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Geotechnical Design Investigation Report
for
Erickson Single Family Residence

T25N R2W S3
Parcel 502 034 007
Jefferson County, Washington

June 9, 2014
Project #1453

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TABLE OF CONTENTS

1.0 INTRODUCTION **1**

1.1 PROJECT INFORMATION 1
1.2 PURPOSE OF INVESTIGATION AND SCOPE OF WORK 1

2.0 SURFACE CONDITIONS **3**

2.1 GENERAL OBSERVATIONS 3
2.2 TOPOGRAPHY 3
2.3 SURFACE DRAINAGE AND WATER BODIES 3
2.4 SLOPE AND EROSION OBSERVATIONS 3

3.0 SUBSURFACE CONDITIONS **5**

3.1 FIELD METHODS, SAMPLING AND FIELD TESTING 5
3.2 GENERAL GEOLOGIC CONDITIONS 5
3.3 SPECIFIC SUBSURFACE CONDITIONS 6
3.3.1 Groundwater *7*

4.0 ENGINEERING ANALYSIS, CONCLUSIONS AND RECOMMENDATIONS **8**

4.1 BUILDING FOUNDATION RECOMMENDATIONS 8
4.1.1 Bearing Capacity *8*
4.1.2 Settlement *8*
4.1.3 Concrete Slabs-on-Grade *9*
4.2 LATERAL EARTH PRESSURES 9
4.3 EARTHWORK CONSTRUCTION RECOMMENDATIONS 9
4.3.1 Excavation *9*
4.3.2 Placement and Compaction of Native Soils and Engineered Fill *10*
4.3.3 Retaining Wall Backfill *11*
4.3.4 Wet Weather Considerations *11*
4.3.5 Building Pads *12*
4.4 SLOPE STABILITY 12
4.4.1 Slope Stability Assessment and Analysis *14*
4.4.2 Building and Footing Setbacks *15*
4.5 EROSION 15
4.6 SURFACE AND SUBSURFACE DRAINAGE 15
4.6.1 Septic Drainfield Impacts *16*
4.7 VEGETATION BUFFER AND CONSIDERATIONS 16
4.8 SEISMIC CONSIDERATIONS AND LIQUEFACTION 16
4.8.1 Liquefaction *17*

5.0 CLOSURE **18**

Appendix A - Site Plan
Appendix B - Soil Information
Appendix C - Slope Stability

1.0 INTRODUCTION

Envirotech Engineering (Envirotech) has completed a geotechnical investigation for a property located west of Sunrise Road in T25N R2W S3 QTR SE 1/4, identified as parcel number 502 034 007, Jefferson County, Washington (Project). As presented herein, this report includes information pertaining to the Project in this Introduction Section; observations of the property and surrounding terrain in the Surface Conditions Section; field methods and soils descriptions in the Subsurface Investigation Section; and, recommendations for foundation, settlement, earthwork, lateral earth pressures, drainage, slope stability and erosion control in the Engineering Analysis and Recommendations Section.

An initial geotechnical evaluation of the Project was conducted by Envirotech with the property proponents, Linda Erickson and John Bubb, on March 16, 2013. It has been determined that construction may influence an Area of High Geologic Hazard, and subsequently requires a geotechnical report.

1.1 Project Information

Information pertaining to the Project was provided by the proponent of the property during the geotechnical investigation. Other information, such as site observations and assumed parameters typical of this type of development were provided by Evirotech during the preparation of this report.

Currently, the property is partially with an existing driveway. The planned development consists of a 1- or 2-story single family residence, on-site septic system, and other ancillary features typical of this type of development. Approximate building footprint and other proposed features with relation to existing site conditions are illustrated on the Site Map provided in Appendix A of this report.

1.2 Purpose of Investigation and Scope of Work

The purpose of this geotechnical investigation is to assess geological hazards, and evaluate the Project in order to provide geotechnical recommendations that should be implemented during development. The investigation included characterizing the general Project surface and subsurface conditions, and evaluating the suitability of the soils to support the planned site activities.

In order to fulfill the purpose of investigation, the geotechnical program completed for the proposed improvements of the Project include:

- Review project information provided by the Project owner and/ or owner's representative;
- Conduct a site visit to document the site conditions that may influence the construction and performance of the proposed improvements;
- Define general subsurface conditions of the site by observing subsoils within test pits and/ or cut banks, review geological maps for the general area, research published references concerning slope stability, and review water well reports from existing wells

near the Project;

- Collect bulk samples at various depths and locations;
- Perform soils testing to determine selected index and/or engineering properties of the site soils;
- Complete an engineering analysis supported by the planned site alterations, and the surface and subsurface conditions that were identified by the field investigation, soil testing, and applicable project research; and,
- Establish conclusions based on findings, and make recommendations for foundations, drainage, slope stability, erosion control, earthwork construction requirements, and other considerations.

2.0 SURFACE CONDITIONS

Information pertaining to the existing surface conditions for the Project was gathered on March 16, 2013 by Michael Staten, geotechnical engineer with Envirotech. During the site visit, the type of geotechnical investigation was assessed, and site features were documented that may influence construction. This Surface Conditions Section provides information on general observations, vegetation, topography, drainage and slope/ erosion conditions for the Project and surrounding areas that may impact the Project.

2.1 General Observations

The property is accessed from an existing driveway west of Sunrise Road. Hood Canal/ Dabob Bay are located about 2,000 feet to the east of the property. The parcel is currently partially developed land, as previously mentioned. Beyond the property lines, rural residential developments exist. Vegetation on and near the Project consists primarily of firs, and other trees and shrubbery common to this area of the Pacific Northwest.

2.2 Topography

The topographic information provided in this section was extrapolated from a public lidar source, and incorporated observations and field measurements. Where necessary, slope verification included measuring slope lengths and inclinations with a cloth tape and inclinometer. See the Site Map in Appendix A of this report for an illustration of general topography with respect to the planned development.

Varying descending slope grades located to the west and southwest of the planned development has an average grade of approximately 77%. The combined vertical relief of descending slope grades exceeding 30% is approximately 180 feet, located to the southwest of southern boundary line of the site.

Ascending grades are generally located to the southeast of the planned development. This slopes vary from 38% - 53% within 300 feet of the Project.

2.3 Surface Drainage and Water Bodies

Stormwater runoff originating upslope from the anticipated development is expected to be minimal to moderate due to the accommodating topography. Excessive scour, erosion or other indications of past drainage problems were not observed at or immediately near the planned development.

There are no apparent water bodies or wetlands located upslope from the planned development that would significantly influence the Project. Walkers Creek is located downslope from the property at about 250 feet to the east.

2.4 Slope and Erosion Observations

The existing steep slopes near the Project signal a potential landslide or erosion hazard area.

Some indicators that suggest past slope movements include:

- Old landslide activity on the northern lot
- Outwash of sediments near the bottom of the slope,
- Fissures, tension cracks or naturally stepped land masses on the face or top of the slope, and parallel to the slope,
- Fine, saturated subsurface soils,
- Old landslide debris,
- Significant bowing or leaning trees, or,
- Slope sloughing or calving.

Significant mass wasting on the property or within the general vicinity of the Project were not observed or discovered during research. Indications of past landslides, current unstable slopes, deep-seated slope problems, or surficial slope failures were not observed during the site visit.

3.0 SUBSURFACE INVESTIGATION

Information on subsurface conditions pertaining to the Project was primarily gathered on March 16, 2013 by Michael Staten, geotechnical engineer with Envirotech. Other subsurface information was obtained from geological maps and work by others. Specific information on field methods, sampling, field testing, general geologic conditions, specific subsurface conditions, and results from soil testing are presented in this section of the report. Appendix B of this report includes pertinent information on subsurface conditions for the Project, such as subsoil cross-section(s), test pit log(s), and water well report(s). Water well reports were utilized to estimate ground water levels, and if sufficient, were used in identifying subsoil types. Additional well reports than what is provided in this report may be available from Envirotech upon request. Applicable test pit locations are depicted on the Site Plan provided in the appendix of this report.

3.1 Field Methods, Sampling and Field Testing

Information on subsurface conditions for the Project was accomplished by examining soils within test pits extending to depths of up to 3 feet below the existing ground surface. Information on subsurface conditions also included reviewing geological maps representing the general vicinity of the project, and water well reports originating from nearby properties.

Soil samples were not obtained from this project. Envirotech measured the relative density of the near-surface in-situ soils by gauging the resistance of hand tools. Within testing locations, field testing results generally indicated medium dense to very dense soil or rock.

3.2 General Geologic Conditions

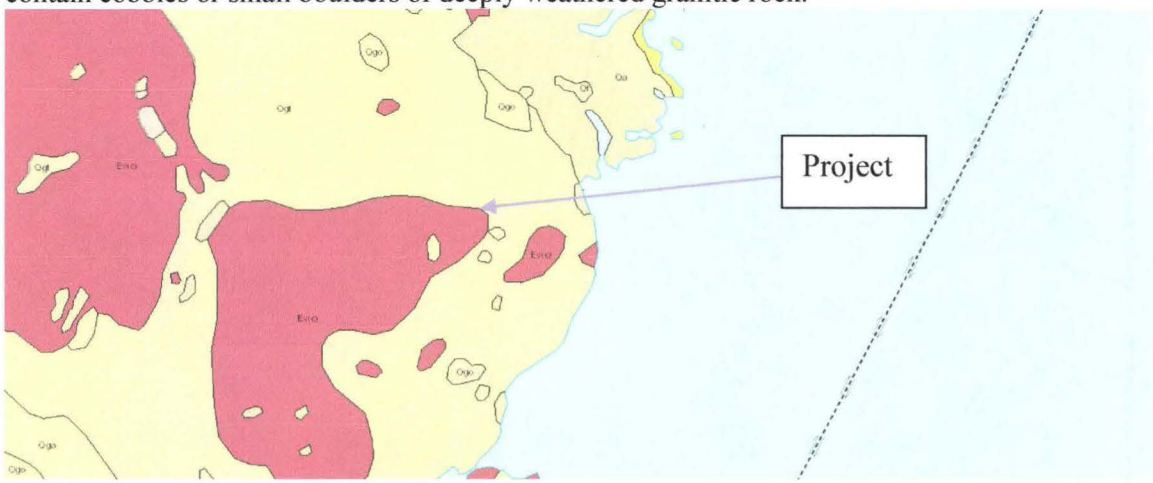
In general, soils at the project are composed of volcanic materials and material from glacial advances. The geologic conditions as presented below, titled "Olympic Mountains," is an excerpt from the "Geologic Map of Washington," compiled by J. Eric Schuster, 2002. This geologic map describes the area of this Project as, IT_v, Lower Tertiary (Oligocene-Paleocene).

Olympic Mountains

The Olympic Mountains, part of the Coast Range, form the core of the Olympic Peninsula. The oldest bedrock of the Olympic Mountains is the lower Tertiary Crescent Formation, a thick sequence of submarine and subaerial basalt flows with some interbedded siltstone and limestone. During middle Tertiary subduction, lower Tertiary marine sediments were continually thrust beneath the Crescent Formation. Uplift of the Olympic Mountains began when the wedge of underplated sediments reached a critical thickness about 17 million years ago. Continental glacial deposits mantle the east and northwest side of the Olympic Peninsula, where the Fraser ice sheet split into the Juan de Fuca and Puget lobes. Alpine glaciation carved the rugged peaks of the Olympic Range and flooded much of the coastal lowland with meltwater carrying sand and gravel.

According to the "Interactive Geologic Map, 1:100,000 Quadrangle," as depicted by the Department of Natural Resources, this Project consists mostly of glacial till, Q_{gt} and Eocene volcanic rocks $E_{v(c)}$. Glacial Till is usually described as "unsorted, unstratified, highly compacted

mixture of clay, silt, sand, gravel, and boulders deposited by glacial ice of the Puget lobe; gray; may contain interbedded stratified silt, and gravel; sand-size fraction is very angular and contains abundant polycrystalline quartz, which distinguishes this unit from alpine till; cobbles and boulders are commonly striated and (or) faceted; although unweathered almost everywhere, may contain cobbles or small boulders of deeply weathered granitic rock."



3.3 Specific Subsurface Conditions

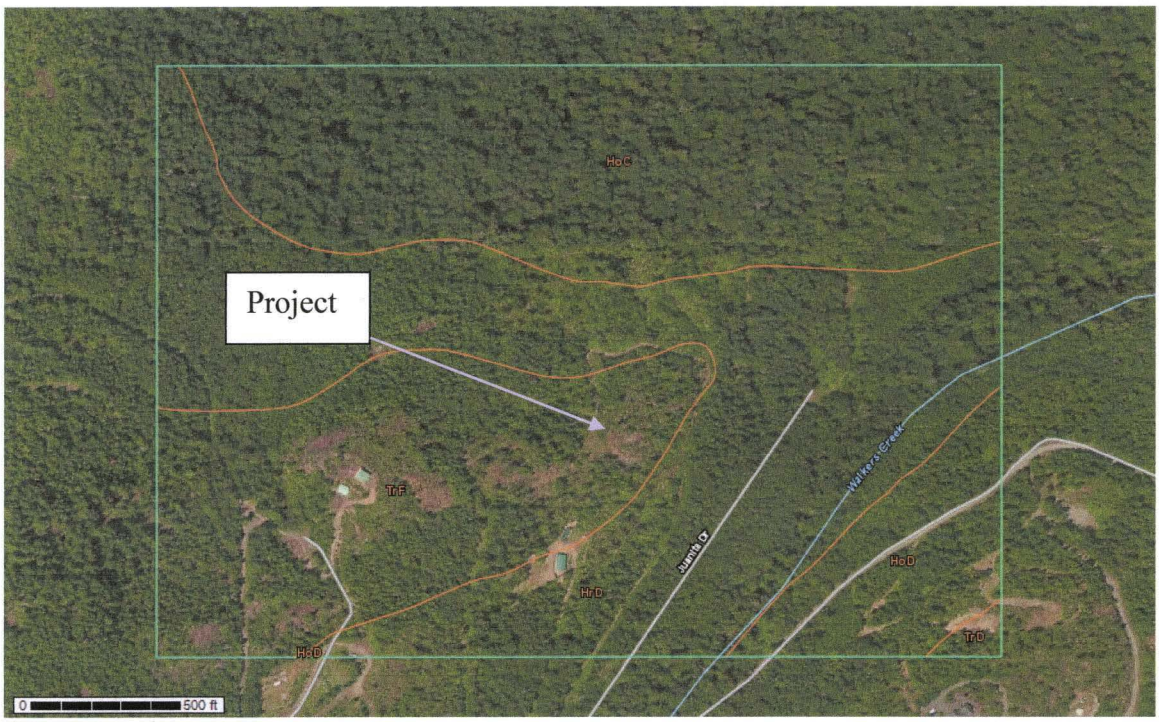
The following subsurface conditions are estimated descriptions of the Project subgrade utilizing information from the depth of penetration at all testing, sampling, observed and investigated locations. Soils for this project were primarily described utilizing the Unified Soil Classification System (USCS) and the Soil Conservation Service (SCS) descriptions.

The Project is currently composed of native soils without indications of borrowed fill. Within test pit locations, soils within the upper 3 to 4 feet of natural ground were observed to be silty sand with gravel (SM) or bedrock. Soils below the upper observed layer to a depth of terminous were observed to be low moisture, silty sand with gravel (SM), locally known as hardpan. The hardpan may extend to depths greater than 50 feet. This is based on nearby well reports, site geology, and/ or knowledge of the general area.

The relative densities of the soil within selected test pits are provided above in Section 3.1. Expanded and specific subsurface descriptions, other than what is provided in this section, are provided in the soil logs located in Appendix B of this report.

According to the "Soil Survey of Jefferson County," by the United States Department of Agriculture, Soil Conservation Service, the project site soils are described as TrF—Triton very gravelly loam, 50 to 70 percent slopes and HrD—Hoodsport-Grove very gravelly sandy loams, 0 to 30 percent slopes.

The upland site soils are delineated as TrF—Triton very gravelly loam, 50 to 70 percent slopes. The soil designations are depicted in the aerial photograph below, and descriptions are provided in Appendix B of this report.



Soil Survey from USDA Natural Resources Conservation Service

3.3.1 Groundwater

From the water well report(s) and knowledge of the general area, permanent groundwater is at least 50 feet directly below the property at the building pad location. Perched groundwater at shallow depths was not observed on-site, nor indicated on the well reports. However, some groundwater is expected to flow directly above the hardpan during some or all wet seasons.

4.0 ENGINEERING ANALYSIS, CONCLUSIONS AND RECOMMENDATIONS

The following sections present engineering analysis and recommendations for the proposed improvements of the Project. These recommendations have been made available based on the planned improvements as outlined in the Introduction Section of this report; general observations including drainage and topography as recapitulated in the Surface Conditions Section; and, soil/ geologic conditions that were identified from the geotechnical investigation that is summarized in the Subsurface Investigation Section. Engineering analysis and recommendations for the Project that is provided herein, includes pertinent information for building foundations, earthwork construction, slope stability, erosion control, drainage, vegetation and seismic considerations.

4.1 Building Foundation Recommendations

Recommendations provided in this section account for the site development of a typical one- or two-story, single family residential structure. The recommended allowable bearing capacities and settlements as presented below, consider the probable type of construction as well as the field investigation results by implementing practical engineering judgment within published engineering standards. Evaluations include classifying site soils based on observed field conditions and soil testing for this Project. After deriving conservative relative densities, unit weights and angles of internal friction of the in-situ soils, the Terzhagi ultimate bearing capacity equation was utilized for determining foundation width and depth. Stepped foundations are acceptable, if warranted for this Project. Continuous, isolated, or stepped foundations shall be horizontally level between the bottom of the foundation and the top of the bearing strata. The frost penetration depth is not expected to extend beyond 12 inches below the ground surface for this Project under normal circumstances and anticipated design features. The soils on-site have **low** frost susceptible characteristics and should be used only to the extents provided in this report.

4.1.1 Bearing Capacity

Existing in-situ soils for this Project indicates that the structure can be established on shallow, continuous or isolated footings. Foundations shall be established on relatively undisturbed native soil. Alternatively, foundations may be constructed on selective re-compacted native soil or compacted engineered fill as described in the Earthwork Construction Recommendations Section of this report. For a bearing capacity requirement of no more than **2000 psf**, a minimum footing width of **15 inches** shall be placed at a minimum of **12 inches** below the existing ground surface. Foundations directly on bedrock do not require significant depth, but should be level, and anchored to the rock per the structural engineer. Foundation recommendations are made available based on adherence to the remaining recommendations that are provided in this report. Alterations to the aforementioned foundation recommendations may be completed upon a site inspection by a geotechnical engineer after the foundation excavation is completed.

4.1.2 Settlement

Total and differential settlement that a structure will undergo depends primarily on the subsurface conditions, type of structure, amount and duration of pressure exerted by the structure, reduction of pore water pressure, and in some instances, the infiltration of free

moisture. Based on the expected native soil conditions, anticipated development, and construction abides by the recommendations in this report, the assumed foundation system may undergo a maximum of 1.0 inch total settlement, and a maximum differential settlement of 0.75 inch.

4.1.3 Concrete Slabs-on-Grade

Interior slabs, if utilized, should be supported on a minimum of 4 inches of compacted coarse, granular material (Passing U.S. Sieve #10 or greater) that is placed over undisturbed native subgrade or engineered fill. Native soils found at the Project site may be suitable for use as material directly beneath concrete slabs if it meets the aforesaid requirements or screened to meet these requirements. The **top 2 to 4 inches** of native soil should be removed prior to the placement and compaction of the aforementioned 4-inch coarse, granular material.

The recommendations for interior concrete slabs-on-grade as presented herein are only relevant for the geotechnical application of this Project. Although beyond the scope of geotechnical engineering, concrete slabs should also be designed for structural integrity and environmental reliability. This may include some type of vapor barrier or moisture control for mitigating excessive moisture in the building.

4.2 Lateral Earth Pressures

Retaining walls may be utilized for this Project. The lateral earth pressures exerted through the backfill of a retaining wall are dependent upon several factors including height of retained soil behind the wall, type of soil that is retained, degree of backfill compaction, slope of backfill, surcharges, hydrostatic pressures, earthquake pressures, and the direction and distance that the top of the wall moves. A structural or geotechnical professional should design retaining walls based on specific conditions.

Soil parameters for the structural design of retaining walls may be estimated as 134 pounds per cubic foot (pcf) and 118 pcf for engineered fill and native soils, respectively. The angle of internal friction may be estimated as 36 degrees and 32 degrees for engineered fill and native soils, respectively. These soil parameters are based on soil type and placement conforming to the Earthwork Construction Recommendations Section in this report.

4.3 Earthwork Construction Recommendations

Founding material for building foundations shall consist of undisturbed native soils. Compacted engineered fill or selective re-compacted native soils may be used to the extents provided in this Earthwork Construction Recommendations Section. The following recommendations include excavations, subgrade preparation, type of fill, and placement of fill for building foundations.

4.3.1 Excavation

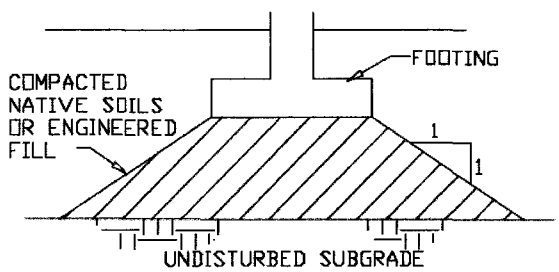
Excavation is recommended to remove any excessive organic content or other deleterious material, if present, beneath foundations and to achieve appropriate foundation depth.

Additional sub-excavation will be required for this Project if the soils below the required foundation depth are loose, saturated, or otherwise incompetent due to inappropriate land disturbing, or excessive water trapped within foundation excavations prior to foundation construction. All soils below the bottom of the excavation shall be competent, and relatively undisturbed or properly compacted fill. If these soils are disturbed or deemed incompetent, re-compaction of these soils below the anticipated footing depth is necessary. Excavations shall be completely dewatered, compacted, and suitable before placement of additional native soil, engineered fill or structural concrete. It is suggested that foundation excavations are inspected by a geotechnical engineer or qualified professional in order to assess the bearing material prior to the placement of structural footings.

4.3.2 Placement and Compaction of Native Soils and Engineered Fill

For engineered fill or disturbed native soils that will be utilized as fill material directly beneath foundations, observation and/ or geotechnical testing is required prior to foundation construction. The following placement and compaction requirements are necessary.

For disturbed native soils or engineered fill beneath foundations, limits of compacted or re-compacted fill shall extend laterally from the bottom edge of the foundation at a rate of one foot for each foot of compacted or re-compacted fill beneath the foundation. See the illustration below.



Both engineered fill and native soils used as compacted fill should be free of roots and other organics, rocks over 6 inches in size, or any other deleterious matter. Engineered fill should consist of the following gradation:

U.S. Standard Sieve	% Finer (by weight)
6"	100
3"	60 – 100
No. 4	20 – 60
No. 200	0 - 8

Table 1
Partical Size Distribution of Engineered Fill

Compaction shall be achieved in compacted lifts not to exceed **6 inches** and **8 inches** for native soils and engineered fill, respectively. Each lift should be uniformly compacted to

at least 95% of the modified Proctor maximum dry density (ASTM D 1557) and within 3% of optimum moisture content. Each lift surface should be adequately maintained during construction in order to achieve acceptable compaction and inter-lift bonding.

Temporary earth cuts and temporary fill slopes exceeding 4 feet in height should be limited to a slope of **1.5:1** (horizontal:vertical). Utility trenches or other confined excavations exceeding 4 feet should conform to OSHA safety regulations.

4.3.3 Retaining Wall Backfill

Native soils may be used as retaining wall backfill for this Project if the recommendations below are followed. Backfill may also consist of engineered fill, as presented in this report, or borrow material approved by a geotechnical engineer. Compaction of these materials shall be achieved in compacted lifts of about 12 inches. Each lift should be uniformly compacted to at least 85%, and no more than 90% of the modified Proctor maximum dry density (ASTM D 1557). In addition, heavy construction equipment should be at a distance of at least ½ the wall height. Over-compaction and limiting heavy construction equipment should be prevented to minimize the risk of excess lateral earth pressure on the retaining structure. Envirotech recommends that retaining wall backfill is compacted with light equipment such as a hand-held power tamper. If clean, coarse gravel soils are utilized as engineered fill, and surcharges will not influence the retaining wall, compaction may be achieved by reasonably densifying granular soils with construction equipment.

Backfill for the retaining wall should extend vertically from the top of the footing to the proposed ground surface. The backfill should also extend horizontally from the back of the retaining wall to at least 2 feet. Perforated drain pipe for retaining walls should have a minimum diameter of 4 inches and direct water to an appropriate infiltration or outfall as recommended in the Surface and Subsurface Drainage Section of this report. Coarse, clean gravel (1 inch diameter) is recommended to be placed at least 24 inches around the drain pipe in order to provide increased drainage capabilities. Non-woven geotextile filter fabric designed to impede fine particles should be wrapped around the aforementioned coarse gravel for reducing the potential of silt migration and clogging of the drain pipe.

4.3.4 Wet Weather Considerations

Due to the types of subsurface soils, additional provisions may be required during prolonged wet weather. Every precaution should be made in order to prevent free moisture from saturating the soils within excavations. If the bottom of excavations used for footing placement changes from a moist and dense/ hard characteristic as presented in this report to muck or soft, saturated conditions, then these soils become unsuitable for foundation bearing material. If this situation occurs, a geotechnical engineer should be notified, and these soils should be completely removed and replaced with compacted engineered fill or suitable native material as presented in this section.

4.3.5 Building Pads

Building pads with fill of at least 12 inches deep should not be utilized for this Project without further recommendations and construction inspection from a geotechnical engineer.

4.4 Slope Stability

Landslides are natural geologic processes, and structures near slopes possess an inherent risk of adverse settlement, sliding or structural damage due to these processes. Geotechnical engineering cannot eliminate these risks for any site with sloping grades because gravity is constantly inducing strain on the sloping soil mass. Excessive wet weather and/ or earthquakes will exacerbate these strains. Geotechnical engineering considers excessive wet weather and 'design' earthquakes in order to provide an acceptable factor of safety for developing on or near sloping terrain for the current conditions. These factors of safeties are based on engineering standards such as defining engineering properties of the soil, topography, water conditions, seismic acceleration and surcharges.

Surface sloughing or other types of surficial slope movements usually do not affect the deep-seated structural capability of the slope. However, excessive and/or repeated surficial slope movements, if not repaired, may represent a threat to the structural integrity of the slope. If this situation does arise, the slope shall be inspected by a geotechnical engineer. Subsequently, maintenance may be required in order to prevent the possibility of further surficial or deep seated slope movements that may be damaging to life and property.

According to the Coastal Zone Atlas of Jefferson County, Washington, the Project is near terrain labeled 'Intermediate' regarding potential landslide activity. Historically, intermediate terrains have no known landslides. However, this site is considered inherently hazardous due the existing geology and/ or topography and previous report of landslide activity on the northern lot, and additional analyses and recommendations concerning the slopes are presented herein. A Stability Map from the Coastal Zone Atlas for the general area of this Project is provided below:

Map from Washington State Department of Ecology Website

According to the Resource Map from the Washington State Department of Natural Resources (DNR), the Project is within terrain labeled 'highly erodible' relating to soils. In addition, DNR did not indicated previous landslide activity near the Project. DNR labeled portions of this project as medium and high slope instability with relation to slopes. This delineation is primarily dependent upon slopes and convergence. Secondly, lithology and precipitation are modeled within this delineation. In summary, this designation is based on mapping without field observations or knowledge of the specific site geology or soils. A Resource Map from the DNR Forest Practices Application Review System is provided below:

Resource Map from Washington State Department of Natural Resources Website

4.4.1 Slope Stability Assessment and Analysis

The Simplified Bishop Method, utilizing 'STABLE' software, was used to analyze the static stability of the site slopes. Seismic conditions were estimated utilizing worst case scenario values from the static analysis, a horizontal peak ground acceleration of 0.2g, and applying the applicable values to STABLE software. Various radii's and center points of the circle were automatically selected, and produced factor of safeties in a graphical and tabular format. Worst case scenario values were used in the slope stability analysis in regards to topography, surcharges, water content, internal friction and cohesion of the site soils. STABLE software has been repeatedly checked with manual calculations, and consistently proved to be a very conservative program. The following

soil properties were used in the analysis, and are based on observed conditions, known geology, and/or published parameters:

Top 4 feet of weathered soils

- Soil unit weight: 132 pcf
- Angle of internal friction: 32 degrees
- Cohesion: 0 psf

Soils below 4 feet

- Soil unit weight: 140 pcf
- Angle of internal friction: 40 degrees
- Cohesion: 400 psf

Based on the slope stability analysis, a minimum factor of safety within the area of development was determined to be 1.5 relative to static slope failures, and 1.1 with relation to seismic conditions. See the slope stability information in Appendix C for a depiction of input parameters and example of outputs.

4.4.2 Building and Footing Setbacks

Provided that assumptions relating to construction occur and recommendations are followed as presented in this report, the factor of safety for slope stability is sufficient for a **30 feet** footing setback from the face of the nearby descending slopes exceeding 30%.

The required setbacks may be reduced, if necessary, but shall include mitigation recommendations from the geotechnical engineer.

4.5 Erosion

Based on the USCS description of the Project soils, the surface soils are considered moderate to highly erodible. Both Jefferson County and DNR mapped the upper elevations of the property as an erosion hazard. Temporary and/ or permanent erosion control measures should be required for site development. Extents of temporary erosion control will mostly depend on the timeliness of construction, moisture content of the soil, and amount of rainfall during construction. Soil erosion typical to the existing site conditions and planned disturbance of the Project include wind-borne silts during dry weather and sediment transport during prolonged wet weather. Sediment transport could be from stormwater runoff or tracking off-site with construction equipment.

4.6 Surface and Subsurface Drainage

Positive drainage should be provided in the final design for all planned residential buildings. Drainage shall include sloping the ground surface, driveways and sidewalks away from the Project structures. All constructed surface and subsurface drains should be adequately maintained during the life of the structure. If drainage problems occur during or after construction, additional engineered water mitigation will be required. This may include a combination of swales, berms,

drain pipes, infiltration facilities, or outlet protection in order to divert water away from the structures to an appropriate protected discharge area.

Both footing perimeter drains and roof drains are required for this Project. Subsurface water intercepted in the footing perimeter drains, and stormwater collected from roof drains shall be separately tight-lined to an appropriate infiltration location that is at least 10 feet from a structure and not encroaching building setbacks as provided in this report. Alternatively, roof water may have an above ground outlet if tightlined to the toe of any critical slope exceeding 30%, the outlet is within a natural drainage convergence, directly from the downspout if roof areas contributing to the downspout is less than 700 sf. Energy dissipation is required at all above ground outlets. Splash blocks are typically used for downspout drains, and 4 ft square by 12 inches deep quarry spalls shall be used for tightlines.

4.6.1 Septic Drainfield Impacts

The approximate location of the proposed septic drainfield is presented on the Site Plan in Appendix A of this report. Based on the septic drainfield location with relation to the existing and proposed topography, the drainfields are not expected to adversely influence the structures near the critical slopes. This is also based on compliance with the recommendations in this report.

4.7 Vegetation Buffer and Considerations

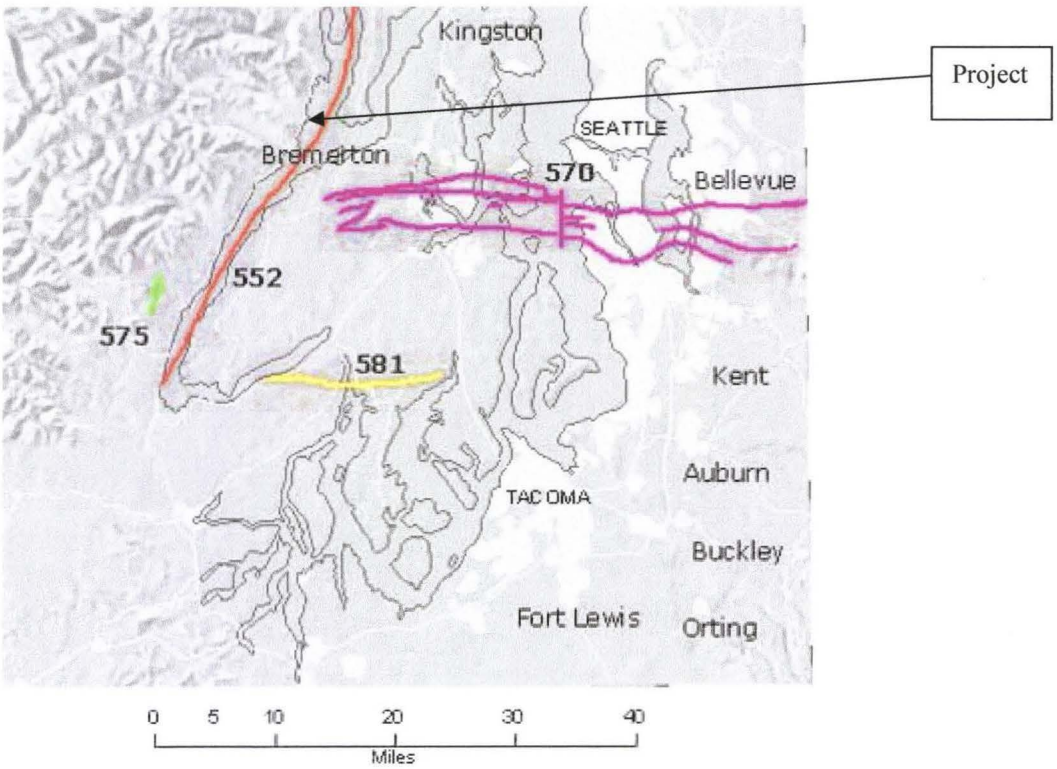
Vegetation is an excellent measure to minimize surficial slope movements and erosion on slope faces and exposed surfaces. By removing trees, the root strength is decreased over time, thereby lowering the 'apparent' cohesion of the soil. Transpiration is decreased, which results in additional groundwater, increased pore water pressure and less cohesion/ friction of the soil particles. Stormwater runoff also increases, and, fewer plants will create less absorption of the force from raindrops, thereby creating the potential for erosion hazards.

Vegetation shall not be removed from the face of the steep slopes of at least 30%, or within a distance of **5 feet** beyond the top or toe of the slope. However, any tree deemed hazardous to life or property shall be removed. If tree removal is necessary, then stumps and roots shall remain in place, and the underbrush and soil shall remain undisturbed as much as possible. Any disturbed soil shall be graded and re-compacted in order to restore the terrain similar to preexisting conditions and drainage patterns.

4.8 Seismic Considerations and Liquefaction

Soils immediately below the expected foundation depth for this Project are generally Type D, corresponding to the International Building Code (IBC) soil profiles. Soils below a depth of 5 feet from the existing ground surface may be considered Type C. According to the IBC, the regional seismic zone is 3 for this Project. The estimated peak ground acceleration ranges from 0.50g to 0.60g. This estimation is based on the United States Geological Survey (USGS) National Seismic Hazard Project in which there is an estimated 2% probability of exceedance within the next 50 years.

There are no known faults beneath this Project. The nearest Class 'A' or Class 'B' fault to this property is the Hood Canal Fault Zone, in which is approximately 2.5 miles to the east of this Project. This information is based on the USGS Quaternary Fault and Fold Database for the United States.



4.8.1 Liquefaction

The potential for liquefaction is believed to be low for this Project. This is based, in part, on the subsurface conditions such as soil characteristics and the lack of a permanent shallow water table. Subgrade characteristics that particularly contribute to problems caused from liquefaction include submerged, confined, poorly-graded granular soils (i.e. gravel, sand, silt). Although gravel- and silt-sized soil particles could be problematic, fine and medium grained sands are typically subjected to these types of seismic hazards. No significant saturated sand stratifications are anticipated to be within the upper 50 feet of the subsoil for this Project.

5.0 CLOSURE

Based on the project information provided by the owner, the proposed development, and site conditions as presented in this report, it is Envirotech's opinion that additional geotechnical studies are not required to further evaluate this Project.

Due to the inherent natural variations of the soil stratification and the nature of the geotechnical subsurface exploration, there is always a possibility that soil conditions encountered during construction are different than those described in this report. It is not recommended that a qualified engineer performs a site inspection during earthwork construction unless fill soils will influence the impending foundation. However, if native, undisturbed subsurface conditions found on-site are not as presented in this report, then a geotechnical engineer should be consulted.

This report presents geotechnical design guidelines, and is intended only for the owner, or owners' representative, and location of project described herein. This report should not be used to dictate construction procedures or relieve the contractor of his responsibility.

Any and all content of this geotechnical report is only valid in conjunction with the compliance of all recommendations provided in this report. Semantics throughout this report such as 'shall,' 'should' and 'recommended' imply that the correlating design and/or specifications must be adhered to in order to potentially protect life and/ or property. Semantics such as 'suggested' or 'optional' refer that the associated design or specification may or may not be performed, but is provided for optimal performance. The recommendations provided in this report are valid for the proposed development at the issuance date of this report. Changes to the site other than the expected development, changes to neighboring properties, changes to ordinances or regulatory codes, or broadening of accepted geotechnical standards may affect the long-term conclusions and recommendations of this report.

By developing the property and following the recommendations provided in this report, the property owner(s) shall be required to acknowledge in writing the risks inherent in developing in a geologic hazard area, to accept the responsibility of any adverse effects which may occur to the subject property or other properties as a result of the development, and to agree to convey the knowledge of this risk to persons purchasing the site by filing a notice on the property title.

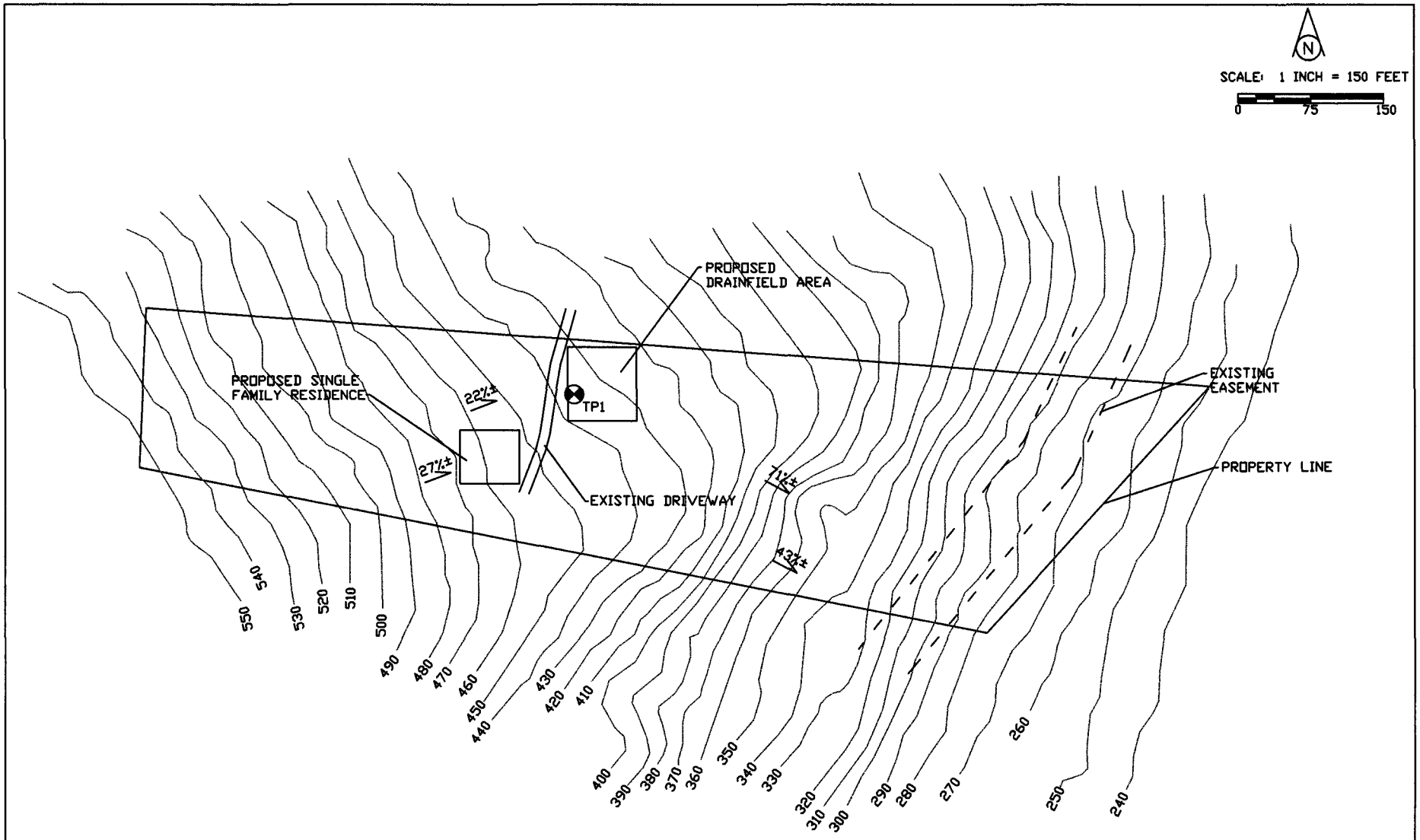
The services described in this report were prepared under the responsible charge of Michael Staten, a professional engineer with Envirotech. Michael Staten has appropriate education and experience in the field of geotechnical engineering in order to assess landslide hazards, earthquake hazards, and general soil mechanics.

Please contact Michael Staten at 360-275-9374 if you have any questions, comments, or require additional information.

Sincerely,
Envirotech Engineering
Michael Staten, P.E.
Geotechnical Engineer

APPENDIX A

SITE PLAN



NOTES:
1. CONTOURS WERE NOT PREPARED BY A LICENSED LAND SURVEYOR. CONTOURS WERE EXTRAPOLATED FROM A PUBLIC LIDAR SOURCE, AND INCORPORATED FIELD MEASUREMENTS AS EXPLAINED IN THE GEOTECHNICAL REPORT.
2. BOUNDARIES WERE NOT PREPARED BY A LICENSED SURVEYOR. LOCATIONS OF SITE FEATURES THAT ARE SHOWN HERE, SUCH AS TOP OF SLOPES, TOE OF SLOOPES, WATER FEATURES, ETC.., WITH RELATION TO THE PROPERTY LINES MUST BE VERIFIED BY THE OWNER. RECOMMENDATIONS IN THE GEOTECHNICAL REPORT PROVIDE SETBACKS, BUFFERS, DEPTHS, ETC.. WITH RELATION TO GEOLOGIC FEATURES, NOT PROPERTY LINES. THESE GEOLOGIC FEATURES MAY BE LOCATED ON THE SUBJECT PROPERTY OR NEIGHBORING PROPERTIES.

LEGEND

	SLOPE INDICATOR
80	EXISTING CONTOUR
TP1	TEST PIT

PROJECT/ OWNER/ LOCATION:
SINGLE FAMILY RESIDENCE
GEOTECHNICAL REPORT

LINDA ERICKSON
T25N R2W S3 SE 1/4
PARCEL 502 034 007
JEFFERSON COUNTY, WASHINGTON

ENGINEER:
ENVIROTECH ENGINEERING
PO BOX 984
BELFAIR, WASHINGTON 98528
360-275-9374

SITE PLAN

APPENDIX B

SOIL INFORMATION

Jefferson County Area, Washington

TrF—Triton very gravelly loam, 50 to 70 percent slopes

Map Unit Setting

- Mean annual precipitation: 55 to 65 inches
- Mean annual air temperature: 48 degrees F
- Frost-free period: 160 to 190 days

Map Unit Composition

- Triton and similar soils: 100 percent

Description of Triton

Setting

- Landform: Mountain slopes
- Parent material: Basal till

Typical profile

- H1 - 0 to 13 inches: slightly acid, very gravelly loam
- H2 - 13 to 17 inches: moderately acid, extremely gravelly sandy loam
- H3 - 17 to 60 inches: strongly acid, very gravelly sandy loam

Properties and qualities

- Slope: 50 to 70 percent
- Depth to restrictive feature: 12 to 20 inches to densic material
- Natural drainage class: Moderately well drained
- Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
- Depth to water table: About 11 to 18 inches
- Frequency of flooding: None
- Frequency of ponding: None
- Available water storage in profile: Very low (about 1.5 inches)

Interpretive groups

- Farmland classification: Not prime farmland
- Land capability classification (irrigated): None specified
- Land capability classification (nonirrigated): 7e
- Hydrologic Soil Group: D

Jefferson County Area, Washington

HrD—Hoodsport-Grove very gravelly sandy loams, 0 to 30 percent slopes

Map Unit Setting

- Elevation: 50 to 500 feet
- Mean annual precipitation: 55 to 90 inches
- Mean annual air temperature: 48 to 50 degrees F
- Frost-free period: 150 to 180 days

Map Unit Composition

- Hoodsport and similar soils: 45 percent
- Grove and similar soils: 45 percent

Description of Grove

Setting

- Landform: Plains, terraces
- Parent material: Glacial outwash

Typical profile

- H1 - 0 to 12 inches: moderately acid, very gravelly sandy loam
- H2 - 12 to 27 inches: moderately acid, very gravelly coarse sand
- H3 - 27 to 60 inches: slightly acid, gravelly coarse sand

Properties and qualities

- Slope: 15 to 30 percent
- Depth to restrictive feature: More than 80 inches
- Natural drainage class: Somewhat excessively drained
- Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
- Depth to water table: More than 80 inches
- Frequency of flooding: None
- Frequency of ponding: None
- Available water storage in profile: Very low (about 2.7 inches)

Interpretive groups

- Farmland classification: Not prime farmland
- Land capability classification (irrigated): None specified
- Land capability classification (nonirrigated): 4e
- Hydrologic Soil Group: A

- Other vegetative classification: Unnamed (G001XY402WA)

Description of Hoodsport

Setting

- Landform: Terraces
- Parent material: Basal till

Typical profile

- H1 - 0 to 6 inches: strongly acid, very gravelly sandy loam
- H2 - 6 to 28 inches: strongly acid, very gravelly sandy loam
- H3 - 28 to 60 inches: strongly acid, very gravelly sandy loam

Properties and qualities

- Slope: 0 to 15 percent
- Depth to restrictive feature: 20 to 40 inches to densic material
- Natural drainage class: Moderately well drained
- Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
- Depth to water table: About 19 to 36 inches
- Frequency of flooding: None
- Frequency of ponding: None
- Available water storage in profile: Very low (about 1.7 inches)

Interpretive groups

- Farmland classification: Not prime farmland
- Land capability classification (irrigated): None specified
- Land capability classification (nonirrigated): 4e
- Hydrologic Soil Group: B
- Other vegetative classification: Unnamed (G001XY302WA)

TEST PIT LOG

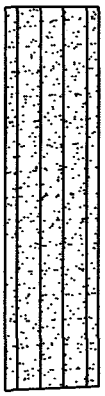
TEST PIT NUMBER TP-1

PROJECT: Erickson Geotechnical Report
PROJECT NO: 1453
CLIENT: Linda Erickson
LOCATION: Parcel 502 034 007
Jefferson County, Washington

DATE OF LOG: 3/16/2013
LOGGED BY: MCS
EXCAVATOR: N/A
DRILL RIG: None
ELEVATION: N/A

INITIAL DEPTH OF WATER: N/A

FINAL DEPTH OF WATER: N/A

DEPTH	SOIL STRATA, SAMPLERS AND TEST DATA	USCS	DESCRIPTION	LL	PI	STANDARD PENETRATION TEST DEPTH	N	CURVE 10 30 50
0		SM	Brown, moist SILTY SAND with gravel, medium dense. Gravel is well-graded and subrounded. Sand is medium and coarse. Non-plastic.					
1								
2			Some gravel, very low moisture, increasing density with depth					
3			hardpan					
4			Excavation terminated at approximately 3.5 feet					
5								
6								
7								
8								
9								
10								

No Groundwater Encountered

This information pertains only to this boring and should not be interpreted as being indicitive of the entire site.

ENVIROTECH ENGINEERING
Geotechnical Engineering

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original with Department of Ecology
Second Copy - Owner's Copy
Third Copy - Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

106345

Notice of Intent 124922
UNIQUE WELL I DACY 986
Water Right Permit No

(1) OWNER: Name Michael Boling Address 1113 Black Point RdBrinnon, Wa 98320

(2) LOCATION OF WELL: County Jefferson SE 1/4 SE 1/4 Sec 3 25N N R 2 WWM WM

(2a) STREET ADDRESS OF WELL. (or nearest address)

TAX PARCEL NO Tract 11 Canal View Highlands

(3) PROPOSED USE: XX Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐ DeWater

(4) TYPE OF WORK: Owner's number of well (if more than one)
XX New Well Method
☐ Deepened ☐ Dug ☐ Bored
☐ Reconditioned ☐ Cable ☐ Driven
☐ Decommission ☐ Rotary ☐ Jetted

(5) DIMENSIONS: Diameter of well 6" inches
Drilled 378 feet Depth of completed well 378 ft

(6) CONSTRUCTION DETAILS
Casing Installed:
XXXX Welded SIX Diam from 1½ ft to 179 ft
☐ Liner installed " Diam from ft to ft
☐ Threaded " Diam from ft to ft

Perforations: XX Yes ☐ No
Type of perforator used Star
SIZE of perforations 1" in by ¼" in
perforations from 38 ft to 41 ft

Screens: ☐ Yes XX No ☐ K-Pac Location
Manufacturer's Name
Type Model No
Diam Slot Size from ft to ft
Diam Slot Size from ft to ft

Gravel/Filter packed: ☐ Yes XX No ☐ Size of gravel/sand
Material placed from ft to ft

Surface seal: XX Yes ☐ No To what depth? ft
Material used in seal Bentonite
Did any strata contain unusable water? ☐ Yes ☐ XX No
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type H P

(8) WATER LEVELS: Land-surface elevation above mean sea level ft
Static level 14 ft below top of well Date 10-11-01
Artesian pressure lbs per square inch Date
Artesian water is controlled by (Cap, valve, etc)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes XX No If yes, by whom?
Yield gal /min with ft drawdown after hrs
Yield gal /min with ft drawdown after hrs
Yield gal /min with ft drawdown after hrs
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal /min with ft drawdown after hrs
Airtest 1½ gal /min with 364 ft drawdown after 2 hrs
Artesian flow g p m Date 10-11-01
Temperature of water 50° Was a chemical analysis made? ☐ Yes ☐ No

(10) WELL LOG or DECOMMISSIONING PROCEDURE DESCRIPTION
Formation Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information Indicate all water encountered

MATERIAL	FROM	TO
Bouldars, hardpan	0	38
Gravel, little H2o	38	39
Hardpan/Boulders	39	178
Basalt, medium gray	178	215
Basalt, hard, gray	215	221
" Medium gray	221	231
" Hard gray	231	235
" Medium gray	235	252
" Hard gray	252	258
" Medium gray	258	270
" Hard Gray	270	280
" Medium Gray	280	283
" Hard Gray	283	288
" Medium Gray	288	308
" Hard Gray	308	316
" Medium Gray	316	331
" Hard Gray	331	349
" Medium Gary	349	359
" Hard Gray	359	362
" Medium Gray	362	366
" Hard Gray	366	372
" Medium Gray	372	378

RECEIVED
DEC 06 2001
DEPARTMENT OF ECOLOGY
WELL DRILLING UNIT

180 ft casing

Work Started 9-25-01 Completed 10-10-01

WELL CONSTRUCTION CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards Materials used and the information reported above are true to my best knowledge and belief

Type or Print Name Dave Maberry License No 1717
(Licensed Driller/Engineer)

Trainee Name License No

Drilling Company Olympic Drilling
(Signed) Daniel Maberry License No 1717
(Licensed Driller/Engineer)

Address P.O. Box 88 Brinnon, Wa 98320

Contractor's Registration No Brinngco12c5 Date 10-21-01

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer For special accommodation needs, contact the Water Resources Program at (360) 407-6600 The TDD number is (360) 407-6006

ECY 050-1-20 (11/98)

APPENDIX C

SLOPE STABILITY

STABLE Version 9.03.00u

Bishop
****

TITLE
dynamic
****
UNITS (Metric/Imperial) = I

****
GEOMETRY DEFINITION

POINTS

NO.	X	Y
1	0.000	0.000
2	50.000	-15.000
3	150.000	-25.000
4	200.000	-75.000
5	0.000	-4.000
6	50.000	-19.000
7	150.000	-29.000
8	200.000	-79.000
9	20.000	-6.000
10	28.420	-8.530
11	36.840	-11.050
12	45.260	-13.580
13	53.680	-15.370
14	62.110	-16.210
15	70.530	-17.050
16	78.950	-17.890
17	87.370	-18.740
18	95.790	-19.580
19	104.210	-20.420
20	112.630	-21.260
21	121.050	-22.110
22	129.470	-22.950
23	137.890	-23.790
24	146.320	-24.630
25	154.740	-29.740
26	163.160	-38.160
27	171.580	-46.580
28	180.000	-55.000

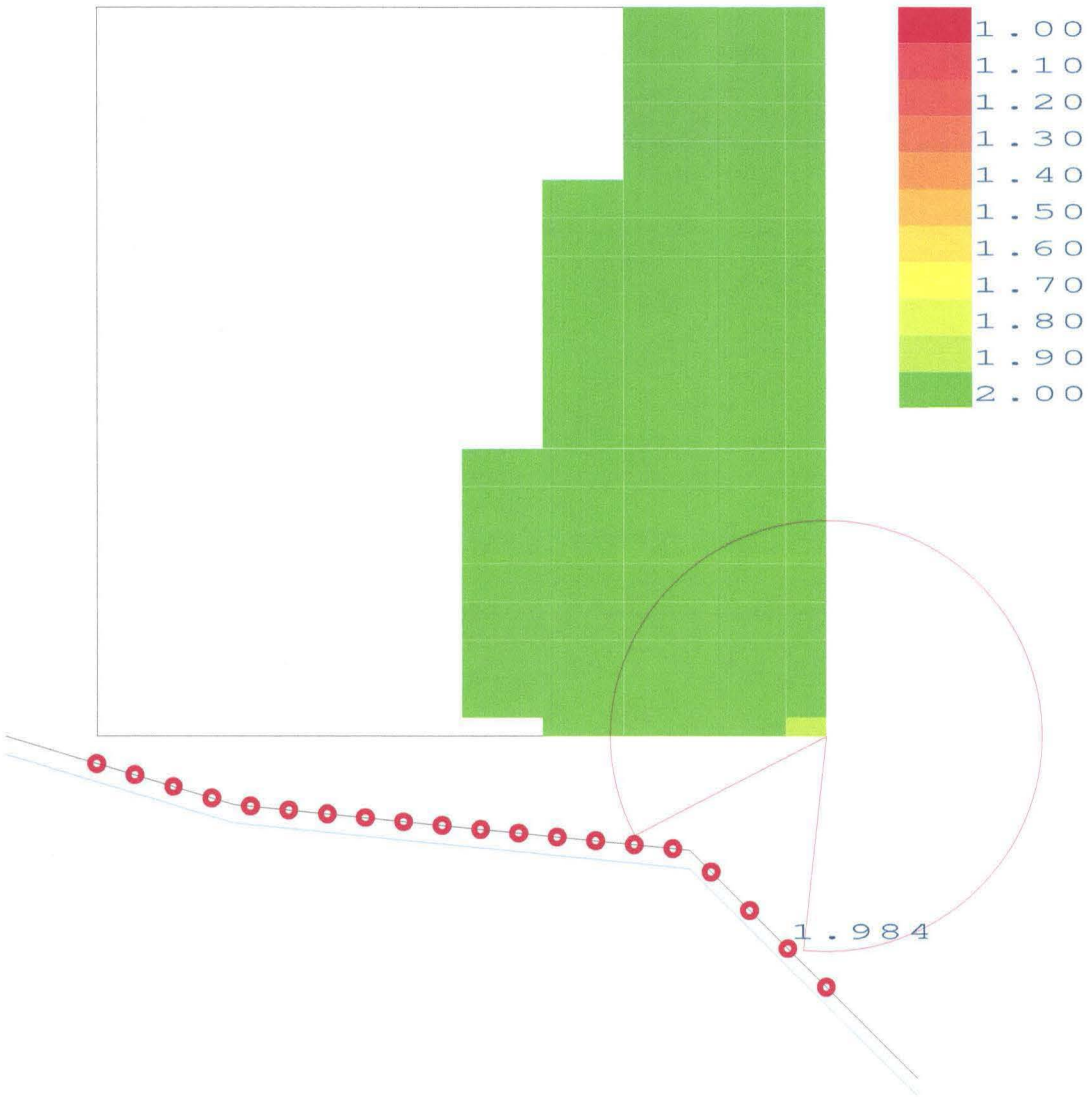
LINES

Lo X	Hi X	SOIL
1	2	1
2	3	1
3	4	1
5	6	2
6	7	2
7	8	2

****
SOILS

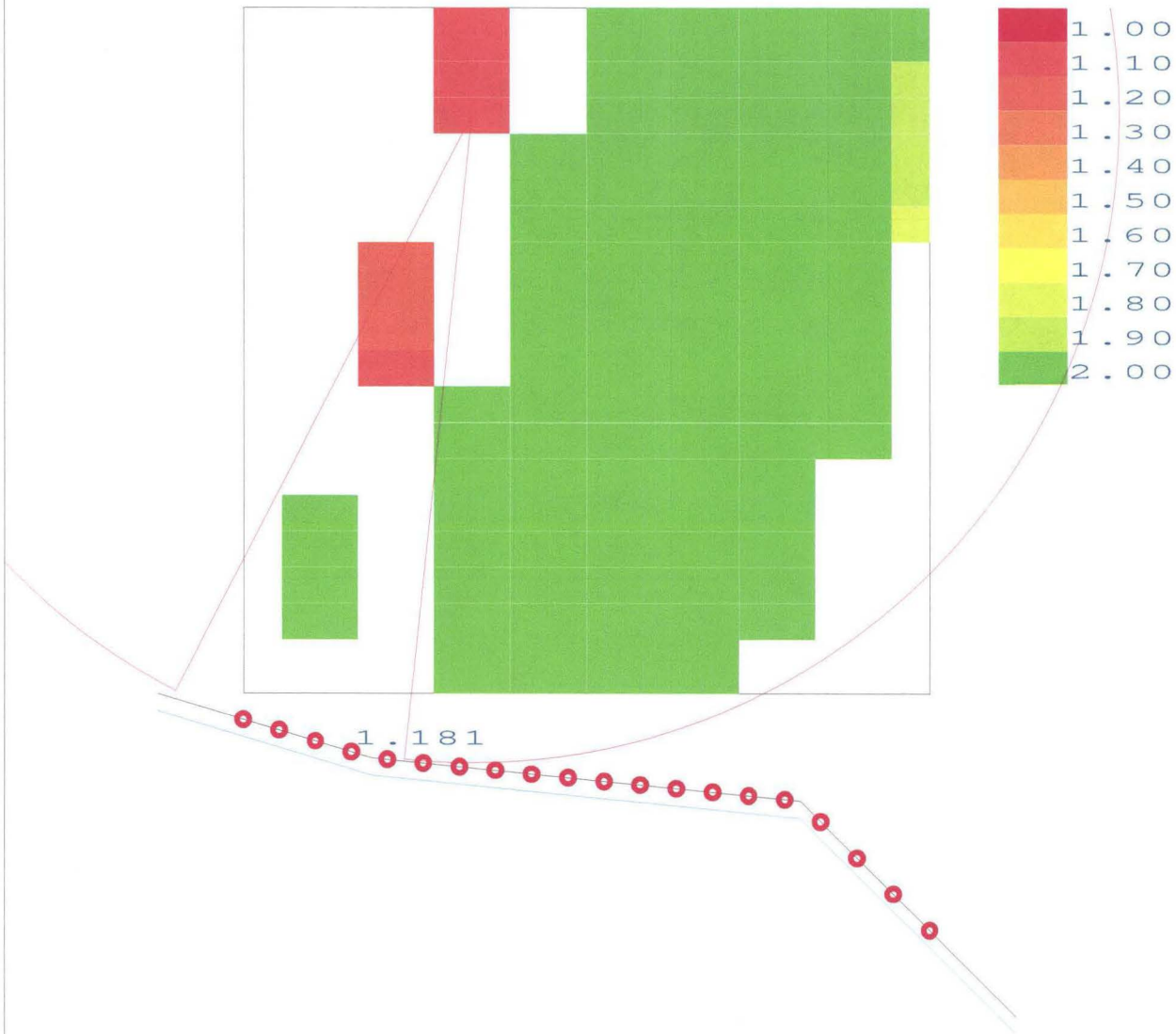
SOIL NAME LINETYPE-PEN COHESION FRICTION UNIT WT.

```
   1  Soil_1          CONTINUOUS-BLACK        0.00    32.0   132.000
   2  Soil_2          CONTINUOUS-BLUE       400.00    40.0   140.000

*********************************************************
PORE PRESSURE SPECIFICATION

SOIL PIEZO  RU        EXCESS
     Y/N/P  Value     Value

   1   N    0.000     0.000
   2   N    0.000     0.000

PIEZOMETRIC SURFACE

 POINT


POINT PORE PRESSURES

POINT  PRESSURE


*********************************************************

SLIP DIRECTION  (+/- X) = +

*********************************************************
SLIP-CIRCLES

AUTOMATIC

Circle Centre Grid Extremities

               160.000
           ***************
           *             *
    20.000 *             *   180.000
           *             *
           ***************
                 0.000

X spacing -- no. of cols (max 10)=   10
Y spacing -- no. of rows (max 20)=   20


Grid    1    Circles through point     9
Grid    2    Circles through point    10
Grid    3    Circles through point    11
Grid    4    Circles through point    12
Grid    5    Circles through point    13
Grid    6    Circles through point    14
Grid    7    Circles through point    15
Grid    8    Circles through point    16
Grid    9    Circles through point    17
Grid   10    Circles through point    18
Grid   11    Circles through point    19
Grid   12    Circles through point    20
Grid   13    Circles through point    21
Grid   14    Circles through point    22
```



Project : Erickson
Datafile : static
Analysis : Bishop

STABLE-2002 MZ Associates Ltd



Project : Erickson
Datafile : dynamic
Analysis : Bishop

STABLE-2002 MZ Associates Ltd