 feet wide on the top surface, and has landward-facing slopes that are inclined at gradients of 35 to 40 percent (approximately 2.9H:1V to 2.5H:1V). The slopes on the river side are typically near-vertical or undercut. The third segment of levee, north of Bigelow Creek, is generally wider, higher, a more even, planar top, and is more consistent in dimension throughout. The levee is 3 to 7 feet high, 20 to 30 feet wide, and the banks are generally vertical to undercut on the river side, and inclined to 15 to 45 percent (approximately 6.7H:1V to

2.2H:1V) on the landward side. There is what appears to be an old road or railroad grade in this vicinity that runs subparallel and inland from the levee, joining the main BNSF rail grade farther downstream (to the north). While the levee on the river side is oversteepened and undercut in places, we observed no other indication of instability along this segment of embankment (e.g. on the "landward" side). The river bank adjacent to the BNSF railroad grade has been armored with large rip rap from about Station 103+00 to approximate Station 106+00, where a slight bend in the river impinges at a bend in the railroad line.

Stream Banks of Bigelow Creek

The exposed upper banks of Bigelow Creek west of the levee system are generally less than 1 to 2 feet high and are abrupt and steeply inclined, but do not appear to be actively eroding or failing. Bigelow Creek was measured to be about 4 feet deep just upstream of a small, low beaver dam located approximately 250 feet upstream from its outfall into the Snohomish River. The creek bed is composed of soft material consisting of very organic-rich matter. At the west side of the Simpson Category I wetland, Bigelow Creek is about 20 to 30 feet wide, forming a small open body of water parallel to the BNSF railroad easement. The slopes of the stream bank in this area appear to be gently inclined. The flow in Bigelow Creek was low and slack at the mouth of the creek at the time of our visit.

Simpson Pad

North Simpson Pad Fill Slopes

The surface of the Simpson Pad is a very gently undulating surface that ranges from approximate Elevation 16 to 23 feet. The northwestern corner of the pad is slightly lower than the remainder of the fill pad, ranging from about Elevation 16 to less than 20 feet. An access road is present along the perimeter of the pad. There are two sets of fill slopes along the perimeter of the Simpson Pad. The upper slopes are generally discontinuous and located on the upslope side of perimeter access road, while the typically more prominent slopes extend down from the perimeter access road to the toe of the fill pad.

The lower slopes on the north side of Simpson Pad are densely vegetated with blackberries, alders, ferns, and larger hardwoods, and are inclined from 40 to 70 percent (approximately 2.5H:1V to 1.4H:1V). There are indications of possible minor past sloughing/slumping in isolated spots, but the banks generally appear to be stable under current conditions. The embankment slopes flatten slightly and decrease in height from east to west. The slopes are inclined at gradients of 50 to 55 percent (2H:1V to 1.8H:1V) in the east, decreasing to gradients of 40 to 45 percent (2.5H:1V to 2.2H:1V) in the west. The height of the embankment slopes are about 10 to 12 feet high in the east, decreasing to about 8 to 10 feet high in the west. There is a scarp-like feature on a 40 percent slope at the northwest corner of the pad. However, it is our opinion that the feature was likely caused by erosion from beavers which are active in the area, rather than being related to slope movement (Photograph Sheet 5). There is only about a 200-foot-long section of road where a slope is present upslope of the road. The slope is a maximum of about 3 to 5 feet high.

A large culvert crosses underneath the access road at northwest corner of Simpson Pad. The slopes adjacent to the culverts appear to be stable and well drained. In general, we observed no indication of instability or recent large-scale erosion along the north Simpson Pad embankments.

West and south Simpson Pad Embankments

The fill slopes on the west and south sides of the Simpson Pad grade down to the access road surrounding the pad, and then down into the west and south wetland complexes. The slopes are thickly vegetated with blackberries, ferns, alders, and shrubs. Slopes range from 20 to 70 percent (approximately 5H:1V to 1.4H:1V), and are up to about 8 feet high on the downhill side and generally about 2 to 3 feet high on the uphill side of the road. There is one area where the slope above the access road is about 5 or more feet high. We observed no indications of erosion or soil movement on these banks.

The south-southwest-facing slope at the southern-most corner of the pad is downslope of the access road and is inclined at a gradient of about 65 to 70 percent (approximately 1.5H:1V to 1.4H:1V) and varies from about 10 to 12 feet high. As with other slopes in the area, these slopes are vegetated with blackberries, ferns, alders, and larger hardwoods. We observed minor sloughing or soil creep on the slopes facing the southern wetland complex, although we observed no distinct failures.

Road and Railroad Embankments

Access Roads

A series of unpaved roads provide access to the Simpson Pad. These include the southwest access road, which separates the south and west wetland complexes, the northwest access road, which separates the west and north wetland complexes, and an old decommissioned grade that crosses the west wetland complex.

The slopes of the road prisms are generally inclined to 55 to 65 percent (approximately 1.8H:1V to 1.5H:1V), but reach gradients of up to 100 percent (1H:1V) in isolated locations. The roads are elevated 2 to 6 feet above the adjacent wetland complexes, and the banks are vegetated with thick blackberries and small shrubs (with the exception of the old road grade which is completely overgrown with alders and large hardwood trees, swamp grasses, and various shrubs). We did not observe areas of significant instability or recent erosion on any of the road embankments.

The fill slopes located adjacent to the northwest access gate (west of the BNSF railroad tracks) have been subject to considerable recent erosion, apparently due to poorly managed overland flow from the slopes above (see Photograph Sheet 5). These slopes are inclined at gradients up to about 65 percent (approximately 1.5H:1V), are 10 to 12 feet high, and are vegetated with grasses (apparently from relatively recent hydroseeding). While measures have been taken to prevent further erosion of these slopes, they provide an indication of the erosion potential on similar man-made slopes in the area if drainage is not controlled.

BNSF Railroad

The BNSF mainline railroad embankment is composed of coarse gravel ballast on top of fill (silty-sand with gravel) and is stabilized in places with coarse rip rap. The railroad embankment is generally inclined at gradients of 40 to 50 percent (approximately 2.5H:1V to 2H:1V) and are less than 4 feet high along the south wetland complex, 4 to 6 feet high along the west and north wetland complexes, and 7 to 9 feet high along the left bank of the Snohomish River.

We observed indications of minor slumping and/or sloughing in isolated places along the railroad embankment, most notably where it joins the banks of the Snohomish River (Photograph Sheet 6). Additionally, there were two small failures on the east side of the railroad grade just above the water level adjacent to the north wetland complex. BNSF has placed coarse rip rap at these locations to help prevent erosion on these slopes.

FLOOD HAZARD ANALYSIS

GeoEngineers evaluated flood surface elevations across the site for the “existing conditions” scenario. A UNET hydraulic model was developed by West Consultants for Snohomish County as part of a 2001 Flood Insurance Study of the Snohomish River for the Federal Emergency Management Agency (FEMA). UNET Version 3.2 is an open channel hydraulic model that provides time histories of stage, flow, velocity, and other hydraulic variables at specified cross section locations along the river. We evaluated output for all cross sections in the vicinity of the proposed development. The site runs adjacent to cross sections L, M, N, and O, as shown in Figures 7 and 8.

The base flood elevations (BFE's) for the 10, 50, 100, and 500 year floods predicted by the model have been adopted by FEMA. Local jurisdictions are required to update their regulations to include the most recently adopted floodway and floodway fringe if they elect to participate in the federal flood insurance program.

The elevations used for the UNET model are generated in vertical datum NGVD 29. The FEMA floodway maps also present flood elevations in vertical datum NGVD 29. Some current topographic data is provided in a more current vertical datum, NAVD 88. To avoid confusion over the differing datum, flood elevation data is presented in both NAVD 88 and NDGVD 29. In addition, a brief summary of vertical datum for the Everett region is provided below. To apply the flood elevation data to ground topography, both sets of data must be in the same vertical datum, otherwise there could be an error of 3.7 feet, which is the local difference between the datum.

VERTICAL DATUM

Mean Sea Level (MSL) is a tidal datum determined over a 19-year National Tidal Datum Epoch. It pertains to local mean sea level and should not be confused with the fixed datums of North American Vertical Datum of 1988 (NAVD 88). NGVD 29 and NAVD 88 are fixed geodetic datums whose elevation relationships to local MSL and other tidal datums may not be consistent from one location to another.

NGVD 29 is a fixed datum adopted as a national standard geodetic reference for heights but is now considered superseded. NGVD 29 is sometimes referred to as Sea Level Datum of 1929 or as Mean Sea Level on some early issues of Geological Survey Topographic Quads. NGVD 29 was originally derived from a general adjustment of the first-order leveling networks of the U.S. and Canada after

holding mean sea level observed at 26 long term tide stations as fixed. Numerous local and wide-spread adjustments have been made since establishment in 1929. Bench mark elevations relative to NGVD 29 are available from the National Geodetic Survey (NGS) data base via the World Wide Web at National Geodetic Survey.

NAVD 88 is a fixed datum derived from a simultaneous, least squares, minimum constraint adjustment of Canadian/Mexican/United States leveling observations. Local mean sea level observed at Father Point/Rimouski, Canada was held fixed as the single initial constraint. NAVD 88 replaces NGVD 29 as the national standard geodetic reference for heights. Bench mark elevations relative to NAVD 88 are available from NGS through the World Wide Web at National Geodetic Survey.

Table 1 below shows conversion between the three vertical datum for Everett. For Everett, NAVD 88 is 3.38 feet higher than NGVD 29.

Table 1. Tidal Datum Regions, Whidbey Island Region 99 – Everett, Washington

Relation Between Various Datum Planes

Datum Plane	MLLW	NGVD 29	NAVD88
Highest Estimated Tide	14.50 +/- 0.5	8.6	12.28
Mean Higher High Water	11.11	5.18	8.86
Mean High Water	10.25	4.32	8.00
Mean (Half) Tide Level	6.52	0.59	4.27
NGVD	5.93	0.00	3.68
Mean Low Water	2.80	-3.13	0.55
Mean Lower Low Water	0.00	-5.93	-2.25

Notes:
US Army Corps of Engineers http://www.nwd-wc.usace.army.mil/nws/hh/tides/

METHODS

Application of the UNET Model

Water surface elevation results predicted by the FEMA-adopted UNET model were provided to GeoEngineers by West Consultants and used to determine flood elevations for the 10-, 50-, 100-, and 500-year peak flows. Hydrology for the UNET model was derived by a statistical analysis of flows at Pilchuck River (USGS gage #12155300) combined with flows at the Snohomish River gage in Monroe (USGS gage # 12150800).

It is important to note that for tidally influenced river systems, FEMA normally requires that the boundary conditions assume a fixed downstream stage equal to mean higher high water (MHHW) plus one foot. The Seattle District Corps of Engineers conducted a tidal surge analysis, and established tidal surge elevations at the mouth of the Snohomish River for the 10-, 50-, 100-, and 500-year events. These tidal elevations, shown in Table 1, superseded any lower water surface elevations simulated in the UNET model and were used as the downstream boundary conditions for the water surface predictions.

Table 2. Tidal Elevations at Everett, Washington

Flood Interval	Tidal Elevation (NGVD 29)
500-year	8.7
100-year	8.4
50-year	8.2
10-year	7.8
MHHW	5.2

The significance of the assumed boundary conditions is the conservatism in the water surface elevation predictions. The modeling method assumes that the highest river flows coincide with the highest tidal elevations. This provides a clear factor of safety for planning purposes and for a flood insurance study; however, from a process-based perspective there is no reason to assume that peak flows will occur simultaneously with high tides.

Cross sections for the UNET model were provided by Snohomish County, from an FEQ model of the system. This data was supplemented with data from the US Army Corps, Washington Department of Transportation, Burlington Northern Santa Fe Railroad, and various additional surveys throughout the study area. The cross sections that correspond to the project reach are L, M, N, and O. The locations of these sections are shown in Figures 7 and 8. Data output for these cross sections are shown in Tables 2 through 5.

The UNET model assumes conditions are constant from one cross section to the next cross section downstream. This means that water surfaces calculated for cross section O, for example, are considered valid from O through N; and data from cross section N is considered valid through M, and so on.

Hydraulic models such as UNET require a calibration process to determine that water surface predictions are consistent with field observations. The intent of this report is not to document the calibration process that was completed; however, it should be noted that the model was calibrated to both bankfull and high flow conditions. GeoEngineers review of the calibration process completed by West Consultants for the UNET provides a high degree of confidence in the results.

Field Verification

A field reconnaissance of the project area was completed both by land and water to identify locations, relative elevations, and general conditions of the levees along the river adjacent to the project area.

RESULTS

Results of the UNET model demonstrate that the river at this location is dominated by riverine rather than tidal processes. Although tidal influence does extend upstream through the project reach, the impact of tidal processes on channel morphology and hydrology is not as great as the impact of riverine processes. This means the river in this reach is subject to moderately high energy flooding events, velocities, and shear stresses, as presented in Tables 2 through 5.

The data presented in Tables 2 through 5 presents hydraulic model output from the FEMA study completed for the Snohomish River. West Consultants completed the model for the FEMA study and provided select data to GeoEngineers for inclusion in this report. The FEMA cross section identifies which cross section adjacent to the project site that data has been generated for. These cross sections match the designations in the FEMA study. It is important to note here that the results of this study are not intended to define the FEMA floodway, but are used to define the flood hazard along the proposed Everett Riverfront development. We assume that the flood control levees along the Snohomish River through the reach will remain intact during flood events. The purpose of this study is to demonstrate the extent of inundation the site can expect with the 100 and 500 year flood events, under existing topographic conditions.

Stage refers to the maximum water surface elevation for the given flood event, provided in both NAVD 88 and NGVD 29. Total flow is the streamflow volume in the Snohomish River calculated for each given flood recurrence interval. Channel velocity is the average, modeled channel velocity through each cross section under each flood event. Shear stress is a function of velocity and depth and is a measure of the erosive force acting on the channel boundary through a cross section. The values in the tables represent the maximum shear over the channel boundary at a cross section. Typically, 1 lb/ft2 is a good indication of the threshold between soft engineering and hard structures to withstand forces acting on a stream bank. Maximum shear stress values calculated for the 100-year and 500-year floods demonstrate that this reach of river is fairly low energy, with little erosive potential applied to the streambed or stream banks. Essentially, this can be interpreted as a measure of high channel stability through the reach.

Table 3. Results for 10-Year Flow

FEMA Cross-Section	River Mile	Stage NGVD 29	Stage NAVD 88	Total Flow (cubic feet/second)	Channel Velocity (ft/s)	Max Shear (lbs/ft^3)
L	5	10.23	13.91	58836	5.84	0.75
M	5.59	11.45	15.13	60743	5.39	0.63
N	6.25	12.49	16.17	60826	5.46	0.63
O	6.77	13.33	17.01	61250	6.82	0.93

Table 4. Results for 50-Year Flow

FEMA Cross-Section	River Mile	Stage NGVD 29	Stage NAVD 88	Total Flow (cubic feet/second)	Channel Velocity (ft/s)	Max Shear (lbs/ft^3)
L	5	10.86	14.54	65282	6.31	0.92
M	5.59	12.02	15.7	65583	5.67	0.89
N	6.25	13.15	16.83	65597	5.59	0.74
O	6.77	13.96	17.64	65686	6.96	1.09

Table 5. Results for 100-Year Flow

FEMA Cross-Section	River Mile	Stage NGVD 29	Stage NAVD 88	Total Flow (cubic feet/second)	Channel Velocity (ft/s)	Max Shear (lbs/ft^3)
L	5	10.94	14.62	66133	6.37	0.97
M	5.59	12.34	16.02	68538	5.84	1.02
N	6.25	13.52	17.2	68606	5.69	0.85
O	6.77	14.38	18.06	68944	7.04	1.22

Table 6. Results for 500-Year Flow

FEMA Cross-Section	River Mile	Stage NGVD 29	Stage NAVD 88	Total Flow (cubic feet/second)	Channel Velocity (ft/s)	Max Shear (lbs/ft^3)
L	5	13.01	16.69	84943	7.51	1.08
M	5.59	14.9	18.58	102272	7.75	1.19
N	6.25	16.68	20.36	110944	7.19	1.01
O	6.77	17.9	21.58	114624	8.85	1.47

Figure 7 presents the extent of predicted flooding across the site for the 100-year peak flow. The predicted water surface elevations for the 100-year flow at cross section M (roughly in the middle of the project reach) is 16.02 (NAVD 88). Floodwaters are expected to inundate portions of the North, East, and West wetland complexes surrounding the Simpson Pad. A small lobe along the Northwest of the

Simpson pad is shown to flood; this area, along with the West wetland complex, receives flood waters via a culvert that passes flow from the Snohomish River near the Southeast corner of the pad. The Eclipse Mill site waterward of the BNSF rail prism also floods under the 100-year water surface elevation.

Figure 8 presents the predicted flood surface across the project area for a 500-year peak flow event. At cross section M, the 500-year flood elevation is estimated to be 18.58 feet (NAVD 88). Additional areas flooded under a 500-year event include a greater portion of the Simpson Pad, along with portions of the southern site to the west of the BNSF rail prism. The major area protected under the 100-year event but flooded under the 500-year event is the Tire Fire/Landfill site

Proposed finish grades for the development are presented in Figures 4.1-1, 4.1-1A, and 4.1-1B of the Environmental Impact Statement. Figure 4.1-1 shows finish grades for the area near the East Wetland Complex and the Simpson Pad. The plan shows that the pad will be raised to elevations above the 500-year water surface. Figure 4.1-1B shows planned grades for the Eclipse Mill site. This area is shown to also have finish grades above the 500-year flood elevation. Significant improvements for flood protection under extreme events will result from the proposed finish grades throughout the development.

CONCLUSIONS

CHANNEL MIGRATION POTENTIAL

It is our opinion that the potential for future migration of the channel is very low. Based on our review of aerial photographs, soil conditions and our field observations, undercutting levee and native material will continue to erode both banks during flood events and tidal influence. In our opinion, any future loss of levee or other bank fill material will not increase in the risk of channel migration or avulsion based on the geomorphic characteristic of the channel.

SLOPE STABILITY

The project area is underlain by alluvium (geologic unit Qal), while the levees, fill pads and other embankments are constructed of fill material. It is not known if the fill slopes of the levees, the Simpson Pad or associated road embankments were constructed as engineered fill. According to City of Everett Ordinance 2909-06, all slopes consisting of uncontrolled fill with gradients greater than 15 percent are considered landslide hazard areas with a very high/severe rating. However, the new ordinance does not distinguish between varying heights of fill. Slopes underlain by alluvium with gradients steeper than 25 percent are considered to have a high to very high/severe risk of erosion, and all slopes inclined steeper than 40 percent are considered to have a high risk of erosion. Therefore, a high or greater erosion hazard is considered present along the Simpson Pad, the access road embankments, stream banks and most embankment/levee slopes, based on City of Everett Critical Areas Ordinance.

In general, we observed minor evidence of active erosion or instability on the access road embankments, Simpson Pad fill slopes, and Bigelow Creek. There were, however, a few isolated areas where sloughing, incipient slumping, or potential for instability were observed (Figure 6). Generally, areas of possible concern include:

- The swale on the southeast side of Simpson Pad, where the fill slope at the head of the swale is higher, steeper, and has a convergent slope form that tends to concentrate surface water runoff.
- Along the southern embankment/levee approximately 100 feet south of the culvert crossing where there are pavement cracks in the footpath and other signs of soil creep or slope movement,
- The steep (up to 100 percent) slopes along the southwest access road embankments,

- The BNSF railroad embankment, particularly where slumping was observed along the left bank of the Snohomish River
- The fill slopes near the northwest utility gate that show signs of considerable erosion, and
- Other slopes that are steeper than 60 percent and higher than 10 feet above the surrounding grade.

There are numerous signs of erosion and instability along the banks of the Snohomish River, including undercut and near-vertical slopes that are actively slumping/sloughing, particularly in areas where trees have toppled, loosening and disturbing the river banks. These features also affect the embankments/levees present immediately adjacent to the river banks. The presence of numerous recent failures along the shoreline indicates that these stream banks are prone to continued erosion in the future, but the erosional processes do not appear to be rapid, based on the channel migration evaluation. The river channel also appears to be relatively deep (8 or more feet deep at low tide). Therefore, a relatively high, steep slope is present along the left bank of the river along the project property.

The banks of Bigelow Creek do not appear to be actively eroding or failing. Based on our observations, we do not believe that the banks of Bigelow Creek pose a stability or erosion hazard during times of normal flow. Stability may, however, be adversely affected on these banks by inundation during high flows.

Embankments associated with roads and the Simpson Fill pad we observed are typically vegetated with large trees, which have roots that add strength to the slopes and redue the potential for erosion. Removal of trees on these slopes may decrease slope stability by reducing root strength, and potentially making them more susceptible to erosion or undercutting during flood events. Alluvial deposits underlying the site are saturated at relatively shallow depth below the original ground surface, and are therefore likely susceptible to liquefaction and lateral spreading during seismic events. The free faces along the river bank in particular are likely susceptible to lateral spreading. The site, including fill embankments, fill areas and natural slopes may experience settlement, lateral spreading and the potential for seismically-induced slope failures during strong ground shaking. The explorations presently being completed in the Simpson Pad area will aid in evaluating some of these concerns.

FLOOD HAZARDS

The bulk of the project area proposed for development is free of flooding hazards up to the 500-year peak flood. The Category 1 wetland area and riparian complex are poorly protected by levees and will be flooded at events as frequent as the 10-year peak flow. It is our understanding that this area is intended to remain free of development but may contain elevated walking pathways and environmental education observing stations. These structures should be designed to function above the flood elevations noted. The primary area of concern is the Eclipse Mill Site riverward of the BNSF rail embankment. Our field observations, topographic data, and model results do not provide sufficient confidence to determine the flood event for which this area is currently protected. We recommend more detailed survey of the elevations and conditions of levees and revetments adjacent to this portion of the project site.

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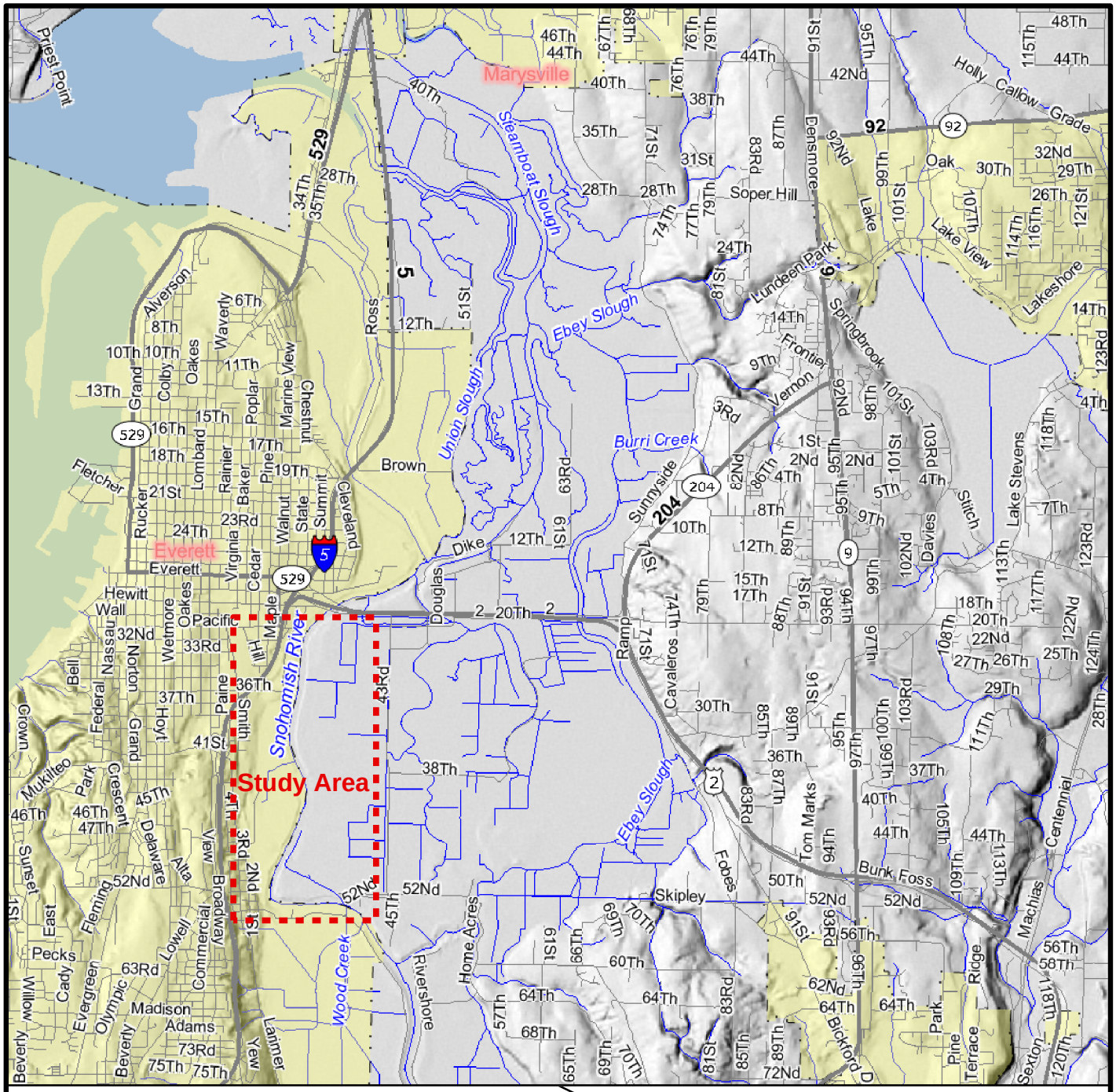

Data Sources: Interstates, state routes, and roads from TIGER 2000.
10m DEM Hillshade, county boundaries, cities, and waterbodies
from Department of Ecology.

All locations are approximate.

Lambert Conformal Conic
Washington State Plane North
North American Datum 1983

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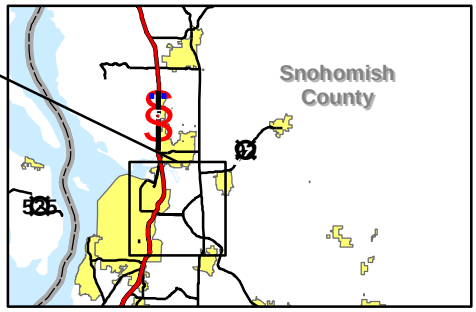

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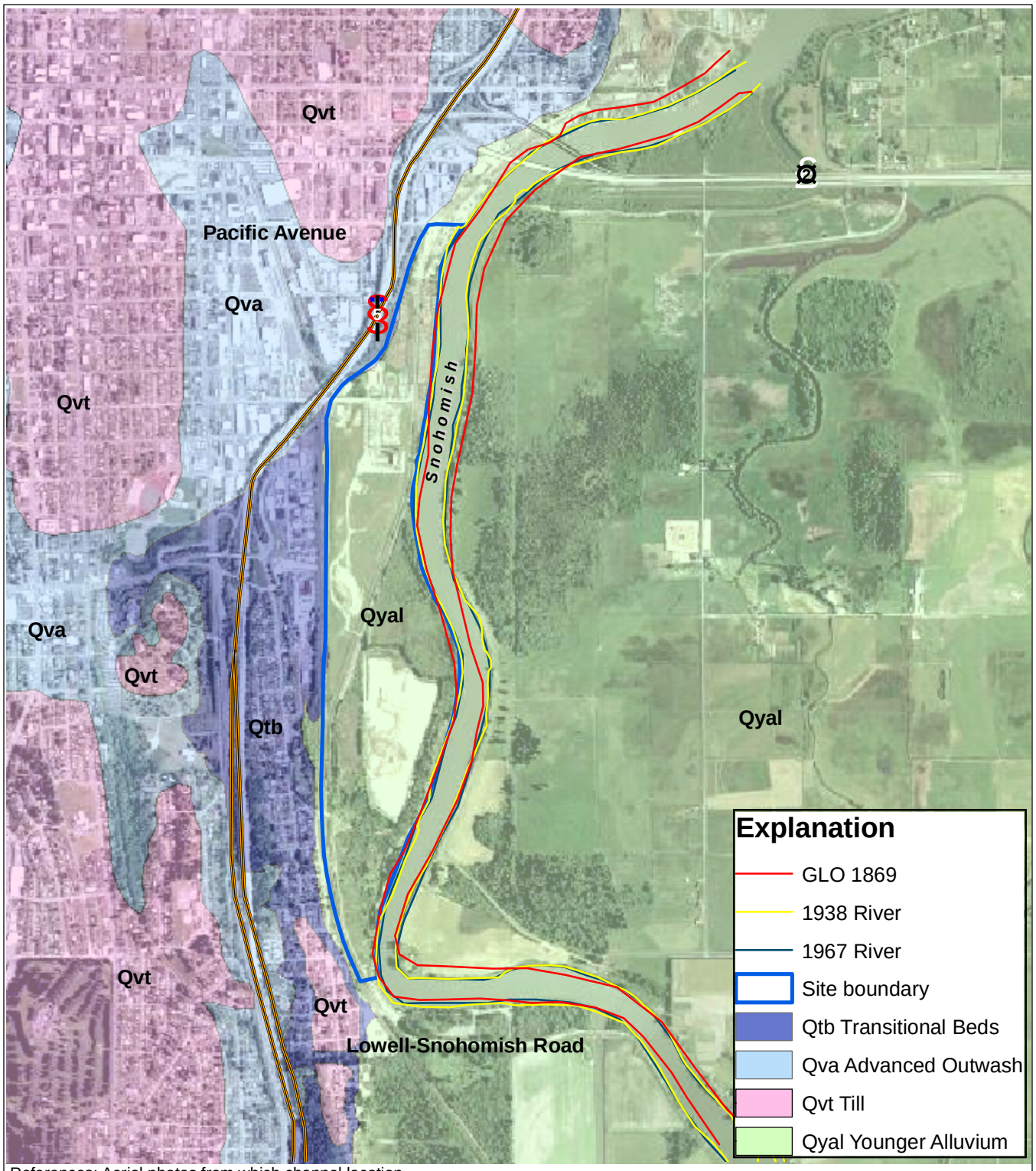
VICINITY MAP

FIGURE 1

Office: RED Path: P:\6\6191002\01\GIS\MXDs\VicinityMap.mxd Map Revised: 12/18/06



References: Aerial photos from which channel location derived provided by http://riverhistory.ess.washington.edu/ Geology digitized USGS Geological Map of Everett 7.5 Quadrangle Snohomish County, WA. James P Minard 1985. Government Land Office (GLO) 1869 map was rectified but may not be accurate because the oblique angle of the map figure. Aerial image ontained from TerraServer dated Thursday, June 13, 2002.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for infomation purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record oth this communication.

2,000 1,000 0 2,000 Feet

Historic Tracks and Geology
Channel Migration Analysis: Snohomish River

Everett Riverfront Redevelopment
Everett, Washington

GEOENGINEERS

Figure 2

Map Revised:1/20/07

Path:P:\6\6191002\03\GIS\MXD\Fig2

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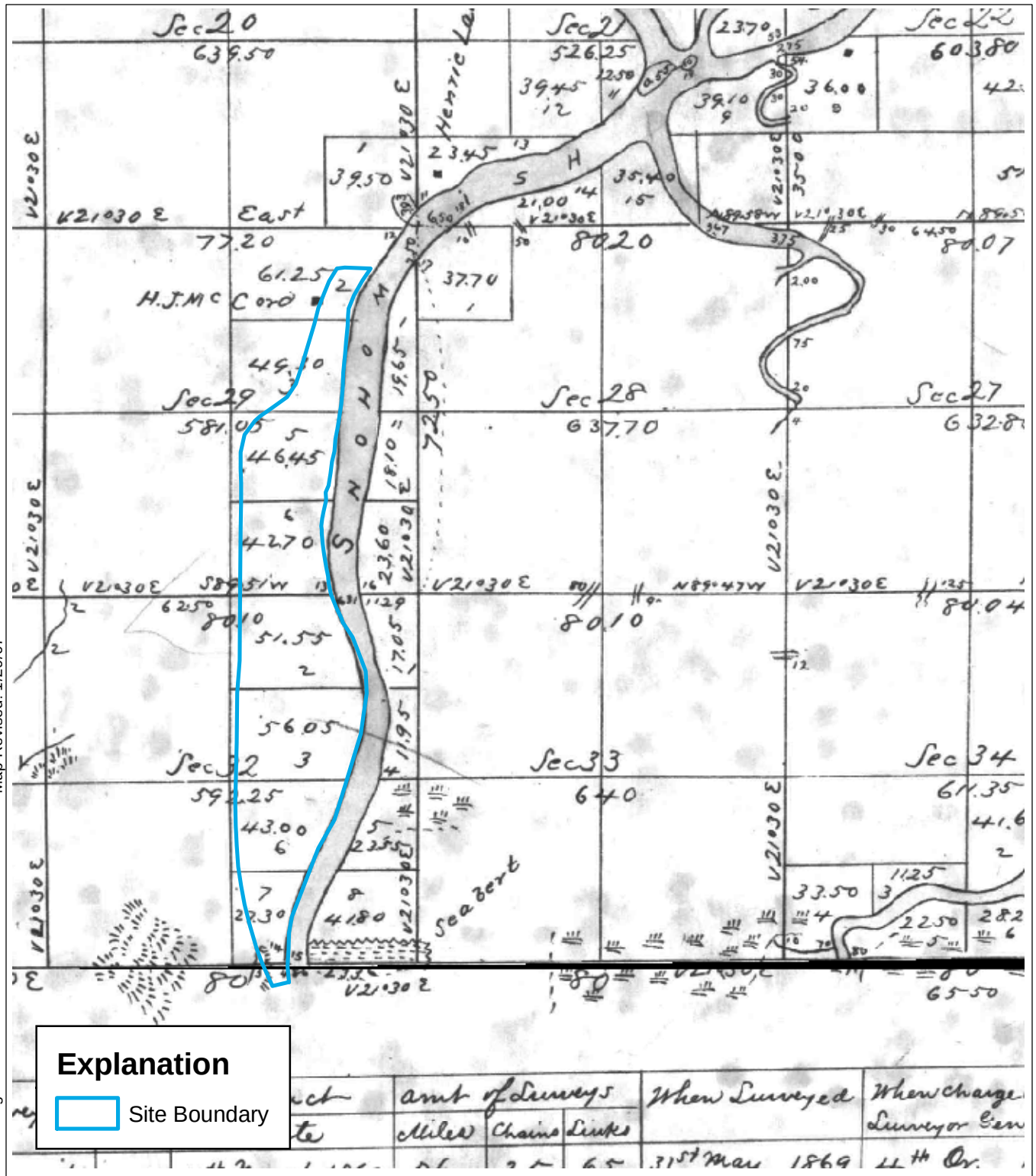

Reference: 1869 Government Land Office Survey (GLO) provided by Puget Sound River History Project.

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Notes:
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1869 GLO Map
Snohomish River

Everett Riverfront Redevelopment
Everett, Washington

GEOENGINEERS

Figure 3

Map Revised: 1/29/07

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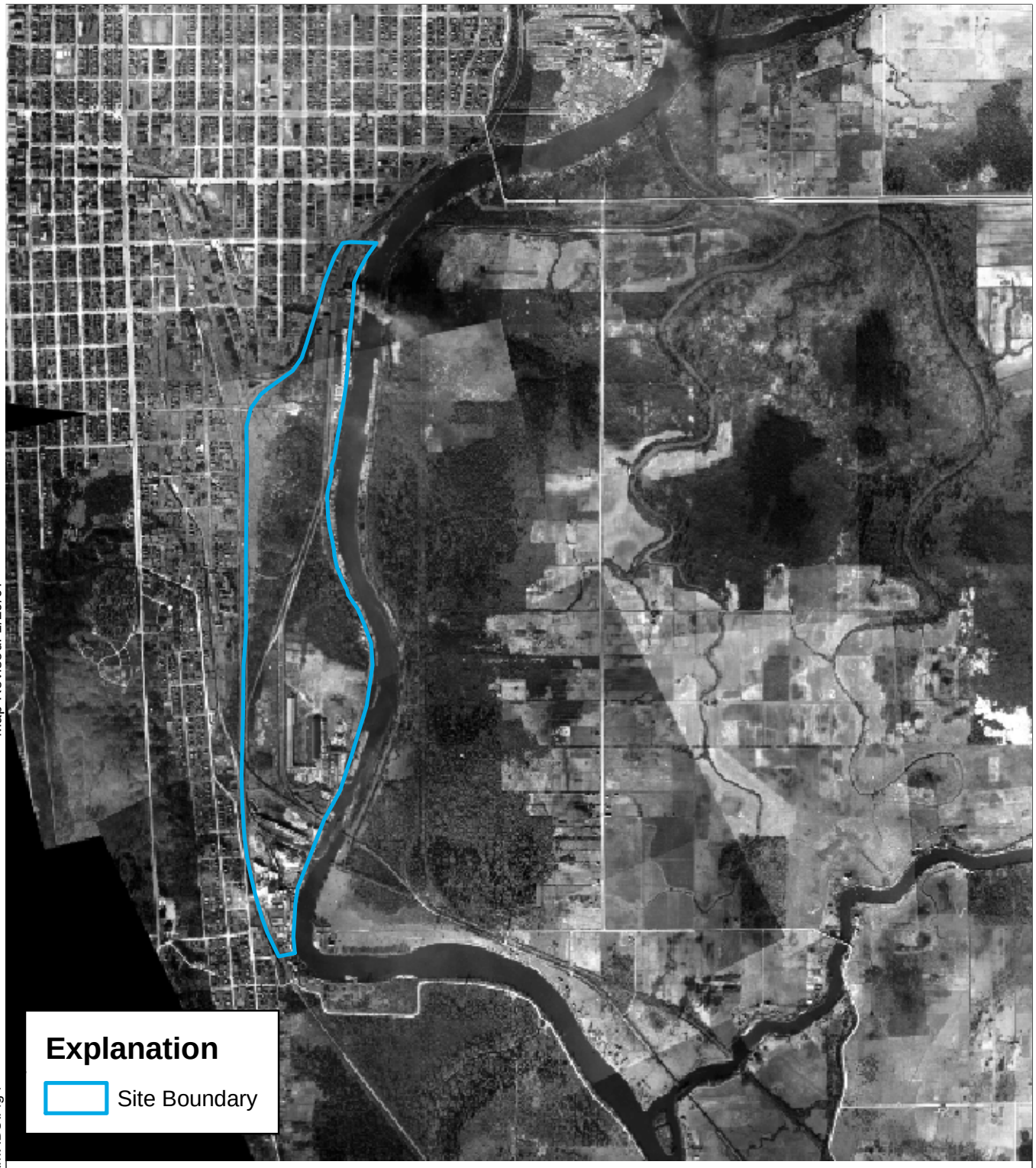

Reference: 1938 aerial photograph obtained from Puget Sound River History Project.

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Notes:
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1938 Aerial Photograph
Snohomish River

Everett Riverfront Redevelopment
Everett, Washington

GeoEngineers

Figure 4

Map Revised: 1/29/07

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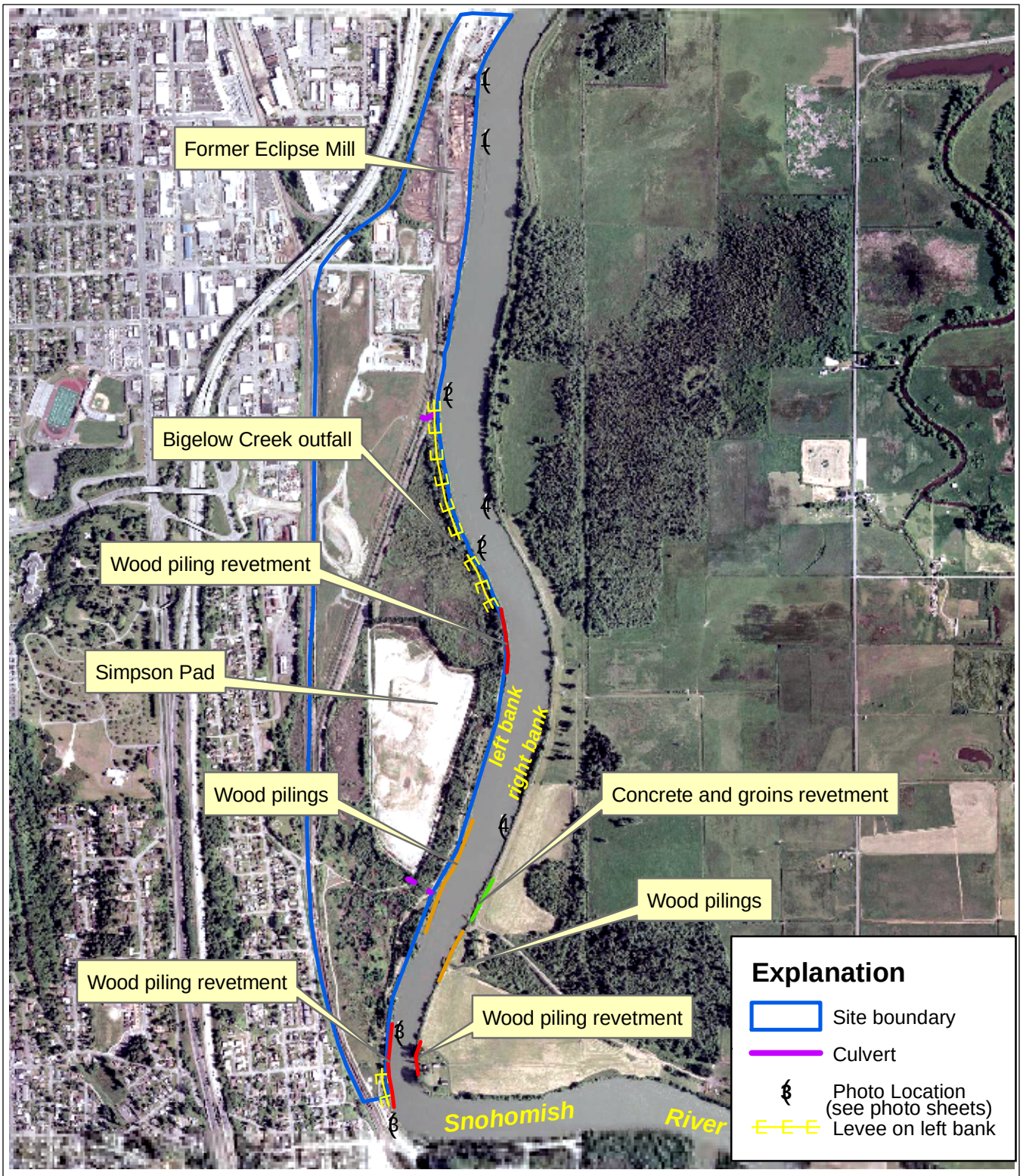

Reference: Aerial image obtain from TerraServer dated Thursday, June 13, 2002.

2,000 1,000 0 2,000 Feet

Notes:
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2. This drawing is for infomation purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record oth this communication.

Site Reconnaissance
Channel Migration Analysis: Snohomish River

Everett Riverfront Redevelopment
Everett, Washington

GEOENGINEERS

Figure 5

Map Revised:01/23/07

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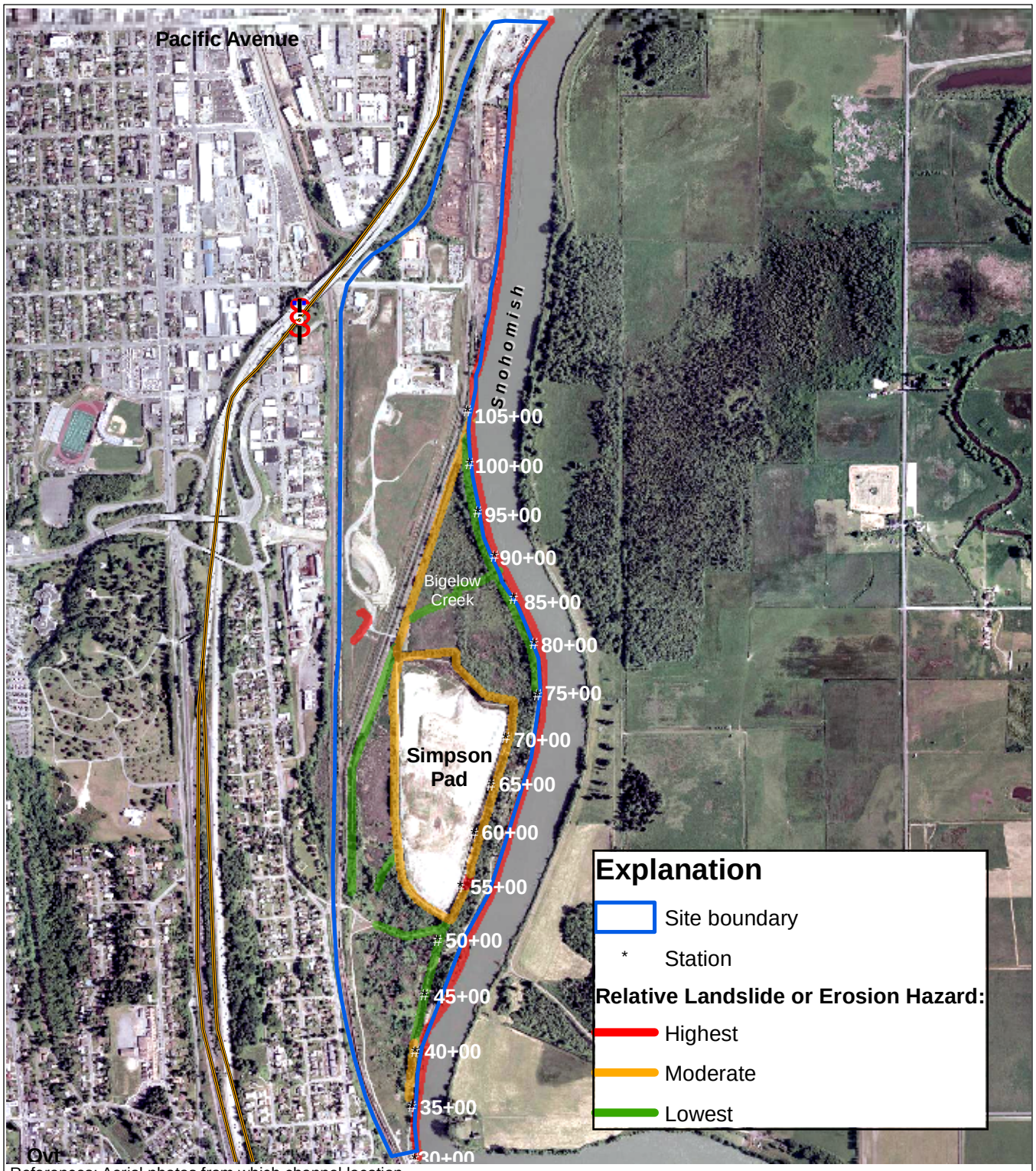

References: Aerial photos from which channel location derived provided by http://riverhistory.ess.washington.edu/ Geology digitized USGS Geological Map of Everett 7.5 Quadrangle Snohomish County, WA. James P Minard 1985. Government Land Office (GLO) 1869 map was rectified but may not be accurate because the oblique angle of the map figure. Aerial image ontained from TerraServer dated Thursday, June 13, 2002.

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1,400 700 0 1,400 Feet

Station Locations and Relative Slope Hazards
Slope and Bank Stability Reconnaissance

Everett Riverfront Redevelopment
Everett, Washington

GeoEngineers

Figure 6

Map Revised:1/20/07

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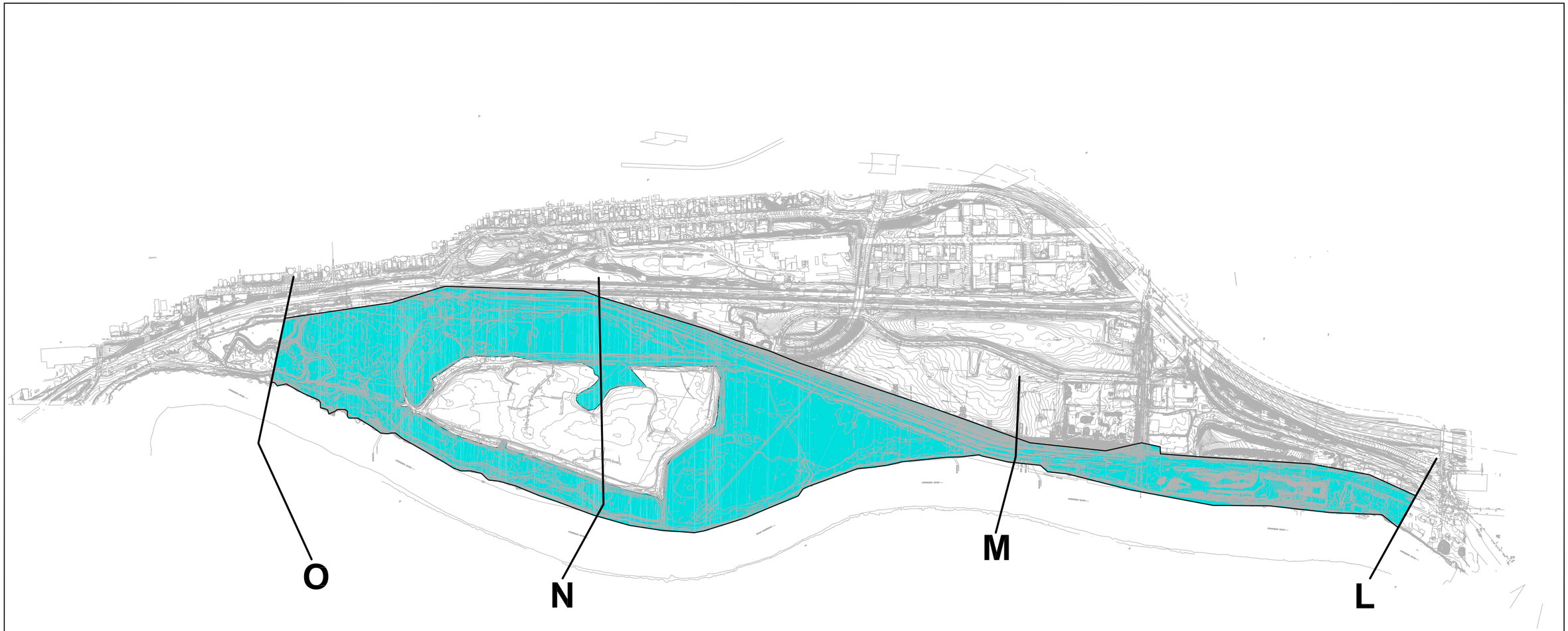

Notes:

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2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. Actual flood extents on the Simpson Pad and areas in the west wetland complex are based on culvert flow, and dependent on both duration and stage of flows in the Snohomish River. Estimated flood extent is extrapolated from modeled water elevations in the Snohomish River and no culvert flow was determined.

Reference: Base survey layer obtained from Pertect, Inc.

Legend:

Estimated 100-Year Flood Extent

O — FEMA Flood Insurance Study Cross Sections

800 0 800
FEET

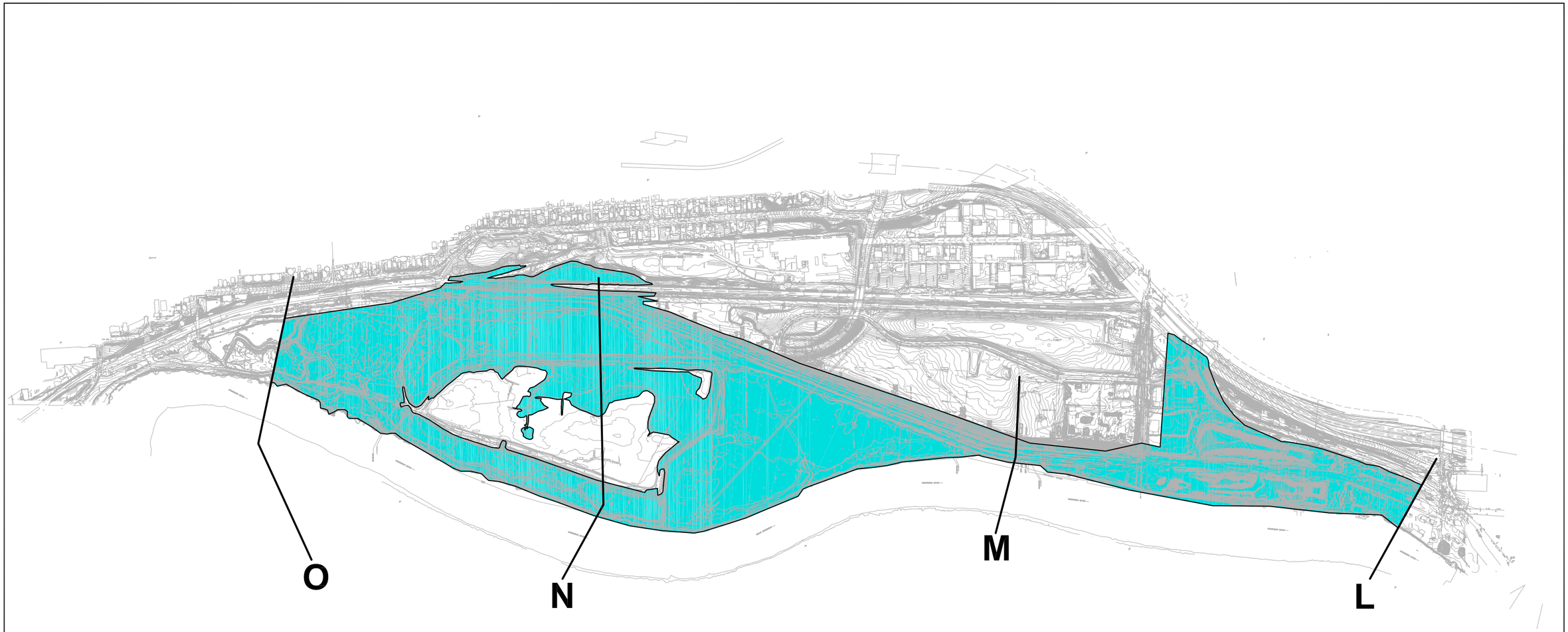
Estimated 100-Year Flood Extent

Everett Riverfront Redevelopment Project
Landfill Site
Everett, Washington

GEOENGINEERS

Figure 7

W:\REDMOND\PROJECTS\6161\002\03\CAD\FLOOD FIGURE.DWG\TAB:F7 MODIFIED BY GGLADDEN ON NOV 16, 2007 - 11:26



Notes:

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Reference: Base survey layer obtained from Pertect, Inc.

Legend:

Estimated 500-Year Flood Extent

O — FEMA Flood Insurance Study Cross Sections

800 0 800
FEET

Estimated 500-Year Flood Extent

Everett Riverfront Redevelopment Project
Landfill Site
Everett, Washington

GeoEngineers

Figure 8

W:\Redmond\Projects\1619\002\03\CAD\FLOOD FIGURE.dwg\TAB:F8 modified by ggladden on Nov 16, 2007 - 11:26

Asphalt/concrete rip-rap revetment along the left bank.

Laminated, cohesive silty sediments along the left bank. The same conditions were observed along the right bank directly across the river.

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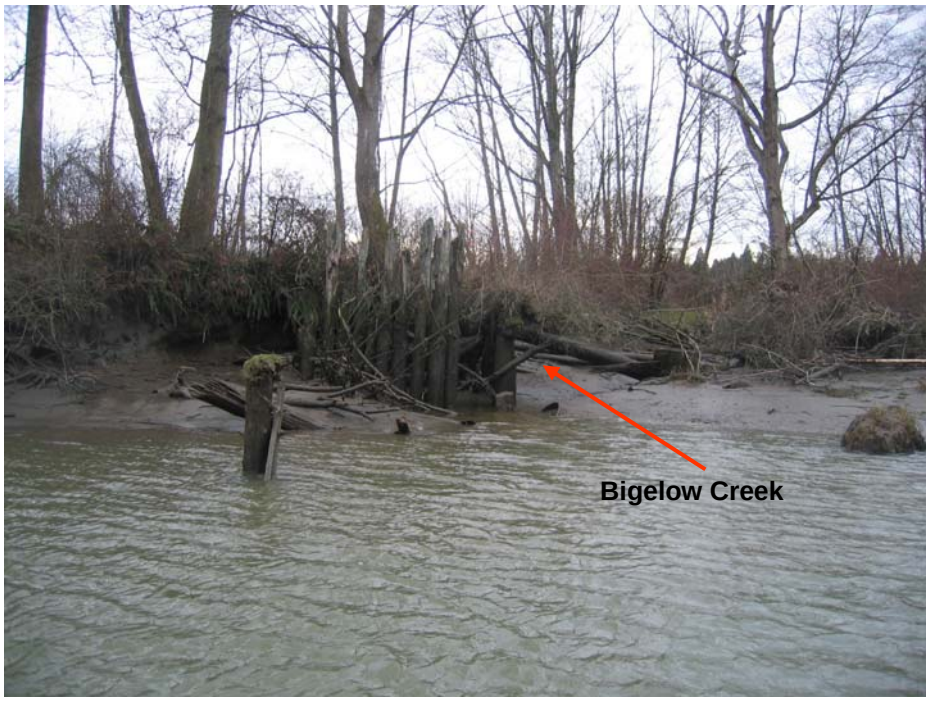
GeoEngineers
Earth Science + Technology

Site Photographs

Sheet 1

Rip-rap revetment along the left bank at railroad embankment.



Confluence of Bigelow Creek with Snohomish River on the left bank.

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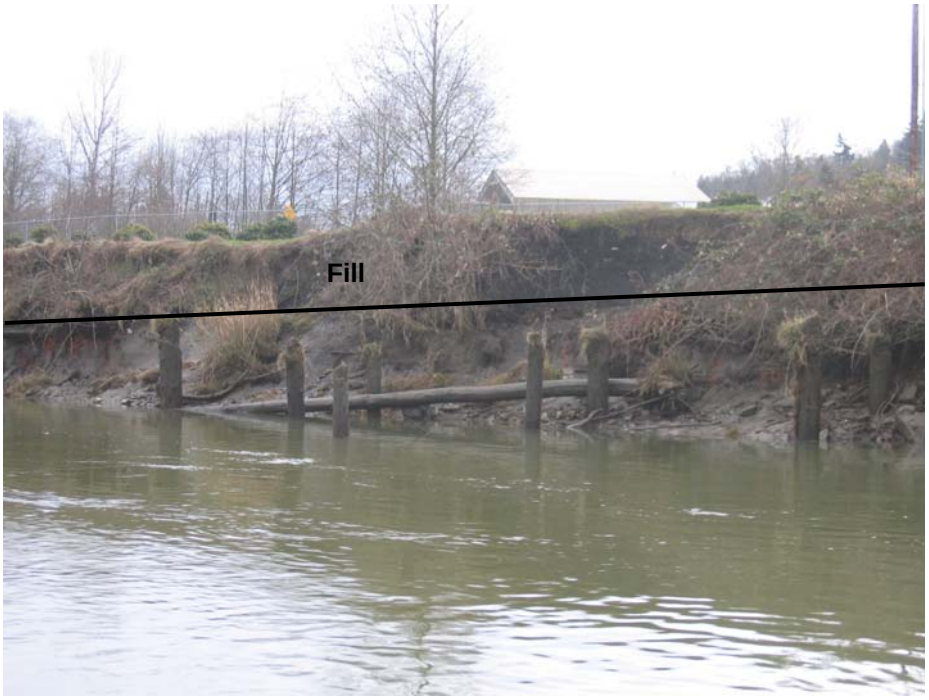
Earth Science + Technology

Site Photographs

Sheet 2

Wood pile revetment along the left bank.



Eroding fill along the left bank nearly 90 degree bend in the river.

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GeoEngineers
Earth Science + Technology

Site Photographs

Sheet 3

Undercutting and slumping of the reworked levee material along the right bank at the OHWM. The same conditions were observed along the left bank.

Silty fine sand on a gentle slope along the right bank. The same conditions were observed along the left bank directly across the river.

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GeoEngineers
Earth Science + Technology

Site Photographs

Sheet 4

Slope degradation facilitated by beaver erosion has created scarp-like features on the north embankment of Simpson Pad.

Fill banks adjacent to the northwest access gate have eroded significantly because of poorly managed overland flow from the slopes above.

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Site Photographs

Sheet 5

Small fill failures were observed along the east side of the BNSF railroad prism adjacent to the north wetland complex.

Numerous ballast failures were observed where the BNSF mainline joins the stream bank.

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Site Photographs

Sheet 6

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Appendix A

Report Limitations and Guidelines for Use

APPENDIX A
REPORT LIMITATIONS AND GUIDELINES FOR USE[1]

This appendix provides information to help you manage your risks with respect to the use of this report.

GEOTECHNICAL SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES, PERSONS AND PROJECTS

This report has been prepared for the exclusive use of OliverMcMillan Everett LLC and its authorized agents. This report is not intended for use by others, and the information contained herein is not applicable to other sites.

GeoEngineers structures our services to meet the specific needs of our clients. For example, a geotechnical or geologic study conducted for a civil engineer or architect may not fulfill the needs of a construction contractor or even another civil engineer or architect that are involved in the same project. Because each geotechnical or geologic study is unique, each geotechnical engineering or geologic report is unique, prepared solely for the specific client and project site. Our report is prepared for the exclusive use of our Client. No other party may rely on the product of our services unless we agree in advance to such reliance in writing. This is to provide our firm with reasonable protection against open-ended liability claims by third parties with whom there would otherwise be no contractual limits to their actions. Within the limitations of scope, schedule and budget, our services have been executed in accordance with our Agreement with the Client and generally accepted geotechnical practices in this area at the time this report was prepared. This report should not be applied for any purpose or project except the one originally contemplated.

A GEOTECHNICAL ENGINEERING OR GEOLOGIC REPORT IS BASED ON A UNIQUE SET OF PROJECT-SPECIFIC FACTORS

This report has been prepared for the Coty of Everett Riverfront Development project area. GeoEngineers considered a number of unique, project-specific factors when establishing the scope of services for this project and report. Unless GeoEngineers specifically indicates otherwise, do not rely on this report if it was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored.

SUBSURFACE CONDITIONS CAN CHANGE

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by manmade events such as construction on or adjacent to the site, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. Always contact GeoEngineers before applying a report to determine if it remains applicable.

MOST GEOTECHNICAL AND GEOLOGIC FINDINGS ARE PROFESSIONAL OPINIONS

Our interpretations of subsurface conditions are based on field observations from widely spaced sampling locations at the site. Site exploration identifies subsurface conditions only at those points where

[1] Developed based on material provided by ASFE, Professional Firms Practicing in the Geosciences; www.asfe.org .

subsurface tests are conducted or samples are taken. GeoEngineers reviewed field data and then applied our professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ, sometimes significantly, from those indicated in this report. Our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions.

A Geotechnical Engineering Or Geologic Report Could Be Subject To Misinterpretation

Misinterpretation of this report by others can result in costly problems. You could lower that risk by having GeoEngineers confer with appropriate members of the design team after submitting the report. Also retain GeoEngineers to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering or geologic report. Reduce that risk by having GeoEngineers participate in pre-bid and preconstruction conferences, and by providing construction observation.

Read These Provisions Closely

Some clients, design professionals and contractors may not recognize that the geoscience practices (geotechnical engineering or geology) are far less exact than other engineering and natural science disciplines. This lack of understanding can create unrealistic expectations that could lead to disappointments, claims and disputes. GeoEngineers includes these explanatory “limitations” provisions in our reports to help reduce such risks. Please confer with GeoEngineers if you are unclear how these “Report Limitations and Guidelines for Use” apply to your project or site.

Geotechnical, Geologic And Environmental Reports Should Not Be Interchanged

The equipment, techniques and personnel used to perform an environmental study differ significantly from those used to perform a geotechnical or geologic study and vice versa. For that reason, a geotechnical engineering or geologic report does not usually relate any environmental findings, conclusions or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. Similarly, environmental reports are not used to address geotechnical or geologic concerns regarding a specific project.