Focused Geological Hazards Evaluation

East Monroe Rezone – Heritage Baptist Church
Monroe, Washington

for

PACE Engineers, Inc.

June 10, 2015

GeoEngineers
Earth Science + Technology

Focused Geological Hazards Evaluation

East Monroe Rezone – Heritage Baptist Church
Monroe, Washington

for
PACE Engineers, Inc.

June 10, 2015

GeoEngineers

8410 154th Avenue NE
Redmond, Washington 98052
425.861.6000

Focused Geologic Hazards Evaluation

East Monroe Rezone – Heritage Baptist Fellowship
Monroe, Washington

File No. 21119-001-01

June 10, 2015

Prepared for:

PACE Engineers, Inc.
11255 Kirkland Way, Suite 300
Kirkland, Washington 98033

Attention: Susan Boyd

Prepared by:

GeoEngineers, Inc.
8410 154th Avenue NE
Redmond, Washington 98052
425.861.6000

Eliya R. Hogan
Staff Geologist

Craig Erdman, LG, LEG
Senior Engineering Geologist

Galan McInelly, LG, LEG, LHG
Principal Geologist

State of Washington
Engineering Geologist
620
Licensed Geologist
Galan W. McInelly

ERH:CFE:GWM:cam

Disclaimer: Any electronic form, facsimile or hard copy of the original document (email, text, table, and/or figure), if provided, and any attachments are only a copy of the original document. The original document is stored by GeoEngineers, Inc. and will serve as the official document of record.

Table of Contents

INTRODUCTION **1**

SCOPE OF SERVICES **1**

PROJECT DESCRIPTION **2**

PROJECT SETTING **3**

Location and General Description 3

GEOLOGY **3**

Regional 3
Project Area 3
- Fill/Modified land (Qf) 4
- Peat deposits (Qp) 4
- Alluvial deposits (Qa) 4
- Landslide deposits (Qls) 4
- Advance outwash (Qga(v)) 4
- Olympia beds (Qc(ol)) 4
- Glaciomarine and glaciolacustrine glacial deposits (Qgl(p)) 4
- Continental non-glacial river deposits (Qc(pf)) 5

SOIL **5**

REVIEW OF AERIAL PHOTOGRAPHS **5**

1948 6
1955 6
1969 7
1981 7
1990 7
2002 8
2014 8

SITE CONDITIONS **8**

General 8
Topography 9
Subsurface Conditions 9
Vegetation 9
Groundwater 9
Surface Drainage and Seepage 10
Erosion Hazards 10
Landslide Hazards 10
- Observed Slope Conditions 11

HYDRAULIC CONDITIONS **12**

POTENTIAL IMPACTS **14**

Erosion Hazards 14
Landslide Hazards 15

MITIGATION **17**

Erosion 17
Landslides 17

LIMITATIONS **17**

REFERENCES **18**

AERIAL PHOTOGRAPHS **19**

LIST OF FIGURES

Figure 1. Vicinity Map
Figure 2. Site Plan
Figure 3. Geologic Map
Figure 4. NRSC Soil Units Map
Figure 5. Slope Gradient Map
Figure 6. Erosion and Landslide Hazard Map [GIS] {Existing Conditions}
Figure 7. Geologic Cross Section A-A'
Figure 8. Geologic Cross Section B-B'
Figure 9. Geologic Cross Section C-C'

ATTACHMENTS

Attachment A. Aerial Photographs
Attachment B. Report Limitations and Guidelines for Use

INTRODUCTION

GeoEngineers, Inc. (GeoEngineers) is pleased to present our report of supplemental geotechnical and geologic consultation services related to erosion and landslide hazards for the East Monroe Rezone project located in Monroe, Washington. The Rezone area consists of five parcels, which, for the purpose of this report are referred to as the "project property." The project property is located at the east end of Monroe, Washington and north of U.S. Highway 2 (see Figure 1). We understand there is a No Action-No Development Alternative (existing conditions) and three development alternatives. We understand that the proposed development alternatives will have the same footprint and same impervious areas. They will differ primarily by site layout and type of building.

The purpose of our services is to provide additional evaluation and opinions regarding erosion and landslide hazards related to the proposed rezone and potential future development of the project property. Steeply inclined slopes and known landslides were documented in the letter prepared by GeoEngineers, titled "Geotechnical Consultation Services, Proposed Development, Monroe, Washington" and dated June 16, 2013.

We also understand that potential changes to flows in an abandoned meander located near the toe of the steep slope are of particular concern with respect to potential slope stability issues. In order to facilitate our evaluation of the stream and associate potential impacts, we reviewed numerical simulations of hydraulic conditions for baseline (existing) conditions and proposed development conditions, including flood elevation and modeled velocity data completed by Watershed Science & Engineering (WSE), subcontracted by PACE Engineers, Inc. (PACE). WSE used the U.S. Army Corps of Engineers Hydrologic Engineering Center - River Analysis System (HEC-RAS) software to generate the 100-year flood elevations and the velocity data.

The results of our services will be incorporated by PACE into a Supplemental Environmental Impact Statement (SEIS). It is our understanding that the products developed through our scope of services are not intended to meet the City of Monroe Critical Areas Ordinance requirements of a formal geologically hazardous area report. Instead, the scope of work is intended to address specific comments made by the Growth Management Hearings Board with respect to erosion and slope stability relative to the proposed rezone.

Our objective is to provide our professional opinion on the potential effects that proposed site development may have on an adjacent steep slope and abandoned meander.

SCOPE OF SERVICES

Our services included tasks such as obtaining and reviewing pertinent information on the past and present conditions of the slope and stream paths, suggesting locations to develop and survey stream cross sections, performing a detailed geologic reconnaissance of the area, and presenting our results and conclusions to PACE. Following is the scope of work completed for this report.

1. Reviewed our previous letter and geotechnical reports in the site vicinity, geologic and topographic maps, Light Detection and Ranging (LiDAR) data, available information regarding subsurface soil and groundwater conditions and documented slope stability mapping.

2. Provided input regarding surveyed cross section locations completed for the hydraulic analyses by others.
3. Obtained and reviewed stereographic pairs of aerial photographs 1948, 1955, 1969, and 1981 that cover the project area. Reviewed historical digital imagery from 1990 to 2014 available on-line using Google Earth Pro®. Interpreted changes in land-use, potential changes in slope configuration and movement, changes in vegetative cover and potential changes in morphology of the abandoned meander at the toe of the slope.
4. Completed a geologic reconnaissance to observe existing slope features, exposed soil conditions, seepage, and the existing abandoned meander configuration to the extent allowed by access agreements and vegetative cover. We completed photographic documentation, sketched significant features including existing slope movements, shallow probing, and excavation of surficial soils using hand tools.
5. Compiled data from office review and our site reconnaissance.
6. Developed a qualitative assessment of slope stability based on our office review and our reconnaissance visit and with consideration of hydraulic analyses completed by others. .
7. Provided our opinion regarding existing slope stability based on our review, and recommendations on the types of activities that should be avoided in order to minimize the risk of landslides. To evaluate the development alternatives, we incorporated the results of the hydraulic modeling including consideration of any changes in flood water elevation or stream velocity for the abandoned meander.
8. Prepared a draft written report summarizing our reconnaissance, mapping, and conclusions regarding the landslide risk.
9. Finalized our report based on comments received.

PROJECT DESCRIPTION

The City of Monroe, on behalf of Heritage Baptist Fellowship, is requesting an amendment to the Monroe Comprehensive Plan that would change the zoning of five parcels of land located in East Monroe near the Skykomish River from “Limited Open Space” to “General Commercial” so that the land may be developed at some time in the future. This proposed rezone area is on the north side of Highway 2 in an area containing an abandoned meander that is connected to the Skykomish River at its western (downstream) end (Figure 2).

A total of four alternatives are being evaluated for the SEIS. The “No Action – No Development” is for the project property to remain in its existing state and not be developed. The other three options include commercial development of the properties. Each of these alternatives would require placing a fill pad to elevate the developed areas above the 100-year flood elevation. We understand that the fill pad for each of these alternatives would have the same dimensions. In addition, the impervious areas for each alternative would also be the same. Therefore, the proposed development alternatives would only vary in building configuration and heights and becomes primarily a matter of aesthetics.

Therefore, from the perspective of geologic hazards, there are essentially only two alternatives: the No Action-No Development Alternative and a developed alternative.

PROJECT SETTING

Location and General Description

The site is located at the eastern City Limits of Monroe, Washington, on the northern side of both U.S. Highway 2 and of a major southward (left viewing downstream) bend in the Skykomish River (see Figure 1). In general, the site is comprised of about 40 acres of relatively flat to slightly rolling land, and is bounded by steeply rising topography to the north and west (see Figure 2). An abandoned meander of the Skykomish River commences near the southeast corner of the site then turns to the west (left) just south of the northern project boundary, extending westward along the toe of a south-facing slope. Most of the slope is located north of and outside of the project property boundaries. The abandoned meander bends slightly southwest, along the toe of the slope, where water in the meander channel flows off-site, then through culverts under U.S. Highway 2 and the Burlington Northern Railway into the Skykomish River.

GEOLOGY

We reviewed the geologic map of the Monroe area, prepared by Dragovich et al. (2011) for this report.

Regional

The Monroe area is underlain by Tertiary bedrock and Quaternary sedimentary units. Tertiary bedrock includes Eocene volcanic deposits, Eocene to Oligocene marine and fluvial deposits, and Miocene volcanic to sedimentary deposits. During the early to late Quaternary (dating from about 2 million years to about 10,000 years before present) the Puget lowlands were occupied by at least four episodes of continental glaciation. During this time (from early to late Pleistocene), deposits consisted of glacial and interglacial deposits. Only materials from mid-Pleistocene to latest Quaternary in age are present at the surface in the project vicinity. Materials deposited in the late Quaternary (Holocene – the last 10,000 years to the present) consist of alluvium, landslide and peat.

Structure in the area consists of northeast-trending anticlinal and synclinal structures with associated reverse faults. The Skykomish River is also mapped in the area, flowing west and then southwest with wide meanders, and roughly following the outline of the uplands through Quaternary alluvial deposits.

Project Area

Geologic units in the vicinity of the site were mapped by Dragovich et al. (2011), and are presented in Figure 3. With the exception of one recent landslide deposit, older deposits are generally mapped on the slope along the northern margins of the project area and along the ridge top north of the project area. More recent deposits are mapped in the lowland area of the Skykomish River floodplain located at the toe of the slope.

Older geologic units mapped on the slope and ridge top include Pleistocene pre-Fraser continental non-glacial river deposits (Qc(pf)), glaciomarine and glaciolacustrine deposits of the Possession glaciation (Qgl(p)), local beds of the Olympia non-glacial interval (Qc(ol)), Fraser-age advance outwash (Qga(v)), and Fraser-age fluvial recessional outwash (Qgof) of the Vashon Stade. Younger deposits include recent alluvium (Qa), peat (Qp) along the stream channel, and a small area of artificial fill and/or modified land (Qf) near the southwest corner of the site. Unit descriptions, from youngest to oldest, are described below.

Fill/Modified land (Qf)

Fill typically consists of loose granular material, such as sand with silt and gravel. Fill soil may include small quantities of colluvium (material that has naturally been deposited on hill slopes). In the project area, artificial fill and modified land are described together as mixed earth materials, including fill and natural deposits, which have been disturbed and obscured as a result of construction.

Peat deposits (Qp)

Peat generally consists of organic material that may contain small amounts of clay, silt and sand associated with glacial outwash plains, floodplain, delta and estuarine environments. In the project area, this unit is located in the abandoned Skykomish River channel, and is described as loose to soft peat, muck, organic silt and clay, with occasional beds of tephra.

Alluvial deposits (Qa)

Alluvial deposits (soil deposited by water) are generally loose to medium dense granular material, ranging in size from boulders and cobbles, to pebbles, gravel, sand, silt and clay. The alluvium within the project area was deposited by the Skykomish River and is comprised of loose cobble and gravel, as well as sand, silt, and variable quantities of peat and organic matter, including woody debris.

Landslide deposits (Qls)

Landslide deposits are generally loose, poorly sorted, non-stratified deposits of varied particle sizes, including angular to subangular boulders, cobbles and gravel. These are located at the base of slopes, and occur as a result of slope failure. In the project area, landslide deposits include slump-earthflows, debris slumps, debris flows and some colluvium.

Advance outwash (Qga(v))

Advance outwash deposits are deposited by glacial meltwater prior to glacial advancement over an area. Vashon advance outwash was deposited as a lobe of the Fraser Glaciation advanced southward, and is typically encountered directly under the Vashon till. In the project area, advance outwash generally consist of sandy gravel, sand, and cobbles, with occasional silt interbeds.

Olympia beds (Qc(ol))

During a non-glacial interval prior to the Vashon ice advance, sedimentary beds of sand to silt, with some clay and peat were deposited by the Skykomish River, and are informally named the Olympia beds. In the project area, this unit consists of dense, well-stratified, well-sorted and bedded silt, sand, and gravel, with some peat, paleosols (old soil horizons) and organic material.

Glaciomarine and glaciolacustrine glacial deposits (Qgl(p))

Deposits during the time of the Possession glaciation are collectively mapped as glacial deposits, and include features characteristic of a multiple depositional processes, such as outwash, rivers and till. In general, this unit consists of hard or dense well sorted to poorly sorted silt, clay and scattered gravel (dropstones). Some areas demonstrate bedding or lamination.

Continental non-glacial river deposits (Qc(pf))

Prior to the Fraser Glaciation, the Snoqualmie and Skykomish Rivers deposited continental and non-glacial materials, including sand, silt, clay with some organics (woody debris) and peat, and lesser amounts of gravel. Bedding is described as dense, laminated to thickly bedded, and generally well stratified, with occasionally observed cross bedding, graded beds, trough-and-ripple features, and evidence of liquefaction.

SOIL

We reviewed the Natural Resource Conservation Service (NRCS) soil data obtained on-line (2015). The following is a table summarizing the soils within the project boundaries and the surrounding area.

TABLE 1. NATURAL RESOURCE CONSERVATION SERVICE SOIL UNITS IN THE PROJECT VICINITY

Map Unit Symbol	Map Unit Name
4	Alderwood-Everett gravelly sandy loams, 25 to 70 percent slopes
7	Bellingham silty clay loam
17	Everett gravelly sandy loam, 0 to 8 percent slopes
28	Kitsap silt loam, 8 to 25 percent slopes
29	Kitsap silt loam, 25 to 50 percent slopes
50	Pilchuck loamy sand
55	Puget silty clay loam
56	Puyallup fine sandy loam
66	Sultan silt loam

The relatively flat portion of the site is predominately underlain by Sultan silt loam and Puyallup fine sandy loam and a lesser amount of Puget silty clay loam. The northern portion of the site and the hillslope is underlain by Alderwood-Everett gravelly sandy loams, according to the Soil Conservation Service (1983). Everett gravelly sandy loam underlies most of the ridge top north of the project property, with the exception of a small area underlain by Kitsap silt loam. Other soil units listed in the above table are located in the vicinity of the project area as shown in Figure 4.

REVIEW OF AERIAL PHOTOGRAPHS

We used a magnifying stereoscope to review and compare aerial photography of the site for the years 1948, 1955, 1969 and 1981. A selected photograph from each year of stereo photographs is presented in Attachment A. We also reviewed historical Google Earth Pro® (accessed 2015) imagery of the site, dating from 1990 to 2014. A copy of the aerial imagery from GoogleEath Pro® is also presented in Attachment A. Below is a brief summary of the main features of the site and how these features changed over time, if at all.

1948

Topography

The 1948 aerial photograph shows about 50 acres of relatively flat to rolling land bordered by steep slopes on the north and west, and by an east-west trending railroad to the south. Slightly rolling topography is observed in sub-parallel semi-arcuate features (meander scars) on the lower portion of the site, which follow the general shape of the river channel.

Local Development

A homestead occupying about 3 acres is located in the northeast corner of the site, at the base of the slope and northeast of the abandoned meander channel. Areas along the ridge top are either vegetated or lightly populated. Development along the ridge top area is present north of Calhoun Road.

Vegetation

While the slope appears densely vegetated, one narrow area with significantly less vegetation is observed on the north-central portion of the slope, extending from the ridge top to the abandoned meander channel at the toe of the slope. The land below is mostly vegetated with grasses, except for a border of shrubs or small trees along the entire length of the abandoned meander channel, and similar vegetation in the northeast corner of the property around the homestead. A relatively small region (about 3.5 to 4 acres) of trees and likely blackberry bushes is also observed just south of the property line.

Abandoned Meander Channel Morphology

Similar to its path today, the abandoned meander channel is shown to enter the project property in the southeast corner, meander across the area in a northwest direction, then curve to the west and southwest along the base of the slope. There are several locations where the abandoned meander has bends that are located away from the toe of the slope. These bends have persisted throughout the photo record reviewed.

1955

Changes in Topography

No major changes in slope topography are observed between the aerial photos of 1948 and 1955.

Local Development

Between 1948 and 1955 construction of U.S. Highway 2 took place in the parcel just south of the project property parallel to and north of the railroad. In the 1955 photograph a corridor over 100 feet wide south of the southern edge of the project property was used for the road. No significant changes occurred on the ridge top area, or in the homestead area in the northwest portion of the project property.

Vegetation

In the 1955 photograph about half of the bushes or small trees located south of the project area are missing, due to construction of U.S. Highway 2. In the north, the previously observed area with sparse vegetation down the slope appears to have become at least partially re-vegetated by the time of the 1955 photograph. A slight increase in vegetation (likely blackberry bushes and trees) is observed south of the homestead area.

Abandoned Meander Channel Morphology

No major changes in channel morphology are observed between the aerial photos of 1948 and 1955.

1969

Changes in Topography

No major changes in slope topography are observed between the aerial photos of 1955 and 1969.

Local Development

Between 1955 and 1969 significant development occurred on the ridge top above the slope. Tree clearing and development of neighborhoods and roads are observed along the entire length of the top of the slope. Below the slope, some development occurred east of the homestead.

Vegetation

Significant (up to about 50 percent) removal of vegetation occurred at the top of the slope between 1955 and 1969 to allow for residential development.

Abandoned Meander Channel Morphology

No major changes in channel morphology are observed between the aerial photos of 1955 and 1969.

1981

Changes in Topography

No major changes in slope topography are observed between the aerial photos of 1969 and 1981.

Local Development

On the ridge top, additional buildings (homes) and roads were developed between 1969 and 1981. Generally, however, the development did not encroach further toward the slope. Additionally, the homestead initially established in the northeast corner of the property was removed.

Vegetation

Between 1969 and 1981, localized tree removal occurred at the edge of the ridge top in the vicinity of a few newly constructed homes. More extensive tree removal occurred in an area just north of the ridge top, in conjunction with new development.

Abandoned Meander Channel Morphology

No major changes in channel morphology are observed between the aerial photos of 1969 and 1981.

1990

Changes in Topography

No major changes in slope topography are observed between the aerial photos of 1981 and 1990.

Local Development

In general, no major changes in development are observed between the aerial photos of 1981 and 1990. However, it appears that perhaps one or more homes were constructed on the northwest side of the ridge top, near the edge of the slope.

Vegetation

In general, no major changes in vegetation are observed on the slope or ridge top between 1981 and 1990. However, it appears that localized clearing near the new development occurred at the top of the slope. South of the channel, in the western portion of the property, a strip of vegetation (likely blackberry bushes and hydrophilic grasses or reeds) about 450 feet long and 50 feet wide is observed in the aerial imagery. In the northeast side of the property, distinct sections of land appear more densely vegetated than others.

Abandoned Meander Channel Morphology

In the 1990 photo, in the north-west portion of the project property, a low spot contains ponded water during August. This ponded area appears to vary in degree of inundation throughout the subsequent years depending on season.

2002

Changes in Topography

No major changes in slope topography are observed between the aerial photos of 1990 and 2002.

Local Development

In general, no major changes in development are observed between the aerial photos of 1990 and 2002.

Vegetation

Between 1990 and 2002, clearing of vegetation occurred in multiple locations along and extending below the crest of the slope. In some regions, cleared areas appear to extend half way down the slope. Additionally, the presence of evergreen trees appears to be reduced on areas of the slope downslope of many homes.

Abandoned Meander Channel Morphology

It appears that between 1990 and 2002 a beaver dam was constructed near the south-west corner of the property, resulting in increased depth of water in the abandoned meander channel and the ponded area observed in the 1990 photo.

2014

Changes in Topography

No major changes in slope topography are observed between the aerial photos of 2002 and 2014.

Local Development

Since 2002, additional homes have been built on the ridge top, specifically in the north-central region. No new development has occurred on the project property.

Vegetation

Between 2002 and 2014, the presence of tall trees continued to diminish on the slope. This is particularly true on the slope above the northeast portion of the project property. Along the abandoned meander channel, the vegetation appears to become denser and taller.

Abandoned Meander Channel Morphology

No major changes occurred in channel morphology between 2002 and 2014.

SITE CONDITIONS

General

GeoEngineers completed a field reconnaissance to observe existing slope features, exposed soil conditions, seepage, and the abandoned meander channel conditions at the toe of the slope to the extent allowed by access agreements and vegetative cover. We photographed selected site features, sketched significant features such as existing slope movements, and completed shallow probing and excavation of surficial soils

using hand tools to evaluate near-surface soil conditions. We were not able to observe much of the upper slope because of access restrictions.

The following discussion of site conditions is based on our field reconnaissance completed February 20, 2015, in conjunction with information developed in our office review.

Topography

The valley bottom ranges from approximate Elevation 56 to 63 feet North American Vertical Datum (NAVD) 88, the ridge top elevation is generally at Elevation 210 feet, with one topographic rise exceeding Elevation 260 feet. Slopes from the valley floor to the ridge top ranged from about 34 percent (or about 19 degrees) north east of the project property to about 50 percent (or about 27 degrees) in the west, with the majority of the slope having an inclination around 40 percent (or about 22 degrees). Estimated length of the slope is generally approximately 400 feet. The project property is located predominately on the valley floor of the Skykomish River, but it also extends up the adjacent slope between about 60 and 250 feet.

Figure 5 presents a slope gradient map of the project area. This figure shows that most of the slope north of the project area is typically inclined at gradients greater than 40 percent. The ridge top area is relatively flat. Slope gradients we measured at base or lower portions of the slope were inclined at gradients of 34 to 50 percent.

Near the base of the slope, we observed uneven ground ("hummocky topography") often indicative of slope failures. We also identified some locations on the slope as relatively small healed failure scars, evidenced by arcuate, convex areas in the slope with no well-established vegetation.

Subsurface Conditions

During our field reconnaissance, we did not observe any distinct outcrops of geologic units. However, we did observe occasional exposures of silt and clay deposits, silty sand and sandy silt deposits, and some areas in which gravel and cobbles were present. These were observed in regions with hummocky topography and were occasionally exposed in ephemeral drainages. Two shallow (3.5 to 4.5 feet deep) hand auger explorations advanced near the toe of the slope encountered loose silty sand and medium stiff to stiff silt (see Figure 2).

Vegetation

Vegetation on the valley floor predominately consists of grass. Near the channel, however, dense blackberry bushes grow in abundance, ranging in height from about 5 to 10 feet. Horsetails and other hydrophilic plants were also observed near the channel and along some lower portions of the slope.

In general, the slope is thickly vegetated with deciduous trees (e.g., alders) and shrubs, and occasional evergreen trees. We observed that evergreen trees often demonstrated downslope bowing of their trunks. We also observed fan-shaped or chute-like areas along the slope in which evergreen or older trees were distinctly missing, while alder trees and other rapid-growth vegetation were more abundant.

Groundwater

Based on the soil survey data (SCS, 1983), the depth to high water table in the Sultan silt loam and the Puget silty clay loam is estimated to be 2 to 4 feet below the ground surface. The depth to high water table

in the Puyallup sandy loam is estimated to be more than 6 feet below the ground surface. Based on mapped alluvium and the proximity of the project property to the abandoned meander and Skykomish River, we anticipate that groundwater levels will roughly fluctuate with river and channel stages.

Surface Drainage and Seepage

As described above, the project property includes an abandoned meander channel. We estimated flow in this channel to range from less than 10 gallons per minute (gpm) (at the southeast culvert) to between 300 and 350 gpm (at the southwest culvert). A wetland area is also present around the channel. It is bordered by blackberries, vegetated by horsetails and hydrophilic grasses, and ranges from about 110 to 260 feet in width.

In the areas we were able to access, we observed at least 3 seeps in hummocky topography in the northeast corner of the project property, and at least 3 small surface drainages were discharging water into the wetland at the time of our visit. Due to thick vegetation and access restrictions, we could not determine if the drainages originated from seeps, or from upslope runoff.

Erosion Hazards

According to the Monroe Municipal Code Chapter 20.05, Critical Areas, an Erosion Hazard area is defined as:

"At least those areas identified by the U.S. Department of Agriculture's Natural Resources Conservation Service as having "severe" or "very severe" rill and inter-rill erosion hazard."

According the NRCS Soil Survey data, the following soil units are present at or near the site and have severe or very severe erosion hazard ratings:

- Alderwood-Everett gravelly sandy loams, 25 to 70 percent slopes;
- Kitsap Silt Loam, 8 to 25 percent slopes, and
- Kitsap silt loam, 25 to 50 percent slopes

Erosion hazards based on soil type are presented in Figure 6. Note that the Erosion Hazard area, based on soil type mapping by the NRCS, extends beyond the sloped areas. Therefore, it is our opinion that the Erosion Hazards roughly correspond to the Landslide Hazard areas shown on Figure 6.

Landslide Hazards

According to the Monroe Municipal Code Chapter 20.05, Critical Areas, a Landslide Hazard area is defined as:

"Areas potentially subject to landslides based on a combination of geologic, topographic and hydrologic factors. They include areas susceptible because of any combination of bedrock, soil, slope (gradient), slope aspect, structure, hydrology or other factors. Examples of these may include, but are not limited to, the following:

a. Areas of historic failure, such as: (i) Those areas delineated by the U.S. Department of Agriculture's Natural Resources Conservation Service as having a "severe" limitation for building site development; or (ii) Areas designated as quaternary slumps, earthflows, mudflows, lahars, or landslides on maps published by the U.S. Geological Survey or Department of Natural Resources;

b. Areas with all three of the following characteristics: (i) Slopes steeper than fifteen percent; and (ii) Hillsides intersecting geologic contacts with a relatively permeable sediment overlaying a relatively impermeable sediment or bedrock; and (iii) Springs or groundwater seepage;

c. Areas that have shown movement during the Holocene epoch (from ten thousand years ago to the present) or that are underlain or covered by mass wastage debris of that epoch;

d. Slopes that are parallel or subparallel to planes of weakness (such as bedding planes, joint systems, and faults) in subsurface materials;

e. Slopes having a gradient steeper than eighty percent subject to rock fall during seismic shaking;

f. Areas potentially unstable because of rapid stream incision, stream bank erosion, and undercutting by wave action;

g. Areas located in a canyon or on an active alluvial fan, presently or potentially subject to inundation by debris flows or catastrophic flooding; and

h. Any area with a slope of forty percent or steeper and with a vertical relief of ten or more feet except areas composed of consolidated rock. A slope delineated by establishing its toe and top and measured by averaging the inclination over at least ten feet of vertical relief."

In addition, the Monroe Municipal Code 20.05 further defines steep slopes using the following criteria:

"Steep slopes means those slopes forty percent or steeper within a vertical elevation change of at least ten feet. A slope is defined by establishing its toe and top and is measured by averaging the inclination over at least ten feet of vertical relief. For the purpose of this definition:

1. The toe of slope is a distinct topographical break in slope that separates slopes inclined at less than forty percent from slopes forty percent or steeper. When no distinct break exists, the toe of slope of a steep slope is the lowermost limit of the area where the ground surface drops ten feet or more vertically within a horizontal distance of twenty-five feet; and

2. The top of slope is a distinct, topographical break in slope that separates slopes inclined at less than forty percent from slopes forty percent or steeper. When no distinct break exists, the top of slope is the uppermost limit of the area where the ground surface drops ten feet or more vertically within a horizontal distance of twenty-five feet."

According to the NRCS Soil Survey, the following soil units are present at or near the site and are rated "very limited" for buildings and roadways:

- Alderwood-Everett gravelly sandy loams, 25 to 70 percent slopes;
- Kitsap Silt Loam, 8 to 25 percent slopes; and
- Kitsap silt loam, 25 to 50 percent slopes.

Observed Slope Conditions

One landslide is mapped by Dragovich et al. (2011) in the western corner of the project property and on the adjacent slope to the north. During our field reconnaissance we observed hummocky topography at the base of the slope, shallow drainage channels and strips of limited vegetation on the slope, and a small fan-shaped deposit of silty sand at the western edge of the mapped feature. During our review of aerial photographs we observed features potentially indicative of multiple shallow slides in the mapped area.

Based on these observations and the interpretation presented in the cross section (Figure 7), this mapped landslide area is not a deep-seated landslide. We infer that this area is affected by erosion along drainage channels on the slope and by shallow (typically less than about 10 feet deep) landslides.

A recent landslide was observed in the northwest part of the site, as shown on the Site Plan (Figure 2). The head of the slide appears to be approximately 60 feet vertically above the banks of the abandoned meander channel. The toe of the landslide was obscured by dense blackberry shrubs, but we estimate it is located at or very near the elevation of the narrow terrace on the north side of the abandoned meander channel. We estimate the landslide is about 40 to 50 feet wide and 6 to 10 feet deep. Erosional rills were observed along the feature, cutting through exposed silt, sand and gravel. The landslide did appear to have directly deposited into the abandoned meander channel, and we anticipate that the remaining landslide deposits will gradually erode and be deposited in the channel.

We observed evidence of slope failure at the top of the northwest part of the slope, directly below a home and associated property. This was evidenced by a sagging fence line situated directly above what appeared to be exposed, loose soils.

Tree cover and stumps are distinctly lacking in at least one area along the fall line of the slope. The area ranges from about 30 to 40 feet wide, and the base of slope is characterized by hummocky topography vegetated by water-loving plants. We interpret this area to be an older, relatively small, shallow landslide.

Several seeps and springs were observed along the base of portions of the slope (see Figure 2); these were often accompanied by hummocky topography, and may be remnants of old shallow failures.

Based on our observations, the soil deposits along the northern side of the channel on the project property are likely a combination of colluvium (primarily deposits from erosion of the slope) and deposits from episodic landslides.

We developed geologic cross sections at three locations down the slopes north of the project boundary (see Figures 7, 8 and 9). Cross section A-A' (Figure 7) was developed along the approximate centerline of the landslide mapped by Dragovich et al. (2011). The profile does not have the accentuated concave upper slope and convex lower slope that is typical of a deep-seated landslide. Slope morphology similar to that observed in Cross Section A-A' is present in the other two cross sections. Therefore, it is our opinion, that slope movements (landslides) along the slope are typically relatively shallow (less than about 10 feet deep).

Figure 6 presents our interpretation of landslide hazard areas, based on one or more criteria for a landslide hazard per Monroe Municipal Code 20.05.120.B.

HYDRAULIC CONDITIONS

We were provided a draft copy of the technical memorandum regarding hydraulic conditions prepared by WSE, dated May 28, 2015. WSE completed a reconnaissance of the abandoned meander channel as part of their hydraulic analyses. This reconnaissance included evaluating the upstream inlet through a culvert under U.S. Highway 2 and the connection to the Skykomish River at the downstream end of the channel. Although there is a culvert under U.S. Highway 2, WSE found that there is no culvert under the

Burlington Northern Railroad. Therefore, based on their reconnaissance, there is no direct upstream connection to the Skykomish River.

Based on the May 28th, 2015 memorandum, a slight rise (less than an inch) in flood elevation was estimated in the project area, assuming the proposed fill pad dimensions with a 2H:1V (horizontal:vertical) fill slope. They also estimated very slight increases in maximum velocity at a section located about half-way along the length of the abandoned meander channel through the project property. It was their opinion that the rise observed could be accommodated by modification of the fill if needed, during final design.

The flow velocities during the rise and fall of the FEMA 100-year flow event were also evaluated by WSE. WSE presented flow velocities at a point during the rising limb, a point near the peak and a point during the falling limb of the modeled 100-year flow event (see Table A-1 in Attachment A of WSE, 2015). These tables indicate very slight variations (less than ±0.01 feet per second [fps]) between baseline and proposed conditions for velocities at each cross section within the project boundaries.

It is important to note that the model indicates that there is a backwater effect during the FEMA 100-year flow event, such that water flows into the channel from the downstream end of the abandoned meander channel during the rise of flood water in the Skykomish River. Water then drains out of the abandoned meander channel during the retreat of the flood water.

The absolute magnitude of flow velocities in the meander channel near the peak elevation for the 100-year flow event are 0.1 fps or less, with the exception of the downstream 300 feet (in the vicinity of the culverts) (see Table A-1 of WSE (2015). Higher velocities are reported in Table A-1 at a point during the rising limb of the hydrograph at a culvert crossing within the project property, where absolute flow velocities are about 0.3 fps. The absolute flow velocities reported at the culvert crossing during the falling limb was less than 0.1 fps for proposed and existing conditions, with a slight increase (about 0.03 fps) under proposed conditions.

At a beaver dam located about 300 feet downstream of the project property boundary, the absolute magnitude of flow velocity at a point during the rising limb as reported by WSE (2015) in Table A-1 was close to 2 fps. However, the results reported by WSE (2015) during the falling limb were about 0.1 fps for both existing and proposed conditions.

Based on results presented in Table A-1 in Attachment A of WSE (2015), the absolute magnitude of flows in the vicinity of the culverts under the highway and the railroad (at the downstream end of the abandoned meander channel) range from about 0.59 fps to 4.0 fps during the rise, near the peak, and during the fall of the floodwaters. The results also indicate that the variations in absolute magnitude of flows between existing and proposed conditions are less than 0.1 fps.

Because the data presented in Table A-1 in Attachment A of the memorandum prepared by WSE (2015) provide only a snapshot of the flow velocities, we asked to see a summary of velocities for all of the cross sections through time. WSE provided GeoEngineers with graphs summarizing flow velocities at each cross section at 1-hour time-steps in an e-mail dated March 17, 2015. The graphs present flow velocities for existing conditions and proposed conditions at each cross section location at one hour time-steps. The graphs consisted of flow velocity versus meander channel distance (from the downstream end of the model) and provide a more complete summary of the flow velocities over time than the snapshots on the rising limb, near the peak, and during the falling limb that are presented in Table A-1 in Attachment A of

WSE (2015). For the existing and proposed conditions, the one-hour time-step graphs indicate that flow velocities along most of the meander channel length within or near the project boundary range from less than 0.1 fps to about 0.3 fps (see discussion above regarding flows at the downstream end of the abandoned meander channel). Areas of higher flow correspond to a beaver dam (located about 300 feet upstream of U.S. Highway 2 and about 300 feet downstream of the project property) and the location of a culvert located about 2,400 feet upstream of U.S. Highway 2 within the project property. This culvert is located under the fill placed for the existing access road to the northeast portion of the project property.

Based on the one-hour time-steps, maximum absolute peak flow velocity at the beaver dam is about 3.2 fps under existing conditions during rising water (flow into the channel from the Skykomish River). Under proposed conditions, the peak flow velocity is estimated to be 3.5 fps during rising water. During falling water conditions, the peak flows at the beaver dam are on the order of 2 fps for both existing and proposed conditions.

Based on the one hour time steps, maximum absolute peak flow velocities at the culvert location are about 2.5 fps for existing conditions during rising water, but the estimated peak flow velocity for proposed conditions is slightly more than 1.2 fps. The maximum absolute magnitude of peak flows during falling water conditions are about 1 fps for both existing and proposed conditions, based on one-hour time-steps.

Additional modeling will likely be required, once a project reaches design stage, to achieve the zero net rise. To help achieve zero net rise, it might be possible to use retaining structures or mechanically stabilized earth (MSE) to reduce the fill footprint (i.e. create a fill slope steeper than 2H:1V).

POTENTIAL IMPACTS

Erosion Hazards

Potential erosion hazards typically consist of those areas underlain by soil susceptible to erosion that are exposed to runoff. Erosion can also occur where fast flowing surface waters erode the banks of a stream.

Existing Hazards

Figure 6 shows erosion hazard areas based on Monroe Municipal Code 20.05120.A. Development on the ridge top was completed prior to modern codes that provide more specific requirements for control of surface water discharge. Because of lack of access permission, it was not possible to determine if surface water runoff and storm drain facilities discharge to slopes above the project property. Therefore it is not possible to evaluate how runoff from the ridge top area presently affects erosion (and slope stability). Active erosion appears to be occurring along poorly defined channels that descend from the upper slopes.

There does not appear to be active erosion along the banks of the abandoned meander channel within the project property. Based on hydraulic analyses, most flow velocities within the meander channel are very low, typically less than 0.3 fps during a flood event. Highest flow velocities based on modeling are present in the vicinity of the culverts at the downstream end of the abandoned meander loop (just upstream of the confluence of with the Skykomish River). Within or near the project boundaries, higher flows are estimated in the vicinity of the existing beaver pond, located about 300 feet downstream of the project property, and in the vicinity of a culvert in the meander channel about 2,400 feet upstream from U.S. Highway 2 (within the boundary of the project property). Maximum absolute flow velocities, in the vicinity of the beaver dam are estimated at 3.2 fps, based on flow velocities estimated at one-hour time-steps during a flood event.

The banks in the vicinity of the beaver dam are densely vegetated with tall grasses and the channel bottom downstream of the dam also is densely vegetated. We did not observe indications of erosion in this area such as eroding banks or bare soil at the time of our visit. The absolute magnitude of flow velocities in the vicinity of the on-site culvert is 2.5 fps during the rising limb for existing conditions, based on one-hour time-steps.

For comparison, maximum permissible velocities for grass-lined channels should not exceed 3 to 5 fps on channel slopes of 0 to 5 percent, depending on the type of grass, according to the NRCS design guideline details for a grass-lined swale (NRCS, 1995). Long, dense growths of grass, legumes, shrubs and vegetation are sufficient, in our opinion, to prevent significant erosion during the higher velocity flows anticipated.

Potential Hazards from Proposed Conditions

Under the proposed conditions, it is our opinion that erosion will continue to occur on the slopes located on- and off-site and deliver sediment to the north side of the abandoned meander channel. Over a long period of time, this may result in a reduced channel capacity, but, in our opinion is not likely a significant change from existing conditions.

Based on the review of the hydraulic analyses under the proposed conditions, there may be some slight variations in the elevation of the flood flows and slight changes to flow velocities in the abandoned meander channel under the proposed conditions. The most significant change was in the vicinity of the existing beaver dam, where there appears to be a relatively short duration of slightly higher flow velocity during rising floodwaters. The maximum absolute flow velocities in the vicinity of the beaver dam are estimated at 3.5 fps, based on flow velocities estimated at one-hour time-steps during a flood event. This is slightly higher than the existing conditions. The absolute magnitude of flow velocities in the vicinity of the on-site culvert is about 1.2 fps during the rising limb for proposed conditions, which is about 1.3 fps less than existing conditions. Where there are increases in the absolute magnitude of flow velocities, it is our opinion that the changes will not result in significant erosion along the channel banks because of the existing dense vegetation along the channel, provided that the vegetation is maintained.

Removal of vegetation during grading activities will expose soil and increase the potential for local erosion. However, the proposed grading is located away from slopes or will reduce slope gradients adjacent to the abandoned meander channel on the left bank. We do recommend that a temporary erosion and sedimentation control plan (TESCP) be developed during the design phase to minimize the potential for erosion during grading.

Runoff from impervious surfaces following construction can also increase erosion if concentrated flows are allowed to discharge onto sloped surfaces. This can be addressed during the design phase of the project.

Landslide Hazards

Landslide hazards consist of the slow to rapid downslope movement of soil and/or rock. The forces that work to cause material to slide are referred to as driving forces. Driving forces consist of gravity and the mass of the material or any surcharge, such as adding material on a slope or near the crest of a slope. Forces that resist movement include the strength of the geologic materials expressed as friction and cohesion. Tree roots can contribute to the strength of the soil mass. Removing material at the toe of a slope can reduce the resisting forces.

Landslides result from a variety of natural and human-related activities. Over time, geologic materials can weather, which reduces the strength of the material. Landslide occurrence can also be related to increased periods of precipitation, which results in soil saturation, elevated groundwater levels and a corresponding reduction in soil strength. Removal of tree cover can also reduce the strength of the soil-root mass over time that can contribute to slope movement. Adding mass at the top of the slope can increase the loading and cause instability. Removal of material at the toe of the slope can cause loss of support, whether removal is from natural processes or excavation of material by humans.

Existing Hazards

Existing landslide hazard areas as defined by Monroe Municipal Code 20.05.120.B are presented on Figure 6. The slopes north of the project property and along the northern margins of the abandoned meander channel are subject to periodic landslides. The mapped landslide (see Figure 3) does not appear to be a deep-seated landslide. Instead, it is our opinion that landslides in this area tend to be shallow (less than about 10 feet deep), similar to the most recent landslide observed to the east of the landslide mapped by Dragovich et al. (2011).

Landslide activity is generally expected to increase during periods of extended precipitation or rain-on-snow events, but may be episodic and sporadic.

As stated under the discussion of Existing Conditions for Erosion Hazards, development on the ridge top was completed prior to modern codes that provide more specific requirements for control of surface water discharge. Because of lack of access permission, it was not possible to determine if surface water runoff and storm drain facilities discharge to slopes. Therefore it is not possible to evaluate how runoff in the ridge top area presently affects erosion and therefore slope stability.

Potential Hazards from Proposed Conditions

No development and therefore no disturbance of vegetation or alteration of the ground surface is proposed on the hillslopes located on the north side of the abandoned meander in the proposed development alternatives. Therefore, it is our opinion that landslide activity will continue as it currently occurs under existing conditions, provided that no significant changes occur at the top of the slope.

The excavation conceptually proposed to accommodate compensatory flood storage along the abandoned meander channel will not, in our opinion, result in removal of support of the slope north of the project property and along the northern margins of the project property.

Since we do not expect significant erosion in the channel as the result of the proposed project, it is also our opinion that no significant adverse impacts to slope stability will occur as the result of the proposed development alternatives.

Development in the northeastern portion of the project property could include excavation. Any excavations near the toe of the slope should be evaluated during the design phase. In addition, two areas meeting the criteria for steep slopes as defined by Monroe Municipal Code 20.05 are present in this area. These areas should be evaluated during the design phase if development activities are proposed near them.

MITIGATION

Erosion

Temporary increased potential for erosion will occur as the result of grading activities. However, preparation and implementation of a Stormwater Pollution Prevention Plan (SWPPP) and a TESCP should address the anticipated temporary impacts.

Final site drainage should control runoff on-site and be designed to prevent concentrated flows onto slopes steeper than 3H:1V. This should be re-evaluated during the design phase. It is likely that permanent stormwater control will be routed to an on-site detention facility or facilities, therefore, it should be possible to discharge water to an appropriate location with appropriate erosion control measures at the outfall.

If erosion is observed along the north bank of the abandoned meander channel in the future, it may be possible to use vegetation to stabilize the bank. Other measures could include installation of straw or coir logs, jute/coir cloth or geotextile wrapped soil, cribwalls, riprap or other types of bank stabilization measures as described in the Washington State Department of Fish and Wildlife "Integrated Streambank Protection Guidelines" (2002).

Stream flow velocities at the access road crossing of the abandoned meander channel should be evaluated during project design. Bank protection may be needed to reduce any concerns for erosion. Alternatively, the existing culvert could be replaced with a larger culvert or a bridge.

Landslides

Grading activities in the vicinity of landslide hazard areas as defined by Monroe Municipal Code 20.05.120.B should be evaluated during the design phase to avoid impacts.

Some of the measures suggested above (e.g. cribwalls, riprap/rock buttress) for erosion mitigation along the abandoned meander channel could be designed and implemented along the north bank of the channel to help improve slope stability if slope movement becomes a concern. Such measures would only be effective for stabilizing the lower portion of the slope. However, it is our opinion that the likelihood that such measures would be needed is low, provided that conditions at the top of the slope are properly managed (i.e. yard waste or other materials are not deposited on slopes and runoff is controlled so as not to exacerbate erosion of the slope).

During design phase, appropriate setbacks will need to be established from the toe of the slope in the northeastern portion of the project property. It does not appear that additional setbacks from landslide hazards will need to be established for the primary development area where fill is to be placed.

LIMITATIONS

We have prepared this report for PACE related to the East Monroe Rezone project. PACE may distribute copies of this report to Heritage Baptist Church and Heritage Baptist Church's authorized agents and regulatory agencies as may be required for the project.

Our services were provided to assist in the change of land use sought for the property included in the rezone that is located along or near potentially unstable slopes. Our recommendations are intended to qualitatively

evaluate the overall stability of the site and assess potential consequences of damage to the proposed project property from landslides or the potential for increased risk of slope movement from the proposed development. Qualified engineering and construction practices can help mitigate the risks inherent in construction on slopes, although those risks cannot be eliminated completely. Favorable performance of structures in the near term is useful information for anticipating future performance, but it cannot predict or imply a certainty of long-term performance, especially under conditions of adverse weather or seismic activity.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the field of geotechnical engineering in this area at the time this report was prepared. The conclusions, recommendations, and opinions presented in this report are based on our professional knowledge, judgment and experience. No warranty or other conditions, expressed or implied, should be understood.

Any electronic form, facsimile or hard copy of the original document (email, text, table and/or figure), if provided, and any attachments should be considered a copy of the original document. The original document is stored by GeoEngineers, Inc. and will serve as the official document of record.

Please refer to the attachment titled "Report Limitations and Guidelines for Use" for additional information pertaining to use of this report.

REFERENCES

Dragovich, J. D.; Anderson, M. L.; Mahan, S. A.; Koger, C. J.; Saltonstall, J. H.; MacDonald, J. H., Jr.; Wessel, G. R.; Stoker, B. A.; Bethel, J. P.; Labadie, J. E.; Cakir, Recep; Bowman, J. D.; DuFrane, S. A., 2011. Geologic map of the Monroe 7.5-minute quadrangle, King and Snohomish Counties, Washington. Washington Division of Geology and Earth Resources Open File Report 2011-1, 1 sheet, scale 1:24,000, with 24 p. text.

PACE Engineers, Inc., 2013. Drawing titled "East Monroe Comprehensive Plan Amendment and ReZone, EIS Topographic Map, Appendix J., 1 sheet, scale 1:1,200. Project No. 13372.10. Dated September 2013.

GeoEngineers, Inc., 2013. Geotechnical Consultation Services, Proposed Development, Monroe, Washington. For PACE Engineers, Inc. and Heritage Baptist Church. File No. 21119-001-00. Dated June 16, 2013.

Natural Resource Conservation Service, 1995. Illinois Urban Manual Standards – Grass-Lined Swale. Accessed from http://www.aiswcd.org/wp-content/uploads/2013/06/urbst84011.pdf on March 18, 2015.

Soil Conservation Service, 1983. Soil Survey of Snohomish County Area, Washington. U.S. Department of Agriculture, Soil Conservation Service, the Washington State Department of Natural Resources and the Washington State University Agriculture Research Center.

Watershed Science and Engineering, Inc., 2015. Memorandum titled "Monroe Rezone Area -- Hydraulic Analysis." From Shaina Sabatine EIT, Larry Karpack P.E., to PACE Engineers, Inc., dated May 28, 2015.

AERIAL PHOTOGRAPHS

[Aerometric, 1948] Flight line frames D48-1176, D48-1177; approximate scale of 1:17,000, dated March 25, 1969.

[Aerometric, 1948] Flight line frames D48-1228, and D48-1229, approximate scale of 1:14,000.

[Aerometric, 1955] Flight line frames D55-21S-18 through -20, and D55-22S-20 through -22; approximate scale of 1:12,000, dated August 8, 1955.

[Aerometric, 1969] Flight SN C 69, Line frames 1-28 and 1-29; approximate scale of 1:18,000, dated March 25, 1969.

[Aerometric, 1969] Flight line frames 1-28 and 1-29; approximate scale of 1:18,000, dated March 25, 1969.

[Aerometric, 1981] Flight SS1-81, Line 22B, Frames 16 and 17; approximate scale of 1:18,000, dated March 1, 1981.

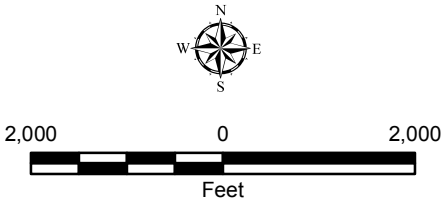
[Aerometric, 1981] Flight SS1-81, Line 23, Frames 29 and 30; approximate scale of 1:22,000, dated March 2, 1981.

[Aerometric, 1985] Flight SKP-85, Line 30, Frames 2 through 4; approximate scale of 1:18,000, dated March 10, 1985.

GoogleEarth Pro. 2015. Historical Aerial Imagery for August 1990 (U.S. Geological Survey), April 2002 (DigitalGlobe) and July 15, 2014 (Unspecified). Resolution varies. Accessed February through May 2015.

FIGURES

GeoEngineers



Notes:
1. The locations of all features shown are approximate.
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. It is unlawful to copy or reproduce all or any part thereof, whether for personal use or resale, without permission.

Data Sources: ESRI Data & Maps

Projection: NAD 1983 UTM Zone 10N

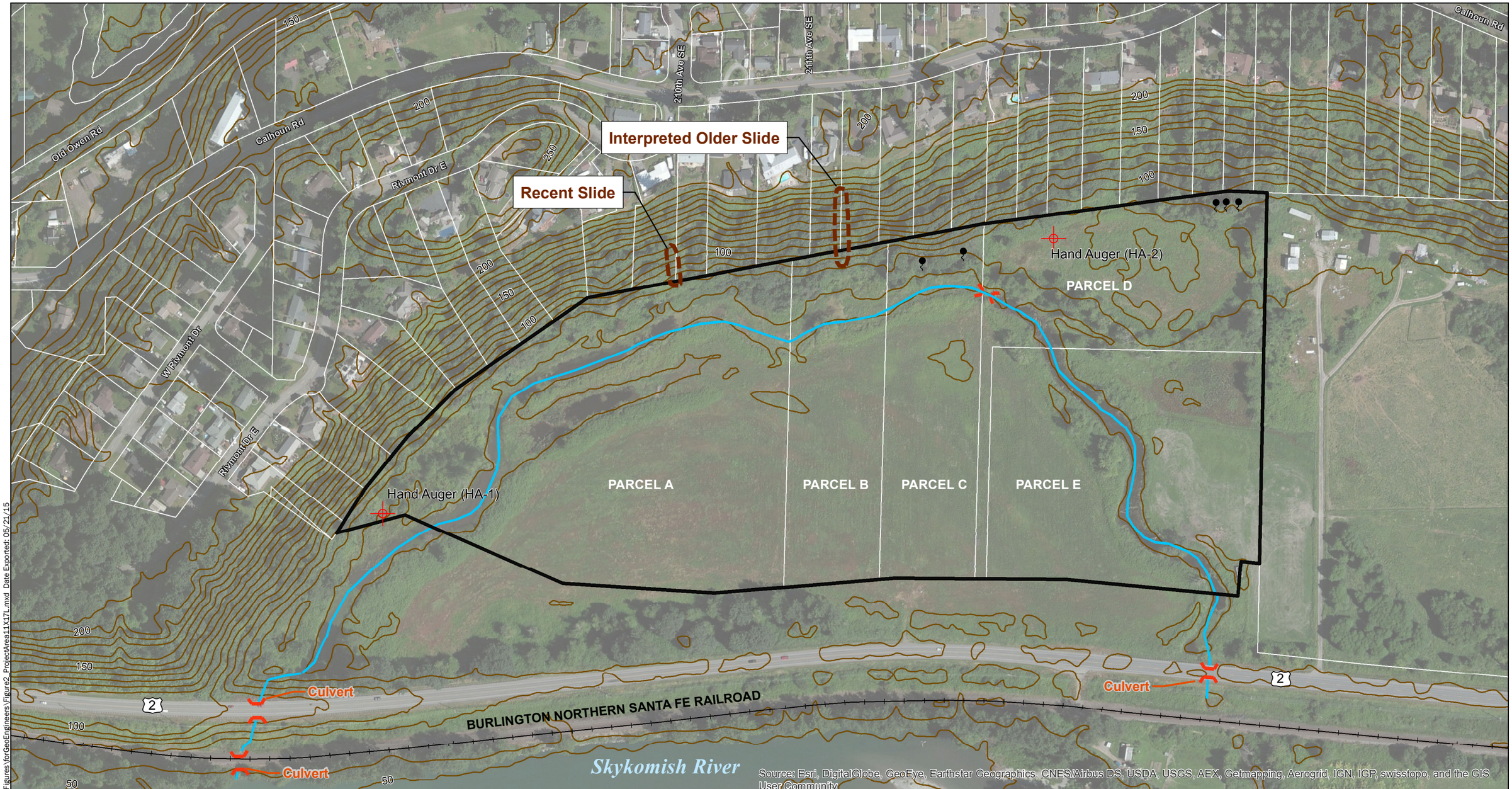
Vicinity Map

East Monroe ReZone
Monroe, Washington

GEOENGINEERS

Figure 1

Office: SEA Path: P:\21\21119001\GIS\MXD\2111900101VM.mxd Map Revised: 19 March 2015 cerdman



Data Source:
Parcel Data From Snohomish County Sept 2014
LiDAR Data From PSLC 2006

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information 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 of this communication.

Projection: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet

Legend

- Project Area Boundary
- 10-ft Contour
- Parcel Lines
- Watercourse
- Spring or Seep

N W E S

250 0 250
Feet

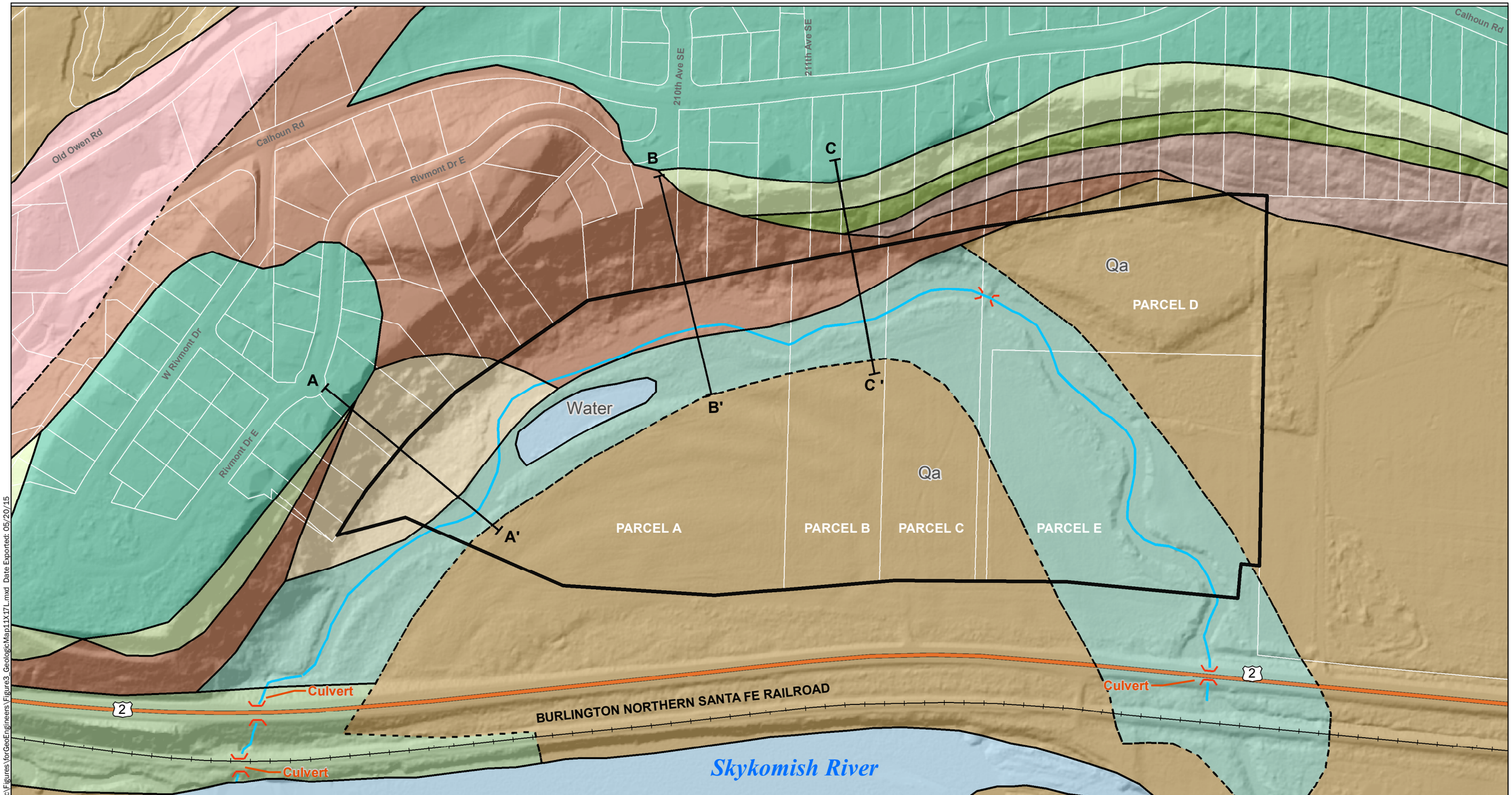
Site Plan

East Monroe Rezone Project
Monroe, Washington

GEOENGINEERS

Figure 2

P:\P13\13372 East Monroe EIS\GIS\ArcMapDoc\Figures\forGeoEngineers\Figure2_ProjectArea11X17L.mxd Date Exported: 05/21/15



Data Source: WA DNR Surficial Geology Digital database, 2015

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information 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 of this communication.

Projection: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet

Legend

- Project Area Boundary
- A — A' Cross Section
- Geologic Unit Boundary
- Inferred Geologic Unit Boundary
- Parcel Boundary

- Qf — Fill or Modified Land
- Qls — Quaternary Landslide Deposits
- Qp — Quaternary Peat Deposits
- Qa — Quaternary Alluvium Deposits
- Qgof — Quaternary Fluvial Outwash Deposits
- Qga(v) — Vashon Advance Outwash
- Qc(ol) — Olympia Beds, local provenance
- Qgl(p) — Glaciomarine/Glaciolacustrine Fine Deposits
- Qc(pf) — Pre-Fraser Non-Glacial deposits

N W E S

250 0 250
Feet

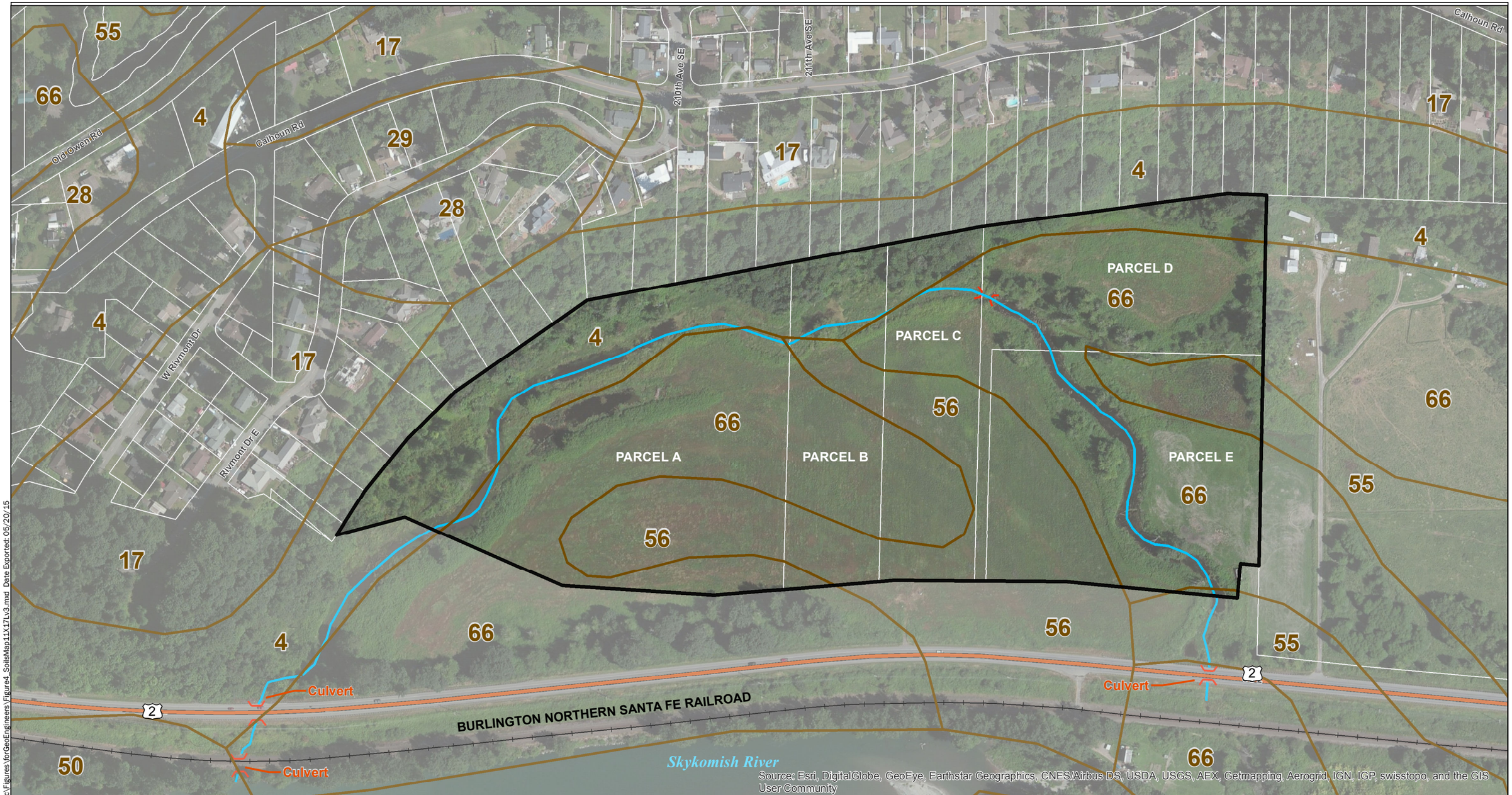
Geologic Map

East Monroe Rezone Project
Monroe, Washington

GEOENGINEERS

Figure 3

P:\P13\13372 East Monroe EIS\GIS\ArcMapDoc\Figures\forGeoEngineers\Figure3_GeologicMap11X17L.mxd Date Exported: 05/20/15



Data Source: NRCS Soil Survey

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information 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 of this communication.

Projection: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet

Legend

- Project Area Boundary
- Soil Unit Boundary
- Parcel Boundary

4	Alderwood-Everett gravelly sandy loams, 25 to 70 percent slopes
17	Everett gravelly sandy loam, 0 to 8 percent slopes
28	Kitsap silt loam, 8 to 25 percent slopes
29	Kitsap silt loam, 25 to 50 percent slopes
50	Pilchuck loamy sand
55	Puget silty clay loam
56	Puyallup fine sandy loam
66	Sultan silt loam

N W E S

250 0 250
Feet

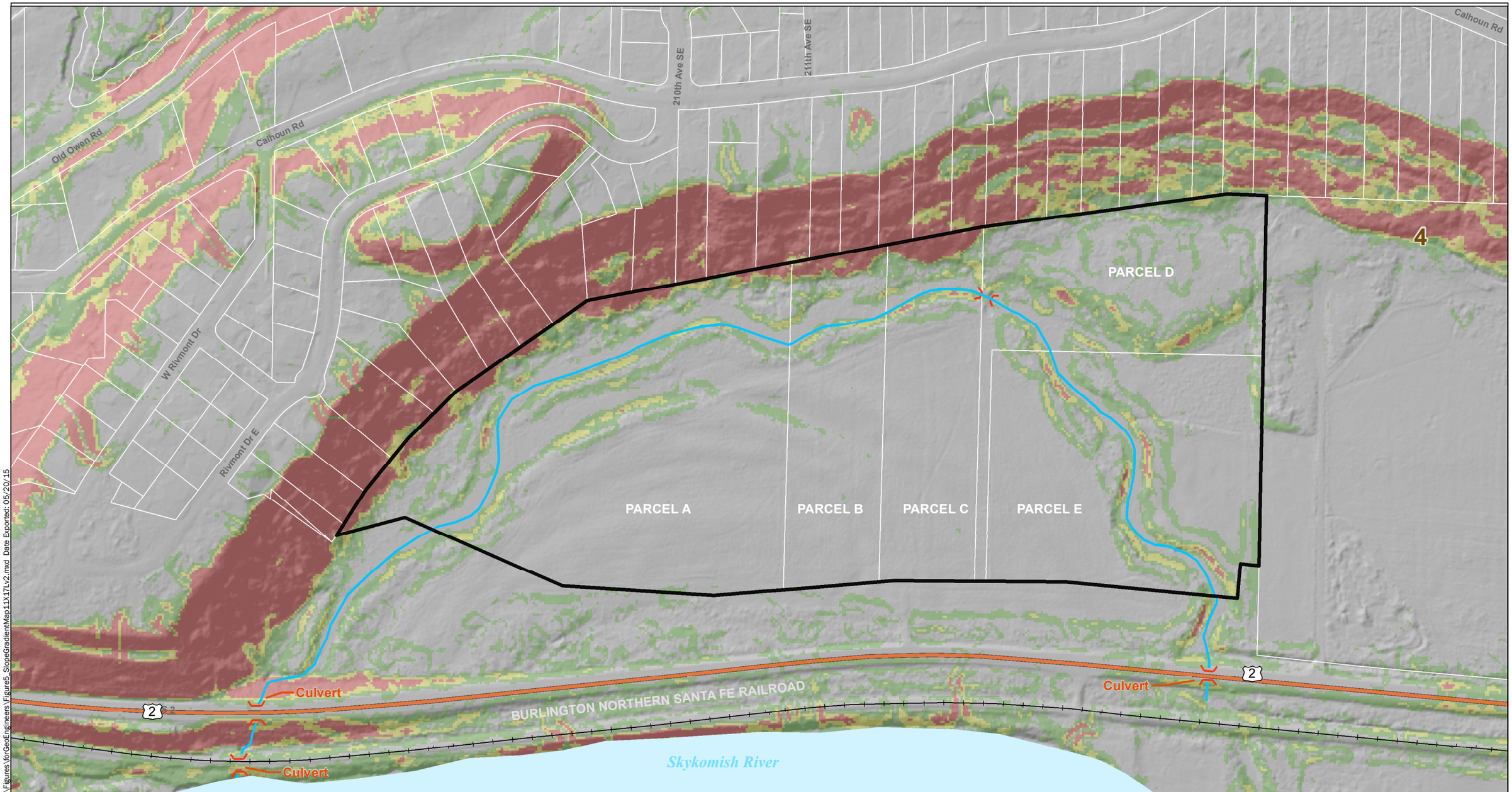
NRSC Soil Units Map

East Monroe Rezone Project
Monroe, Washington

GeoEngineers

Figure 4

P:\P13\13372 East Monroe EIS\GIS\ArcMapDoc\Figures\forGeoEngineers\Figure4_SoilsMap11X17Lv3.mxd Date Exported: 05/20/15



Data Source: LiDAR from PSLC 2006

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information 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 of this communication.

Projection: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet

Legend

- Project Area Boundary
- Parcel Boundary
- Watercourse

Slope Gradient (%)

- 15 - 30
- 30 - 40
- > 40

N W E S

250 0 250
Feet

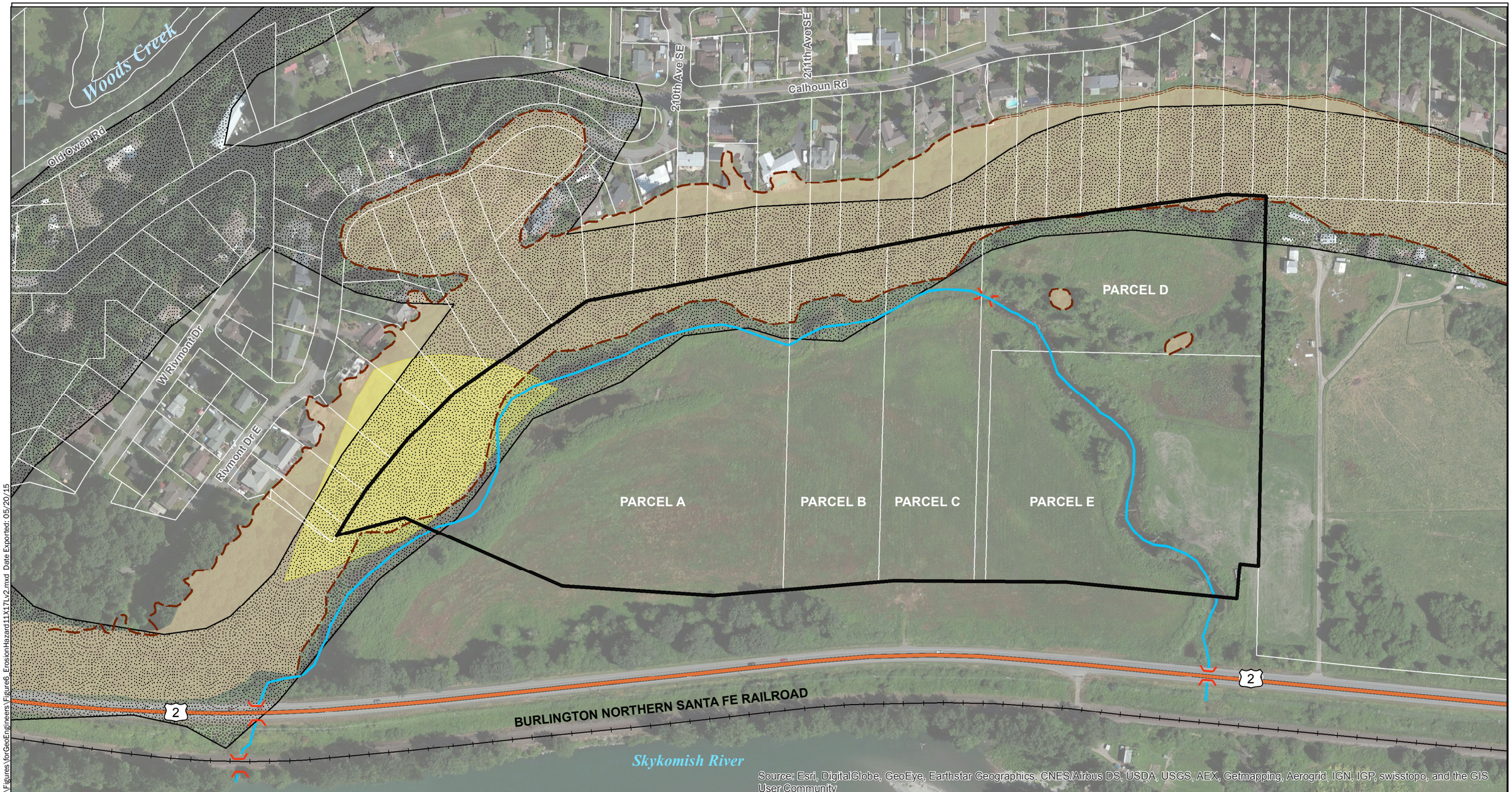
Slope Gradient Map

East Monroe Rezone Project
Monroe, Washington

GeoEngineers

Figure 5

P:\P13\13372 East Monroe EIS\GIS\ArcMapDoc\Figures\forGeoEngineers\Figure5_SlopeGradientMap11X17Lv2.mxd Date Exported: 05/20/15



Data Source: GeoEngineers delineation of hazard areas using exisiting LiDAR data, Stet.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information 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 of this communication.

Projection: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet

Legend

- Project Area Boundary
- Parcel Boundary
- Approximate Hazard Boundary
- Uncertain Hazard Boundary
- Watercourse
- Preliminary Landslide Hazard Area
- ErosionHazardArea
- Qls - Quaternary Landslide Deposits

N W E S

250 0 250
Feet

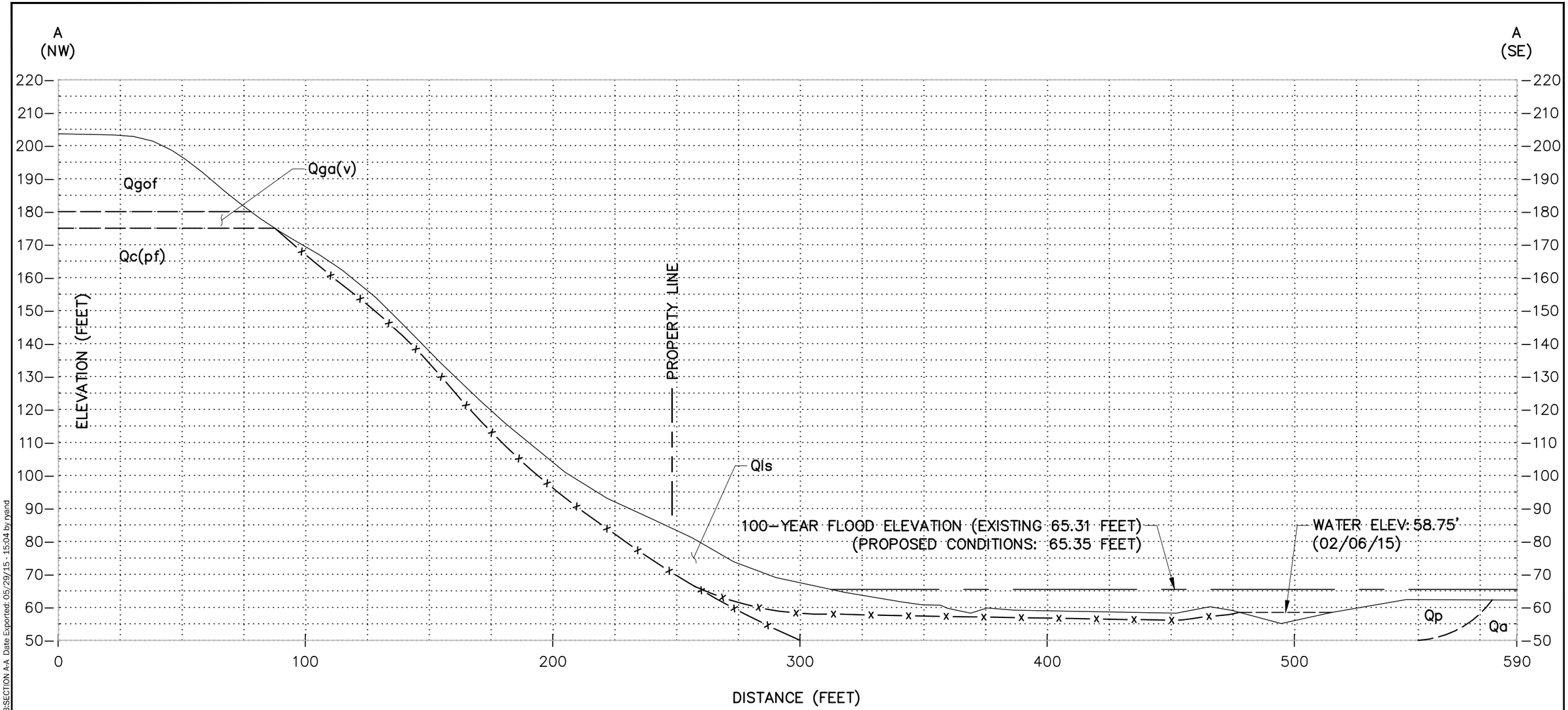
Erosion and Landslide Hazard Map

East Monroe Rezone Project
Monroe, Washington

GEOENGINEERS

Figure 6

P:\P13\13372 East Monroe EIS\GIS\ArcMapDoc\Figures\forGeoEngineers\Figure6_ErosionHazard11X17Lv2.mxd Date Exported: 05/20/15



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information 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 of this communication.

Data Source:
Topographic profile from drawing provided by PACE Engineers titled "X13372-SRV-JF.dwg" and dated 2/26/2015.

Legend

- Geologic contact, certain
- Geologic contact, inferred or approximate
- Geologic contact, uncertain

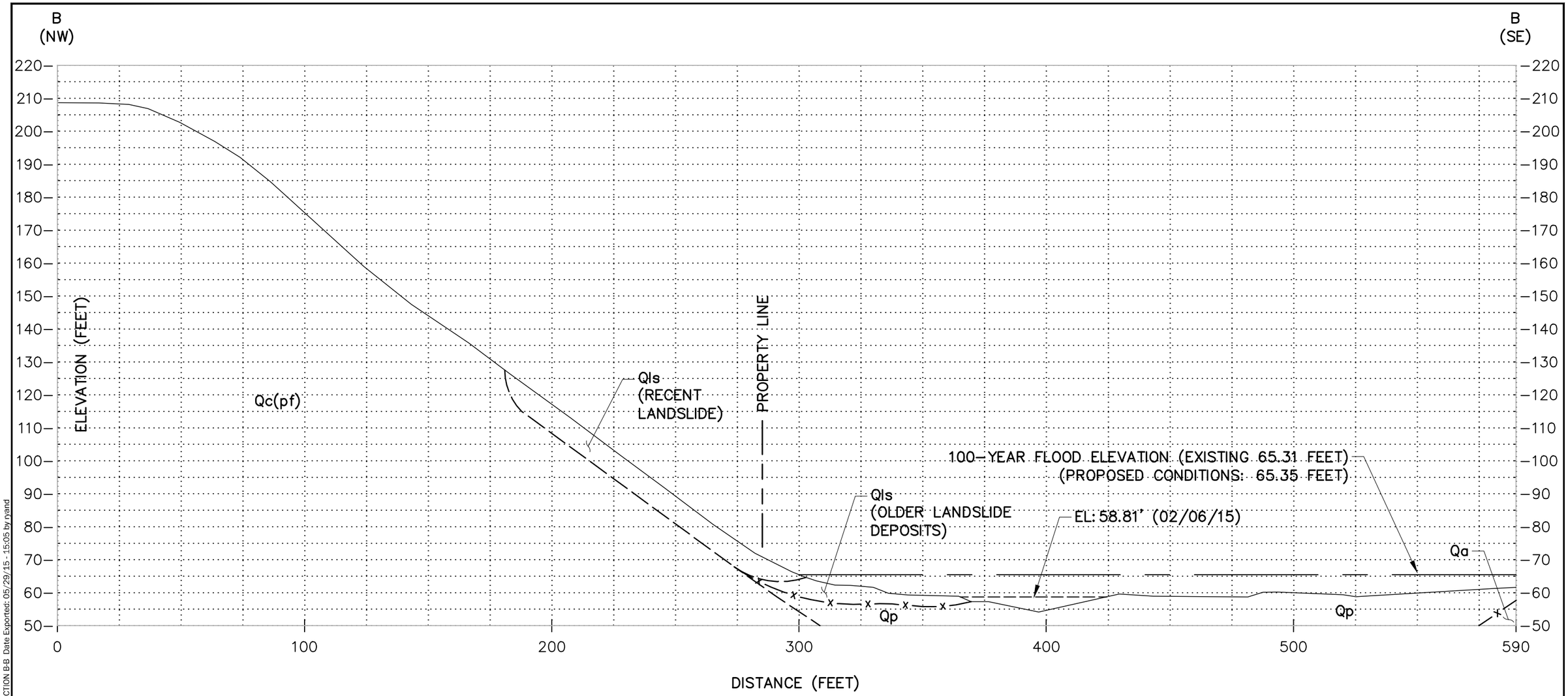
N
W E
S

SCALE: H= 1"=40'
V= 1"=30'

40 0 40
FEET

Cross Section A-A'	
East Monroe Rezone Monroe, Washington	
GEOENGINEERS	Figure 7

P:\P13\13372 East Monroe EIS\CAD\Figures\Sheets\P13372-SEC2.dwg TAB:SECTION A-A Date Exported: 05/29/15 - 15:04 by ryand



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information 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 of this communication.

Data Source:
Topographic profile from drawing provided by PACE Engineers titled "X13372-SRV-JF.dwg" and dated 2/26/2015.

Legend

- Geologic contact, certain
- Geologic contact, inferred or approximate
- Geologic contact, uncertain

N
W E
S

40 0 40
FEET

SCALE: H= 1"=40'
V= 1"=30'

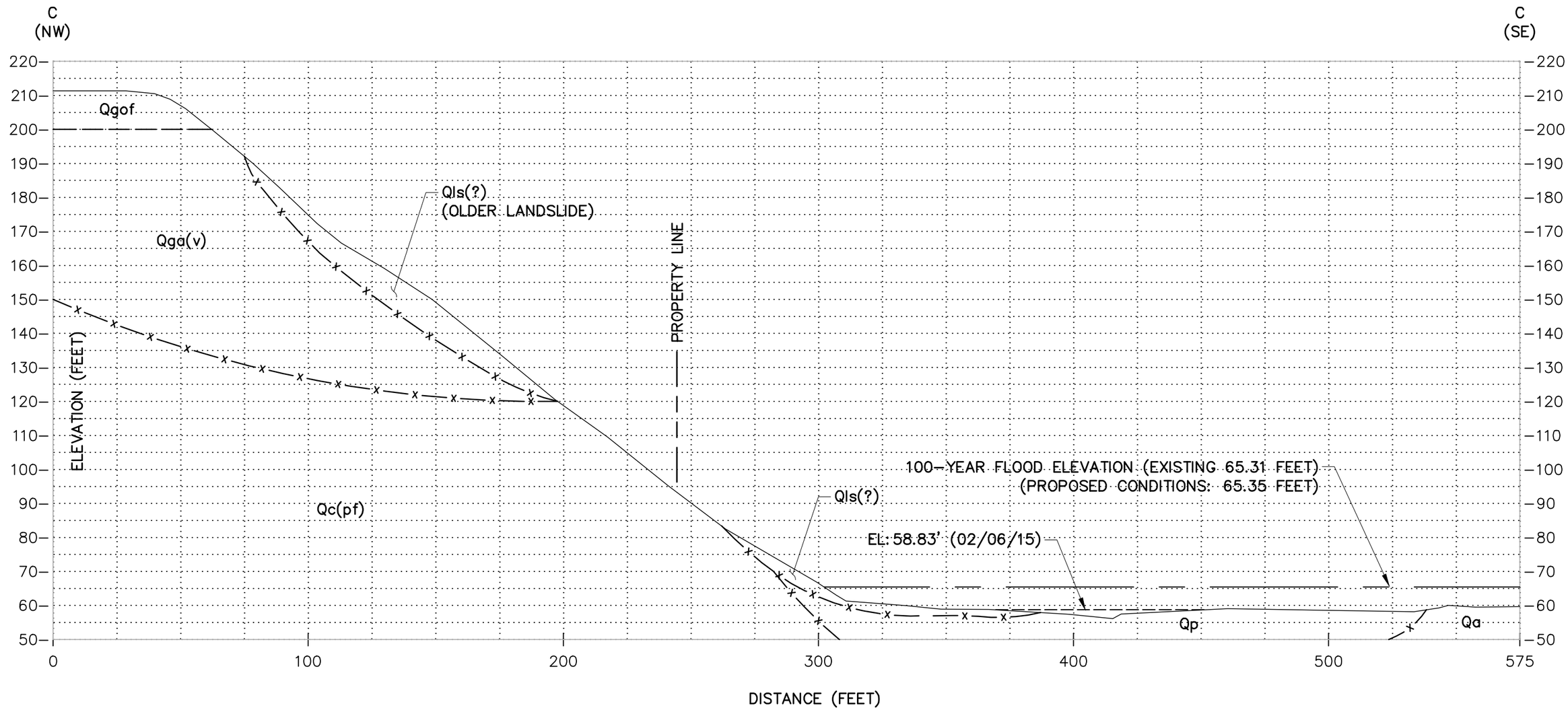
Cross Section B-B'

East Monroe Rezone
Monroe, Washington

GEOENGINEERS

Figure 8

P:\P13\13372 East Monroe EIS\CAD\Figures\Sheets\P13372-SEC2.dwg TAB:SECTION B-B Date Exported: 05/29/15 - 15:05 by ryand



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information 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 of this communication.

Data Source:
Topographic profile from drawing provided by PACE Engineers titled "X13372-SRV-JF.dwg" and dated 2/26/2015.

Legend

Geologic contact, certain
Geologic contact, inferred or approximate
Geologic contact, uncertain

N
W
E
S

SCALE: H= 1"=40'
V= 1"=30'

40 0 40
FEET

Cross Section C-C'

East Monroe Rezone
Monroe, Washington

GEOENGINEERS

Figure 9

P:\P13\13372 East Monroe EIS\CAD\Figures\Sheets\P13372-SEC2.dwg TAB:SECTION C-C Date Exported: 05/29/15 - 15:05 by ryand

APPENDICES

GeoEngineers

ATTACHMENT A
Aerial Photographs

D 48 - 1176
1969

D55-21S-20
1955

SN C 69
I-29
1969

SS1-81
3/1/81
228-16
1981
220

Q D 3
SKP-85
3-10-85
9400 ABL 6" Z
30
2
112663
153.476mm
1985

USGS August 1990
from Google Earth Pro (2015)
Legend
Woods Creek Rd
Old Owen Rd
215th Ave SE
219th Dr SE
226th Ave SE
225th Ave SE
Calhoun Rd
151st Pl SE
204th Ave SE
Ogden St
Eagle Park Dr
Rivmont Dr W
Rivmont Dr E
Railroad Ave
Stevens Pass Hwy 2
S Ann St
Simons Rd
Al Borlin Park Trail
Google earth
Image U.S. Geological Survey
2000 ft
N

DigitalGlobe April 2002
from Google Earth Pro (2015)
Legend
Old Owen Rd
215th Ave SE
219th Dr SE
225th Ave SE
226th Ave SE
Calhoun Rd
151st Pl SE
204th Ave SE
Woods Creek Rd
Ogle St
Eagle Park Dr
Rivmont Dr W
Rivmont Dr E
Railroad Ave
Stevens Pass Hwy
Simons Rd
S Ann St
Charles St
Al Borlin Park Trail
Google earth
Image © 2015 DigitalGlobe
N
2000 ft

Unspecified July 2014
from Google Earth Pro (2015)
Legend
Old Owen Rd
215th Ave SE
219th Dr SE
225th Ave SE
226th Ave SE
151st Pl SE
Calhoun Rd
204th Ave SE
Woods Creek Rd
Ogle St
Eagle Park Dr
Rivmont Dr W
Rivmont Dr E
Railroad Ave
Stevens Pass Hwy 2
Simons Rd
Al Borlin Park Trail
Google earth
N
2000 ft

ATTACHMENT B
Report Limitations and Guidelines for Use

Attachment B
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.

Geological Services Are Performed for Specific Purposes, Persons and Projects

This report has been prepared for the exclusive use of PACE Engineers, Inc. (PACE) and their authorized agents. This report may be made available to the local governmental agencies for review. This report is not intended for use by others, and the information contained herein is not applicable to other sites.

GeoEngineers, Inc. (GeoEngineers) structures our services to meet the specific needs of our clients. For example, a 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 geologic study is unique, each 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 geological 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 Geologic Report Is Based on a Unique Set of Project-Specific Factors

This report has been prepared for the East Monroe Rezone project as described in this report. 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; or
- Completed before important project changes were made.

For example, changes that can affect the applicability of this report include those that affect:

- The function of the proposed structure;
- Elevation, configuration, location, orientation or weight of the proposed structure;
- Composition of the design team; or
- Project ownership.

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

If important changes are made after the date of this report, GeoEngineers should be given the opportunity to review our interpretations and recommendations and provide written modifications or confirmation, as appropriate.

Subsurface Conditions Can Change

This 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.

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.

Biological Pollutants

GeoEngineers' Scope of Work specifically excludes the investigation, detection, prevention or assessment of the presence of Biological Pollutants. Accordingly, this report does not include any interpretations, recommendations, findings, or conclusions regarding the detecting, assessing, preventing or abating of Biological Pollutants and no conclusions or inferences should be drawn regarding Biological Pollutants, as they may relate to this project. The term "Biological Pollutants" includes, but is not limited to, molds, fungi, spores, bacteria, viruses and/or any of their byproducts.

If Client desires these specialized services, they should be obtained from a consultant who offers services in this specialized field.

Have we delivered World Class Client Service?

Please let us know by visiting **www.geoengineers.com/feedback**.

GeoEngineers