REVISED SECTION 4.3
WATER RESOURCES
SURFACE WATER AND CHANNEL MIGRATION

(INCLUDES FEMA LETTER OF MAP REVISION)

4.3 WATER RESOURCES – SURFACE WATER (INCLUDING FLOOD HAZARDS) AND CHANNEL MIGRATION

The site is located in an area that has identified potential for hazards from flooding. Proximity to the Snohomish River introduces the potential for the river channel to migrate in a manner that would impact the proposal. The proposal includes alterations to existing site topography through various cut and fill activities which in turn may cause variations in existing surface water and groundwater flow and conditions. This section summarizes the existing site conditions related to potential groundwater and surface water impacts associated with the proposed alternatives. The groundwater discussion focuses on existing groundwater conditions and quality, and the surface water sections discuss the potential impacts that the alternatives may have on the flooding and channel migration characteristics of the adjacent water bodies: Bigelow Creek and the Snohomish River. Note that stream and wetland habitats are addressed in Section 4.5 Plant and Animal Resources. The surface water discussion focuses on an evaluation of existing flood hazard conditions and includes results from a proposed conditions model that simulates the affects of site development on local and reach-scale flood hazards. The discussion also considers the potential impacts from global climate change affecting sea level on the development.

4.3.1 Methodology

Information for on-site groundwater conditions was collected and evaluated from published agency data and previously completed environmental and geotechnical reports. Groundwater is also addressed in Section 5.7, Environmental Health and Hazardous Materials.

Data for surface water analysis were collected from a variety of sources, including the United States Geological Survey (USGS), the US Army Corps of Engineers (Corps), Snohomish County, the National Oceanic and Atmospheric Administration (NOAA) and multiple consultant reports. Data on flood elevations was provided by West Consultants, who also completed the hydraulic modeling for the FEMA approved floodplain and floodway analysis. A flood hazard and channel migration zone analysis was completed for the site by GeoEngineers (see Appendix C, *Revised Flood Hazard Analysis, Channel Migration Potential, and Slope Stability Evaluation Report* dated February 26, 2007). This document is the primary source for the findings presented here related to surface water impacts.

4.3.2 Existing Conditions/Affected Environment

4.3.2.1 Surface Water

Regional Setting

The Snohomish River Basin, encompassing 1,856 square miles, is the second largest river basin draining to the Puget Sound. The basin is drained by three major rivers: the Skykomish, the Snoqualmie and the Snohomish. The Snohomish River flows through broad lowland 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 subbasin provides significant sediment production, and the river's gradient is generally high. The lower portion of the Snohomish River basin, of which the project site is a part, 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 (Water Resource Inventory Area [WRIA] 7).

Local Setting

The project site is located approximately between River Mile 5 and 6.77 in the Snohomish River Estuary within the broader Snohomish River delta. The project site is bounded to the west by erosion-resistant uplands and by the Snohomish River to the east. Although the Snohomish River at this site is dominated by riverine processes, the elevation of flows in the river are influenced by 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).

Hydrology

The Snohomish River at the confluence of the Snoqualmie and Skykomish Rivers has an average runoff of 6,973,000 acre-feet per year (afy) and an average 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 gauge # 12150800). The mean annual hydrograph of the Snohomish River is characterized by a dual peak; one occurs during late autumn or early winter, driven by autumn 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 autumn.

Floodplain Management

Floodplains[1] are managed in an integrated federal, state and local system. At the root of the system is the National Flood Insurance Program (NFIP) managed by the Federal Emergency Management Agency (FEMA). The NFIP is a system of risk assessment to establish rates for insurance premiums. The federal government is the insurer (with management contracted to a private entity that then works with other private insurers). Under the NFIP flood risk is quantified through maps (Flood Insurance Rate Maps-FIRM). State and local governments must have programs in place to establish FIRM maps in areas under their jurisdiction and then subsequently manage land uses in flood prone areas to meet federal and local requirements for minimizing the risk of damage from floods. While the federal government may, in times of declared emergencies, provide some assistance to private parties for flood damage, the form of assistance available to private parties is typically loans[2] (with direct grants typically being made to government agencies for impacts to publicly owned assets).

The basic purpose of the NFIP is not to prohibit floodplain development, but to guide development in floodplain areas in such a way as to greatly lessen the economic loss and social disruption caused by impending flood events.[3] Washington State's flood program is managed by the Department of Ecology. Everett's floodplain regulations, embodied in Chapter 30 of the Zoning Code have been adopted and approved by the state pursuant to RCW Chapter 86.

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[1] 44 CFR 9.4 *Floodplain* means the lowland and relatively flat areas adjoining inland and coastal waters including, at a minimum, that area subject to a one percent or greater chance of flooding in any given year. Wherever in this regulation the term ''floodplain'' is used, if a critical action is involved, ''floodplain'' shall mean the area subject to inundation from a flood having a 0.2 percent chance of occurring in any given year (500-year floodplain). *Floodway* means that portion of the floodplain which is effective in carrying flow, within which this carrying capacity must be preserved and where the flood hazard is generally highest, i.e., where water depths and velocities are the greatest. It is that area which provides for the discharge of the base flood so the cumulative increase in water surface elevation is no more than 1 foot. *Flood Fringe* means that portion of the floodplain outside of the floodway (often referred to as ''floodway fringe'').

[2] Since government actions to provide flood relief outside of the NFIP is a case-by-case determination there are no strict governing rules to cite beyond the earlier generalized statement.

[3] Floodplain Management A Local Floodplain Administrator's Guide to the National Flood Insurance Program 3rd Edition, Region 10 Federal Emergency Management Agency, January 2000 p. 1

Floodplain maps are the basis for implementing floodplain regulations. Most communities have a Flood Insurance Rate Map (FIRM) based on a flood insurance study (FIS) The FIRMs generally include Base Flood Elevations (BFEs), flood zones, floodways, and flood elevations at specific sites within a community. (A Flood Insurance Study (FIS) is prepared by FEMA to determine the flood hazards present in a community and insurance zones that are used to write flood insurance. The FIS includes a written report containing a description of flooding conditions, and flood profiles showing the 500-, 100-, 50- and 10-year flood elevations for each stream reach studied.[4] In addition; the FIS contains specific field reference points to aid surveyors in establishing the relationship between Base Flood elevation (BFE) and a specific development site.

FIS are performed periodically. Floodplain data can be revised for various reasons including correction of minor errors, better ground elevation data, authorized filling in the floodplain, better flood data or new flood works. These changes can be made in the form of a Letter of Map Amendment (LOMA) or Letter of Map Revision Based on Fill (LOMR-F). A LOMA was issued in 2007 for the Snohomish River FIRM applicable to the Proposal. An activity that could change how flood waters move (a channel or potential obstruction such as a bridge) requires a new analysis and physical map change.

Everett's floodplain regulations apply overlay zones to properties based on the zones shown on the most recent FIRM for Snohomish County (2005). The overlay zones that apply to the Riverfront development are Floodway, and Urban Flood Fringe District (UFFD). Activities in the Floodway, since that is the area carrying the greatest flood flow, are restricted to those which will not obstruct flood flows and with low flood danger (such as lawns, parking areas, boat-launch ramps). The fringe is outside of the floodway and has less carrying capacity and less risk. Developments in the flood fringe districts are required to employ flood protection measures which include elevating structures, outdoor storage, and areas within 15 feet two feet or more above the regulatory flood protection elevation. Parking areas and driveways may be no lower than one foot below the regulatory flood protection elevation. Following construction of structures, a floodplain development certification is required to verify the actual elevation and certify that flood proofing criteria have been met at which point they are eligible for flood insurance pursuant to the NFIP.

Most of the site for the Proposal is presently located in the **floodplain** identified by FEMA in the FIRM (as changed by the 2007 LOMA). Edges of the site and the wetland located north of the Simpson Pad and most of the railroad grade east of the landfill (where tracks are being abandoned) are located in the **floodway**. A large percentage of the area proposed to be developed is located in Zone X of the FIRM which is an area identified as having a 0.2% annual chance of flooding (also referred to as the 500 year flood).

Water Surface Elevations

GeoEngineers evaluated flood surface elevations across the site for the "existing conditions" because the FIRM does not necessarily have all current data. Changes in elevations from fill or consolidation of soil can change elevations up or down. Other features can also change the way flood waters would actually flow. A UNET hydraulic model (UNET models were originally developed for analyzing flood impacts by the US Army Corps of Engineers) 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. Output for all cross sections in the vicinity of the proposed development applying recent elevation data

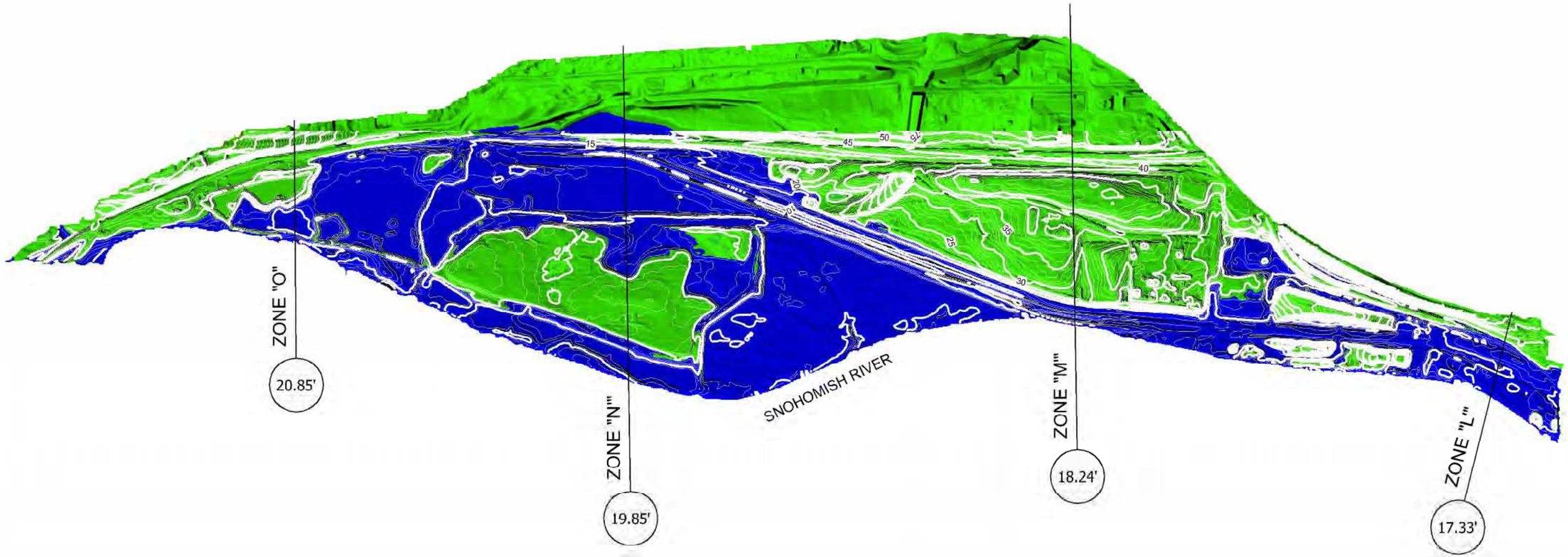
[4] Floodplain Management A Local Floodplain Administrator's Guide to the National Flood Insurance Program 3rd Edition, Region 10 Federal Emergency Management Agency, January 2000 p. 4

was evaluated to understand flood potential. The site runs adjacent to cross sections L, M, N, and O, as shown in Figures 4.3-1, Estimated 100-Year Flood Extent, and 4.3-2, Estimated 500-Year Flood Extent.[5]

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.

[5] The estimated flood extents depicted in Figures 4.3-1 and 4.3-2 were developed by GeoEngineers to estimate the flood conditions under the existing site topography. Two temporary ditches that bisect the Simpson pad are assumed to be filled to the 500-year flood elevation. Flood elevation data was provided to GeoEngineers by West Consultants, who developed the UNET hydraulic model from which the FEMA approved flood elevations were determined. Site topography was provided by Perteet. The estimated extents of flooding for the 100- and 500-year floods is determined by a "spread analysis", which compares elevations of the water surface to the land surface. Only contiguous areas of flooding can occur. Levee overtopping and culvert backflow occurs to flood areas along the western portion of the site. The estimated extents of flooding differ from the recent FEMA LOMAR maps of this site because the FEMA floodway boundary ultimately is a negotiation between FEMA and the local agency (City of Everett). The floodway through this reach of the Snohomish River also assumes that areas within the urban growth boundary and designated by the City as the Urban Flood Fringe will be filled to above the 100-year flood elevation. This accounts for the discrepancy between the GeoEngineers figures, which depict existing flooding extents based purely on flood elevation analysis, versus the FEMA floodway maps, which are a product of a negotiated boundary and takes future development into consideration.



1 PLAN VIEW

Scale: 1" = 800'

Notes:

1. The locations of all features shown are approximate.
2. Existing conditions assume temporary ditches on the "Simpson Pad" will be filled to above 500 year flood elevation.
3. 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.
4. 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 Contour layer obtained from TIN data by Perteet, Inc on NAVD 88. Flood Plan Zones on NAVD 88 .

LEGEND:

FLOOD ZONE

ABOVE FLOOD ZONE

19.80' ZONE "M" — FLOOD ELEVATIONS DERIVED FROM FLOOD MODEL PROVIDED BY WEST CONSULTANTS

Estimated 100-Year Flood Extent
(Existing Conditions)

Everett Riverfront Redevelopment Project
Landfill Site
Everett, Washington

GEOENGINEERS

Figure 4.3-1

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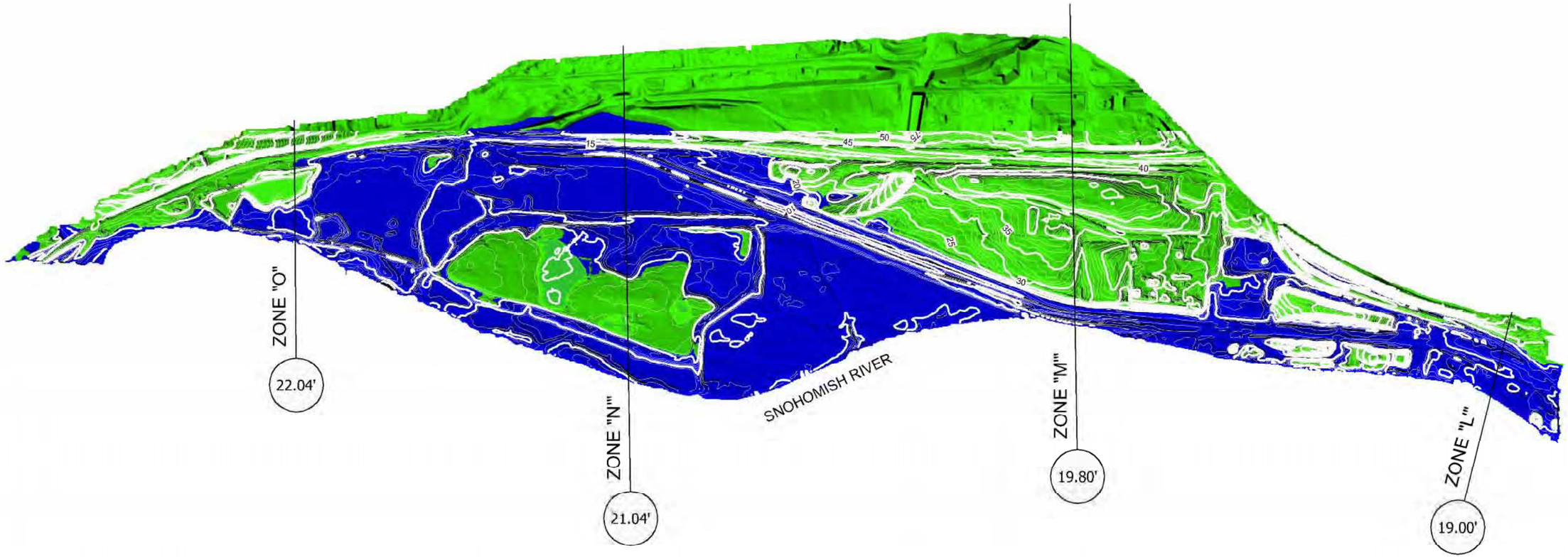

1 PLAN VIEW

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Reference: Base Contour layer obtained from TIN data by Perteet, Inc on NAVD 88. Flood Plan Zones on NAVD 88 .

LEGEND:

FLOOD ZONE

ABOVE FLOOD ZONE

19.80' ZONE "M" — FLOOD ELEVATIONS DERIVED FROM FLOOD MODEL PROVIDED BY WEST CONSULTANTS

Estimated 500-Year Flood Extent
(Existing Conditions)

Everett Riverfront Redevelopment Project
Landfill Site
Everett, Washington

GEOENGINEERS

Figure 4.3-2

\\RED\PROJECTS\6\6191002\03\ENG\MODEL\6191002O3 FLOOD PLANE Q500.DWG\TAB:4.3-2-MODIFIED BY GGLADDEN ON MAY 23, 2008 - 13:25

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 4.3-1 below shows conversion between the three vertical datum for Everett. For Everett, NAVD 88 is 3.68 feet higher than NGVD 29.

Table 4.3-1. 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/

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 1 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 4.3-2, Tidal Elevations at Everett, Washington, 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 4.3-2. 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 4.3-1 and 4.3-2. Data output for these cross sections are shown in Tables 4.3-3 through 4.3-6.

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. 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 4.3-3 through 4.3-6.

The data presented in Tables 4.3-3 through 4.3-6 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. 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. It was assumed that the flood control levees along the Snohomish River through the reach will remain intact during flood events.

The values in the tables represent the maximum shear over the channel boundary at the various cross sections on the maps in Figures 4.3-1 and 4.3-2. Typically, 1 lb/ft^2 is a good indication of the threshold between soft engineering and the need for 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 4.3-3. Results for 10-Year Flow

FEMA Cross Section	River Mile	Stage[6] NGVD 29	Stage[7] NAVD 88	Total Flow[8] (cubic feet/second)	Channel Velocity[9] (ft/s)	Max Shear[10] (lb/ft^2)
L	5	10.71	14.39	63587	6.19	0.75
M	5.59	11.79	15.47	63589	5.56	0.63
N	6.25	12.88	16.56	63594	5.54	0.63
O	6.77	13.68	17.36	63604	6.90	0.93

Table 4.3-4. 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 (lb/ft^2)
L	5	12.89	16.57	77019	6.94	0.92
M	5.59	13.93	17.61	84309	6.69	0.89
N	6.25	15.35	19.03	85353	6.10	0.74
O	6.77	16.21	19.89	85326	7.54	1.09

Table 4.3-5. 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 (lb/ft^2)
L	5	13.65	17.33	80359	7.14	0.97
M	5.59	14.56	18.24	92326	7.16	1.02
N	6.25	16.17	19.85	96363	6.57	0.85
O	6.77	17.17	20.85	96386	8.01	1.22

[6] Stage refers to the maximum water surface elevation for the given flood event, in NGVD 29

[7] Stage refers to the maximum water surface elevation for the given flood event, NAVD 88

[8] Total flow is the streamflow volume (in cubic feet per second) in the Snohomish River calculated for each given flood recurrence interval

[9] Channel velocity is the average, modeled channel velocity through each cross section under each flood event

[10] 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.

Table 4.3-6. 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 (lb/ft^2)
L	5	15.32	19.00	85009	7.51	1.08
M	5.59	16.12	19.80	102272	7.77	1.19
N	6.25	17.36	21.04	111315	7.18	1.01
O	6.77	18.36	22.04	116286	8.86	1.47

Figure 4.3-1 presents the extent of predicted flooding across the site for current conditions 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 18.24 (NAVD 88). Under current conditions floodwaters during a 100 year event would be expected to cover a little more than half of the Simpson Pad, the extreme south corner of the Landfill, and most of the Eclipse site while the wetland complexes surrounding the Simpson Pad and the railroad tracks being abandoned would be inundated.

Figure 4.3-2 presents the predicted flood surface across the project area under present conditions for a 500-year peak flow event. At cross section M, the 500-year flood elevation is estimated to be 19.8 feet (NAVD 88). Under current conditions in a 500-year event nearly all Simpson Pad is reached by flood waters and a little larger area of the Eclipse site is affected.

Channel Migration Zone Potential of the Snohomish River

The dynamic physical processes of rivers, including the movement of water, sediment and wood, cause the river channel in some areas to move laterally, or "migrate," over time. This is a natural process in response to gravity and topography and allows the river to release energy and distribute its sediment load. The area within which a river channel is likely to move over a period of time is referred to as the channel migration zone (CMZ). [11] Snohomish County guidance for channel migration zone delineation dictates that this site is not subject to lateral migration. Notwithstanding the Snohomish County study, GeoEngineers also conducted a study of channel migration potential based on the Forest Practices Board approach.

To complete the Forest Practices Board Manual approach regarding whether the channel may possibly migrate, the historical migration zone was assessed by GeoEngineers (2007) (Appendix C) through a comparison of the 1869 General Land Office (GLO) map and historical aerial photographs from 1938 and 1967 with recent aerial photographs from 2002 relative to the current channel configuration in the project area. The comparison of the 2002 photographs to the GLO map and the 1938 and 1967 historical aerial photographs clearly indicates that the basic channel pattern or configuration has not changed appreciably, and there has been no observable channel migration.

Based on both the Snohomish County and Forest Practices Board approaches, it is determined that the potential for future migration of the Snohomish River at the project location is very low. Based on a review of aerial photographs, soil conditions and field observations, GeoEngineers determined that undercutting of the levee and native material may continue to erode the river banks during flood events. However, any future loss of levee or other bank fill material will not increase the risk of channel migration or avulsion based on the geomorphic characteristic of the channel (GeoEngineers Channel Migration Report 2007, see Appendix C). The minor erosion observed (absent channel migration) will

[11] WAC 173-26-221

have no impact on activities set back and separated from the bank and levees by additional fill and development.

4.3.3 Potential Effects/Impacts of the Project

4.3.3.1 Surface Water Impacts Common to the "Action" Alternatives

Proposed finish grades for the Proposal are presented in Figures 4.3-3 through 4.3-3G of this Section. The proposed finish grades will provide flood protection to all areas of the project where development is proposed. Grades in all areas of development are at a minimum more than 2 feet above the Base Flood Elevation (100 year flood). As a comparison of Tables 4.3-5 and 4.3-6 indicate the elevation for the 500 year flood in the Project area is between 1.67 and 1.19 feet higher than the 100 year flood elevation so all of the developed area would be protected from the 500 year flood as well. Indeed, the average proposed grade on the Simpson Pad is proposed to be about 23.7 feet which is nearly 4 feet above the 100 year flood elevation. The lowest elevation proposed for the Landfill/Tire Fire is 25 feet south of the 41st Street ramp which is nearly 6 feet above the Base Flood Elevation while north of the ramp the lowest elevation is 28 feet which is more than 8 feet above the Base Flood Elevation. Grades on the Eclipse Site are proposed to be at least 2 feet above the 100 year flood elevation.

Under the proposal the road from the Landfill/Tire Fire Site to Pacific Avenue will be at or above the 100 year flood elevation. The only activities occurring in the Floodway under the Preferred Alternative will be vegetative buffers, the boat area, and restoration/mitigation west of Wetland C, and potentially parts of the Shoreline Public Access trails. Trails would be designed to withstand flooding and/or be easily replaced. The boat house will be on the slope of the landfill and designed to comply with applicable flood regulations.

West Consultants modified the existing conditions UNET hydraulic model to simulate the affects of filling the Simpson Pad to the proposed grades Results show a maximum predicted increase of 0.06 feet (less than ¾ inch) in a 500 year event at cross sections throughout the project reach, upstream and downstream (the cross-sections are identified on Figures 4.3-1 and 4.3-2). The model shows that the proposed fill will have a negligible influence on future flood elevations.

No impacts to the Channel Migration Zone of the Snohomish River were identified in the analyses.

Table 4.3-7 Impact of Fill on Simpson Pad During 500 Year Flood

FEMA Section	River Mile	Difference following fill (ft)
	4.681	0.06
	4.717	0.05
K	4.84	0.05
	4.91	0.05
L	5	0.06
M	5.59	0.05
N	6.25	-0.03
O	6.77	0.04
P	7.31	0
Q	7.66	0.01
R	7.92	0

4.3.3.2 Impacts Common to the "No Action" Alternative

Eventual development within the Site would necessitate flood proofing similar to the Action Alternatives.

4.3.3.3 Impacts of the No-Action Alternative

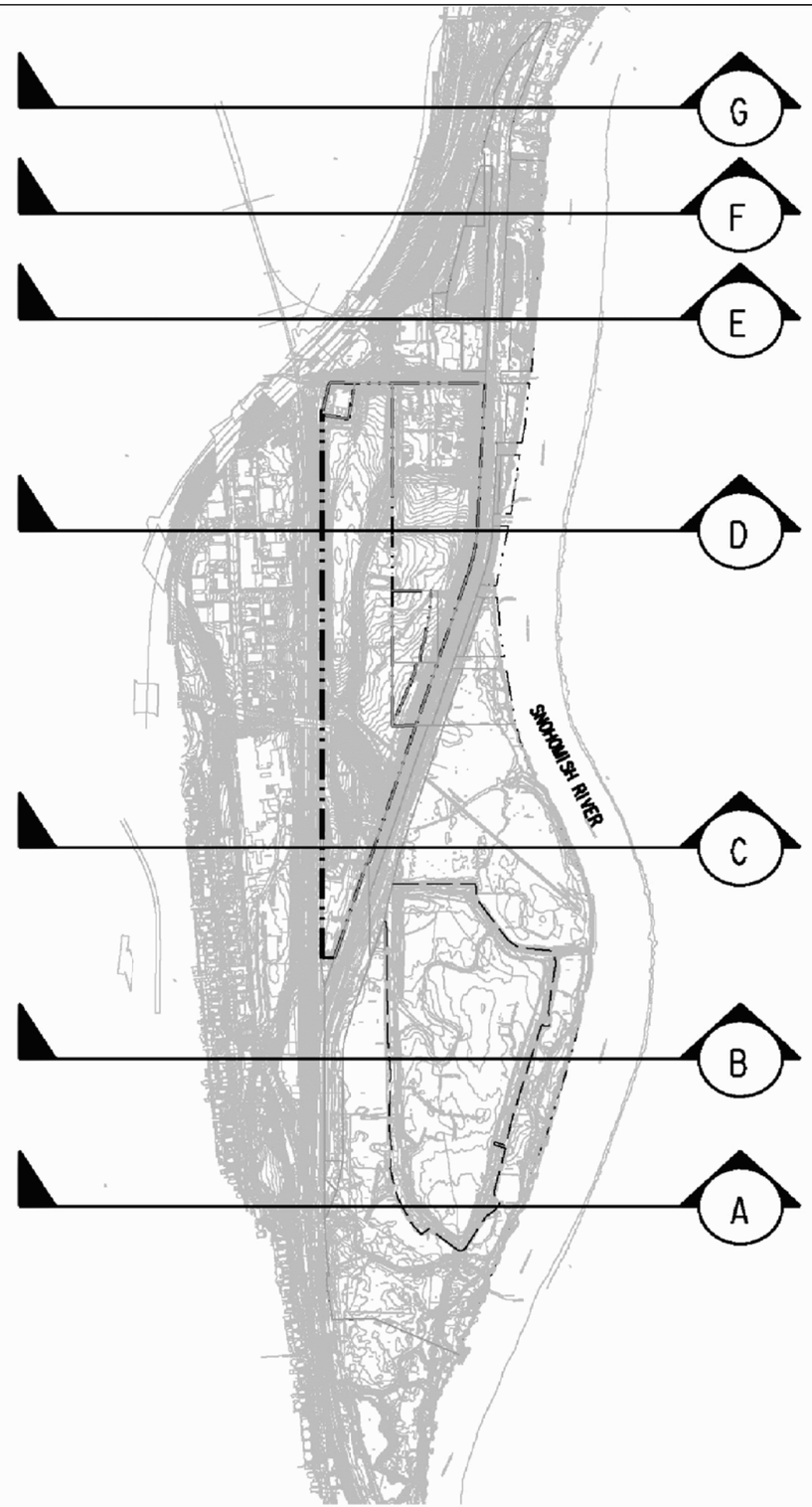
The impacts to water resources are included in the discussion of impacts on earth resources in Section 2.3, Chapter 2, Site/Proposal Description and Alternatives.

4.3.4 Groundwater

Existing groundwater conditions are described in conjunction with earth resources in Section 4.1.3.

4.3.4.1 Groundwater Impacts Common to the All Alternatives

The impacts to water resources are included in the discussion of impacts on earth resources in Section 5.7, Environmental Health and Hazardous Materials.



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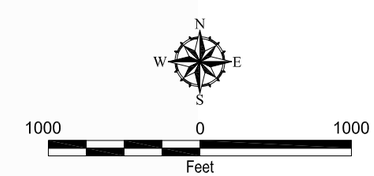
Reference: Image provided by Magnusson Klemencic Associates.



Key Plan

Everett Riverfront Redevelopment
Everett, Washington

GEOENGINEERS

Figure 4.3-3

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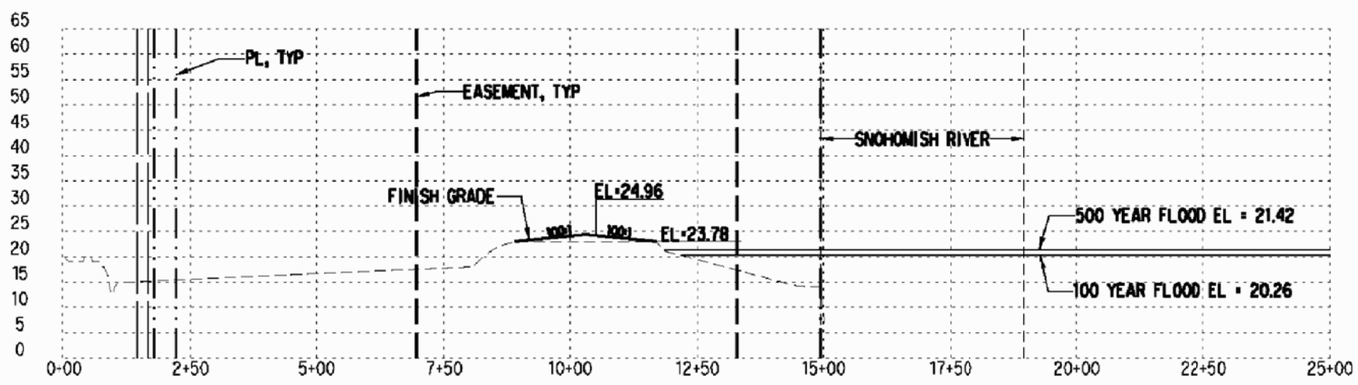

SECTION A

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Reference: Image provided by Magnusson Klemencic Associates.

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Section A

Everett Riverfront Redevelopment
Everett, Washington

GEOENGINEERS

Figure 4.3-3A

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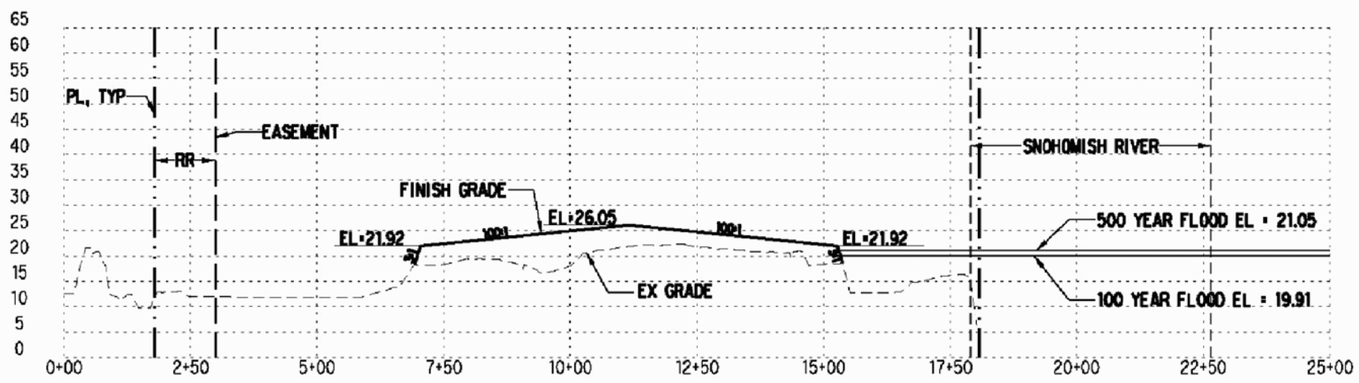

SECTION B

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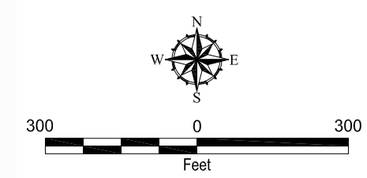

Section B

Everett Riverfront Redevelopment
Everett, Washington

GEOENGINEERS

Figure 4.3-3B

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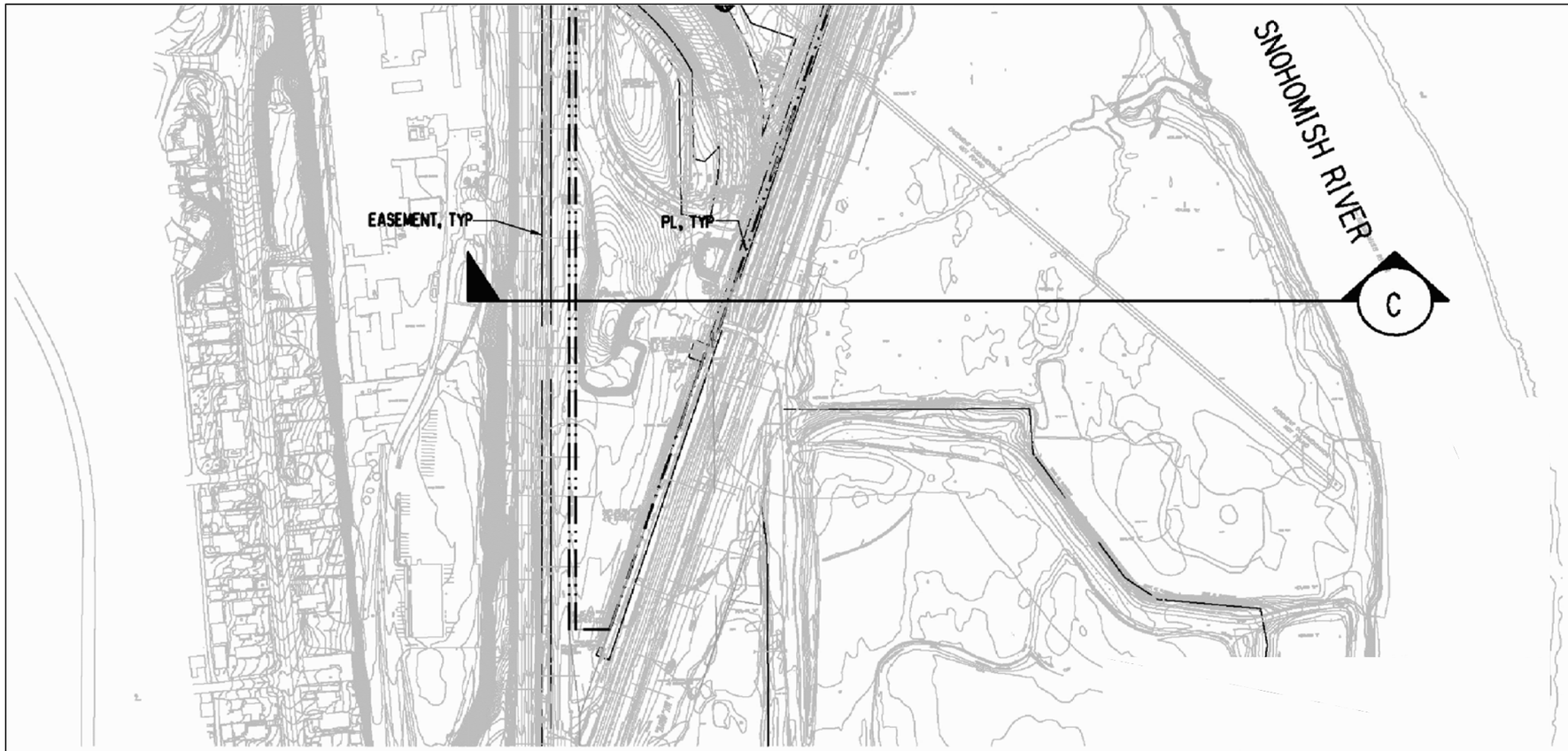

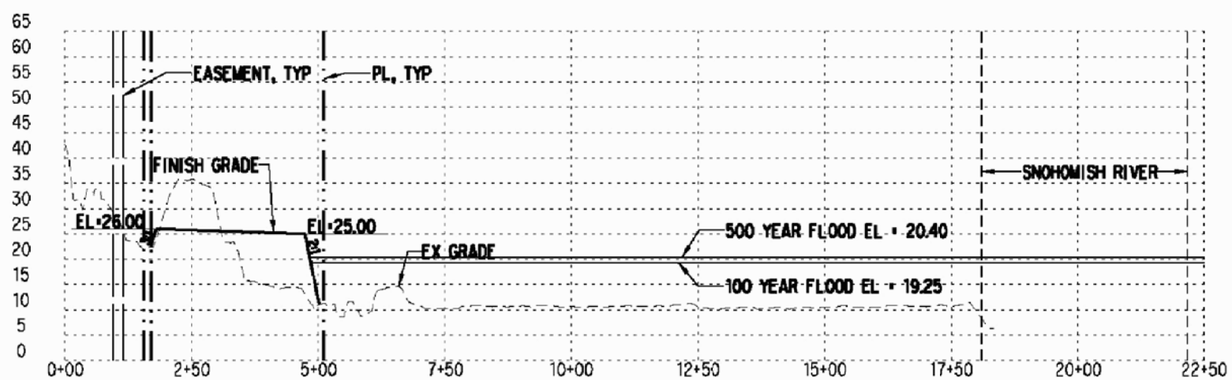

SECTION C

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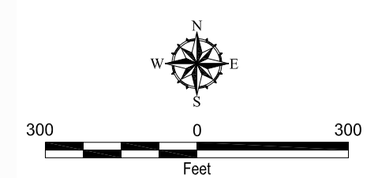
Reference: Image provided by Magnusson Klemencic Associates.



Section C

Everett Riverfront Redevelopment
Everett, Washington

GEOENGINEERS

Figure 4.3-3C

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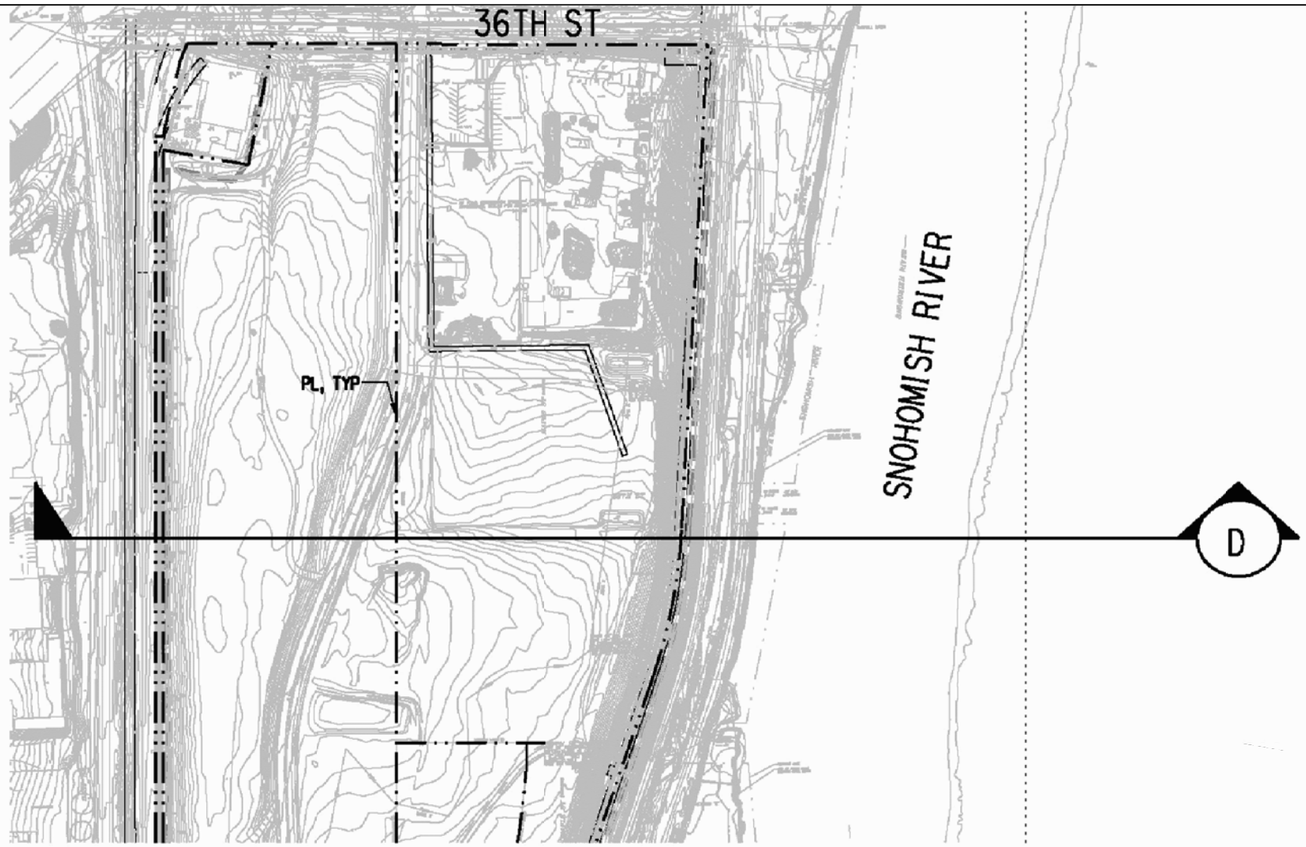

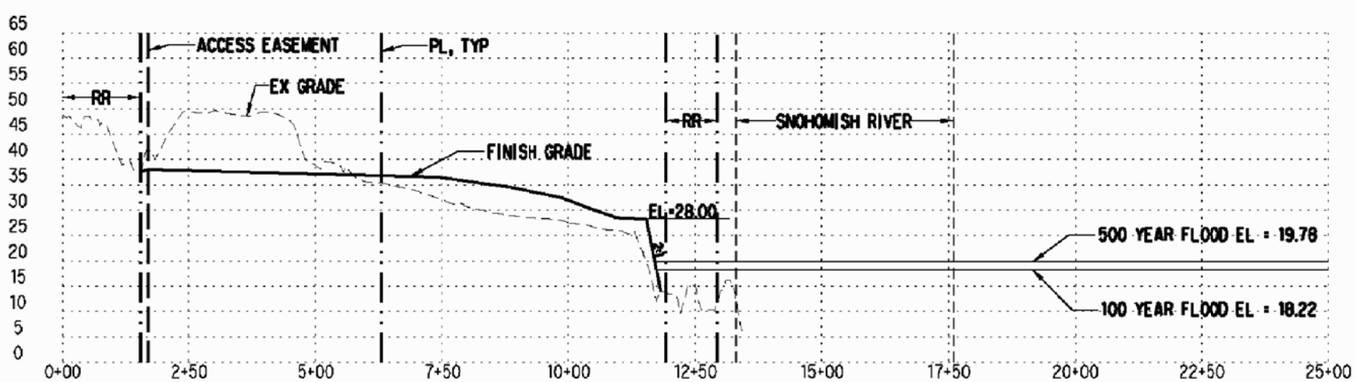

SECTION D

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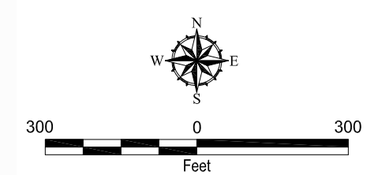
Reference: Image provided by Magnusson Klemencic Associates.



Section D

Everett Riverfront Redevelopment
Everett, Washington

GEOENGINEERS

Figure 4.3-3D

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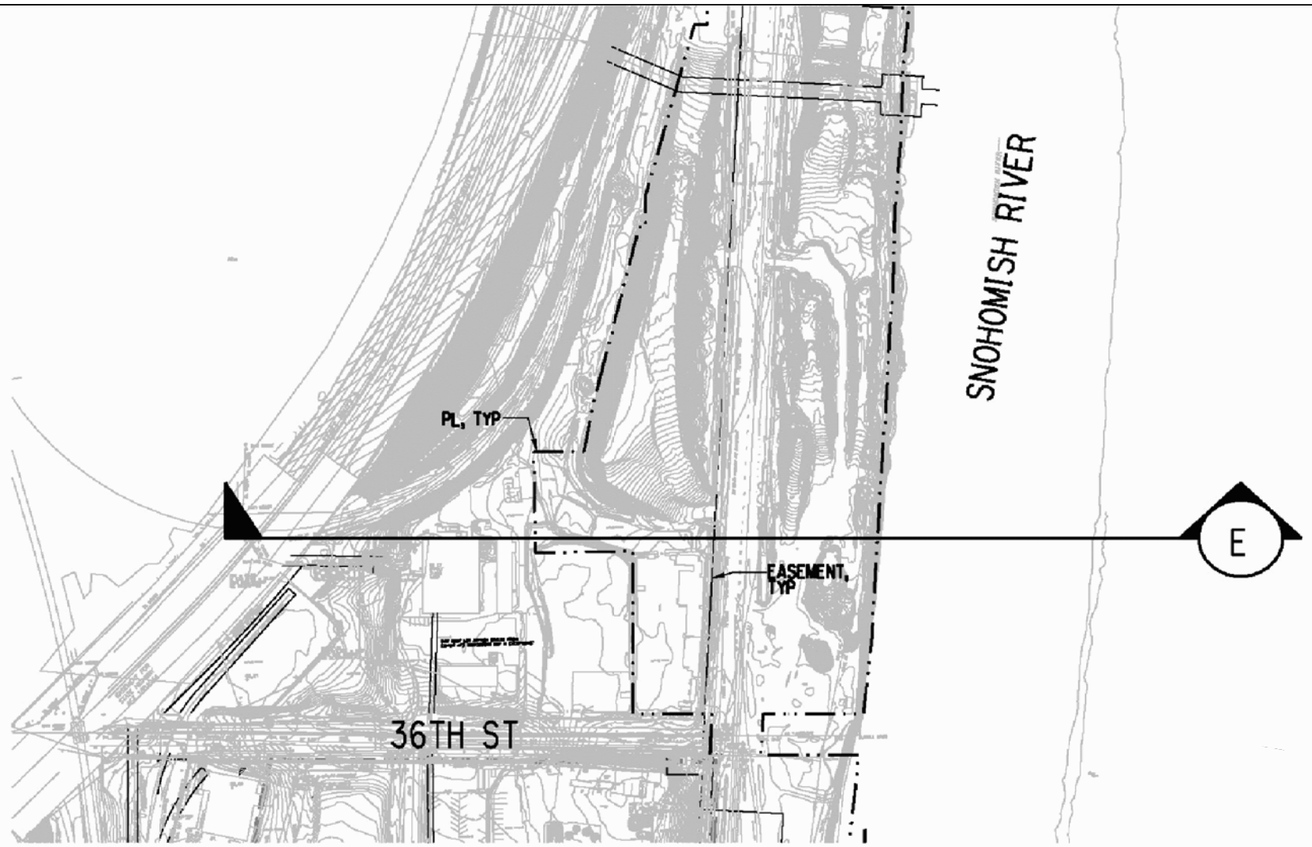

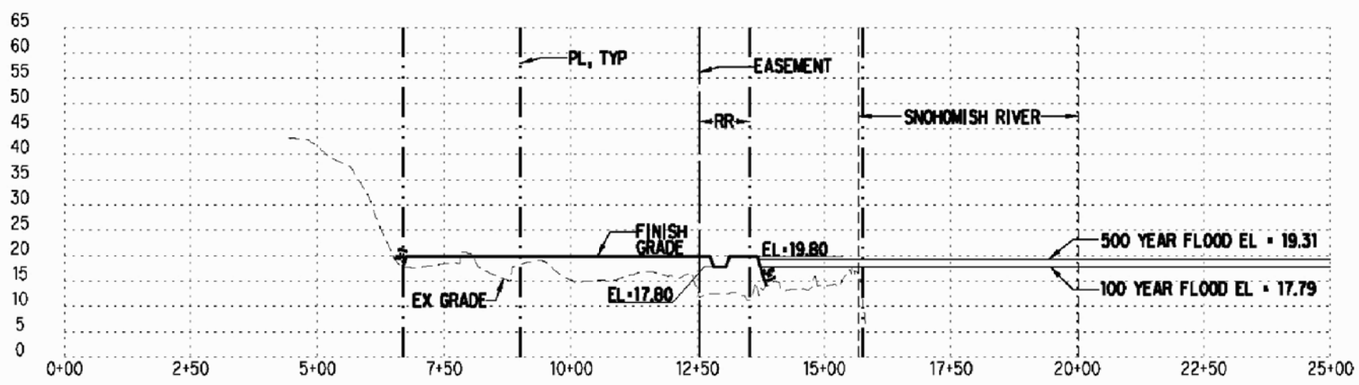

SECTION E

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Reference: Image provided by Magnusson Klemencic Associates.

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Section E

Everett Riverfront Redevelopment
Everett, Washington

GEOENGINEERS

Figure 4.3-3E

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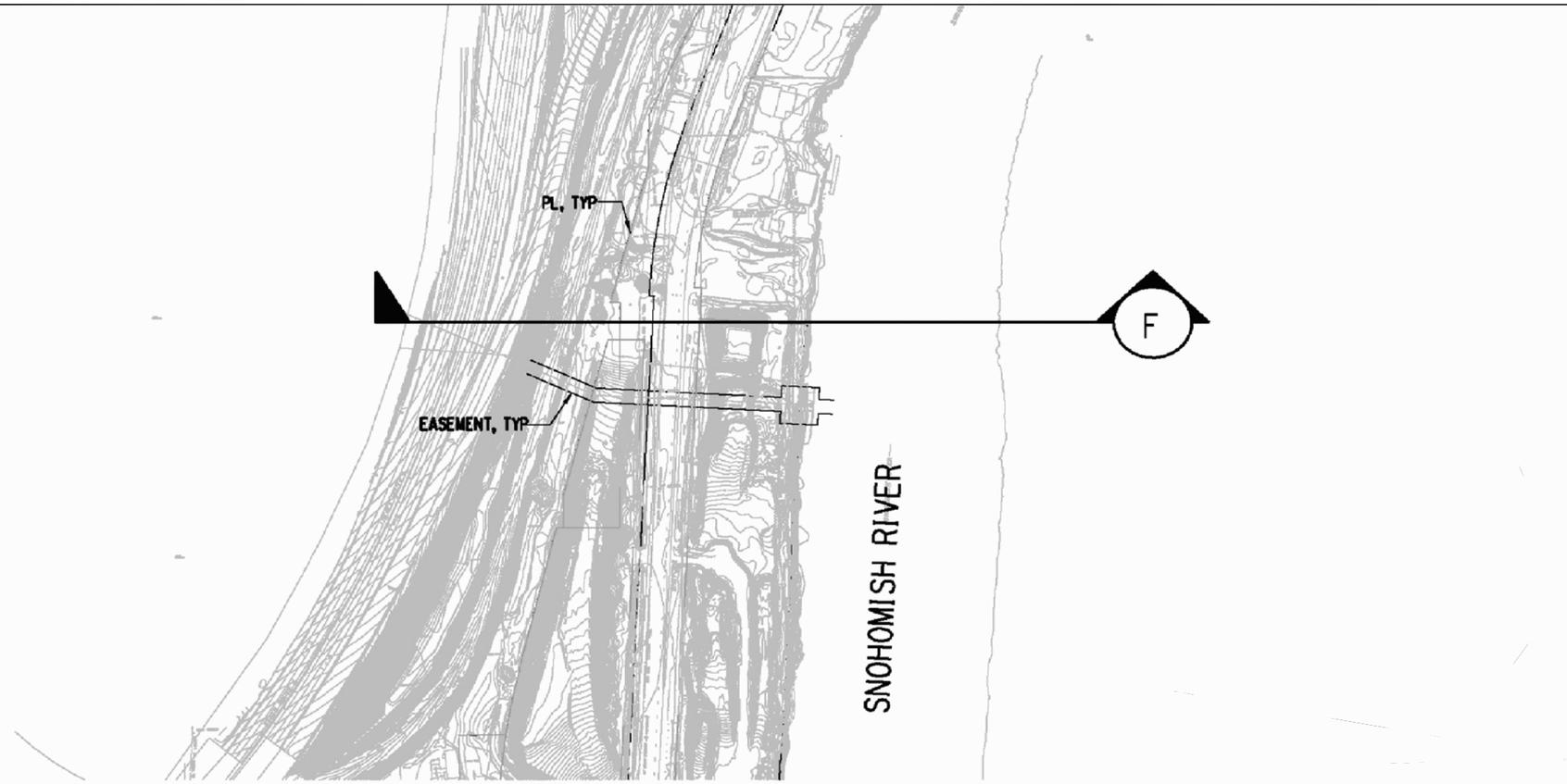

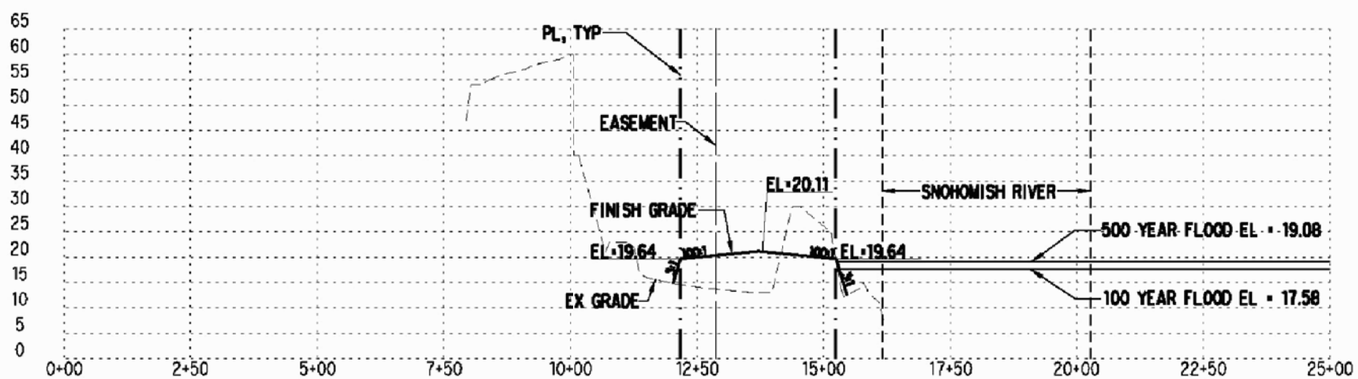

SECTION F

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Reference: Image provided by Magnusson Klemencic Associates.

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Section F

Everett Riverfront Redevelopment
Everett, Washington

GEOENGINEERS

Figure 4.3-3F

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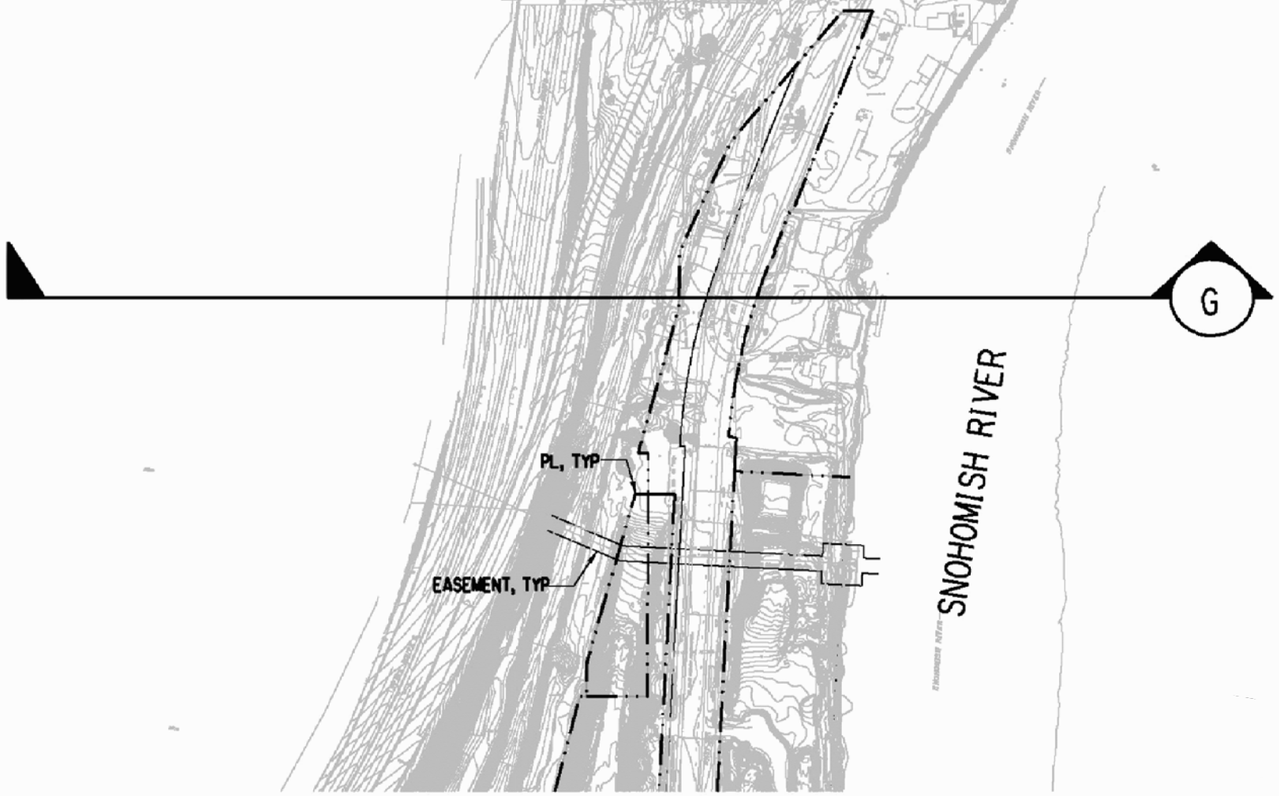

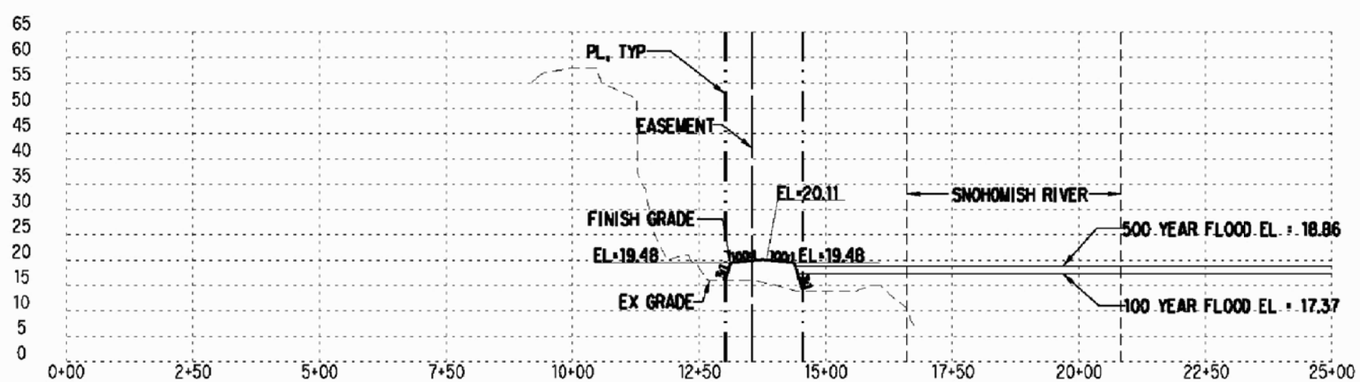

SECTION G

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Reference: Image provided by Magnusson Klemencic Associates.

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Section G

Everett Riverfront Redevelopment
Everett, Washington

GEOENGINEERS

Figure 4.3-3G

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4.3.5 Potential Effects of Climate Change on Surface Water Elevations at the Everett Riverfront Development

Research on the hydrologic implications of climate change suggests that the historic runoff patterns in Western Washington river systems are likely to change as a result of global warming. Currently, runoff in river systems on the west side of the Cascades is characterized by a dual peak, one in response to fall and early winter rain storms, and a second peak in the spring or early summer driven by melting snowpack. Research at the University of Washington Climate Impacts Group (http://www.hydro.washington.edu/Lettenmaier/Presentations.html) points out that snowpack in the Cascade Mountains are particularly sensitive to small increases in temperature, since snow falls at low elevation (4,000 feet) and near the freezing temperatures (30° F) (compared to say the Rockies where snow falls at high elevations (>8,000 feet) at low temps (near 22° F)). Increases in mountain temperature will cause more rain at higher elevations, less snowpack accumulation, and earlier melting of the snowpack. The combined influence of these factors may lead to a merging of the dual peak hydrograph into a single-peak runoff pattern that occurs in late winter or early spring.

As summers extend into fall and spring comes earlier, the impact on Cascade river systems could be significant. The timing of salmon migration may alter as spikes in stream flow no longer occur during the historical spawning seasons. The timing of runoff will undoubtedly affect reservoir storage and hydropower operations. There seems to be broad consensus that climate change will affect the timing and duration of peak flow patterns in Western Washington river systems. However, there seems to be little prediction that this shift will result in greater streamflow volumes, or increase flow significantly from historic levels.

Increased awareness of climate changes has resulted in many recent analyses of the impact of such a phenomenon on water surface elevations due to rises in sea level. Although there is general consensus in the scientific community regarding the fact that global temperatures are rising, the rates of that increase over the next 100 years depend on numerous variables which could change over time. Sea level rise is contingent on the rates of global warming and melting of the ice sheets, and are impacted by geologic activities including plate tectonics all of which are multi-variable and temporal processes that are subject to significant unknowns.

This analysis has considered many reports which attempt to predict what the potential impacts could be on this project. A recent (2007) National Wildlife Federation (NWF) document titled Sea Level Rise and Coastal Habitats in the Pacific Northwest, An Analysis for Puget Sound, Southwestern Washington, and Northwestern Oregon predicts a rise of sea level in the Snohomish River Estuary and Everett of 1.5 meters (48 inches) by 2100. The study references a model named Sea Level Affecting Marshes Model, Version 5.0, and predicts habitat modifications resulting from the sea level fluctuation.

A brief review of sea level rise scenarios presented by other agencies such as the United States Geological Survey (USGS) and the United Nations Environment Program (UNEP) demonstrates little consensus but are less extreme than the NWF prediction. UNEP estimates of global average sea level rise by 2100 range from 10 centimeters to 1.1 meters. Sea Level Rise in the Coastal Waters of Washington State was recently published by the University of Washington Climates Impact Group and the Washington Department of Ecology (January 2008). That study made a range of estimates of sea level rise considering multiple factors, including global and local impacts, and physical factors such as vertical land movement. For Puget Sound the medium estimate of sea level rise is 6 inches by 2050 and 13 inches by 2100. See the table below, which also identifies the very low and very high estimates.

Table 4.3-8. Sea Level Rise Estimates for Puget Sound[12]

	2050	2100
Very Low	8 cm (3”)	16 cm (6”)
Medium	15 cm (6”)	34 cm (13”)
Very High	55 cm (22”)	128 cm (50”)

Due to the lack of consensus of what impacts will occur from climate changes an analysis was conducted by West Consultants using the UNET model to evaluate the impact of increases of sea level at this location of 1, 3, and 5 feet. These levels range from some predicted results to a level roughly 25% greater than the highest impact projected in any report we could find to give an understanding of the level of potential impacts with a degree of conservatism. The results are shown in Tables.4.3-9 and 4.3-10a below

The results of the sea level analysis are that there would be minimal impact on the Project Site. In the event sea level did rise dramatically, it would raise the 100-year flood elevation by inches, with the greatest rise occurring at the north end of the site near Pacific Avenue where the 100-year flood elevation would increase by just over 11 inches if sea level rose by 5 feet. The reason for these minimal changes is the influence the tides and tidal elevations have on flood elevations. The level of Puget Sound has a controlling effect on the flood elevations such that as the tidal elevation rises river floods have less control on the water elevations in the tidally influenced areas. (For example at present tide elevations, the flood elevations in the lower reach of the river around Smith Island are very near the MHW, which is what would occur further upstream as sea levels rise.) The project area would still be protected from the 500-year flood, except if there was a 5 foot rise in sea level during a 500 year event at edges of the extreme south end of the Simpson Pad there would be a potential minor flood impact of about ¾ inch below the 500-year elevation. (Note: this minor impact does not consider the increased elevations gained from topsoil added after site grading and other factors that would actually raise the surface level above these grades. Less than one inch of flood water in an extreme event would have no significant impact on buildings.).

The sum of the analysis is the potential impacts of sea rise on this site are minimal. Impacts would occur under only the most extreme of circumstances which exceed any estimates and would not materialize for a century.

[12] Sea Level Rise in the Coastal Waters of Washington State , University of Washington Climates Impact Group and the Washington Department of Ecology (January 2008).

Table 4.3-9. Affect of Sea Level Rise on 100-Year Elevations[13]

	100-Year	100-Year	100-Year	100-Year	100-Year	100-Year	100-Year	100 yr
	Present	Present	1-Foot Rise	1-Foot Rise	3-Foot Rise	3-Foot Rise	5-Foot Rise	5-Foot Rise
	NGVD 29	NAVD 88	NGVD 29	NAVD 88	NGVD 29	NAVD 88	NGVD 29	NAVD 88
L	13.65	17.33	13.7	17.38	13.92	17.6	14.59	18.27
M	14.56	18.24	14.58	18.26	14.67	18.35	15.18	18.86
N	16.17	19.85	16.17	19.85	16.21	19.89	16.44	20.12
O	17.17	20.85	17.17	20.85	17.2	20.88	17.34	21.02

Table 4.3-9a. Increase in 100-Year Flood Elevation from Sea Level Rise

	100-Year	100-Year	100-Year	100-Year	100-Year	100-Year
	1-Foot Difference (ft.)	1-Foot Difference (in.)	3-Foot Difference (ft.)	3-Foot Difference (in.)	5-Foot Difference (ft.)	5-Foot Difference (in.)
L	0.05	0.6	0.27	3.24	0.94	11.28
M	0.02	0.24	0.11	1.32	0.62	7.44
N	0	0	0.04	0.48	0.27	3.24
O	0	0	0.03	0.36	0.17	2.04

Table 4.3-10. Affect of Sea Level Rise on 500-Year Flood Elevations[14]

	500-Year	500-Year	500-Year	500-Year	500-Year	500-Year	500-Year	500-Year
	Present	Present	1-Foot rise	1-Foot rise	3-Foot rise	3-Foot rise	5-Foot rise	5-Foot rise
	NGVD 29	NAVD 88	NGVD 29	NAVD 88	NGVD 29	NAVD 88	NGVD 29	NAVD 88
L	15.32	19	15.38	19.06	15.65	19.33	16.18	19.86
M	16.12	19.8	16.16	19.84	16.42	20.1	16.92	20.6
N	17.66	21.04	18.2	21.88	18.26	21.94	18.4	22.08
O	18.36	22.04	20.13	23.81	20.13	23.81	20.16	23.84

Table 4.3-10a. Increase in 500-Year Flood Elevation from Sea Level Rise

	500-Year	500-Year	500-Year	500-Year	500-Year	500-Year
	1-foot Difference (ft.)	1-foot Difference (in.)	3-foot Difference (ft.)	3-foot Difference (in.)	5-foot Difference (ft.)	5-foot Difference (in.)
L	0.06	0.72	0.33	3.96	0.86	10.32
M	0.04	0.48	0.3	3.6	0.8	9.6
N	0.84	10.08	0.9	10.8	1.04	12.48
O	1.77	21.24	1.77	21.24	1.8	21.6

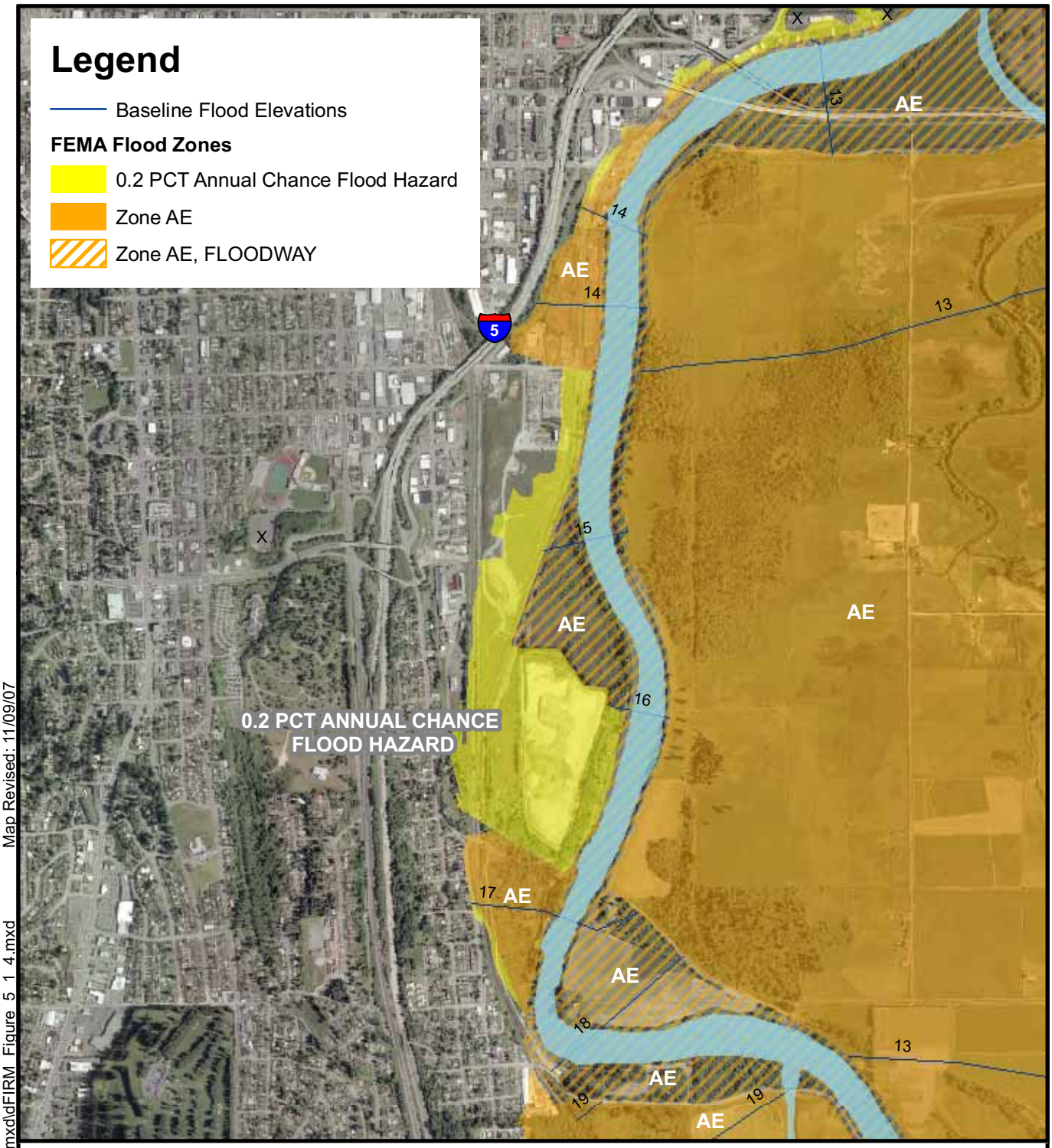
[13] Raymond Walton, West Consultants April 7, 2008
[14] Ibid

4.3.6 Mitigation

4.3.6.1 Flooding and Channel Migration Zone Hazards

Mitigation for potential flood impacts includes filling the Eclipse site to be at least 2 feet above the 100-year flood elevations and above the 500 year flood level. Additional fill on the Simpson Pad (about 3 feet) and the Landfill/Tire Fire Site (about 5 feet) will increase the elevation of those areas to protect them from the 100-year flood and take them out of the 500 year flood plain as well. Because there are no long-term impacts identified for channel migration zone hazards, no mitigation measure are identified here to address those type of impacts. Additionally, it should be noted that there are plans in place to enhance existing wetland and riparian areas along the Snohomish River and Bigelow Creek. Enhancing these areas will benefit the flood storage potential, water quality filtering and habitat quality of these streamside ecosystems.

FEMA LETTER OF MAP REVISION



Data Sources: Aerial photo from Snohomish County; FEMA Flood Zones and Baseline Elevations provided by the Federal EmergencyManagement Agency. FEMA Flood Zones Modified by GEI to reflect most current delineations.

1,750 875 0 1,750 Feet

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Federal Emergency Management Agency Flood Zones

Everett Riverfront Redevelopment
Everett, Washington

GEOENGINEERS

Figure 5.1-4

Office:BAM Path\P:\6\619100\2\03\GIS\mxd\dFIRM Figure 5 1 4.mxd Map Revised: 11/09/07

✓ Gerry Ervine - original
c: Matt Welborn
Chris Muth-Schulz

Federal Emergency Management Agency

Washington, D.C. 20472

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MAY 01 2007
MAYOR'S OFFICE
Everett, WA 98201

April 24, 2007

THE HONORABLE RAY STEPHANSON
CITY OF EVERETT
CITY HALL
2930 WETMORE AVE, STE. 10-A
EVERETT, WA 98201

CASE NO.: 07-10-0433A
COMMUNITY: CITY OF EVERETT, SNOHOMISH COUNTY, WASHINGTON
COMMUNITY NO.: 530164

DEAR MR. STEPHANSON:

This is in reference to a request that the Federal Emergency Management Agency (FEMA) determine if the property described in the enclosed document is located within an identified Special Flood Hazard Area, the area that would be inundated by the flood having a 1-percent chance of being equaled or exceeded in any given year (base flood), on the effective National Flood Insurance Program (NFIP) map. Using the information submitted and the effective NFIP map, our determination is shown on the attached Letter of Map Revision based on Fill (LOMR-F) Determination Document. This determination document provides additional information regarding the effective NFIP map, the legal description of the property and our determination.

Additional documents are enclosed which provide information regarding the subject property and LOMR-Fs. Please see the List of Enclosures below to determine which documents are enclosed. Other attachments specific to this request may be included as referenced in the Determination/Comment document. If you have any questions about this letter or any of the enclosures, please contact the FEMA Map Assistance Center toll free at (877) 336-2627 (877-FEMA MAP) or by letter addressed to the Federal Emergency Management Agency, 3601 Eisenhower Avenue, Suite 130, Alexandria, VA 22304-6439.

Sincerely,

William R Blanton Jr

William R. Blanton Jr., CFM, Chief
Engineering Management Section
Mitigation Division

LIST OF ENCLOSURES:

LOMR-F DETERMINATION DOCUMENT (REMOVAL)

cc: State/Commonwealth NFIP Coordinator
Community Map Repository
Region
Mr. Allan Giffen
Mr. Kenneth Gish, Jr.

RECEIVED
MAY - 1 2007
CITY OF EVERETT
Planning Dept.

 | Date: April 24, 2007 | Case No.: 07-10-0433A | LOMR-F

Federal Emergency Management Agency

Washington, D.C. 20472

LETTER OF MAP REVISION BASED ON FILL DETERMINATION DOCUMENT (REMOVAL)

COMMUNITY AND MAP PANEL INFORMATION		LEGAL PROPERTY DESCRIPTION
COMMUNITY	CITY OF EVERETT, SNOHOMISH COUNTY, WASHINGTON	A portion of Lot 4, as shown on the Boundary Line Adjustment No. 05-008 recorded as File No. 200608215004; a parcel of land as shown on the Boundary Line Adjustment No. 04-014 recorded as File No. 200411105394; both in the Office of the Auditor, Snohomish County, Washington
	COMMUNITY NO.: 530164	
AFFECTED MAP PANEL	NUMBER: 53061C1030F; 53061C1035F	The portion of property is more particularly described by the following metes and bounds:
	DATE: 9/16/2005; 9/16/2005	COMMENCING at the northwest corner of Lot 4; thence S20°
FLOODING SOURCE: SNOHOMISH RIVER		APPROXIMATE LATITUDE & LONGITUDE OF PROPERTY: 47.960, -122.188 SOURCE OF LAT & LONG: PRECISION MAPPING STREETS 7.0 DATUM: NAD 83

DETERMINATION

LOT	BLOCK/ SECTION	SUBDIVISION	STREET	OUTCOME WHAT IS REMOVED FROM THE SFHA	FLOOD ZONE	1% ANNUAL CHANCE FLOOD ELEVATION (NGVD 29)	LOWEST ADJACENT GRADE ELEVATION (NGVD 29)	LOWEST LOT ELEVATION (NGVD 29)
4	--	--	--	Portion of Property	X (shaded)	15.9 feet	--	16.4 feet

Special Flood Hazard Area (SFHA) - The SFHA is an area that would be inundated by the flood having a 1-percent chance of being equaled or exceeded in any given year (base flood).

ADDITIONAL CONSIDERATIONS (Please refer to the appropriate section on Attachment 1 for the additional considerations listed below.)

LEGAL PROPERTY DESCRIPTION
PORTIONS REMAIN IN THE FLOODWAY
FILL RECOMMENDATION
SUPERSEDES PREVIOUS DETERMINATION

This document provides the Federal Emergency Management Agency's determination regarding a request for a Letter of Map Revision based on Fill for the property described above. Using the information submitted and the effective National Flood Insurance Program (NFIP) map, we have determined that the described portion(s) of the property(ies) is/are not located in the SFHA, an area inundated by the flood having a 1-percent chance of being equaled or exceeded in any given year (base flood). This document revises the effective NFIP map to remove the subject property from the SFHA located on the effective NFIP map; therefore, the Federal mandatory flood insurance requirement does not apply. However, the lender has the option to continue the flood insurance requirement to protect its financial risk on the loan. A Preferred Risk Policy (PRP) is available for buildings located outside the SFHA. Information about the PRP and how one can apply is enclosed.

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Assistance Center toll free at (877) 336-2627 (877-FEMA MAP) or by letter addressed to the Federal Emergency Management Agency, 3601 Eisenhower Avenue, Suite 130, Alexandria, VA 22304-6439.

William R Blanton Jr

William R. Blanton Jr., CFM, Chief
Engineering Management Section
Mitigation Division

Federal Emergency Management Agency
Washington, D.C. 20472

LETTER OF MAP REVISION BASED ON FILL DETERMINATION DOCUMENT (REMOVAL)

ATTACHMENT 1 (ADDITIONAL CONSIDERATIONS)

LEGAL PROPERTY DESCRIPTION (CONTINUED)

43'28"W, 920.30 feet; thence S14°39'31"W, 190.00 feet to the POINT OF BEGINNING; thence S88°00'00"E, 470.00 feet; thence S35°00'00"E, 512.00 feet; thence S81°00'00"E, 290.00 feet; thence S08°00'00"W, 222.78 feet; thence N62°19'04"W, 1334.86 feet; thence N22°13'52"E, 137.35 feet; thence S67°46'08"E, 120.23 feet to the POINT OF BEGINNING

PORTIONS OF THE PROPERTY REMAIN IN THE FLOODWAY (This Additional Consideration applies to the preceding 1 Property.)

A portion of this property is located within the Special Flood Hazard Area and the National Flood Insurance Program (NFIP) regulatory floodway for the flooding source indicated on the Determination/Comment Document while the subject of this determination is not. The NFIP regulatory floodway is the area that must remain unobstructed in order to prevent unacceptable increases in base flood elevations. Therefore, no construction may take place in an NFIP regulatory floodway that may cause an increase in the base flood elevation, and any future construction or substantial improvement on the property remains subject to Federal, State/Commonwealth, and local regulations for floodplain management. The NFIP regulatory floodway is provided to the community as a tool to regulate floodplain development. Modifications to the NFIP regulatory floodway must be accepted by both the Federal Emergency Management Agency (FEMA) and the community involved. Appropriate community actions are defined in Paragraph 60.3(d) of the NFIP regulations. Any proposed revision to the NFIP regulatory floodway must be submitted to FEMA by community officials. The community should contact either the Regional Director (for those communities in Regions I-IV, and VI-X), or the Regional Engineer (for those communities in Region V) for guidance on the data which must be submitted for a revision to the NFIP regulatory floodway. Contact information for each regional office can be obtained by calling the FEMA Map Assistance Center toll free at (877) 336-2627 (877-FEMA MAP) or from our web site at http://www.fema.gov/about/regoff.htm.

FILL RECOMMENDATION (This Additional Consideration applies to the preceding 1 Property.)

The minimum NFIP criteria for removal of the subject area based on fill have been met for this request and the community in which the property is located has certified that the area and any subsequent structure(s) built on the filled area are reasonably safe from flooding. FEMA's Technical Bulletin 10-01 provides guidance for the construction of buildings on land elevated above the base flood elevation through the placement of fill. A copy of Technical Bulletin 10-01 can be obtained by calling the FEMA Map Assistance Center toll free at (877) 336-2627 (877-FEMA MAP) or from our web site at http://www.fema.gov/mit/tb1001.pdf. Although the minimum NFIP standards no longer apply to this area, some communities may have floodplain management regulations that are more restrictive and may continue to enforce some or all of their requirements in areas outside the Special Flood Hazard Area.

This attachment provides additional information regarding this request. If you have any questions about this attachment, please contact the FEMA Map Assistance Center toll free at (877) 336-2627 (877-FEMA MAP) or by letter addressed to the Federal Emergency Management Agency, 3601 Eisenhower Avenue, Suite 130, Alexandria, VA 22304-6439.

William R Blanton Jr

William R. Blanton Jr., CFM, Chief
Engineering Management Section
Mitigation Division

Federal Emergency Management Agency
Washington, D.C. 20472

LETTER OF MAP REVISION BASED ON FILL DETERMINATION DOCUMENT (REMOVAL)

ATTACHMENT 1 (ADDITIONAL CONSIDERATIONS)

SUPERSEDES OUR PREVIOUS DETERMINATION (This Additional Consideration applies to all properties in the LOMR-F DETERMINATION DOCUMENT (REMOVAL))

This Determination Document supersedes our previous determination dated 3/6/2007, for the subject property.

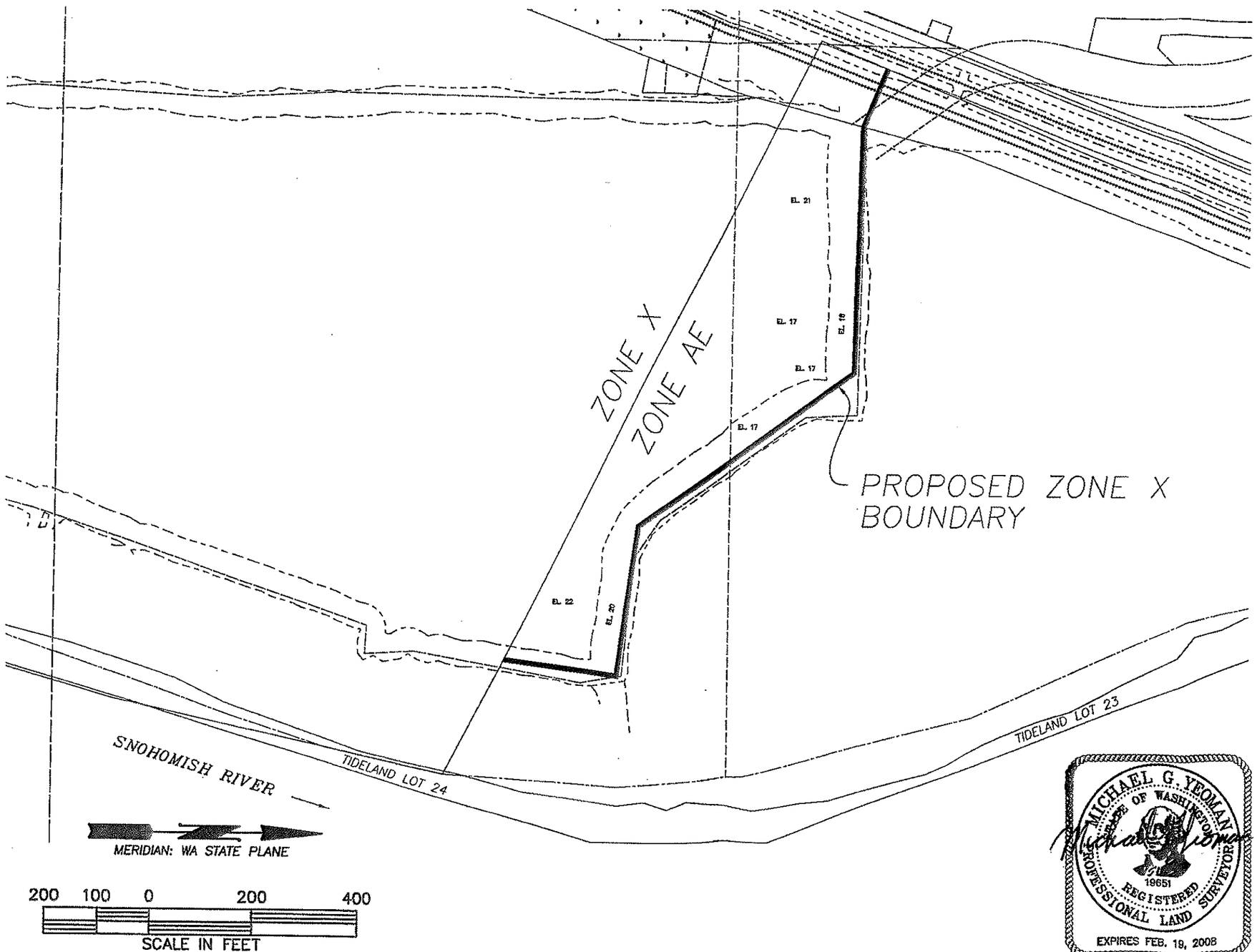
This attachment provides additional information regarding this request. If you have any questions about this attachment, please contact the FEMA Map Assistance Center toll free at (877) 336-2627 (877-FEMA MAP) or by letter addressed to the Federal Emergency Management Agency, 3601 Eisenhower Avenue, Suite 130, Alexandria, VA 22304-6439.

William R Blanton Jr

William R. Blanton Jr., CFM, Chief
Engineering Management Section
Mitigation Division

PORTIONS OF

GOV'T LOTS 2 & 3, SECTION 32, TWP 29 N, RGE 5 E, W.M.



MICHAEL G. YEOMAN
STATE OF WASHINGTON
19651
REGISTERED
PROFESSIONAL LAND SURVEYOR
EXPIRES FEB. 19, 2008
Jan. 17, 2007

Perteet

Perteet Inc.
2707 Colby Avenue, Suite 900
Everett, Washington 98201

425 | 252 | 7700
Fax: 425 | 339 | 6018

SURVEY DATE:	1996–2006
PLOT DATE:	JANUARY 2007

RIVERFRONT – LOMR–F

FOR: CITY OF EVERETT
PUBLIC WORKS DEPARTMENT
3200 CEDAR STREET
EVERETT, WA 98201

JOB NO:	S2753.006
DWG NO:	2753fema.dwg
WM NO:	29–29–05
SCALE:	1"=200'
DRAWN BY:	TMC
FIELD BOOK:	752

SHEET 1 OF 1

Plotted: Jan 17, 2007 - 3:03pm tmc S:\1 Job Files\1999\99-2753-Riverfront\2753.006\4 Mapping\2753fema.dwg Layout Name: Layout1