GEOTECHNICAL REPORT

PROPOSED 6-LOT HOUSING SUBDIVISION
438 WASHINGTON STREET, WOODLAND, WA

Prepared for:

Windsor Engineers, Inc.
Attn: Dan Koistinen
E-mail: DKoistinen@windsorengineers.com

June 30, 2023

STRATA Project No. 23-0910

Prepared By:

Randy Goode, PE
Principal Engineer

2117 NE OREGON STREET, SUITE 502
PORTLAND, OREGON 97232
971.400.0269 MAIN
STRATA-DESIGN.COM

TABLE OF CONTENTS

FIGURES

1.0 INTRODUCTION

This report presents our geotechnical site evaluation for the proposed residential subdivision located at 438 Washington Street in Woodland, Washington (Figure 1). This report summarizes the work accomplished and provides our conclusions and recommendations for site development.

As detailed in this report, the site is mantled with native silt underlain by interbedded sandy and clayey soils. Based on our understanding of the project and the subsurface conditions disclosed by our subsurface exploration, foundation support for the proposed structures can be provided by conventional spread footings as proposed, provided the final design meets the intent of the recommendations provided in this report. The developer and contractor should be aware that the area is prone to seasonally high levels of groundwater, even though absent during the subsurface evaluation of June 2023.

2.0 PROJECT DESCRIPTION

The planned development consists of partitioning the current approximately 170 foot by 190 foot lot into 6 new building sub-lots. We understand the proposed structures as currently planned will consist of relatively lightly loaded, wood-framed, 1- to 2-level structures with be supported by continuous exterior footings, column footings, or slab on grade. We anticipate the project will require relatively minor amounts of grading. Based on our review of available structural plan documents, we understand the structures are Seismic Risk Category II structures under International Residential Building Code.

3.0 SITE DESCRIPTION AND GEOLOGY

3.1 Surface Conditions

The 0.93-acre site is currently developed with a single-level single family home and detached sheds and gravel access ways. The site is bordered to all sides by existing residences. The subject and surrounding properties are relatively flat with ground surface elevations at the site ranging from about of about 24 to 30 feet (NAD 83). The undeveloped portions of the site are covered at the ground surface with grass, and with gravel surfacing along the access drives.

3.2 Site Geology and Regional Mapping

The site is located within the Portland Basin, the Willamette Valley segment of the Puget-Willamette Lowland that extends from Puget Sound into west-central Oregon. Positioned along the meandering Lewis River northeast of the confluence of the Lewis River into the Columbia River, the site is found on a stabilized point bar composed of silt, coarser sand and gravel formed by repeated flooding of the Lewis and Columbia Rivers (11,700 years ago to present). The deposits also include volcanic debris from Mount St. Helens[1].

[1] Evarts, Russell C. "Geologic Map of the Ridgefield Quadrangle, Clark and Cowlitz County, Washington", US Geological Survey, Scientific Investigations Map 2844, 2004.

The area was exposed to repeated cataclysmic glacial lake outburst floods, known as the Missoula Floods, that swept down the Columbia River Gorge as many as 40 times during the Pleistocene (2.6 million years ago to 11,700 years ago). Flooding became restricted between Kalama and St. Helens, due to Goble Volcanics found within those areas that acted as a boulder in the streambed, slowing the flow, flooding the area as deep as 400-feet and allowing the sand and gravel to drop as sediment as exposed in the higher elevations of Ridgefield[2].

4.0 SUBSURFACE CONDITIONS

4.1 Field Explorations

Subsurface explorations were carried out by STRATA on June 30, 2023 by advancing three hand-augered borings, designated HA-1 through HA-3. The approximate locations of the explorations are shown on the Site Exploration Plan (Figure 2). Logs of the borings are attached to this report.

Groundwater was not encountered at the time of advancing the hand-augered borings which explored the site to depths of about 7 feet. It should be anticipated that groundwater levels will fluctuate during the year depending on climate, irrigation season, extended periods of precipitation, drought, and other factors. Shallow perched groundwater conditions may develop in the near-surface fine-grained soils.

4.2 Infiltration Testing

STRATA completed falling-head infiltration testing at a depth of 3.5 feet in HA-2. The infiltration test was conducted by filling the 3-inch-diameter hole with about 12 inches of head and conducting a falling-head infiltration test through the pipe. Prior to conducting the test, the hole was soaked by maintaining an approximate 12- to 24-inch head of water until a constant rate of infiltration, or equilibrium condition, was reached. Our measured rate of infiltration testing within the native sand was 15 inches per hour. We recommend reducing the field infiltration rate by a factor of at least 2 to account for soil variability and the reduction in the rate of infiltration over time due to clogging.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 General

As noted in the Subsurface Conditions portion of this report, the site is mantled with relatively soft topsoil and silt soils overlying sands and sandy silts, with potential for seasonally high groundwater table. Based on the results of our field explorations and observation of site conditions, it is our opinion that the site can be developed as proposed and supported on shallow foundations.

Our specific recommendations for site development are provided in the following paragraphs.

---

[2] Allen, Burns, & Burns, "Cataclysms on the Columbia", Ooligan Press-Portland State University, 2009.

5.2 Construction Considerations

Our explorations encountered variable soft to medium stiff Silt, underlain by loose sand during our subsurface exploration. On-site soil conditions are more favorable for earthwork in dry weather conditions. Fine-grained soils on the site easily lose strength when disturbed by construction traffic and activities during wet weather. We recommend earthwork take place during the typically dry months of the year. It can be expected that grading costs will be escalated if earthwork is planned for the wet winter and spring months, as the site preparation, utility trench work, and excavation can create extensive wet and/or soft areas that would often necessitate mitigation costs. Earthwork should be planned and executed to minimize subgrade disturbance.

To prevent disturbance and softening of the silty subgrade soils during wet weather or ground conditions in areas outside existing paved surfaces, movement of construction traffic should be limited to granular haul roads and work pads in these areas. In general, a minimum of 18 to 24 inches of relatively clean, granular material is required to support concentrated construction traffic, such as dump trucks and concrete trucks, and protect the subgrade. A 12-in.-thick granular work pad should be sufficient to support occasional light-truck traffic and low-volume construction operations. If wet-weather construction is anticipated, a geotextile separation fabric may be placed on the exposed subgrade prior to placement and compaction of the granular work pad to improve the performance of work pads and haul roads. The imported granular material should be placed in one lift over the prepared or undisturbed subgrade and compacted using a smooth-drum, non-vibratory roller. It should be noted that existing pavement may not be designed for use with repeated heavy construction traffic, and thus may become distressed during construction and some repair may be required. Formal pavement design for the development is beyond our scope for this project.

5.3 Site Preparation

Areas of proposed development should be stripped of existing vegetation, surface organics, and loose or soft surface soils. We estimate stripping will likely be necessary to depths of about 12 inches. Stripping may need to extend into non-organic soils in areas where significant roots are present. Depending on the methods used, considerable disturbance and loosening of the subgrade could occur during stripping. Strippings should be removed from the site or stockpiled for use in landscaped areas. Following the removal of organic soils and roots, the area should be evaluated by STRATA for the presence of soft, yielding soils. Where encountered, these soils should be removed to expose competent, native soils. We recommend excavations and subgrade preparation be completed with smooth-edged buckets equipped to hydraulic excavators to minimize disturbance to subgrade. Over-excavations should be backfilled with structural fill.

Various pipe work may have been installed as part of past farming operations on the site. Demolition activity may necessitate removal of existing improvements across the proposed new building footprints, including any remnant agricultural elements such as drainage or water supply pipes, etc. Please note that it is our experience that residual pipes are typically full of water and may conduct excess water into the work area. Thus, the pipes should be drained and removed prior to any excavation or grading work.

Any existing building footings, floor slabs, pavement, septic tanks and drain fields and other structural elements should be removed from the site in the locations of the planned improvements. Existing utilities underlying new footings, structural fill, or other structural elements should be abandoned by removing the conduit and backfilling with granular structural fill. Openings in existing utilities that underly landscape areas and daylight into excavations should be capped or grouted to avoid loss of excavation backfill or subgrade soils into voids. Soil disturbed during building demolition and grubbing operations should be removed to expose firm undisturbed subgrade. The resulting excavations should be backfilled with structural fill.

We recommend STRATA be retained to observe all subgrade preparation to evaluate the consistency of the subgrade soils during excavation by observing a proof roll with a fully loaded dump truck and/or by probing the subgrade with a foundation probe. The proof rolling should be observed by STRATA to identify areas of excessive yielding. Areas of excessive yielding or unsuitable subgrade should be excavated and replaced with compacted materials recommended for structural fill. Areas that appear to be excessively wet and/or yielding to support proof rolling equipment should be prepared in accordance with the recommendations for wet weather construction presented in this report.

Grades should be developed and maintained to drain surface and roof runoff away from structures and other site improvements. Permanent cut and fill slopes should be planned no steeper than 2H:1V (Horizontal:Vertical).

5.4 Temporary Excavations, Shoring, and Groundwater Management

5.4.1 General

Based on our discussions with the project team and review of preliminary plans, we understand the structures will be at-grade, and that the maximum depth of temporary excavations for new structures are anticipated to be less than about 5 feet, with the exception of the concrete piers, which may extend below a depth of 5 feet (further discussed in the Concrete Piers Construction Considerations section of this report). Deeper trenching may be required for installation of new utilities; however, this information is currently unavailable. Once plans are finalized, STRATA should review available plan and specification documents to provide additional or revised recommendations if needed. As discussed in the Subsurface Conditions section of this report, we anticipate seasonal groundwater levels at the site are relatively shallow and within the planned depths of temporary excavation throughout much of the year; however, more-shallow groundwater levels, perched-groundwater, and groundwater levels approaching the ground surface are possible during the wet winter and spring months or during periods of prolonged rainfall. Considering this, temporary excavation dewatering and/or groundwater management are likely to be significant considerations during construction of the project, depending on the time of year construction is to proceed and the depth of planned excavations.

We anticipate engineered shoring systems may be required for temporary excavation support for deep trenches, or trenches extending below the water table, particular in the sandy soils. Open cut could also be considered above the groundwater table and where site access allows. The method of excavation and design of temporary excavation support and dewatering systems are the responsibilities of the contractor and are subject to applicable local, state, and federal safety regulations, including the current OSHA excavation and trench safety standards. The means, methods, and sequencing of construction operations and site safety are also the responsibilities of the contractor. The information provided below is for the use of our client and should not be interpreted to imply we are assuming responsibility for the contractor's temporary excavation and dewatering design, actions, or site safety.

Unsupported cut slopes may exhibit distress in the form of localized sloughing or raveling, particularly if seepage develops in portions of the slopes with higher sand content. The on-site soil, if groundwater or seepage is not present, is classified as "Soil Type C". For planning purposes. Temporary cut slopes in this type of soil should be made at 1.5H:1V (Horizontal:Vertical) or flatter. If significant seepage, running-soil conditions, or slope instability are observed during excavation, flatter slopes may be necessary. Some minor amounts of sloughing, slumping, or running of temporary slopes should be anticipated during and shortly after excavation. Open-cut excavations should be completed and backfilled in the shortest practical sequence. In our opinion, the short-term global stability of temporary slopes will be adequate if surcharge loads due to construction traffic, vehicle parking, material laydown, foundations for existing nearby structures, etc., are maintained a horizontal distance equal to the height of the slope away from the top of the excavation and if the excavations are made above groundwater. However, smaller horizontal offsets may be appropriate for surcharge loads that act over smaller areas, such as point loads and foundation loads of limited areal extent.

5.4.2 Groundwater Management

If groundwater is encountered, groundwater levels should be maintained at a minimum depth of 2 feet below the base of the excavation, or as required, to maintain base stability during construction. Selection or design of dewatering methods are the responsibility of the contractor. We anticipate groundwater inflow, if encountered, can generally be managed by pumping from sumps within the excavations in conjunction with a granular drainage/stabilization layer. However, depending on actual groundwater levels at the time of construction, positive control of groundwater using external dewatering wells or well point systems may be required. If groundwater is encountered in the excavations, it will typically be necessary to over-excavate the base of the excavation and install a granular drainage/stabilization layer to facilitate groundwater management and provide a firm working surface for construction. The actual required depth of over-excavation and thickness of granular drainage/stabilization layer will depend on the conditions exposed in the excavation and the effectiveness of the contractor's groundwater management or dewatering efforts and must be evaluated based on actual observations during construction.

The maximum depth of excavation for new utilities on the development property is unknown currently. STRATA should be notified once finalized plans are made available to provide additional recommendations if necessary. The method of excavation and design of temporary excavation support and dewatering systems, as well as safe working conditions, are the responsibilities of the contractor and are subject to applicable local, state, and federal safety regulations, including the current OSHA excavation and trench safety standards. Temporary excavations should either be shored or sloped in accordance with applicable regulations.

All utility trenches that will be underlying new pavements, walkways, buildings, or new structural fill should be backfilled with structural fill. Trench backfills should consist of well-graded imported granular material (see Structural Fill section below) with a maximum particle size of 1.5-inch and less than 8 percent by weight passing the U.S. Standard No. 200 Sieve. The material should be free of roots, organic matter, and other unsuitable materials.

Trench backfills in the bedding zone and pipe zone should be placed and compacted in maximum lifts of 6 inches. Trench backfills above the pipe zone should be placed and compacted in 8-in. (loose) lifts. A minimum cover of 3 feet over the top of the pipe should be placed before compacting with a hydraulic plate compactor (hoe-pack). The granular backfill should be compacted to at least 95% of the maximum dry density determined by ASTM D698. Flooding or jetting the backfilled trenches with water to achieve the recommended compaction should not be permitted.

5.5 Permanent Slopes

Although we anticipate permanent slopes within the boundaries of new construction will be relatively flat, permanent cut and fill slopes should not exceed a grade of 2H:1V (Horizontal to Vertical). Slopes that will be maintained by mowing should not be constructed steeper than 3H:1V. Structures and paved surfaces should be located at least 5 feet from the slope face.

The slopes should be planted with vegetation to provide protection against erosion. Surface water runoff should be collected and directed away from slopes steeper than 3H:1V to prevent water from running down the face of the slope.

5.6 Structural Fill

Fill within building, pavement, and sidewalk areas should be placed as compacted structural fill. Structural fill should be compacted to at least 95 percent of the maximum dry density as determined by ASTM D698/AASHTO T-99, the standard Proctor. In landscaped areas or areas not sensitive to settlement, fill should be compacted to about 90% of the maximum dry density determined by ASTM D698. Flooding or jetting structural fill with water to achieve the recommended compaction should not be permitted.

The earthwork contractor's compactive effort should be evaluated based on field observations. Lift thicknesses should be adjusted to meet compaction requirements. The moisture content for compaction should be within 3 percent of optimum.

Brush, roots, construction debris, and other deleterious material should not be placed in the structural fill. Fills should be placed over subgrade that has been prepared in conformance with the Site Preparation and Foundation Support sections of this report. Material used as structural fill should be free of organic matter or other unsuitable materials and should meet specifications provided in WASS 9-03.14, depending upon the application. These materials are discussed below:

Native Soils: The on-site native soil is suitable for use as structural fill in dry-weather conditions for general grading purposes provided it can be moisture-conditioned, separated from concentrations of organics, construction debris, and other unsuitable material, and compacted to the specified density. The on-site native soils should meet the requirements of WASS 9-03.14(3) – Borrow Material. The fill should be placed in lifts with a maximum loose thickness of 8 inches.

General Imported Granular Material: Imported granular material should be pit or quarry run rock, crushed rock, or crushed gravel and sand and should meet the specifications provided in WA SS 9-03.9(1) - Ballast, WA SS 9-03.14(1) - Gravel Borrow, or WA SS 9-03.14(2) - Select Borrow. The imported granular material should be well-graded between coarse and fine material and have less than 5 percent by weight passing the U.S. Standard No. 200 Sieve. Imported granular material should be placed in lifts with a maximum loose thickness of 12 inches.

Where imported granular material is placed over wet or soft-soil subgrades, we recommend a geotextile be placed as a barrier between the subgrade and imported granular material. The geotextile should meet WASS 9-33.2 (Table 3) for soil separation and/or stabilization. The geotextile should be installed in conformance with WA SS 2-12 - Construction Geotextile.

Footing and Slab Base Rock Imported Granular Material: Imported granular material placed at the base of footings should be clean, crushed rock or crushed gravel and sand that is well-graded between coarse and fine. The granular materials should contain no deleterious materials, have a maximum particle size of 1½ inches, have less than 5 percent by weight passing the U.S. Standard No. 200 Sieve, and meet WA SS 9-03.9(3) - Crushed Surfacing or WA SS 9-03.10 - Aggregate for Gravel Base.

Free-Draining Fill: Free-draining material should have less than 2 percent by weight passing the No. 200 sieve (washed analysis). Examples of materials that would satisfy this requirement include open-graded, angular ¾ to ¼ inch, 1½ to ¾ inch, or 3- to 1-inch crushed rock.

5.7 Foundation Support

5.7.1 General

We understand the currently planned structures will be supported by continuous spread footings. The native soils at the site, particularly after removal of a few inches of the topsoil, will likely have a variable consistency. Deleterious over-wet or soft areas should be over excavated to a firm layer and replaced with structural fill. All building foundation surfaces should be prepared in accordance with the Site Preparation Section of this report. The building foundations may be installed on either firm native subgrade or engineered fill. Continuous wall and isolated spread footings should be in accordance with the Residential Building Codes. Continuous wall and isolated spread footings should be established at a minimum depth of 18 inches below the lowest adjacent finished grade.

As discussed, footings or slabs bearing on firm native subgrade or structural fill should be sized for an allowable bearing capacity of 1,500 psf. This is a net bearing pressure. The weight of the footing and overlying backfill can be disregarded in calculating footing sizes. The recommended allowable bearing pressure applies to the total of dead plus long-term live loads. The allowable bearing pressure may be increased by a factor of 1/3 when considering short-term wind or seismic loads.

A STRATA geotechnical engineer (or designated representative) should confirm suitable bearing conditions and evaluate all footing subgrades. Observations should also confirm that loose or soft material, organics, unsuitable fill, and old topsoil zones are removed. Localized deepening of footing excavations may be required to penetrate any deleterious materials.

If construction occurs during wet weather, we recommend that a thin layer of compacted crushed rock (minimum of 3 inches) is placed over the footing subgrades to help protect them from disturbance due to foot traffic and the elements. A thicker layer of crushed rock may be required in subgrade areas that require over-excavation due to soft or otherwise unsuitable subgrade soils.

The footings should be founded below a line projected at a 1 horizontal to 1 vertical (1H:1V) slope from the base of any adjacent, near parallel, open or backfill excavations such as utility trenches. Any footings placed adjacent to any slopes must be embedded so that a minimum of 10 feet of horizontal distance is between the face of the footings and any adjacent, parallel slope.

5.7.2 Settlement

Based on our analysis, total post-construction static settlement was estimated to be less than 1-inch, with post-construction static differential settlement of less than ½-inch for the proposed structures, provided the project is constructed in accordance with our recommendations.

As further discussed in the Seismic Considerations section of this report, our preliminary analyses and review of available liquefaction hazard mapping indicate a moderate to high risk of liquefaction is present at the site, and we have assumed that settlement associated with potential liquefaction from a code-level earthquake is not being mitigated for the planned chicken house structures.

5.7.3 Lateral Resistance

Horizontal shear forces can be resisted partially or completely by frictional forces developed between the bases of spread footings and the underlying soil and by soil passive resistance. The total frictional resistance between the footing and the soil is the normal force times the coefficient of friction between the soil and the base of the footing. We recommend an ultimate value of 0.3 for the coefficient of friction for footings established on undisturbed, firm silt, and an ultimate value of 0.4 for the footings established on granular structural fill. The normal force is the sum of the vertical forces (dead load plus real live load). If additional lateral resistance is required, passive earth pressures against embedded footings can be computed based on an equivalent fluid having a unit weight of 250 pcf. This design passive earth pressure would be applicable only if the footing is cast neat against undisturbed soil or if backfill for the footings is placed as granular structural fill. Adjacent floor slabs, pavements, or the upper 12-inch depth of adjacent, unpaved areas should not be considered when calculating passive resistance.

5.8 Subdrainage and Floor Support

Satisfactory subgrade support for lightly loaded building floor slabs can be obtained on engineered structural fill. A subgrade modulus of 125 pounds per cubic inch may be used to design floor slabs founded on medium stiff or better subgrade, to be evaluated by the geotechnical engineer at the time of subgrade preparation.

Slab-on-grade floors beneath finished, heated, enclosed areas established at, or above adjacent final site grades should be underlain by a minimum 8- in.-thick granular base course. To provide a capillary break, the base-course material should consist of crushed rock of up to 1-in. maximum size with less than about 2% passing the No. 200 sieve (washed analysis). Crushed rock of ¾- to ¼-in. size is often used for this purpose (see the Structural Fill section of this report for Free-Draining Fill). The upper 2 in. of this material may be replaced with relatively clean, ¾-in.-minus, crushed rock to facilitate placement and compaction. The base course should be installed in a single lift and compacted until well keyed by at least four passes with a vibratory roller.

In areas where floor coverings will be provided or moisture-sensitive materials stored, it may be appropriate to install a vapor-retarding membrane in selected in accordance with the design team recommendations.

5.9 Site Drainage

Placement of foundation drains is recommended at the base elevations of footings on the outside of the footings. Foundation drains should consist of a minimum 4-inch- diameter, perforated, PVC drainpipe wrapped with a non-woven geotextile filter fabric. The drains should be backfilled with a minimum of 1 foot of angular, open-graded drain rock per lineal foot of pipe. The drain rock should be encased in a geotextile fabric to provide separation from the surrounding soils. Foundation drains should be positively sloped and should outlet to an appropriate discharge point.

Roof drains should be connected to a tightline drainpipe leading to storm drain utilities. Pavement surfaces (if present) and open space areas should be sloped such that surface water runoff is collected and routed to storm drain utilities. Ground surfaces adjacent to buildings should be sloped to drain away from the buildings.

5.10 Seismic Considerations

5.10.1 General

We understand the project is being designed in accordance with the American Society of Civil Engineers (ASCE) Document 7-16, *Minimum Design Loads for Buildings and Other Structures* (ASCE 7-16), for seismic design. The current IBC and ASCE 7-16 seismic hazard levels are based on a Risk-Targeted Maximum Considered Earthquake (MCE_R).

Based on our review of the soils disclosed by our subsurface explorations, we recommend using Site Class D (Default) to evaluate the seismic design of the planned structures. However, our analysis has identified a potential risk of seismically induced settlement at the site, which is further discussed below. In accordance with ASCE 7-16, sites with soils vulnerable to failure or collapse under seismic loading, such as liquefiable soils, should be classified as Site Class F, which requires a site-response analysis. However, Section 20.3.1 of the code provides an exception for structures having a fundamental period of vibration less than or equal to 0.5 second. Considering the proposed building will have a fundamental period of vibration less than 0.5 second, the design response spectrum can be derived using the non-liquefied subsurface profile in accordance with Sections 20.3.1 and 20.4.

The maximum horizontal-direction spectral response accelerations S_S and S_1 were obtained from the USGS Seismic Design Maps for the project coordinates. Site coefficients F_a and F_v were used to develop the Site Class D (Default) MCE_R-level spectrum in accordance with Section 11.4 of ASCE 7-16. However, Section 11.4.8 of ASCE 7-16 requires a ground-motion hazard analysis be completed for structures on Site Class D sites to determine the F_v coefficient when the S_1 parameter is greater than or equal to 0.2 g. The code provides an exception that waives the ground-motion hazard analysis if the seismic-response coefficient, C_s, is determined in accordance with Section 11.4.8, Exception 2, of ASCE 7-16. We anticipate the response coefficient will be developed as discussed above; therefore, the Site Class D (Default) ground-surface MCE_R response spectrum is appropriate for design of the structures. The design-level response spectrum is calculated as two-thirds of the ground-surface MCE_R spectrum.

ASCE 7-16 CODE BASED RESPONSE SPECTRUM MCE_R GROUND MOTION - 5% DAMPING 1% IN 50 YEARS PROBABILITY OF COLLAPSE	
S_S	0.83G
S_1	0.40G
MAPPED MAXIMUM CONSIDERED EARTHQUAKE SPECTRAL RESPONSE ACCELERATION PARAMETER (SITE CLASS D, DEFAULT)	
F_A	1.20
F_V	1.90
S_{MS}	0.99G
S_{M1}	0.76G
DESIGN SPECTRAL RESPONSE ACCELERATION PARAMETER	
S_{DS}	0.66G
S_{D1}	0.51G*

***Notes:** **(**1) Exception 2 of Section 11.4.8 should be considered when evaluating base shear calculations in Section 12.8. (2) The S_{D1} value is intended only for calculating T_s.

5.10.2 Liquefaction Induced Ground Damage

Liquefaction occurs when saturated granular soils are subjected to cyclic loading, which distorts the soil structure and causes loosely packed groups of particles to collapse, increasing porewater pressure in the soil mass. As pore pressure increases, the soil begins to lose strength and may even temporarily behave as a viscous fluid in the most extreme cases. Liquefaction can result in ground surface settlement, large lateral deformations, decreased bearing capacity, settlement of shallow foundations, and a reduction in the axial and lateral capacity of pile foundations. For the subject site and based on our preliminary analysis and review of available liquefaction susceptibility mapping by the Washington Department of Natural Resources, the risk of liquefaction hazard at the site is moderate to high.

5.10.1 Other Seismic Hazards

Review of available geologic literature indicates no active faults are present within 5 miles of the site. In our opinion, the risk of ground rupture during a design-level earthquake is low unless occurring on a previously unknown or unmapped fault. The risk of tsunami inundation at the site is absent.

6.0 ADDITIONAL SERVICES AND CONSTRUCTION OBSERVATION

Because the future performance and integrity of the structural elements will depend largely on proper site preparation, drainage, fill placement, and construction procedures, monitoring and testing (geotechnical special inspection) by experienced geotechnical personnel should be considered an integral part of the design and construction process. Consequently, we recommend that STRATA be retained to provide the following post-investigation services:

- Review construction plans and specifications to verify that our design criteria presented in this report have been properly integrated into the design.
- Observe footing subgrade before footings are constructed to verify the soil conditions.
- Observe placement of fill and conduct density testing of structural fill, and of underground utility backfill.
- Prepare a post-construction letter-of-compliance summarizing our field observations, inspections, and test results.

7.0 LIMITATIONS

This report has been prepared for the exclusive use of the addressee, and their architects and engineers, for aiding in the design and construction of the proposed development and is not to be relied upon by other parties. It is not to be photographed, photocopied, or similarly reproduced, in total or in part, without the express written consent of the client and STRATA. It is the addressee's responsibility to provide this report to the appropriate design professionals, building officials, and contractors to ensure the correct implementation of the recommendations.

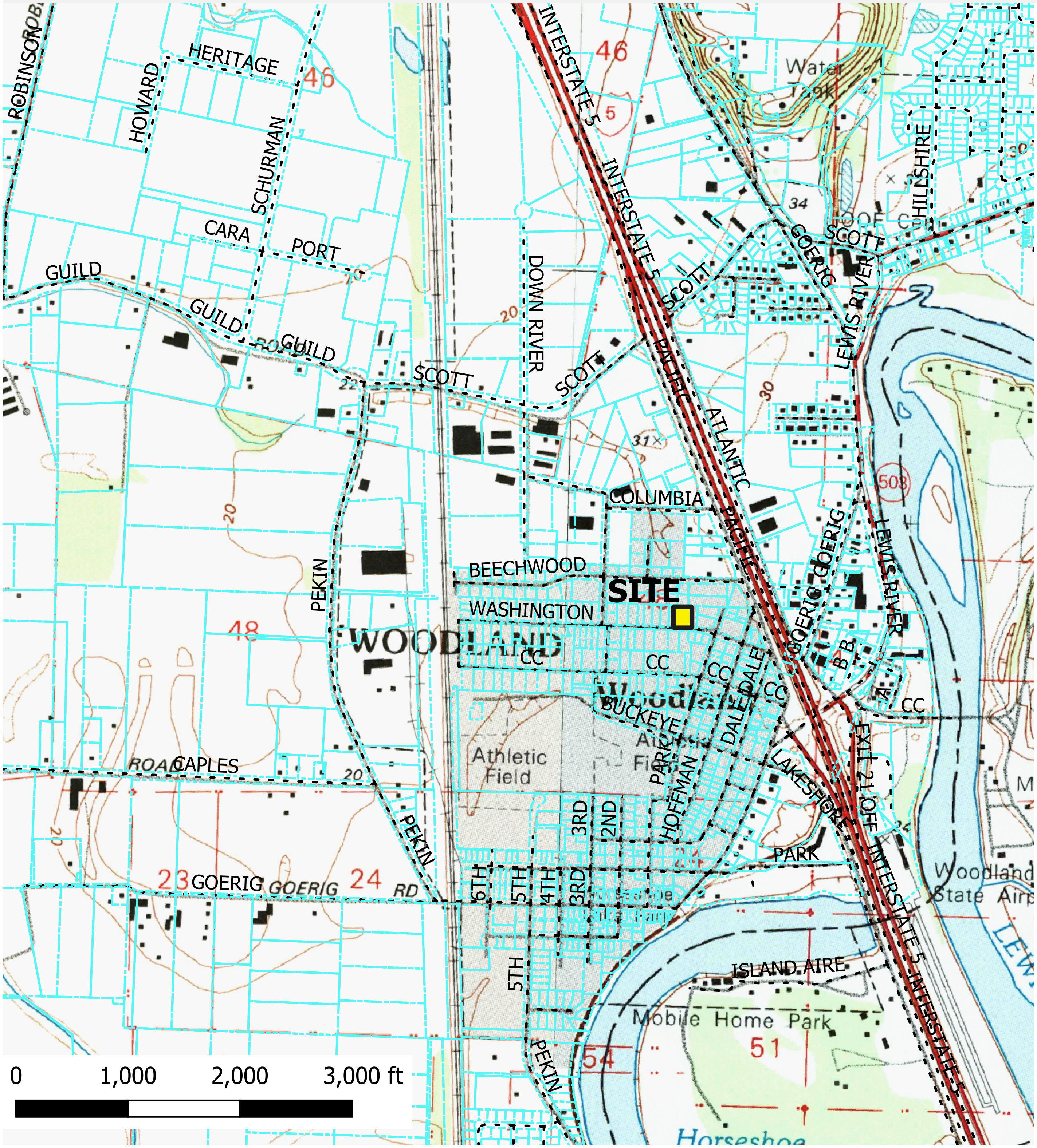
The opinions, comments, and conclusions presented in this report are based upon information derived from our literature review, field explorations, laboratory testing, and engineering analyses. It is possible that soil, rock, or groundwater conditions could vary between or beyond the points explored. If soil, rock, or groundwater conditions are encountered during construction that differ from those described herein, the client is responsible for ensuring that STRATA is notified immediately so that we may reevaluate the recommendations of this report.

Unanticipated fill, soil, and rock conditions, and seasonal soil moisture and groundwater variations are commonly encountered and cannot be fully determined by merely taking soil samples or completing explorations such as soil borings or test pits. Such variations may result in changes to our recommendations and may require additional funds for expenses to attain a properly constructed project; therefore, we recommend a contingency fund to accommodate such potential extra costs.

The scope of work for this subsurface exploration and geotechnical report did not include environmental assessments or evaluations regarding the presence or absence of wetlands or hazardous substances in the soil, surface water, or groundwater at this site.

If there is a substantial lapse of time between the submission of this report and the start of work at the site, if conditions have changed due to natural causes or construction operations at or adjacent to the site, or if the basic project scheme is significantly modified from that assumed, this report should be reviewed to determine the applicability of the conclusions and recommendations presented herein. Land use, site conditions (both on and off site), or other factors may change over time and could materially affect our findings; therefore, this report should not be relied upon after three years from its issue or if the site conditions change.

FIGURE 1 - VICINITY MAP
438 WASHINGTON ST, WOODLAND, WA



STRATA DESIGN

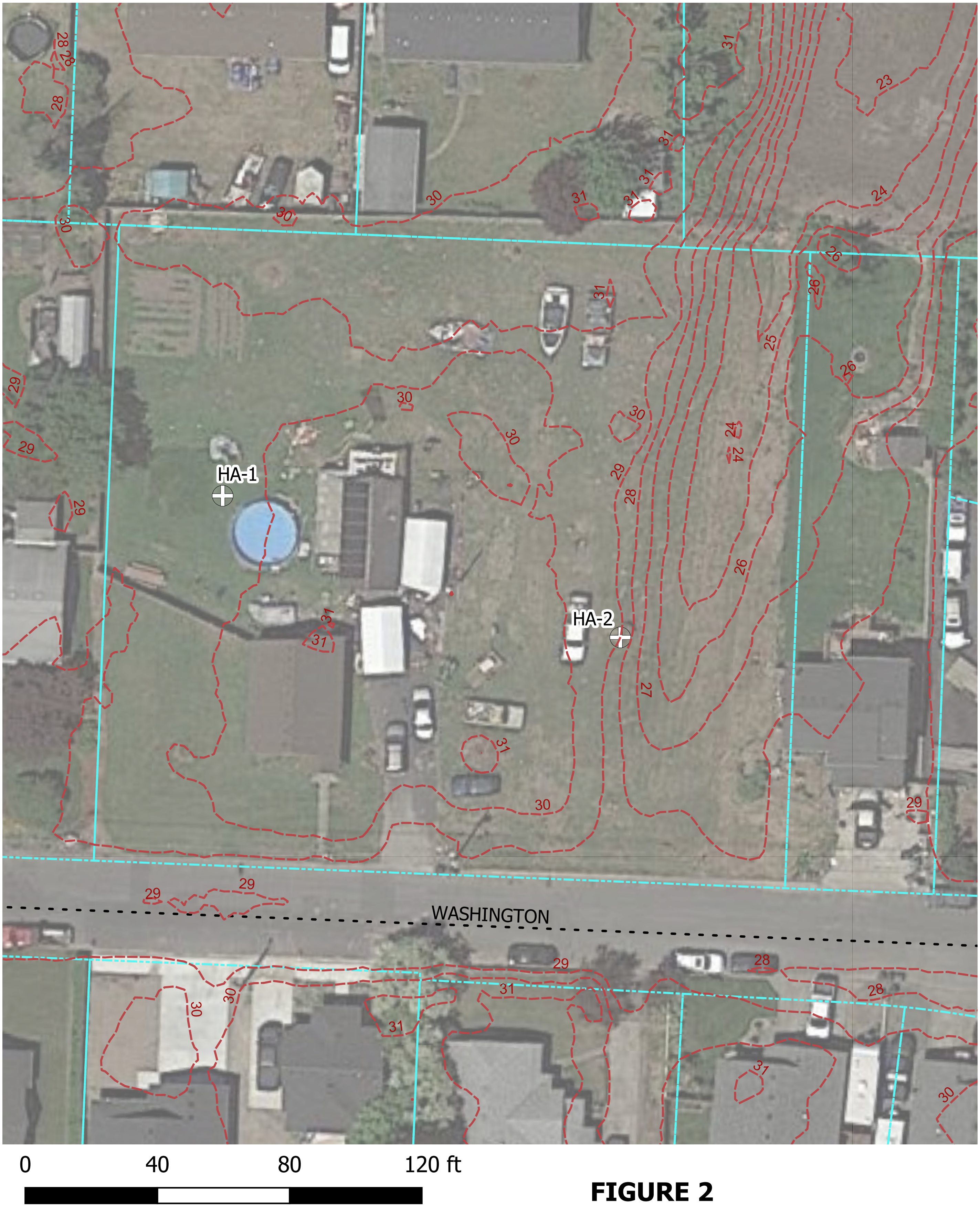


FIGURE 2

EXPLORATION MAP

438 Washington St; Woodland, WA