Geologic Hazard Evaluation

White River to Alderton 230kV Transmission Line Project
Pierce County, Washington

for

Puget Sound Energy

December 19, 2014

GeoEngineers
Earth Science + Technology

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INTRODUCTION

This report presents the results of our geologic hazards assessment for the proposed White River to Alderton 230 kilovolt (kV) Transmission Line project in Pierce County near Sumner, Washington. The new transmission line will be constructed by Puget Sound Energy (PSE) and will extend from the existing White River Substation south to a planned expansion of the existing Alderton Substation. The general alignment of the transmission line is shown on the Vicinity Map, Figure 1. The alignment is also shown in relation to surrounding physical features on the Site Plans, Figures 2 through 10.

These services are a continuation of our involvement on the project. We previously completed a route feasibility study for the project that was summarized in our report dated August 26, 2011. We also completed geotechnical engineering services for design of deep foundation support of structures along the alignment, the results of which have been summarized in our draft Geotechnical Engineering Services report issued September 12, 2014.

PROJECT DESCRIPTION

The project consists of a new 230 kV transmission line to be constructed over a total distance of approximately 8½ miles. The transmission corridor varies in width and will typically be approximately 50 feet wide centered on the proposed transmission line. The transmission line will be supported on a series of poles at 79 locations. The pole numbers range from 0/1 near the White River Substation in the north to Pole 8/4 near the planned expansion of the Alderton Substation to the south. The pole numbering system includes the alignment mile and the pole within that mile, accordingly, Pole 0/1 indicates mile zero, Pole 1. We understand Poles 0/1 through 8/3 will be steel monopoles, while Pole 8/4 will be a wood structure.

The north end of the line will tie into an existing dead-end tower (designated "WR Sub") that was constructed in 2009 within the southeastern portion of the White River Substation. The south end of the line will tie into a dead-end tower (designated "Ald Sub") to be constructed within the planned northward expansion of the Alderton Substation. The project alignment will include a number of running-angle poles, with the remaining poles being tangent poles.

Poles 0/1 through 0/9 will be located within an upland area, while Poles 0/10 through 3/7 and 3/10 through 8/4 will be located within the low-lying White River and Puyallup River valleys. Poles 3/8 and 3/9 will be within the toe of a southeast-facing hillside adjacent to the White River valley. The upland segment of the line will parallel several existing PSE wood pole transmission lines. The line will cross the White River between Poles 1/3 and 1/4, and again between Poles 4/2 and 4/3.

The line will cross the Puyallup River between Poles 4/5 and 4/6, then extend generally south along East Main Avenue, Shaw Road and Pioneer Way East. The line will continue east and then south along or next to the Foothills Trail (a paved Pierce County Parks recreational trail) from Pole 5/7 to Pole 8/4.

We have been tasked with assessing potential geologic hazards along the alignment in accordance with the 2004 Pierce County Code (PCC), City of Sumner Municipal Code (SMC), and City of Puyallup Municipal Code (PMC). The approximate project location is shown on the Vicinity Map, Figure 1. Details of the alignment including proposed pole locations and study corridor are shown on the Geohazard Assessment Figures 2 through 10.

PURPOSE AND SCOPE OF SERVICES

The purpose of our services is to provide a review of geologic conditions along the transmission line corridor and address PCC Title 18E, Development Regulations - Critical Areas, SMC Title 16.5, Landslide and Erosion Hazard Areas, and PMC 21.06, Critical Areas. The services provided by GeoEngineers, Inc. (GeoEngineers) specifically consist of the following tasks:

1. Review readily available geologic maps that include the proposed corridor, as well as the U.S. Department of Agriculture Soil Conservation Service soils map of Pierce County.
2. Perform a field reconnaissance to observe surface geology and slope conditions within the proposed corridor, including channel migration potential of the White and Puyallup Rivers.
3. Discuss our observations with you regarding our assessment of potential geologic hazards along the corridor and prepare this report presenting our review and opinion regarding potential geologic hazards at the site as defined by PCC Title 18E, Development Regulations - Critical Areas, SMC Title 16.5, Landslide and Erosion Hazard Areas, and PMC 21.06, Critical Areas.

GEOLOGY

Published geologic information in the vicinity of the project alignment includes a United States Geological Survey (USGS) map of the Lake Tapps quadrangle (Crandell, 1963).

Mapped geologic conditions in the upland portion of the alignment (Poles 0/1 through 0/9) include glacially consolidated Vashon till (map symbol: Qgt) and older glacial deposits, including undifferentiated glacial drift (Qg), the Salmon Springs drift (Qss), and the Puyallup formation (Qpy). These glacially consolidated soils typically consist of very compact, poorly sorted to sorted mixtures of clay, silt, sand, gravel and cobbles. These soils may include boulders of varying sizes. There are some less compact weathered zones near the ground surface.

Mapped geologic conditions in the White River valley and Puyallup River valley portions of the alignment (Poles 0/10 through 8/4, except Poles 3/8 and 3/9) generally consist of alluvium deposited by these rivers, and mudflow deposits that originated from Mt. Rainier. There are also areas of fill associated with roadway construction and general development along the valley portions of the alignment.

The alluvium is highly variable, and consists of silt, sandy silt, silty sand, sand and layers of peat and organic soil. Some of the alluvial soils contain gravel, cobbles, boulders and logs.

A mudflow deposit (Electron Mudflow, Qme) is mapped at the ground surface and overlies the alluvium in the southern portion of the alignment. An older mudflow deposit (Osceola Mudflow, Qmo) underlies the

alluvium along the valley portions of the alignment. The mudflow deposits typically consist of a loose to medium dense mixture of clay, silt, sand and gravel with cobbles, boulders, and logs.

Poles 3/8 and 3/9 are within an area mapped as Stuck drift (Qst) which consists of older, very dense glacial till. This till is similar in composition to the Vashon till described above, and also contains cobbles and boulders.

GEOLOGIC HAZARD AREAS REQUIREMENTS

This report was completed to satisfy requirements of the Critical Areas ordinances of all applicable jurisdictions, including the following:

- PCC Title 18E Development Regulations - Critical Areas pertaining to geologic hazards.
- SMC Title 16.50 through 16.54 and 16.58, Landslide, Erosion, Seismic, Volcanic, and Flood Hazard Areas.
- PMC Title 21.06.530, Critical Areas.

Definitions and applicable sections of County and Municipal codes satisfied by this report are presented in Appendix A. The geologic hazards identified in these ordinances and evaluated for this report include Mine, Seismic, Volcanic, Erosion, and Channel Migration Zone (CMZ) Hazard areas.

The jurisdictional applicable to each of the proposed pole locations along the project alignment was evaluated to determine the most stringent criteria against which to evaluate each location.

We considered geologic hazards along the project alignment by pole location within each jurisdiction (Table 1 below, and Figures 2 through 10). The City of Sumner does not recognize CMZs in their SMC; therefore we will assign Sumner CMZ boundaries to the jurisdiction of Pierce County. Joint jurisdictional authority may be required for similar county versus city code definition circumstances.

TABLE 1. JURISDICTIONAL AUTHORITY ALONG ALIGNMENT

Segment of Corridor (pole numbers)	Jurisdictional Authority	Notes
White River Substation to 0/7	PCC	
0/8 to 4/1	SMC	4/1 on Pierce County boundary
4/2	PCC	
4/3	SMC	
4/4 to 4/5	PCC	
4/6	PMC	Near (<50 feet) from Pierce County boundary
4/7 to 5/1	PCC	Near (<50 feet) from City of Puyallup boundary
5/2 to 5/3	PCC	
5/4	PCC	Near (<50 feet) from City of Puyallup boundary
5/5 to Alderton Substation	PCC	

SITE DESCRIPTION

General

The project alignment is located near Sumner in Pierce County, Washington, within Township 18 North, Range 1 East in sections: 19, 20, 28, 29, 32, and 33 of the Willamette Meridian (W.M.). The alignment extends through the following jurisdictions (from north to south): 1) unincorporated Pierce County, 2) the City of Sumner, 3) the City of Puyallup, and 4) unincorporated Pierce County. The project alignment extends from the White River Substation at the north end, to the west and down the east slope of the White River valley, south through Sumner to the Puyallup River valley, and eventually to the south end of the alignment at the Alderton Substation. Our site reconnaissance generally extended to as much as 300 feet to either side of the proposed alignment.

A more detailed description of surface conditions along various segments of the alignment is presented in the following sections.

Ground Surface

Upland Segment (Poles 0/1 to 0/9)

The upland segment of the alignment begins at an existing dead-end tower in the southeast portion of the White River Substation, which is northwest of the intersection of Lakeland Hills Way and 22nd Street East. The ground surface within the substation and in the vicinity of Poles 0/1 through 0/3 is approximately level and at about Elevation 635 to 640 feet (NAVD 88 datum). Surface material within the perimeter fence surrounding the substation consists of crushed rock yard surfacing. Vegetation outside of the perimeter fence consists primarily of brush and tall grass. A large residential subdivision is located along the south edge of the substation property.

The alignment extends east from the dead end tower to Pole 0/1 then south to Pole 0/2 near where it crosses the gravel-surfaced entrance drive to the substation. It also crosses the White River flume, a buried concrete pipe that conveys water west from Lake Tapps down to the former Dieringer power plant along East Valley Highway. These facilities were formerly owned by PSE but are now owned by the Cascade Water Alliance.

The alignment then turns west and parallels the White River flume and a series of existing wood pole transmission lines, some of which originate at the substation. This portion of the alignment is accessed by a series of dirt roads. Vegetation along this portion of the alignment consists of brush, and small deciduous and evergreen trees.

The ground surface along the alignment slopes down the east wall of the White River valley from the vicinity of Pole 0/3 to the valley floor west of Pole 0/9. The general slope inclination is about 15 to 20 percent, with locally steeper portions inclined up to 40 percent. There is a total elevation change of about 575 feet from the White River Substation to the valley floor.

White River Valley Segment (Poles 0/10 to 4/3)

The alignment crosses East Valley Highway between Poles 0/9 and 0/10 and remains in the White River valley to Pole 4/3 near downtown Sumner. Topography along this segment of the alignment

is relatively level, except where fill embankments and the White River channel are crossed. The ground surface within this segment of the alignment is generally between Elevation 50 to 60 feet.

From Pole 0/10 to Pole 1/1, the alignment crosses fields with tall grass, the northwest corner of the PSE North Tacoma gate station (a gas transmission facility), and railroad tracks. From Pole 1/1 to Pole 1/3, the alignment extends along the south side of the right-of-way for 24th Street East, and crosses the White River channel between Poles 1/3 and 1/4.

At Pole 1/5, the alignment turns south and extends through the Sumner Industrial Park area, paralleling the west side of 142nd Avenue East. Many of the pole locations along 142nd Avenue East are within landscaped areas between the roadway and paved areas for adjacent warehouses and trucking facilities.

At Pole 3/3, the alignment turns southwest across a small field and a drainage ditch to Pole 3/4. It then turns south and extends along the west edge of a level, grass pasture and parallel to Union Pacific Railroad (UPRR) tracks. The alignment crosses the tracks between Poles 3/6 and 3/7, and crosses West Valley Highway East between Poles 3/7 and 3/8. State Route (SR) 167 parallels the alignment from Pole 3/4 to about Pole 3/10.

Poles 3/8 and 3/9 are located along the base of a southeast-facing hillside. The pole locations are on a bench about 5 to 10 feet above the level of West Valley Highway East. A map accompanying right-of-entry documents from the UPRR indicates that the area around Poles 3/8 and 3/9 was formerly a gravel pit; the area is now developed with roadways, parking areas and buildings.

Poles 3/10 through 4/2 are located within commercial properties. This segment of the alignment crosses Sumner Heights Drive East and Valley Avenue East, then parallels the west side of Houston Road East. The alignment turns south at Pole 4/2 and again crosses the White River channel.

Pole 4/3 is located along the south side of State Street near downtown Sumner. The alignment crosses SR 410 south of Pole 4/3 and extends across City of Sumner wastewater treatment plant property to Pole 4/4 in the Puyallup River valley segment. The confluence of the White and Puyallup Rivers is located just west of the treatment plant.

Puyallup River Valley Segment (Poles 4/4 to 8/4)

Poles 4/4 and 4/5 will be located in a level area southeast of the treatment plant and adjacent to the northeast side of the Puyallup River. The ground surface in this area is covered with grass, deciduous trees and some brush.

The alignment crosses the Puyallup River between Poles 4/5 and 4/6, and remains in the Puyallup River valley to Pole 8/4 near the Alderton Substation. Topography along this segment of the alignment is relatively level, except where fill embankments and the Puyallup River channel are crossed. The ground surface within this segment of the alignment is generally between Elevation 65 to 110 feet.

Pole 4/6 is located within a paved trailhead parking area along the south bank of the river. The alignment continues south and crosses East Main Avenue to Pole 4/7, then extends southwest along railroad tracks and the edge of a level, cultivated field. At Pole 5/1, the alignment turns south, paralleling the east side of Shaw Road and extending along cultivated fields and small wetlands.

At Pole 5/4, the alignment turns east and extends along Pioneer Way East and along the south edge of cultivated fields. The alignment crosses 134th Avenue East near Pole 5/6, and continues east to meet the Foothills Trail starting near Pole 5/7. The trail is a paved recreational trail that parallels a railroad grade (Meeker Southern Railroad) to and beyond the Alderton Substation. The ground surface along the trail is relatively level and vegetated with thick brush, tall grass and, in places, small deciduous and evergreen trees. The trail also extends along identified wetlands and various cultivated fields.

The alignment curves to the south between Poles 6/2 and 6/5, near the crossing of Pioneer Way East. It then follows the Foothills Trail to Pole 7/5, crossing 96th Street East between Poles 7/1 and 7/2. At Pole 7/5, the alignment meets and crosses the right-of-way for Bonneville Power Administration (BPA) lines, and turns to the southwest across cultivated fields and a tree farm. The alignment turns to the south at Pole 7/8 and continues to Pole 8/3, where it makes an eastward jog to Pole 8/4, then south to a dead end tower to be constructed within the future addition to the Alderton Substation.

SUMMARY OF MAPPED GEOLOGIC HAZARDS

General

We completed a desktop study of geological hazards as well as a geologic reconnaissance to evaluate slopes and landslide hazard areas, and areas within potential CMZs along the proposed transmission line alignment. Our slope and landslide hazard reconnaissance of the upland segment was completed February 17, 2012 and our CMZ areas reconnaissance was completed June 17 and 18, 2014. We discuss landslide, erosion including CMZs, seismic and volcanic hazards in the following section of the report.

Landslide Hazards

We completed a desktop study and reconnaissance to evaluate landslide hazards. Table 2 provides a preliminary screening of landslide hazards based on slope gradient.

TABLE 2. GENERALIZED SLOPE AND GEOLOGY ALONG ALIGNMENT

Segment of Corridor (pole numbers)	General Terrain	Observed Slope Inclination(s)	Mapped geology
0/1 to 0/3	Level	Less than 5 percent	Continental Glacial Till – Fraser Age
0/4	Moderate slope	10 to 30 percent	Continental Glacial Till – Fraser Age
0/5 to 0/6	Level to sloping	Less than 15 percent	Continental Glacial Till – Fraser Age
0/7	Steep slope	20 to 40 percent	Continental Glacial Drift – Fraser Age
0/8	Level to sloping	Less than 15 percent	Continental Glacial Drift – Fraser Age
0/9	Steep slope	Adjacent to slopes steeper than 40 percent	Continental Glacial Drift – Fraser Age
0/10 to 0/11	Level	Less than 5 percent	Peat Deposits
1/1 to 6/5;	Level, isolated slopes less than 10 feet high	0 to 40 percent	Alluvium
6/6; 6/8 to 7/2	Level, isolated slopes less than 10 feet high	Less than 20 percent	Lahars
6/7; 7/3 to 8/4	Level, isolated slopes less than 10 feet high	Less than 20 percent	Alluvium

None of the proposed pole locations are situated on slopes that transition from permeable geologic units to low permeability geologic units. We observed no indications of slope movement in the proposed pole locations at the time of our reconnaissance. Pole 0/9 is located within 50 feet of slopes that area greater than 40 percent and we recommend construction activities including staging of equipment are limited to slopes that are inclined at 20 percent or less.

Is it therefore our opinion that no poles are located in landslide hazard areas that are at risk of slope movement.

Mapped Mine Hazard Areas

No proposed pole locations are identified within areas of previous coal mining activities following review of Washington State Department of Natural Resources coal mine map viewer (2014).

Seismic Hazard Area

We reviewed Pierce County's Liquefaction Hazard Map (Pierce County, April 4, 2011) and digital mapping for Washington (Palmer and others, 2004). The generalized liquefaction susceptibility is presented in Table 3.

TABLE 3. GENERALIZED LIQUEFACTION SUSCEPTIBILITY

Segment of Corridor (pole numbers)	Indicated Liquefaction Hazard
0/1 to 0/9	N/A
0/10 to 1/2	Moderate to High
1/3 to 1/4	High
1/5 to 4/1	Moderate to High
4/2 to 5/5	High
5/6 to 8/4	Moderate to High

Site specific pole evaluation for design to address liquefaction and lateral spreading potential have been addressed in our draft Geotechnical Design Report issued September 12, 2014. A summary of hazards described in the seismic portion of the Geotechnical Design Report is provided below.

Surface Fault Rupture

Based on our knowledge of regional geology along the alignment and the substantial thickness of glacial and postglacial sediments beneath the upland and river valley portions of the alignment, we conclude that the potential for surface fault rupture is remote.

Liquefaction Potential

Liquefaction refers to a condition where vibration or shaking of the ground, usually during earthquakes, causes development of excess pore water pressures in saturated soils and subsequent loss of strength in a soil unit so affected. In general, soils that are susceptible to liquefaction include loose to medium dense "clean" to silty sand and soft to stiff sandy silt, which are below the groundwater level.

The map, "Liquefaction Susceptibility for the Sumner Quadrangle, Washington" (Dragovich and Pringle, 1995) indicates that the alluvial and Electron Mudflow soils, where they occur at or close to the ground surface in the White River and Puyallup River valley segments of the alignment, are Category I, High Liquefaction Susceptibility. Osceola Mudflow deposits, where they occur at or near the ground surface, are mapped as Category III, Low Liquefaction Susceptibility. This is attributable to drying and formation of a crust in the deposits.

An accompanying report to the map includes a section by Stephen Palmer titled, "Liquefaction Analysis of Soil Deposits Found in the Sumner Quadrangle." Palmer evaluated the liquefaction susceptibility of the deeper Osceola Mudflow deposits and concluded that they may also be susceptible to liquefaction. The report also describes surface features (such as sand boils) related to occurrences of liquefaction in the Sumner area during the 1949 and 1965 earthquakes.

The soils within the upland segment of the alignment and at Poles 3/8 and 3/9 are typically in a dense to very dense condition and are not considered liquefiable.

The evaluation of liquefaction potential is a complex procedure and is dependent on numerous site parameters, including soil grain size, soil density, site geometry, static stress and the design ground acceleration. Typically, the liquefaction potential of a site is evaluated by comparing the cyclic stress

ratio (CSR), which is the ratio of the cyclic shear stress induced by an earthquake to the initial effective overburden stress) to the cyclic resistance ratio (CRR), which is the soil resistance to liquefaction).

Estimation of the CSR and the CRR were completed using empirical methods (Youd, et al., 2001). Estimated ground settlement resulting from earthquake-induced liquefaction was analyzed using empirical procedures based on correlations from the standard penetration test (SPT) results (Tokimatsu and Seed, 1987; Ishihara and Yoshimine, 1992).

We have completed liquefaction analyses on the alluvial and mudflow soils encountered in the White River and Puyallup River valley segments of the alignment based on the results of the explorations and laboratory tests. We concluded that portions of the alluvial and mudflow deposits could be liquefiable.

We evaluated liquefaction hazards (including settlement and related effects) when the factor of safety against liquefaction was calculated as less than 1.0. In our analyses, we used a design earthquake of magnitude 7.0 based on the USGS interactive deaggregation model, and a design ground acceleration of 0.45g at the ground surface, estimated using Section 1613 of the 2012 IBC and ASCE 7-10. Based on our analyses, we estimate that liquefaction-induced ground settlement in the White River and Puyallup River valley on the order of ½ to 1½ feet could occur during the design earthquake.

Our foundation design recommendations include consideration of potential downdrag effects on deep foundations during the design earthquake. Also, our recommended soil input parameters for lateral load design consider the effects of liquefaction through the application of p-multipliers for LPILE parameters.

Lateral Spreading

Lateral spreading involves lateral displacements of large volumes of liquefied soil. Lateral spreading can occur on near-level-ground as blocks of surface soils are displaced toward a nearby slope of free-face such as a riverbank by movement of the underlying liquefied soil. Flow failures occur when soil liquefies and flows by gravity without further seismic input. The near-surface soils at the proposed pole locations which are near the White and Puyallup River channels include potentially liquefiable alluvial soils.

Poles 1/3, 1/4, 2/9 through 3/5, 4/1 through 4/3 are located within 300 feet of the White River bank, and Poles 4/5 and 4/6 are located within 300 feet of the Puyallup River bank. Poles 3/3, 3/5, 4/1 and 4/2 are within about 100 feet of the bank of the White River. We estimate the vertical distance from the top of the river banks to the bottom of the channels to be on the order of 20 feet.

We completed a typical lateral spread analysis in accordance with the empirical methodology developed by Youd, Hansen and Bartlett (2002) and a traditional lateral spreading analysis using slope stability methods and estimated strength values based on our explorations and laboratory testing. The vertical face (height of river bank) to horizontal distance ratio for these poles is on the order of 1:5 to 1:20. To evaluate the risk of lateral spreading, we performed a slope stability analysis and Newmark displacement analysis. Based on our analysis, it is our opinion that the risk of lateral spreading affecting foundations for Poles 1/3, 1/4, 2/9 through 3/2, 3/4, 4/3, 4/5 and 4/6 is low, while the risk for Poles 3/3, 3/5, 4/1 and 4/2 is moderate to high. We therefore recommend that foundation design for these four poles include the potential effects of additional lateral loads imposed by lateral spreading.

Volcanic Hazard Areas

Volcanic hazard areas are areas subject to pyroclastic flows, lava flows, and inundation by lahars, debris flows, or related flooding resulting from geologic and volcanic events on Mount Rainier specifically within the Puyallup and to a lesser extent the White River. Volcanic hazard areas are those areas that, in the recent geologic past, have been inundated by a Case I, Case II, or Case III (as classified by Pierce County) lahars or other types of debris flow, or have been affected by pyroclastic flows, pyroclastic surges, lava flows, or ballistic projectiles as classified within the PCC code published by the USGS, Revised 1998: USGS Open-File Report 98-428. Volcanic hazard areas also include areas that have not been affected recently, but could be affected by future such events. Volcanic hazard areas are classified into the following categories:

1. **Inundation Zone for Case I Lahars.** Areas that could be affected by cohesive lahars that originate as enormous avalanches of weak chemically altered rock from the volcano. Case I lahars can occur with or without eruptive activity. The average reoccurrence rate for Case I lahars on Mount Rainier is about 500 to 1,000 years.
2. **Inundation Zone for Case II Lahars.** Areas that could be affected by relatively large non-cohesive lahars, which most commonly are caused by the melting of snow and glacier ice by hot rock fragments during an eruption, but which can also have a non-eruptive origin. The average time interval between Case II lahars from Mount Rainier is near the lower end of the 100- to 500-year range, making these flows analogous to the so-called "100-year flood" commonly considered in engineering practice.
3. **Inundation Zone for Case III Lahars.** Areas that could be affected by moderately large debris avalanches or small non-cohesive lahars, glacial outburst floods, or other types of debris flow, all of non-eruptive origin. The average time interval between Case III lahars at Mount Rainier is about 1 to 100 years.
4. **Pyroclastic-Flow Hazard Zone.** Areas that could be affected by pyroclastic flows, pyroclastic surges, lava flows, and ballistic projectiles in future eruptions. During any single eruption, some drainages may be unaffected by any of these phenomena, while other drainages are affected by some or all phenomena. The average time interval between eruptions of Mount Rainier is about 100 to 1,000 years.

Our review of mapping by the USGS (1998) indicates that poles 0/11 to 8/4 are within potential inundation zones for Case I and II lahar hazards. While there is a risk to poles in the event of a Case I or II lahar does occur it is not feasible to avoid or mitigate the lahar hazard for this project. Poles 0/1 to 0/10 are not within mapped lahar hazard areas and the overall project is not mapped within a Pyroclastic-Flow Hazard Zone.

Erosion Hazards

GeoEngineers evaluated erosion and riverine hazards in accordance with erosion hazard area review requirements of PCC 18E.70.020 B.4 for the proposed transmission line alignment. The project includes only one localized area between Poles 0/9 and 0/10 that includes City of Sumner "very severe erosion soils" as identified in U.S. Department of Agriculture Natural Resources Conservation Service Soil mapping (2014) as shown on Figure 2.

Channel Migration Zone Evaluation

We completed a CMZ reconnaissance in the vicinity of proposed pole locations 1/3, 3/3, 3/4, 3/5, 4/2, 4/3, 4/4, 4/5 and 4/6 on June 18th and 19th, 2014 that are in proximity of CMZs as shown in Figures 3, 5, and 6. For CMZ evaluation purposes, we use the White River and Puyallup River segments subdivided to pole locations that include Pole 1/3 (White River), Poles 3/3 to 3/5 (White River), Poles 4/2 to 4/3 (White River) and Poles 4/5 to 4/6 (Puyallup River).

While on site during our reconnaissance, we looked for indications of erosion hazards as defined by PCC 18E.70.020 B.4. For the purpose of this report, we assessed whether channel migration will potentially influence the proposed transmission line in the next five years. The five year time period is pursuant to PCC 18E.110.030 (Erosion Hazard Area Review Procedures), where:

"A geologic assessment for a specific site may be valid for a period of up to five years when the proposed land use activity and site conditions are unchanged."

GeoEngineers delineated a CMZ along portions of the White and Puyallup Rivers for Pierce County in 2003. The CMZ delineated in 2003 is shown on Figures 3, 5 and 6. The delineation included a severe CMZ, based on: 1) the historic channel occupancy tract (HCOT), as determined by the results of an aerial photographic evaluation (from 1931 to 1998) and 2) an area representing the distance the channel could travel in five years of steady lateral migration from the outside boundary of the HCOT. The maximum rate of migration for each geomorphic reach was used in the calculation (GeoEngineers 2003). The effect of river channel levees on channel migration was not included in the 2003 analysis, an important factor when considering the likelihood of channel migration in the project lifetime. Construction of levees and revetments, and channel straightening, dredging, and gravel mining on the lower Puyallup and White Rivers over the past four decades have changed the geomorphic processes operating on the river systems. Therefore, the analysis that delineated areas as low, moderate, or severe CMZ hazard areas, reflects un-confined channel processes that were active prior to basin development and are not directly applicable to the present channel character. Our field observations are presented below. Following the description of our observations, we provide a reach characterization and discussion of channel migration findings that consider the CMZs delineation from the 2003 study and a discussion of the applicability of that CMZ to this project.

Geomorphic features relevant to channel migration observed during our reconnaissance are also shown on Figures 3, 5 and 6. Geomorphic and geologic characteristics are listed with their pole segments in Table 3. These characteristics were utilized to deduce potential channel migration influences on the proposed pole segments. We observed three areas of bank erosion along the channel near a few pole locations, as evidenced by bare or slumping soils or downed trees or exposed tree roots. We also observed four areas with bank protection consisting of boulder-sized riprap. Levees generally surround the White and Puyallup Rivers, mitigating lateral migration caused by bank erosion. Areas with poles adjacent to river channels were measured for slope, examined for geologic material and probed for depth to refusal. Each segment of the transmission alignment where CMZs are present is described below. Location of each pole is shown on Figures 3, 5 and 6.

Sediment from glacial sources and discharge regimes drives channel response in the Puyallup and White River basins. The following descriptions provide an overview of channel migration and relevant components to channel migration for the project alignment.

Channel Migration

Channels meander into erodible sediments on the outside of a bend; depositing material on the inside, an example of lateral migration. The channel meanders back and forth across its down-valley axis, or meander belt. Channels can be influenced by translation migration, the down valley movement of meander bends when bank erosion in meander bends exists at the outer bank between the bend apex and the downstream crossing. Channel migration is primarily controlled by valley width, sediment supply, and the combination of channel gradient and discharge (stream power). The area of most pronounced migration usually occurs where flow converges against the outer bank near the downstream end of a bend, resulting in simultaneous lateral and downstream migration or translation of the bend. Existing levees protect against substantial channel migration in the White and Puyallup River channel of the project area, but localized areas of bank erosion can locally impact levee function. We note that the CMZ study by GeoEngineers in 2003 developed a CMZ now used by the county. The CMZ was developed with the simplifying assumption that the Puyallup and White Rivers were not confined by levees and channel migration could occur based on the active geomorphic processes without interference. This regional view took into account that levees and local bank protections may receive infrequent maintenance that could impact their effectiveness on a regional scale. Therefore actual local site conditions and the potential for channel migration should consider local levee and bank protection (rip rap, etc.) when evaluating impacts to a specific site.

Channel Avulsion

Avulsion is the abrupt relocation of an active channel to a new location within the river corridor or across the floodplain. This process usually occurs in response to sudden infilling of the active channel by sediment or debris (typically during flood events), diverting stream flow onto the floodplain and causing the erosion of a new channel or reoccupation of a formerly abandoned channel. Avulsion is more common in low gradient meander bend reaches, wherein a highly sinuous, meander bend is cut off at the neck. Avulsions are unlikely in the project area due to its constriction by levees.

Bar Formation

Sediment deposition and bar development occurs when sediment loading exceeds the transport capacity of the flow, a channel response to the watershed contributions. Under these conditions, sediment can deposit along the inside bank of meander bends or on the channel as flow velocities dissipate. Sediment accumulated in mid-channel bars deflects flows away from the bar, often towards banks, where banks can be eroded. Sediment accumulated in lateral bars deflects flows towards the opposite bank. Bars in the Puyallup River have direct influence on channel behavior and its role on channel migration.

Logjams

Logjams are built by windthrow, avulsions, and lateral bank erosion. Bank erosion recruits riparian forests that accumulate within areas of deposition. Logjams form and alter local channel conditions, such as forming upstream bars that develop into mid-channel islands. Logjam formation has consequential effects on Puyallup and White River channel migration patterns.

Alluvial terrace

An alluvial terrace is built once migration causes a river channel to vacate from its former position. This terrace is composed of loosely deposited alluvium. They are elongated in nature and separate the channel floor from the non-riverine uplands or an abandoned, older (paleo) terrace. There are several alluvial terraces in both White and Puyallup River segment corridors.

Knickpoint

A knickpoint is an abrupt change in elevation between lower gradient sections. Knickpoints can be produced in a variety of ways, e.g. sudden base level change, tectonic deformation or main stem incision which sends an incisional pulse upstream into its tributaries. Knickpoint migration or propagation can provide a link between main stem and tributary incision which illustrates basin scale responses to base level or tectonic change. Research has shown that knickpoint propagation will continue upstream until the channel is too steep to support the knickpoint, at which point debris flow scour will control channel incision (Seidle 1993). A possible knickpoint influences channel behavior between Poles 4/5 and 4/6.

Conditions at Proposed Transmission Line Segments

GeoEngineers evaluated local channel characteristics for migration potential in the vicinity of the proposed pole locations within the identified CMZs. Field observations were compared against the 2003 CMZ boundary (Figures 3, 5 and 6). River channel and floodplain characteristics were evaluated for their influence on channel behavior adjacent to the proposed pole locations. The river channel bedforms (riffles, pools, etc.), bed composition (substrate) and density of the bed and banks soils were examined in the field. River banks were evaluated for composition and armoring. Most of the White River banks are constricted by a historic levee revetment composed of silt and sand fill that was constructed during prior river dredging events. These characteristics are summarized in Table 3 and shown on Figures 3, 5 and 6.

TABLE 3. GENERALIZED CHANNEL MORPHOLOGY ALONG SEGMENT OF CORRIDOR

Segment of Corridor (pole numbers)	Bed and Bar Conditions	Bank Conditions	Location in Planform	Pole location relative to Mapped CMZ Boundary	Mapped surficial geology
1/3 to 1/4	Uniform width and depth Sediment accretion towards left bank	Leveed. Fine-grained soils. Less than 5% slope	Pole 1/3 left bank side Pole 1/4 right bank side Inside of bend of ~2,000 foot meander	Pole 1/3 at edge of boundary Pole 1/4 290 feet from boundary	Alluvium
3/3 to 3/5	Uniform width and depth No bars Sediment accretion towards right bank	Leveed. Undercutting 2:1 slope	Right bank side Poles 3/4 and 3/5 located downstream end of meander	Pole 3/3 55 feet Pole 3/4 260 feet Pole 3/5 90 feet from boundary	Alluvium and Peat Deposits
4/2 to 4/3	Uniform width and depth No bars Sediment accretion towards right bank	Leveed. 1:1 slope bank erosion undercutting	Downstream of 750 foot wide meander bend 4/2 right bank side 4/3 left bank side	Pole 4/2 65 feet from boundary Pole 4/3 120 feet from boundary	Alluvium and Glacial till
4/4 and 4/5 to 4/6	Lateral and mid-channel cobble bars Sediment accretion towards left bank	Leveed. 1:1 slope Riprap on left and right bank (Main St. Bridge) 30-40% slope on right bank near Pole 4/5	4/5 right bank side 4/6 left bank side	Pole 4/4 is located within 100 feet of the boundary. Poles 4/5 and 4/6 are located within the boundary	Alluvium

We considered channel behavior by how it responds to watershed conditions, including its sediment and discharge regime. Cobble bar substrate sizes and deposition patterns were evaluated for their influence on channel behavior. We inventoried individual pieces of large wood and log jams or any other obstruction that influenced channel behavior. We also conducted a desktop study of CMZ reports (GeoEngineers 2003) and the relevant geographic information system (GIS) data (primarily using available LiDAR and aerial photographs). The desktop study complemented our field reconnaissance to determine migration potential in the vicinity of the proposed pole locations.

The White and Puyallup Rivers in our project alignment are constricted by state or federally regulated levees. Proposed utility pole locations will be exempt from building restrictions in a mapped CMZs; therefore our findings will guide modifications to help mitigate for potential channel migration.

The following describes our field and desktop observations and channel migration characterizations at segments of the proposed transmission line alignment. Local conditions such as bed, bar and bank conditions are summarized first for each pole along the transmission line corridor. The condition summaries are followed by a channel characterization and channel migration influence on proposed pole locations.

Poles 1/3 to 1/4

Site Conditions

This segment of the alignment crosses the White River near Sumner at river mile 3.3 (Figure 3) at about the apex of a meander bend. Poles 1/3 and 1/4 are located landward of the right and left banks, respectively. Pole 1/3 is located on the inside of the meander bend, while pole 1/4 is located on the outside of the meander bend. The bed of the White River channel include a slope at approximately 0.1 percent, with uniform depth channel at this transmission line crossing (Table 3, Photo B-1).

Banks are sandy in the vicinity of Pole 1/3 (Photo B-2). No bank armoring was detected on either side of the channel. Soils are very dense in the vicinity of Pole 1/4, probing to less than 2 inches.

Reach Characteristics and Channel Migration Findings

Slight changes in bank positions were documented over available photograph record (c. 1931) in the vicinity of Pole 1/4. Between 1931 and 1940 the meander bend shifted southwest towards the right bank and Pole 1/4 location. The channel remained in the same relative position on its right bank since the 1930s era shift. Pole 1/4 is out of the mapped CMZ because of the levees constricting migration over the available photograph record (c. 1931).

Pole 1/3 is located on the pointbar of the meander bend, on the accretionary side of the channel (Figure 3). Point bars accumulate sediment, rather than erode. There is no levee protecting the banks of the inside of the bend in near Pole 1/3 (Figure 3). Pole 1/3 is within the area mapped as a severe CMZ. Its inclusion in the CMZ is the result of upstream river avulsion potential during an episodic high sediment and discharge event. LiDAR interpretation suggests that the channel has occupied the point bar in the past. The channel constriction at the upstream of the meander bend likely prevents from such avulsions onto the point bar.

We observed no channel migration over the available historic photograph record. Because of the constriction by levees, it is our opinion that Poles 1/3 and 1/4 will not be influenced by channel migration in the next five years.

Poles 3/3 to 3/5

Site Conditions

The poles along this segment of the transmission line corridor are located on the right bank of the White River (Figure 6). These pole locations are situated on a gentle gradient paleo terrace (Table 3). The terrace is overgrown with invasive thistles and tall grasses. The edge of the right bank is about 130 feet from the Pole 3/3. The soil on the terrace is brown silt to silty sand at Pole 3/3. The depth to refusal while probing is 10 inches on the terrace. There is no observable evidence of a high flow channel or historic channel occupancy. Pole 3/4 is located on a flat grass pasture near the base of rail road ballast on the same terrace. Pole 3/4 is located about 200 feet from the right bank of the White River

channel. Pole 3/5 is bounded between railroad ballast 60 feet to the east, and the White River bank top 60 feet to the west.

The active channel of the White River bordering this segment of the transmission alignment is approximately 80 feet wide with a 0.2 percent slope. The thalweg is positioned towards the right bank. High flows during the June 18th field visited prohibited bed composition observations along this segment of the transmission line alignment.

The right bank waterward of Pole 3/3 is 6 feet above the wetted width at a 2H:1V slope. The bank slopes an additional 4 feet above the bank top. Slight bank erosion is evident from undercutting (Photo B-3) and an exposed rootwad. There is no armoring or revetment visible on either bank. The right bank is composed of fine sand with silt with an approximate 1H:1V slope. There is exposed soil on the lower 3 to 4 feet of the bank near the bank toe. A 10- to12-foot high bank rises from the channel about 200 feet waterward of Pole 3/4. A tributary contributes flow immediately upstream from Pole 3/4. Riprap is on the opposite bank from Pole 3/4 (Figure 5). Two banks separate the White River channel from Pole 3/5. The channel bank is composed of fine sand with silt. The bank is 8 to 10 feet in height, undercut with bowed trees and roots (Photo B-4). A second bank lies above an alluvial terrace. The bank is composed of silt with gravels. The opposite bank from Pole 3/5 has bare soil exposure - up to 15 feet above the wetted width (Photo B-5).

Reach characteristics and channel migration findings

The poles in this segment of the transmission line alignment are outside of the mapped severe CMZ. The White River channel has not occupied the pole locations over the available aerial photograph record (*c.* 1931). This bend has been locked in place over the duration of the photo record by a system of levees. Pole 3/3 is situated at the upstream end of a meander bend. We did not observe evidence of channel movement in the vicinity of Pole 3/3 over the past 10 years. It is our opinion that Pole 3/3 will not be influenced by channel migration hazards over the next five years.

Erodible soils along the banks near Pole 3/4 (Photo B-4) has not caused channel movement over the past 10 years. The levee system prevents migration into the vicinity of pole 3/4. We do not expect channel migration to influence Pole 3/4 in the next five years.

Pole 3/5 lies immediately downstream from the apex of a meander bend. This pole is positioned near the downstream end of the bend, typically the most pronounced area of migration (GeoEngineers 2003). However, based on aerial photograph review there has been little channel movement over the past 80 years. There has been no notable channel movement over the past 10 years, withstanding the major large flows of 2006 and 2009. The channel likely tops its banks during effective discharge events and occupies the alluvial terrace, only to be constricted by the levee. Following historic aerial photograph and LiDAR review, there is no evidence of historic channel migration landward of levees. It is our opinion that the White River channel is not likely to migrate to the location of Pole 3/5 in the next five years because of the levee system.

Poles 4/2 to 4/3

Site Conditions

The White River crosses this segment of the transmission line corridor approximately 1,500 feet upstream from the confluence with the Puyallup River (Figure 6). As the White River approaches the Puyallup River in this segment, the channel slope is negligible at approximately less than 1 percent.

The thalweg appears to be on the right bank in an otherwise uniform depth channel floor. Pole 4/2 is located about 80 feet from the right ban of the White River. The White River channel at bankfull has a width of 120 feet near Pole 4/2. Pole 4/3 location lies about 200 feet from the left bank of the White River channel. The bed is fine sand without any surface agitation. We observed downed trees and a small logjam on the right bank (Figure 6 and Photo B-6).

The right bank of the White River near Pole 4/2 contains a moderate 2.5H:1V slope. An alluvial terrace resides atop the right bank, about 10 feet from the edge of wetted channel. We probed to 1.5 feet to refusal on the terrace. The terrace is 10 to 15 feet distance to the base of the 2:1 sloped road prism. Bank undercutting was observed on the right bank of the White River about 20 feet upstream from Pole 4/2 in the form of exposed tree roots. The White River banks are covered in blackberry thicket down-slope from Pole 4/3. A steep 1:1 slope bank rises from the channel floor before gradually tapering off near the crest. There are riprap boulders on the opposite bank (right) from Pole 4/3.

Reach Characteristics and Channel Migration Findings

The uniform width and depth channel between Poles 4/2 and 4/3 is caused by years of channel modification for flood control. The channel is leveed and has not migrated over the available photograph record (*c*. 1931). We did not observe any channel movement over the past ten years. Given the proximity of the Pole 4/2 and 4/3 to the channel and the intact levee system, it is our opinion that these poles will not likely be impacted by channel migration over the next five years.

Poles 4/4 and 4/5 to 4/6

Site Conditions

This segment of the transmission alignment is located within the mapped 2003 severe CMZ boundary (Figure 6). However, the "severe" designation does not account for the construction and management of levees and revetments and channel straightening that have altered the river channel behavior in this area. According to our 2003 CMZ analysis, the reach of the Puyallup River that includes pole 4/4 through 4/6 locations is completely confined by levees and reinforced revetments that restrict the river to a generally straight, northwest-trending channel. These confining structures have increased the channel gradient, the channel has become incised, and this reach now serves primarily as a sediment transport reach. The geomorphic evaluation for this reach concludes, "The degree of entrenchment indicates that the channel is detached from its floodplain, and can no longer migrate laterally." Ongoing levee and channel maintenance should be expected to protect infrastructure in this area. Furthermore, the segment of the transmission alignment lies in the middle of a nearly 4,000 foot long meander bend of a levee-controlled reach of the Puyallup River. We describe conditions for Poles 4/4 and 4/5 together as they are on the same side of the river (right bank). The poles in this segment are positioned immediately downstream of the Main Street bridge and Burlington Northern Santa Fe railroad bridge crossing (Figure 6). Pole 4/4 is located somewhat downstream and outside of the mapped CMZ, however the location is within a similar geologic unit (alluvium) and relatively low-lying paleo terrace. Pole 4/5 is situated on a floodplain terrace about 15 to 20 feet higher than the Puyallup River top of bank on its right bank and within the 2003 CMZ boundary which is shown in Figure 6. Pole 4/6 is also mapped in the CMZ boundary, lies about 40 feet adjacent to the edge of bank and approximately 25 feet higher than the top of left bank of the Puyallup River.

The active channel separating Poles 4/5 and 4/6 is approximately 80 feet wide, with the majority of flow capacity situated on the left bank side of the a cobble bar, approximately 1,500 feet in length, situated

near the right bank. This is primarily a lateral bar, but does contain a saturated overflow channel towards the right bank (Appendix B Photo B-7). Bar composition is well-armored, probing is generally less than 1 inch into resistant cobble deposits. The channel floor bed is composed of cobble and gravels, with occasional boulders. This substrate is loosely deposited with no signs of embeddedness. There is a logjam accumulating logs on the right side of the lateral bar at the toe of the right bank (Figure 6, Photo B-8).

The right bank near Pole 4/5 has a slope of approximately 30 to 40 percent. Bank composition is soft silt with sand. We probed to 1.5 feet in the right bank. The banks near Pole 4/6 are 1:1 slope and are armored with riprap (Figure 6, Photo B-9). Downstream of the riprap the bank is composed of cohesive silt.

Reach Characterization and Channel Migration Findings

This segment of the transmission alignment is located within the mapped 2003 severe CMZ boundary (Figure 6). However, the "severe" designation does not account for the construction and management of levees and revetments and channel straightening that have altered the river channel behavior in this area. According to our 2003 CMZ analysis, the reach of the Puyallup River that includes pole 4/4 through 4/6 locations is completely confined by levees and reinforced revetments that restrict the river to a generally straight, northwest-trending channel. These confining structures have increased the channel gradient, the channel has become incised, and this reach now serves primarily as a sediment transport reach. The geomorphic evaluation for this reach concludes, "The degree of entrenchment indicates that the channel is detached from its floodplain, and can no longer migrate laterally." Ongoing levee and channel maintenance should be expected to protect infrastructure in this area.

The long, cobble-surfaced lateral bar has been present in the channel for at least the past 80 years. The channel and bar forms are dynamic features and therefore a wide CMZ was assigned in previous work. The bar has spent time during the 1940s as more of a mid-channel bar position. In the 1940s the channel flowed in the approximate location of Pole 4/5. The bar appears to currently direct sediment and discharge towards the left bank, evidenced by the bifurcated cross channels near the head of the bar. We observed no bank erosion within the leveed segment of the channel over the past ten years of review of aerial photographs. A knickpoint (Figure 6, photo B-7) is present upstream of the bar head and is potentially propagating upstream, lowering the bed elevation as it moves upstream while causing channel instability. The channel instability results from increased incision in the main channel, leading to steepening banks with the potential of undercutting.

The Railway Bridge and Main Street Bridge act as a pinch point, directing the Puyallup River into its confined channel and eliminating opportunity to flow or migrate beyond its leveed banks downstream. No avulsion has occurred in this segment over the available photograph record (*c*. 1931).

Pole 4/4 is sufficiently north and outside of the CMZ and within close proximity to existing infrastructure including SR 410 and the Sumner Water Treatment plant that it is our opinion that the pole is not at risk for channel migration.

The two poles 4/5 and 4/6 in this segment fall under slightly different channel migration scenarios. It should be noted that no channel migration was observed in the vicinity of either proposed pole location for the past 70 years (since the 1940s). In our opinion, the Main Street Bridge located 400 feet upstream and the presence of rip rap along the bridge abutments reduce the risk of migration toward

Pole 4/5 in the next five years. The erodible bank soils (soft silts and sands), gentle bank angles and alluvial deposits from past channel occupancy indicate a possibility for the channel to reoccupy the area, but the bank elevation is likely high enough to prevent migration. The logjam immediately downstream of Pole 4/5 could become an obstruction during high flows, possibly steering flow towards the location of the proposed pole; alternatively, the logs could be remobilized and removed by a high flow event. In our opinion, the risk for channel migration at Pole 4/5 is very low in the next 5 years and would require a flood event capable of causing multiple levee failures, damage or destruction of the railroad and Main Street bridges, and inundation of the Sumner Wastewater Treatment Plant. Levee overtopping and flooding could occur in this area.

The rip rap bank protection, channel levees, higher bank elevation, and the Main Street Bridge pinch point that directs the channel flows away from pole 4/6 reduce the risk for channel migration within the next five years.

Future Plans for River Management

Pierce County is planning for potential levee setback projects to provide additional flood protection along sections of the Puyallup and White Rivers. Specific sections of the Puyallup and White Rivers are being considered for setting back mid-1960s era levees (GeoEngineers 2008). If the county does proceed, the proposed transmission line areas that include poles 1/3 to 1/4 and 4/4 to 4/5 are within these levee setback areas. Levee setback projects could change the potential for channel migration within these localized project areas.

King County also has planned a levee setback and wetland enhancement project along the left bank of the White River upstream of Sumner. They are also beginning planning and analysis of a right bank levee setback project in the same area. Modeling and analysis were used to plan a design that does not change downstream channel dynamics.

The timeframe for execution of the King and Pierce County projects is uncertain but some may begin within 5 years. How the river channels respond to these management activities and projects could affect existing and future development along these rivers systems, including locations of transmission lines.

CONCLUSIONS AND RECOMMENDATIONS

General

Based on definitions contained in the PCC for Critical Areas, one area, the upland segment as discussed above includes localized areas that appear to meet the landslide hazard criteria for steep slopes. However, pole locations avoid these slopes and we observed no indication that the proposed pole location or localized vegetation management will adversely impact the stability of the slopes in the upland segment.

The mapped soil conditions in each of the pole locations consist of dense to very dense sand and gravel from glacially consolidated deposits. This is consistent with our field observations and explorations completed for project design studies. Glacial soils can stand at slopes in excess of about 50 percent and it is our opinion, that the slopes in the steep slope areas pose a very low erosion or landslide risk. The soils may experience minor raveling which is a natural slope process on the steeper portions.

The majority of the segments in the transmission line alignment are out of the path of the identified CMZ. Poles 4/5 and 4/6 are mapped within a severe CMZ on the Puyallup River and pole 4/5 lies in an area of historic channel occupation (1940). However, we conclude that there is a very low risk of channel migration in this area because the analysis that delineated the severe migration zone hazard did not incorporate the protection provided by levees, revetments, and other engineering controls that have been built specifically to reduce channel migration in this area.

City of Sumner Public Works (Public Works) are protecting and maintaining their infrastructure (e.g., bridge, buildings, roads, etc.) from geologic hazards, including channel migration. Public Works maintains levees and builds bank protection (riprap) along Puyallup and White River corridors. The proposed transmission line alignment is primarily within protected Public Works property corridors. Channel instability and bank erosion, such as between Poles 4/5 and 4/6, will likely be monitored and mitigated by Public Works measures to protect infrastructure. However, we recommend further evaluation of planned projects that could change the channel migration potential, such as the Puyallup River levee setback at the pole 4/5 location.

Pole Placement

Pole locations have been modified to avoid the locally steep slopes between poles 0/6 and 0/10.

Pole locations in the White and Puyallup River Valleys could be impacted by seismic activity. We expect that liquefaction (loss of soil strength) during the design earthquake could result in up to several inches of liquefaction-induced settlement. We therefore recommend the design of the proposed poles foundations consider the potential impacts of loss of strength in the alluvial deposits and peat, and liquefaction-induced settlement of these soils due to seismic shaking. We also recommend that lateral spreading along the river reaches be evaluated and the potential impacts considered in the design. We understand that these considerations are being addressed in our Draft Geotechnical Design Report that was issued during September 2014.

Erosion Control

Based on existing site grades at the proposed pole locations, we anticipate that erosion control measures such as silt fences, straw bales and sand bags will generally be adequate for the erosion control measures during construction. However, if construction is to involve significant clearing and road building additional erosion control measures may have to be implemented.

Temporary erosion control should be provided during construction activities and until permanent erosion control measures are functional. Surface water runoff should be properly contained and channeled using drainage ditches, berms, swales, and tightlines and should not discharge onto sloped areas. Any disturbed sloped areas should be protected with a temporary covering until new vegetation can take effect. Jute or coconut fiber matting, excelsior matting or clear plastic sheeting is suitable for this purpose. Graded or disturbed slopes should be tracked in-place with the equipment running perpendicular to the slope contours so that the track grouser marks provide a texture to help resist erosion.

Permanent measures for erosion control should include reseeding or replanting the disturbed areas as soon as possible and protecting those areas until new vegetation has been established. Permanent site grading should be accomplished in such a manner that stormwater runoff is not concentrated and

surface water is not directed to sloped portions or into excavated areas of the site. This can be accomplished by grading to direct the flow to appropriate collection points away from the slopes or excavations.

LIMITATIONS

We have prepared this report for the exclusive use of Puget Sound Energy and their authorized agents for the White River Transmission Line project located in Pierce County, Washington.

The purpose of our services was to review published data and observe the existing surface conditions along the transmission line corridor as a basis for developing an opinion regarding the presence of geologic hazards. 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. No warranty or other conditions, express or implied, should be understood.

Please refer to Appendix C, titled "Report Limitations and Guidelines for Use," for additional information pertaining to use of this report.

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FIGURES

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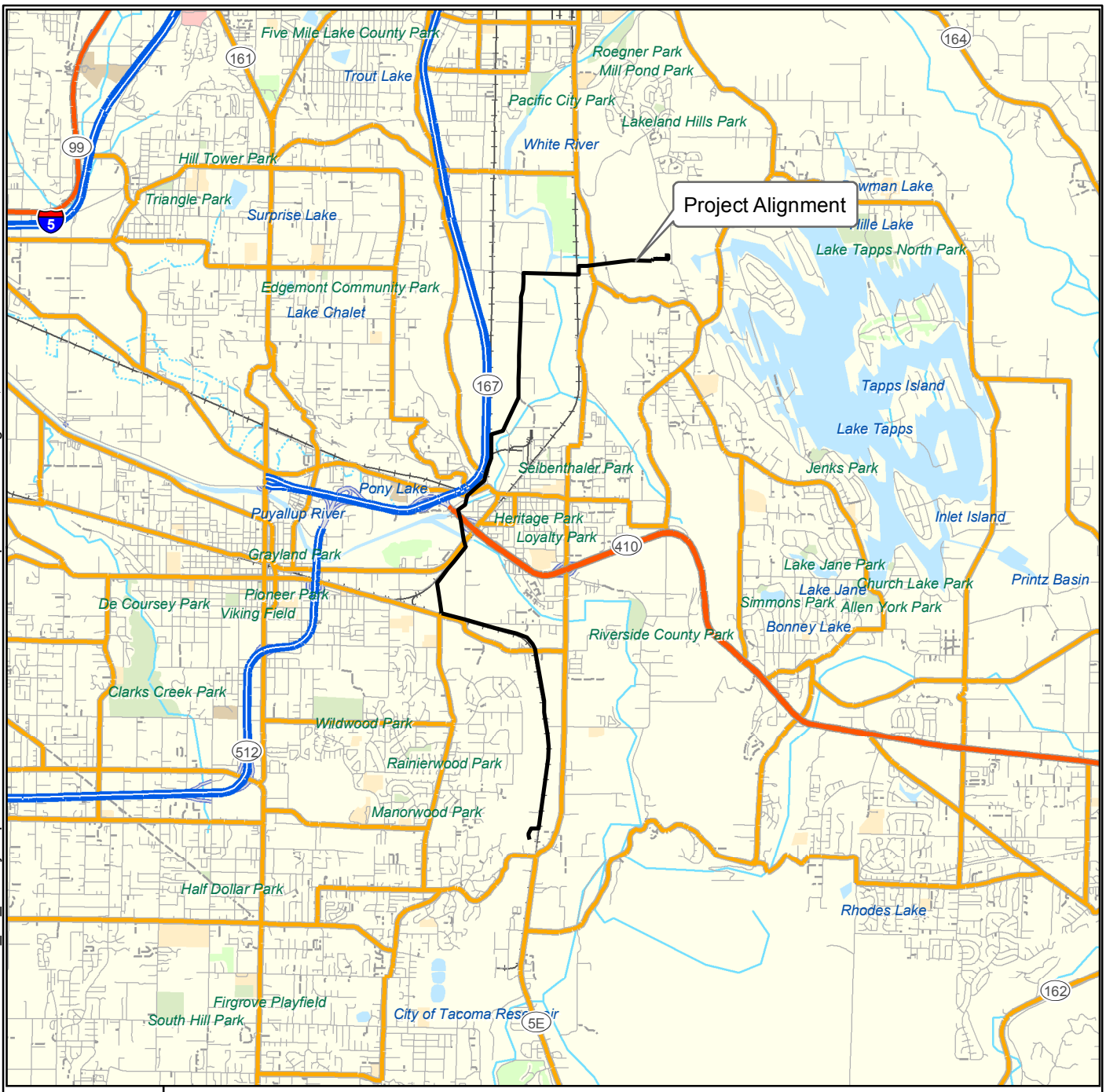

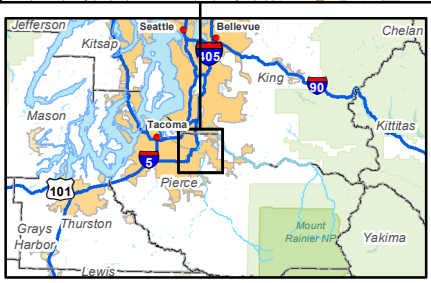

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Feet

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.
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Data Sources: ESRI Data & Maps, Street Maps 2005

Transverse Mercator, Zone 10 N North, North American Datum 1983
North arrow oriented to grid north

Vicinity Map

White River to Alderton 230 kV Transmission Line Project
Pierce County, Washington

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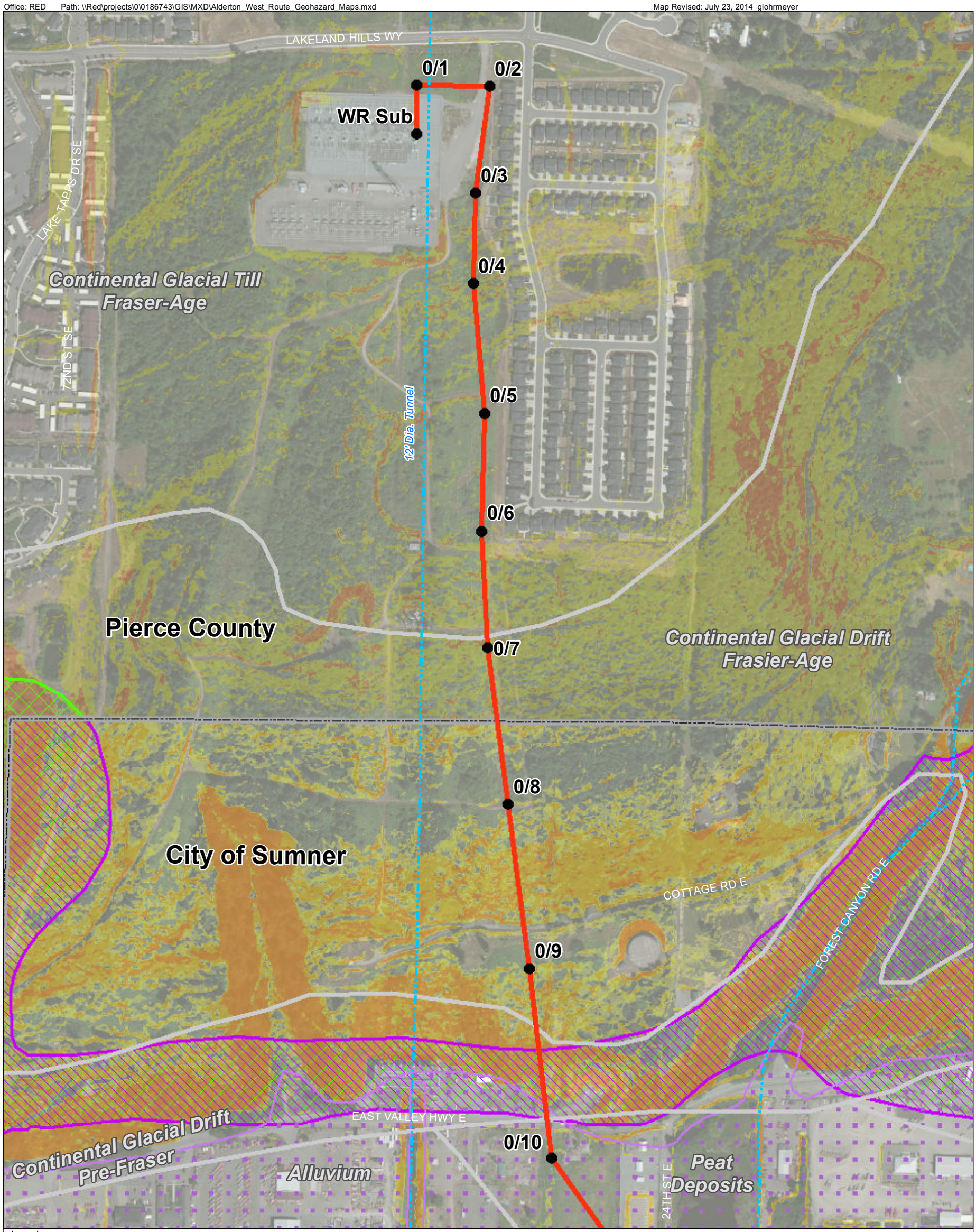
Figure 1

Office: Redmond Path: \\red\projects\0\0186743\GIS\MXD\018674306_F1_VicinityMap.mxd Map Revised: August 6, 2014 EL

Office: RED Path: \\Red\projects\0\0186743\GIS\MXD\Alderton_West_Route_Geohazard_Maps.mxd Map Revised: July 23, 2014 glohrmeyer



Legend

- Poles (December, 2014)
- Alderton Westline Transmission Line
- Geology Boundary (WA DNR)
- City of Sumner Boundary
- City of Sumner very severe erosion soils
- Pierce County slopes >20% with very severe erosion soils

Seismic Liquefaction

- High
- Moderate to High

Channel Migration Features

- Lateral Bar
- Mid-channel Bar
- Point Bar
- Riprap
- Log Jam
- Knickpoint
- Bank Erosion

- Levee

City Of Sumner Slope

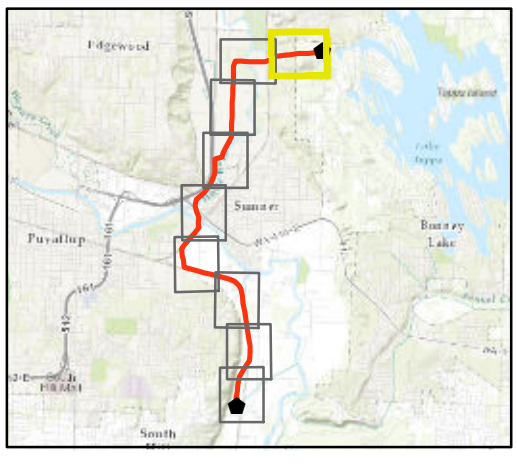
- 15%-25%
- >25 %

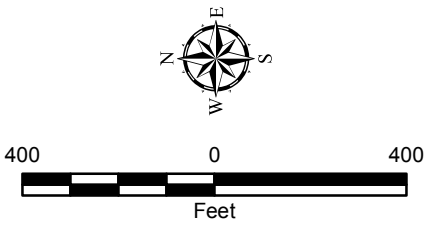
Pierce County Slope

- 20% - 40%
- >40%

Pierce County Mapped Data

- Streams
- Channel Migration Zone





Reference: Pierce County GIS
NAD 1983 HARN Washington State Plane South, Feet

Notes:

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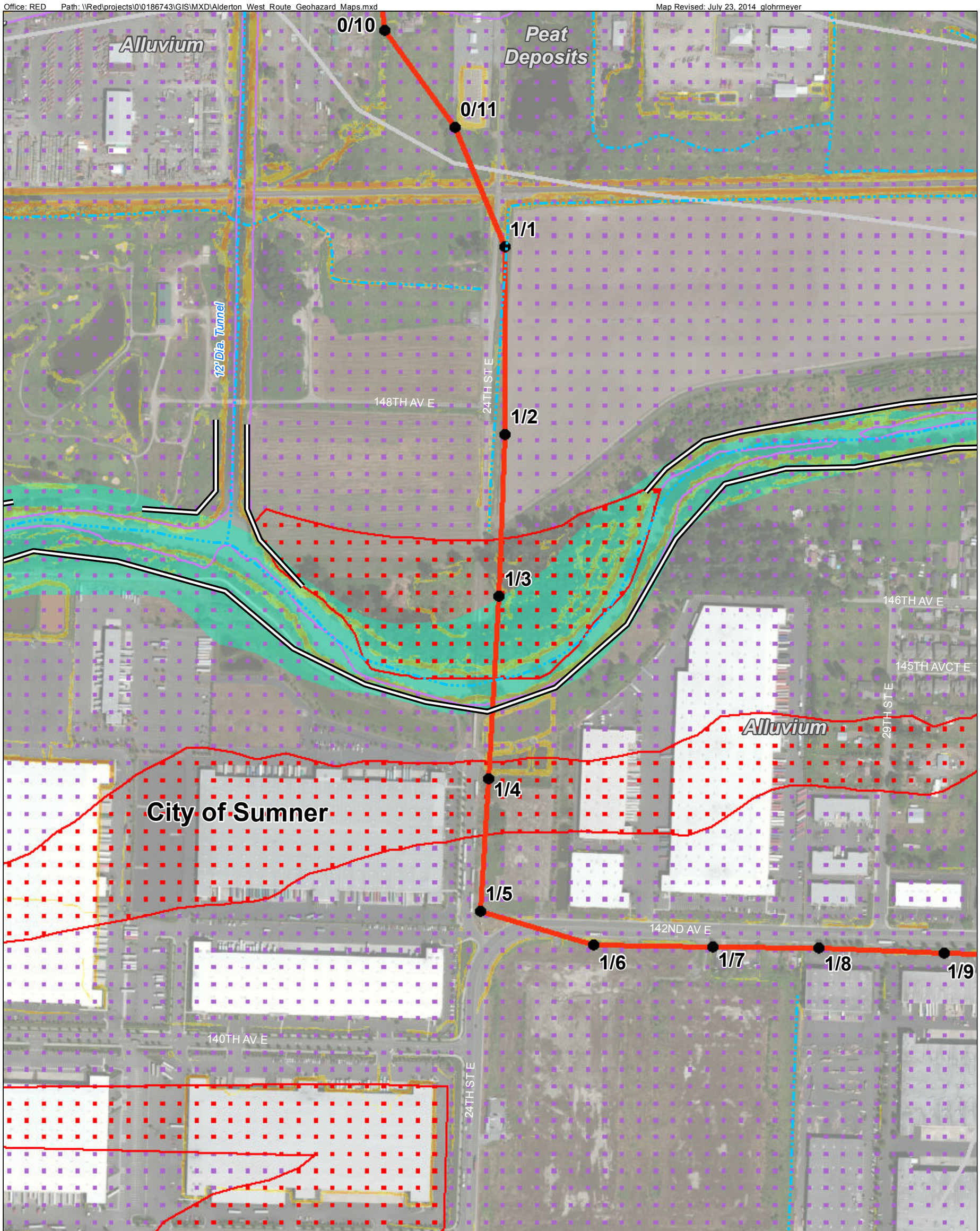
Geohazard Assessment

White River to Alderton 230kV Transmission Line Project
Pierce County, Washington

GeoEngineers

Figure 2

Office: RED Path: \\Red\projects\0\0186743\GIS\MXD\Alderton_West_Route_Geohazard_Maps.mxd Map Revised: July 23, 2014 glohrmeyer



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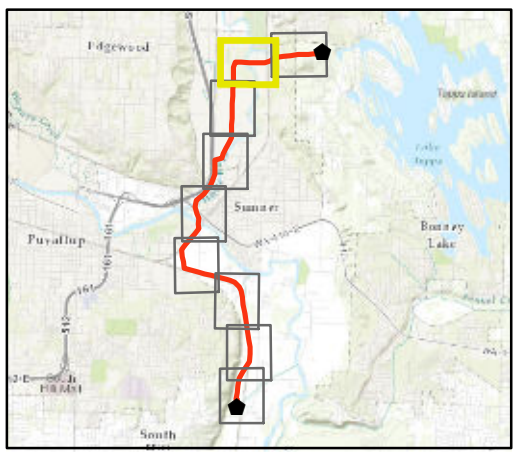
Pierce County Mapped Data

- Streams
- Channel Migration Zone



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Feet

Reference: Pierce County GIS
NAD 1983 HARN Washington State Plane South, Feet

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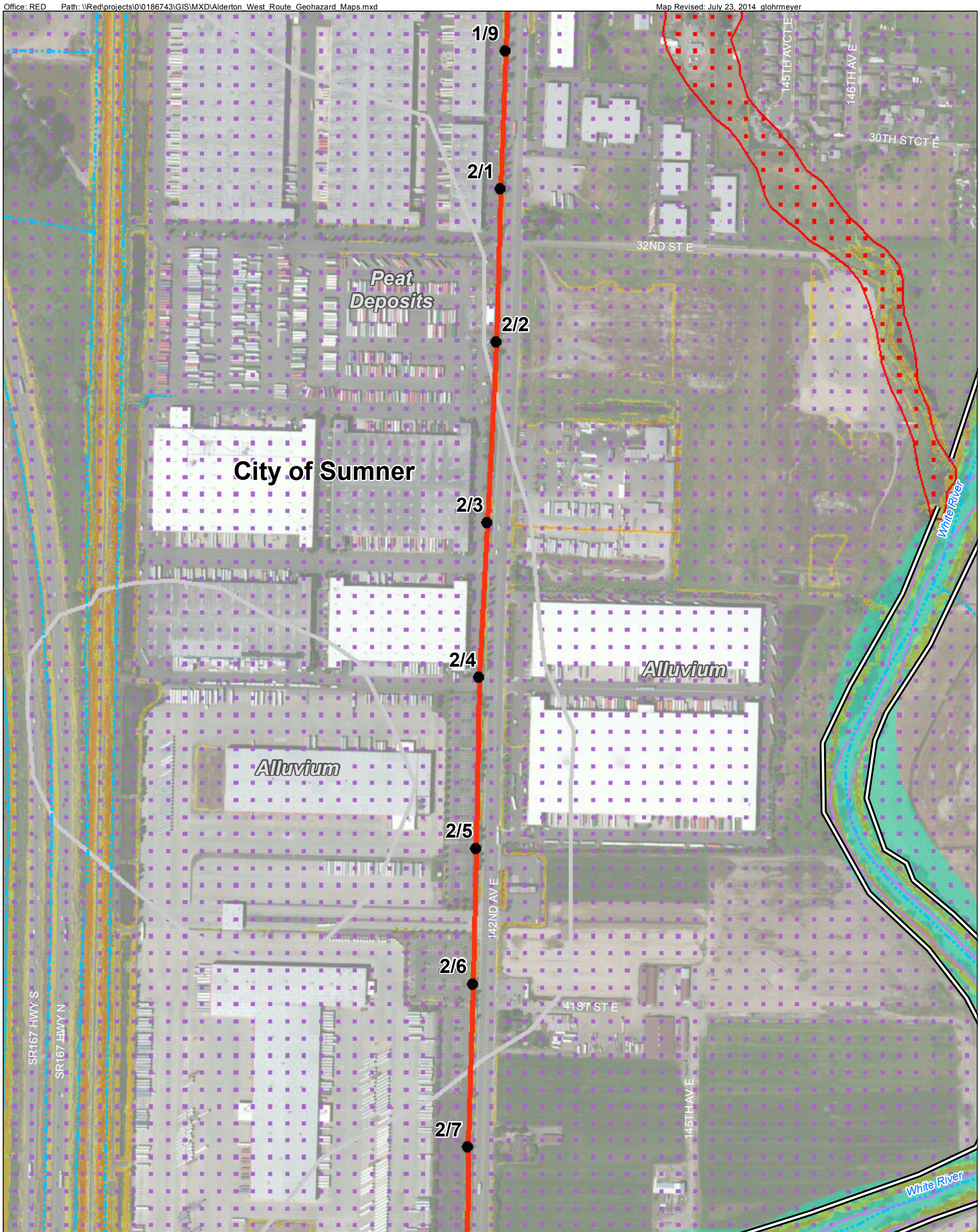
Geohazard Assessment

White River to Alderton 230kV Transmission Line Project
Pierce County, Washington

GeoEngineers

Figure 3

Office: RED Path: \\Red\projects\0\0186743\GIS\MXD\Alderton_West_Route_Geohazard_Maps.mxd Map Revised: July 23, 2014 glohrmeyer



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Pierce County Mapped Data

- Streams
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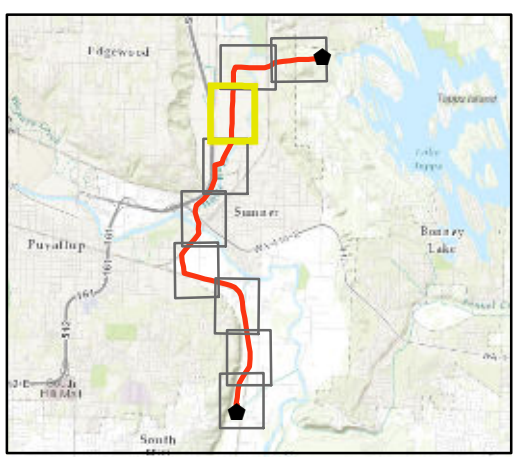

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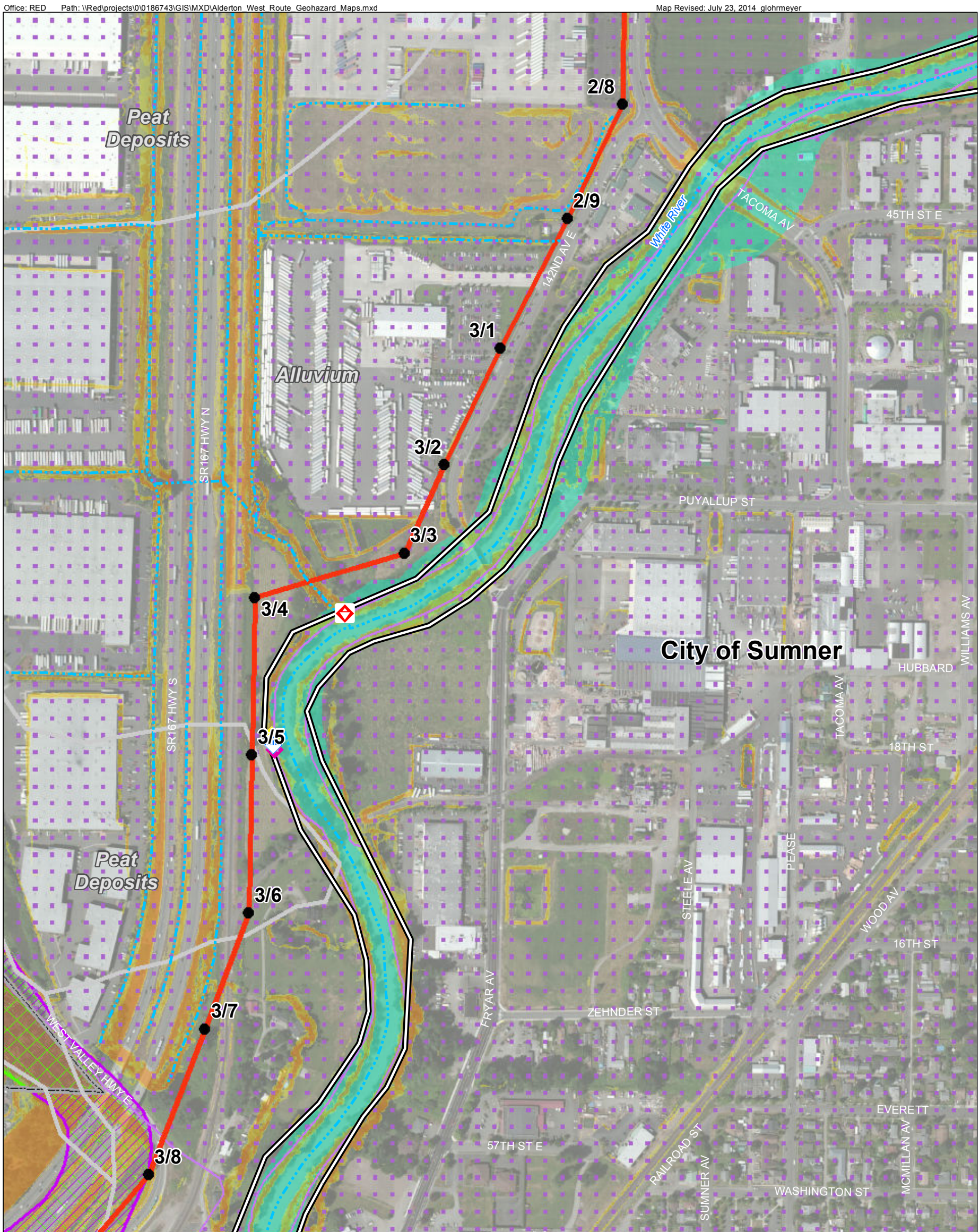
Geohazard Assessment

White River to Alderton 230kV Transmission Line Project
Pierce County, Washington

GEOENGINEERS

Figure 4

Office: RED Path: \\Red\projects\0\0186743\GIS\MXD\Alderton_West_Route_Geohazard_Maps.mxd Map Revised: July 23, 2014 glohrmeyer



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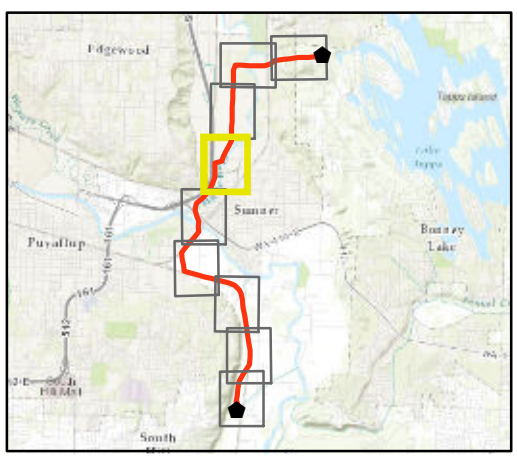
Pierce County Mapped Data

- Streams
- Channel Migration Zone



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Feet

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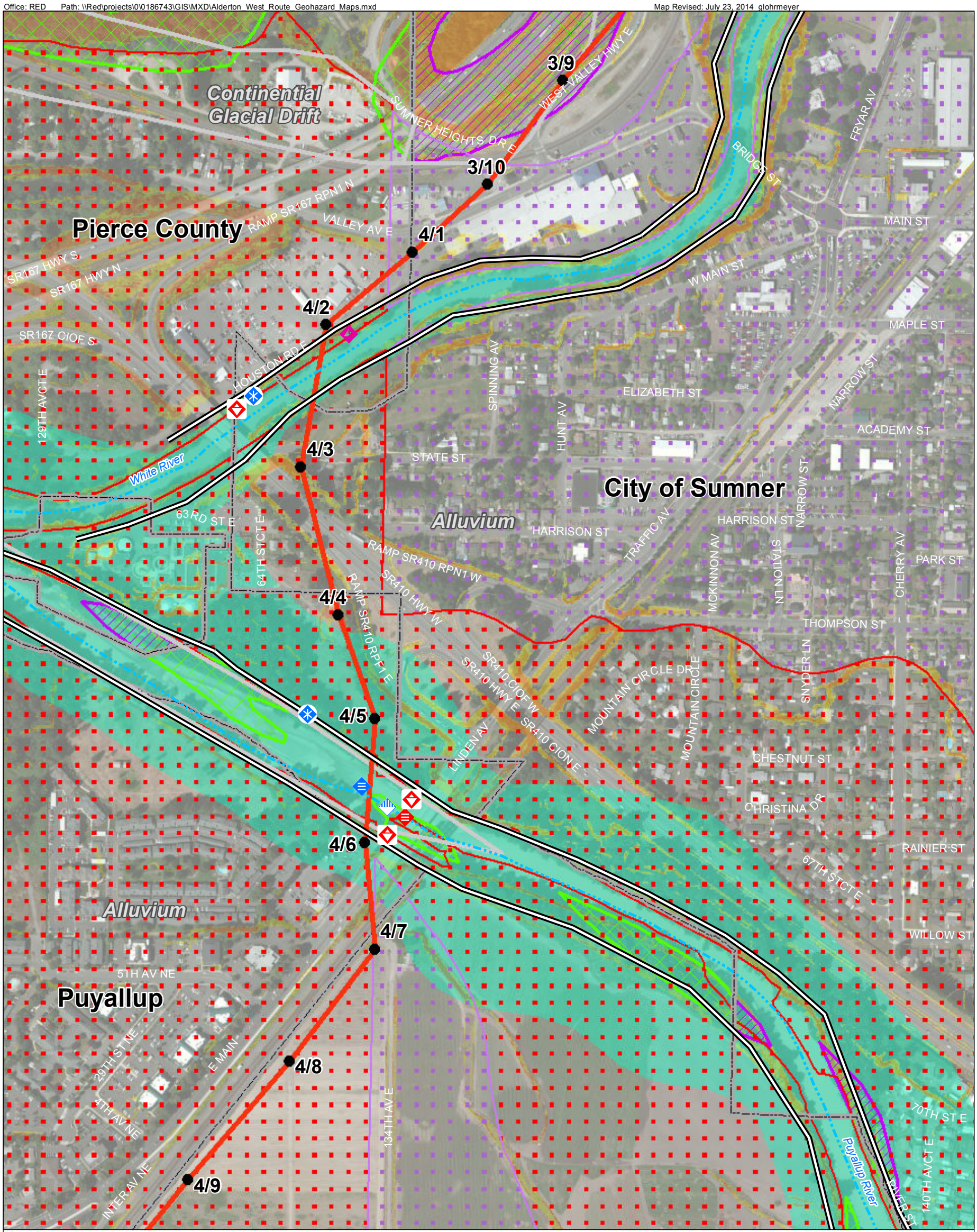
Geohazard Assessment

White River to Alderton 230kV Transmission Line Project
Pierce County, Washington

GeoEngineers

Figure 5

Office: RED Path: \\Red\projects\0\0186743\GIS\MXD\Alderton_West_Route_Geohazard_Maps.mxd Map Revised: July 23, 2014 glohrmeyer



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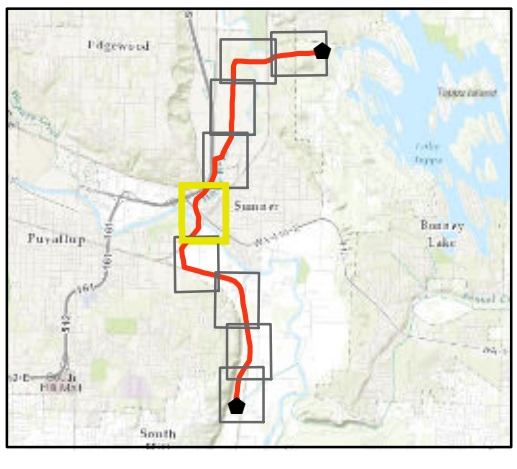
Pierce County Mapped Data

- Streams
- Channel Migration Zone



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Feet

Reference: Pierce County GIS
NAD 1983 HARN Washington State Plane South, Feet

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Geohazard Assessment

White River to Alderton 230kV Transmission Line Project
Pierce County, Washington

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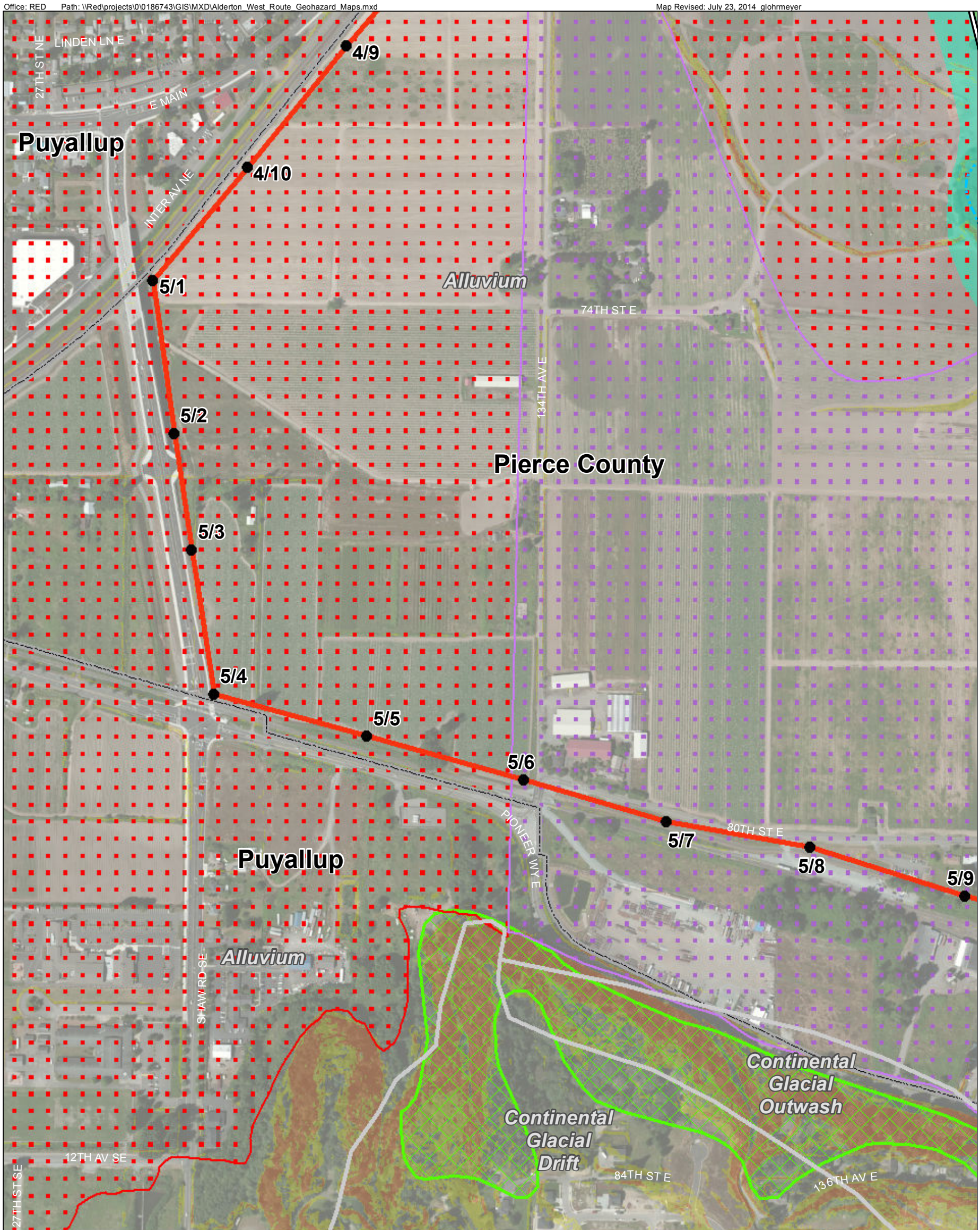
Figure 6

Office: RED Path: \\Red\projects\0\0186743\GIS\MXD\Alderton_West_Route_Geohazard_Maps.mxd Map Revised: July 23, 2014 glohrmeyer



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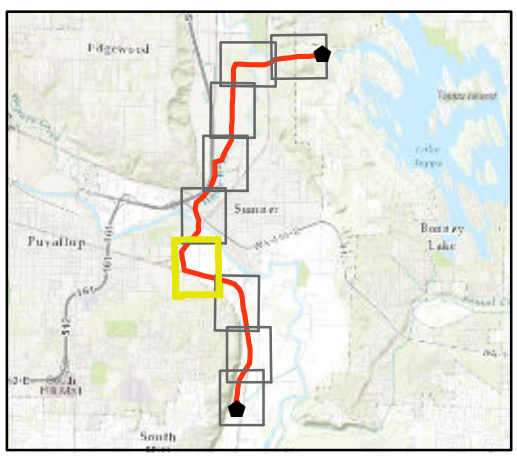
Pierce County Mapped Data

- Streams
- Channel Migration Zone



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Feet

Reference: Pierce County GIS
NAD 1983 HARN Washington State Plane South, Feet

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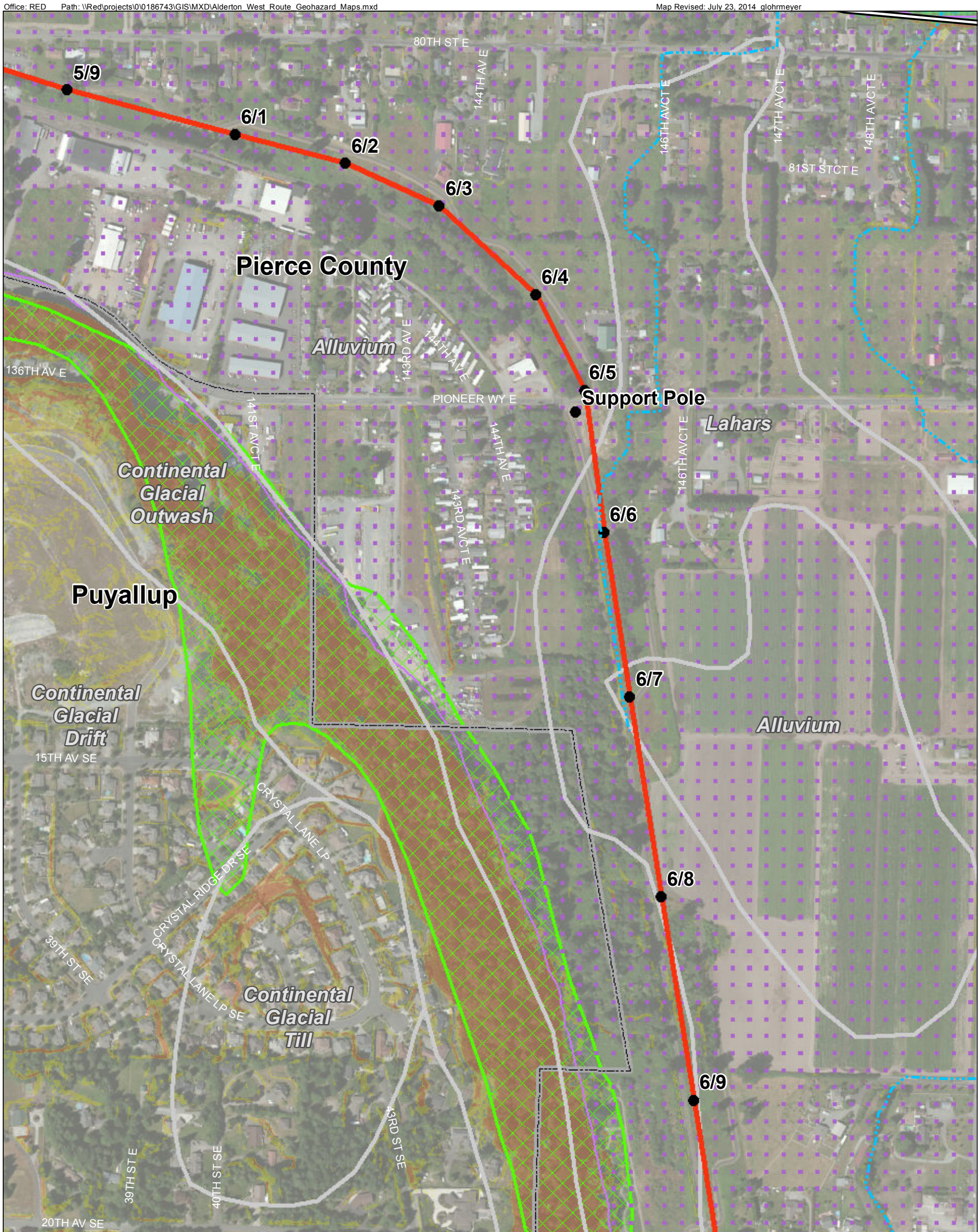
Geohazard Assessment

White River to Alderton 230kV Transmission Line Project
Pierce County, Washington

GEOENGINEERS

Figure 7

Office: RED Path: \\Red\projects\0\0186743\GIS\MXD\Alderton_West_Route_Geohazard_Maps.mxd Map Revised: July 23, 2014 glohrmeyer



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Pierce County Mapped Data

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Channel Migration Features

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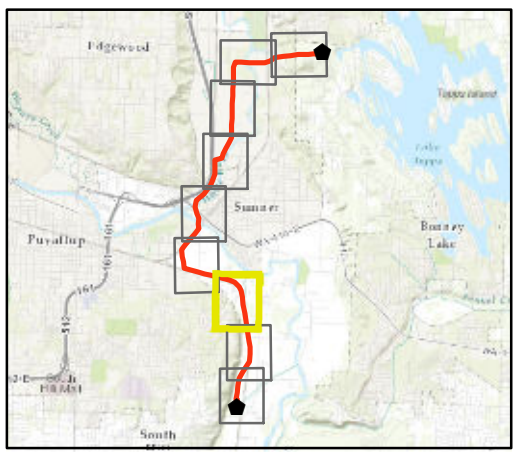

N
W E
S

400 0 400
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Geohazard Assessment

White River to Alderton 230kV Transmission Line Project
Pierce County, Washington

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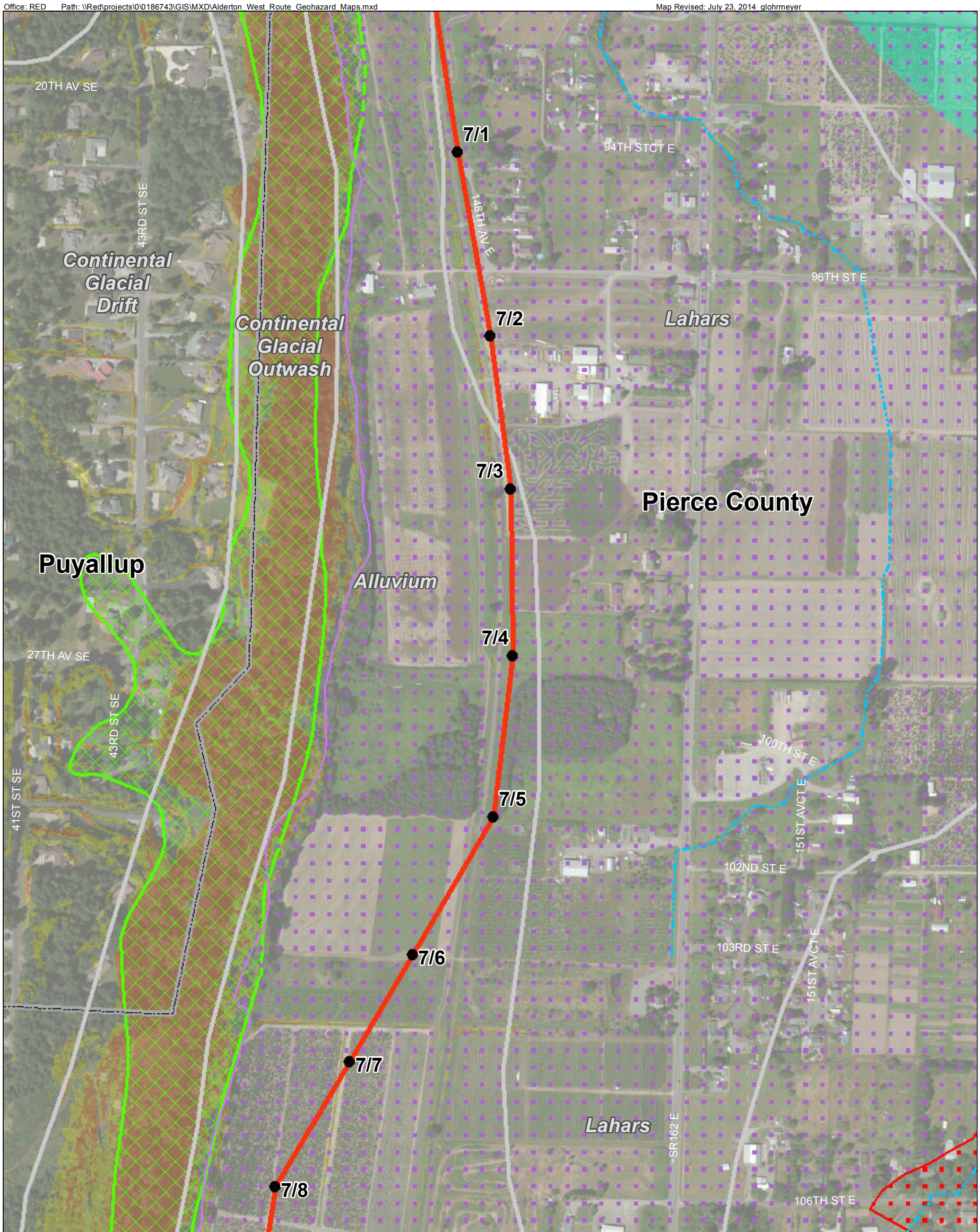
Figure 8

Office: RED Path: \\Red\projects\0\0186743\GIS\MXD\Alderton_West_Route_Geohazard_Maps.mxd Map Revised: July 23, 2014 glohrmeyer



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Pierce County Mapped Data

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Channel Migration Features

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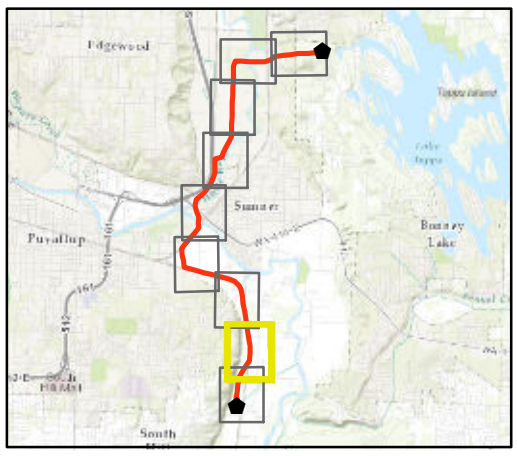

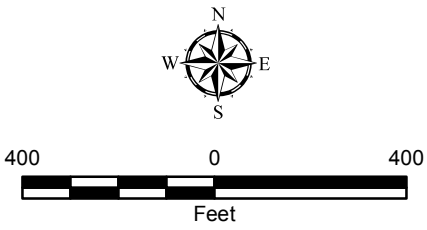

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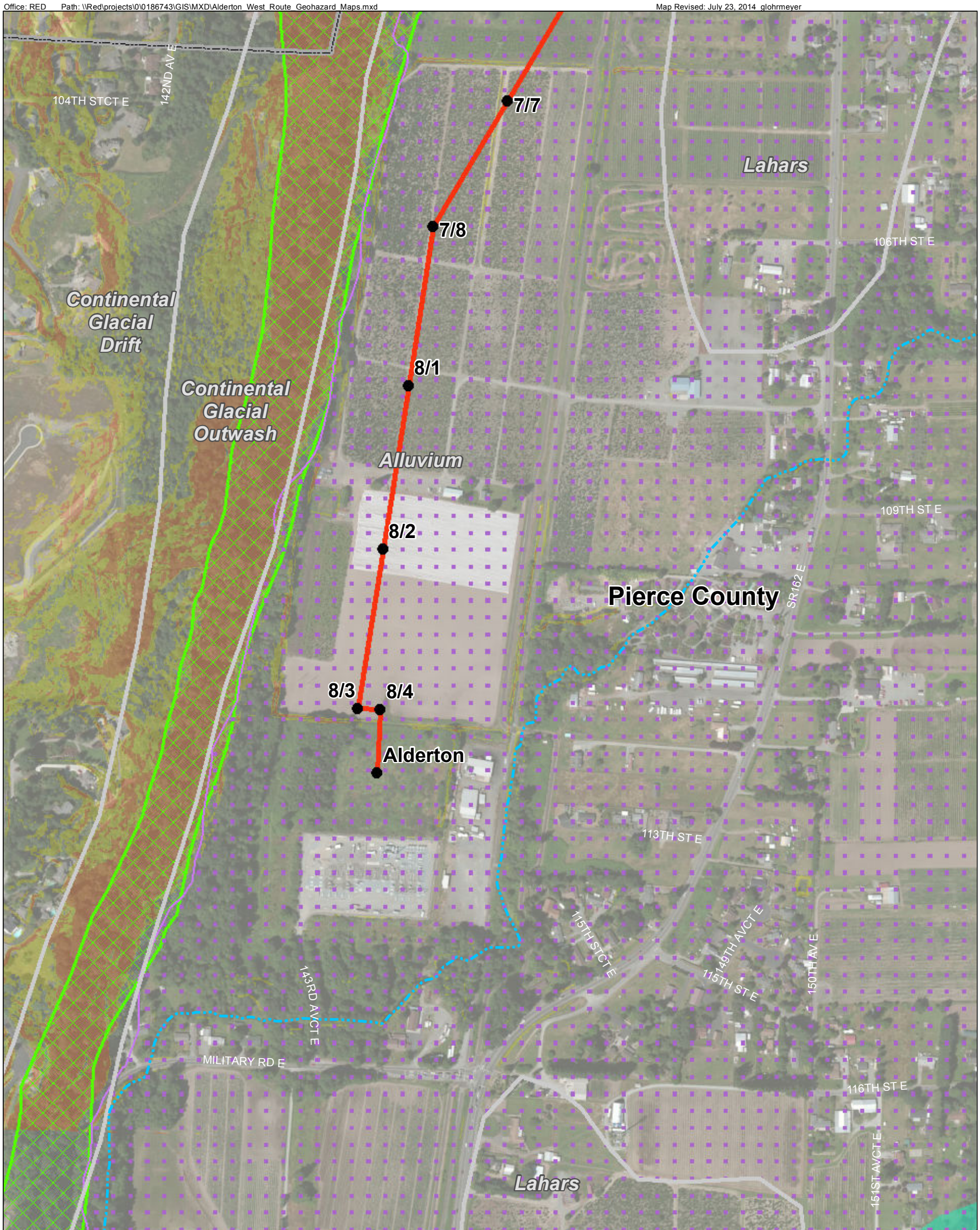
GEOENGINEERS

Figure 9

Office: RED Path: \\Red\projects\0\0186743\GIS\MXD\Alderton_West_Route_Geohazard_Maps.mxd Map Revised: July 23, 2014 glohrmeyer



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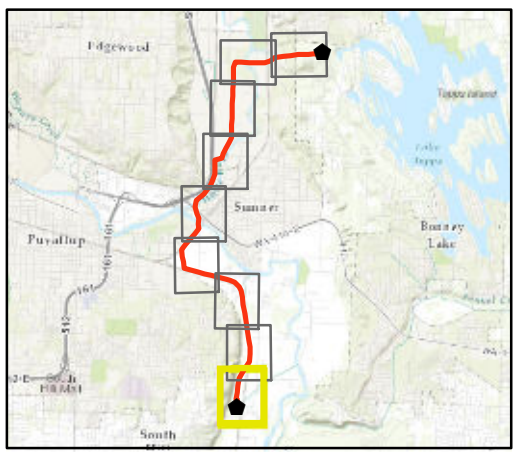

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Geohazard Assessment

White River to Alderton 230kV Transmission Line Project
Pierce County, Washington

GeoEngineers

Figure 10

APPENDICES

GeoEngineers

APPENDIX A
Applicable Critical Areas Ordinances

APPENDIX A.
APPLICABLE CRITICAL AREAS ORDINANCES

Critical areas defined in the PCC are:

"…areas that because of their susceptibility to erosion, sliding, earthquake, or other geological events, may pose a risk to the siting of commercial, residential, or industrial development consistent with public health or safety concerns."

Geologic hazards defined in the PCC consist of volcanic hazard areas, landslide hazard areas, seismic hazard areas, mine hazard areas, channel migration zones and erosion hazard areas.

GeoEngineers, Inc. (GeoEngineers) also addressed geologic hazards as defined by City of Sumner Municipal Code (SMC) and City of Puyallup Municipal Code (PMC). The SMC restricts development activities within or immediately adjacent to critical areas with geologic hazards, including landslide hazard areas, erosion hazard areas, seismic hazard areas, and volcanic hazard areas. The landslide, erosion, seismic and volcanic hazard definitions and guidelines are described from the SMC Title 16, Environment – Division III Natural Resource Lands and Critical Areas, Chapters 16.50 through 16.54.

The City of Puyallup code complies with requirements pursuant to PMC 21.06.530 and requires a critical areas report for geologically hazardous areas. A geotechnical report for a geologically hazardous area shall meet all of the following standards:

A. It shall address the project area of the proposed activity; and all geologically hazardous areas within 200 feet of the project area or that have potential to affect or be affected by the proposal;

B. It shall contain an assessment of geological hazards including at a minimum all of the following information:

   i. A description of the surface and subsurface geology, hydrology, soils, and vegetation found in the project area and in all hazard areas addressed in the report. The report shall also include an assessment of the geologic characteristics and engineering properties of the soils, sediments, and/or rock of the project area and potentially affected adjacent properties; a review of the site history regarding landslides, erosion, and prior grading; and a description of the vulnerability of the site to seismic and other geologic events. Soils analysis shall be accomplished in accordance with accepted classification systems in use in the region. Methods that were used for characterization and analysis of the site shall be described;

   ii. A recommendation for the minimum buffer and minimum building setback from any geologic hazard based upon the geotechnical analysis; and

   iii. When hazard mitigation is required, the report shall specifically address how the activity maintains or reduces the pre-existing level of risk to the site and adjacent properties on a long-term basis (equal to or exceeding the projected lifespan of the activity or occupation). Proposed mitigation techniques shall be considered to provide long-term hazard reduction only if they do not require regular maintenance or other actions to maintain their function. Mitigation may also be required to avoid any increase in risk above the pre-existing conditions following abandonment of the activity.

Geologic hazards were identified based on review of critical areas maps published by Pierce County, soil maps published by the Natural Resource Conservation Service, slope and contour maps developed from LiDAR data generated by GeoDigital International, and geologic maps, volcanic hazard maps, and seismic hazard maps published by the Department of Natural Resources (DNR) and the United States Geological Survey (USGS). Geologic hazards areas, as defined by Pierce County were mapped by compiling geographic information system (GIS) information onto the LiDAR contour and aerial photograph base (Figures 2 through 10). We provide the pertinent sections of code below that reference geologic hazards for Pierce County. A DNR webpage and map-viewer showing Volcanic Hazards from Mount Rainier, Washington was used to evaluate volcanic hazards.

This report includes review of the types of potentially geologically hazardous areas, but focuses on erosion hazard areas, landslide hazard areas, hazards associated with channel migration zones, volcanic hazards, and seismic hazards along the corridor per discussion with Puget Sound Energy (PSE).

Definitions

Pierce County, City of Sumner and City Puyallup use the following characteristics to categorize geologically hazardous areas:

Definitions (Pierce County Code Title 18E, Development Regulations - Critical Areas):

"'Channel migration zone' (CMZ) means the area within the lateral extent of likely stream channel movement due to stream bank destabilization and erosion, rapid stream incision, and shifts in location of stream channels. The CMZ is approximated by evidence of channel locations in the last 100 years, but shall not be strictly bounded by this criteria alone."

"'Erosion hazard areas' means those areas that because of natural characteristics, including vegetative cover, soil texture, slope, gradient, and rainfall patterns, or human-induced changes to such characteristics, are vulnerable to erosion."

"'Landslide Hazard Areas Indicators. Landslide hazard areas are areas potentially subject to mass movement due to a combination of geologic, seismic, topographic, hydrologic, or manmade factors. Landslide hazard areas can be identified by the presence of any of the following indicators:

1. Areas of historic failures, including areas of unstable, old and recent landslides or landslide debris within a head scarp.
2. Areas with active bluff retreat that exhibit continuing sloughing or calving of bluff sediments, resulting in a vertical or steep bluff face with little or no vegetation.
3. Areas with both of the following characteristics:
    a. Slopes steeper than 20 percent with a vertical relief of 20 feet or more (see 18E.80-1 in Chapter 18E.120 PCC); and
    b. Hillsides that intersect geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock
4. Slopes that are parallel or sub-parallel to planes of weakness, such as bedding planes, joint systems, and fault planes in subsurface materials.

5. Areas exhibiting geomorphological features indicative of past slope failure, such as hummocky ground, back-rotated benches on slopes, etc.
6. Areas with tension cracks or ground fractures along and/or near the edge of the top of a bluff or ravine.
7. Areas with structures that exhibit structural damage such as settling and cracking of building foundations or separation of steps or porch from a main structure that is located near the edge of a bluff or ravine.
8. The occurrence of toppling, leaning, bowed, or jackstrawed trees that are caused by disruption of ground surface by active movement.
9. Areas with slopes containing soft or liquefiable soils.
10. Areas where gullying and surface erosion have caused dissection of the bluff edge or slope face as a result of drainage or discharge from pipes, culverts, ditches, and natural drainage courses.
11. Areas where seeps or springs or indicators (e.g., vegetation type) of a shallow groundwater table are observed on or adjacent to the face of the slope.
12. Any area with a slope of 40 percent or steeper and with a vertical relief of 15 or more feet, except those manmade slopes created under the design and inspection of a geotechnical professional or slopes composed of competent bedrock. For the purposes of determining whether a slope is considered to be a landslide hazard area, the horizontal and vertical distance between the top and toe of slope are utilized. (See Figure 18E.80-1 in Chapter 18E.120 PCC.)
13. Areas that are at risk of mass movement due to seismic events
14. Areas that include alluvial or colluvial fans located at the base of steep slopes and drainages.

"'**Mine hazard areas'** means areas directly underlain by, adjacent or abutting to, or affected by mine workings such as adits, tunnels, drifts, or air shafts."

"'**Seismic hazard areas'** means areas subject to severe risk of damage as a result of earthquake induced ground shaking, slope failure, settlement, or soil liquefaction."

"'**Volcanic hazard areas'** means those areas subject to pyroclastic flows, lava flows, and inundation by debris flows, mudflows, or related flooding resulting from geologic or volcanic events on Mount Rainier."

We note that the PCC provides an exemption to the critical areas requirements for public and private utility line construction in Section 18E.20.030, Exemptions, part E:

> "PUBLIC AND PRIVATE UTILITY LINE WORK (NEW CONSTRUCTION, MAINTENANCE AND REPAIR) WITHIN IMPROVED SURFACES (E.G., DRIVEWAYS, PARKING LOTS, CONCRETE OR ASPHALT SURFACES, GRAVEL ROADS AND ROAD SHOULDERS, AND HARD SURFACE-EARTHEN RIGHTS-OF-WAY OR EASEMENTS)."

In addition, pursuant to PCC Section 18E.70.040, Flood Hazard Area Standards, Part B (2):

> "Any development, encroachment, filling, clearing, grading, new construction, and substantial improvement shall be prohibited within the floodway, except as follows:
>
> 2. Structures that do not require a building permit and that do not have any associated fill."

PCC recognizes that utilities are exempt from building permits, pursuant to Pierce County Building Code 105.3 relative to critical areas. PCC 17C.060 says small buildings that house utility equipment are operational facilities and exempt from building permits, adopted from IBC 105.2

Our report is intended to provide an evaluation of the hazard and potential impacts to poles for PSE and reviewing agencies in this regard.

Definitions (City of Sumner, SMC Title 16 Environment)

"Erosion Hazard Areas" are those areas that are identified by the presence of vegetative cover, soil texture, slope, and rainfall patterns, or human-induced changes to such characteristics, which create site conditions which are vulnerable to excessive erosion. Erosion hazard areas are those areas that are classified as having moderate to severe, severe or very severe erosion potential according to the Natural Resource Conservation Service.

"Landslide Hazard Areas" landslide hazard areas are those areas subject to risk of mass movement and meeting any of the following criteria:

1. Areas of historic land failures, including areas of unstable old and recent landslides.
2. Areas with all three of the following characteristics:
    - Slopes steeper than 15 percent;
    - Hillsides intersecting geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock;
    - Any signs of springs or groundwater seepage; and
    - Concave slopes and swales.
3. Slopes that are parallel or sub-parallel to planes of weakness, such as bedding planes, joint systems, and fault planes in subsurface materials.
4. Slopes having gradients steeper than 80 percent subject to rockfall during seismic shaking.
5. Areas potentially unstable as a result of rapid stream incision, stream bank erosion, and undercutting by wave action.
6. Any area with a slope of 15 percent or steeper and with a vertical relief of 10 or more feet. A slope is delineated by establishing the toe and top and measured by averaging the inclination over at least 10 feet of vertical relief. Qualifying slopes of 15 percent or greater to less than 25 percent shall be termed "Type II landslide hazard areas" for purposes of this chapter. Qualifying slopes of 25 percent or greater shall be termed "Type I landslide hazard areas."
7. Areas which have a "severe" limitation for building site development because of slope conditions, according to the USDA's Natural Resource Conservation Service.
8. Slopes that contain impermeable soils (typically silt and clay) frequently interbedded with granular soils (predominantly sand and gravel).
9. Any area which has indications of mass wasting during the Holocene epoch (from 10,000 years ago to the present) or which is underlain by mass wastage debris of that epoch.

Definitions (City of Puyallup (Definitions 21.06.530 General Critical Area report requirements):

"Channel migration zone (CMZ)" means the area along a river within which the channel can be reasonably predicted to migrate over time as a result of natural or normally occurring processes when considered with the characteristics of the river.

"Erosion hazard areas" means lands or areas underlain by soils identified by the U.S. Department of Agriculture Natural Resource Conservation Service (NRCS) as having "severe" or "very severe" erosion hazards. These include, but are not limited to, the following group of soils when they occur on slopes of 15 percent or greater: Alderwood gravelly sandy loam, Indianola gravelly loam, Kapowsin gravelly loam, Kitsap silt loam (KpD), and Xerochrepts.

"Geologically hazardous areas" means areas that may not be suited to development consistent with public health, safety or environmental standards, because of their susceptibility to erosion, sliding, earthquake, or other geological processes as designated by WAC 365-190-080(4). Types of geologically hazardous areas include: erosion, landslide, seismic, and volcanic hazards.

APPENDIX B
Site Photographs

Photo A-1. Uniform width and depth channel between transmission line segment of pole 1/3 to 1/4 .

Site Photographs	
White River to Alderton 230kV Transmission Line Project	
GeoEngineers	Figure B-1

Photo A-2. Sandy soil on left bank, inside of bend near pole 1/3

Site Photographs	
White River to Alderton 230kV Transmission Line Project	
GeoEngineers	Figure B-2

Photo A-3. Exposed soil from undercutting near pole 3/3.

Site Photographs	
White River to Alderton 230kV Transmission Line Project	
GeoEngineers	Figure B-3

Photo A-4. Bowed conifers at apex of bank near pole 3/5.

Site Photographs	
White River to Alderton 230kV Transmission Line Project	
GeoEngineers	Figure B-4

Photo A-5. Bare soils on opposite bank from pole 3/5

Site Photographs	
White River to Alderton 230kV Transmission Line Project	
GeoEngineers	Figure B-5

Photo A-6. Logjam accumulating on the opposite bank from pole 4/3.

Site Photographs	
White River to Alderton 230kV Transmission Line Project	
GeoEngineers	Figure B-6

Photo A-7. Cobble bar with saturated side channel between transmission line segment of poles 4/5 to 4/6. Note the knickpoint at the bar head.

Site Photographs	
White River to Alderton 230kV Transmission Line Project	
GeoEngineers	Figure B-7

Photo A-8. Logjam growing at edge of lateral bar in side channel near pole 4/5.

Site Photographs	
White River to Alderton 230kV Transmission Line Project	
GeoEngineers	Figure B-8

Photo A-9. Riprap armoring left bank waterward of pole 4/6.

Site Photographs	
White River to Alderton 230kV Transmission Line Project	
GeoEngineers	Figure B-9

APPENDIX C
Report Limitations and Guidelines for Use

APPENDIX C
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 PSE 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 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 PSE St. Clair Transmission Line 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.

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[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, and 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**.

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