8/24/2023

Nisqually Meadows HOA
Attn: April Newman; Melissa Worthington
PO Box 2986
Yelm, WA

Subject: **Nisqually Meadows Geotechnical Consultation Report**
TPN: 65080300000; 105th Ave SE, Yelm, WA
QG Project No.: QG23-134

Dear Client:

At your request, Quality Geo NW, PLLC (QG) has completed a preliminary geotechnical review of the above referenced property's existing site conditions, including site visual reconnaissance, subsurface evaluation, and review of existing geologic literature for the site. The project site consists of an existing stormwater pond owned by a neighborhood HOA with two residencies on either side of it. An existing fence along the southern parcel boundary has experienced tilting and displacement. It is our understanding that the client is seeking soil and wall recommendations to remediate and prevent further damage to the southern adjacent property and to the retention pond.

QG understands the client requested a geotechnical consultation to provide any necessary recommendation regarding drainage considerations. The following report presents the findings and conclusions of our review, addresses feasibility of proposed site development, and provides additional geotechnical recommendations for planning and design intended to reduce the inherent risks associated with site development within a potentially geologically hazardous area.

A site region and vicinity map are provided in Appendix A, and a site map is presented in Appendix B. Typical slope conditions are shown schematically on the attached site slope profile in Appendix C, and Exploration Logs are provided in Appendix D.

LITERATURE REVIEW

The Washington Geologic Information Portal (WGIP) maintained by the Department of Natural Resources Division of Geology and Earth Resources provides 1:100,000-scale geologic mapping of the region. The subject site is mapped as continental glacial outwash (Qgog), described as, "Recessional and proglacial, stratified pebble, cobble, and boulder gravel deposited in meltwater streams and their deltas; locally contains ice-contact deposits."

According to the regional-scale interactive map, no deep-seated landslides are known to exist within the site. Available LiDAR imagery of the site did not reveal any obvious or prominent landslide features within the site or immediate vicinity.

The United States Department of Agriculture portal (USDA) provides a soil mapping of the region. The soils in the vicinity are mapped as Everett very gravelly sandy loam (32) and are formed as kames, moraines, and eskers derived from sandy and gravelly glacial outwash. The soils are described as slightly decomposed plant material from 0 to 1 inches, very gravelly sandy loam from 1 to 24 inches, very gravelly loamy sand from 24 to 35 inches, and extremely cobbly coarse sand from 35 to 60 inches. Depth to restrictive feature is more than 80 inches. Capacity of most limiting layer to transmit water (ksat) is listed as high (1.98 to 5.95 in/hr). Depth to water table is more than 80 inches.

SITE INVESTIGATION METHODOLOGY

On 7/14/2023, a QG Geologist visited the site to perform visual reconnaissance of the surface and topographic features of the subject property and its proximal slope. While on site, we conducted site surface explorations for a geologic hazard assessment and site feasibility characterization. Approximate relevant property dimensions and slope topography were documented and mapped at representative intervals as access allowed. Soil conditions were evaluated through local exposures along the slope face. Salient slope features and existing vegetation were documented to assess general site stability as well as observe for signs of local instability of an erosional or subsurface nature currently or in the past.

FIELD WORK

Site exploration activities were performed on 7/14/2023. Exploration locations were marked in the field by a QG Project Geologist with respect to provided maps. The geologist directed the advancement of two hand auger boreholes (HA). The boreholes were advanced within the boundaries of the slope, to depths of approximately 2.0 feet below present grade (BPG) in general accordance with the specified contract depth and equipment capabilities.

During explorations QG logged each soil horizon encountered and field classified them in

accordance with the Unified Soil Classification System (USCS). Representative soil samples were collected from each unit, identified according to boring location and depth, and placed in plastic bags to protect against moisture loss for future reference.

QG advanced two Wildcat Dynamic Cone Penetrometer (DCP) tests at representative locations within the vicinity of the proposed wall location. The penetrometer test was terminated upon reaching the equipment's maximum practical extent. During penetrometer advancement, blow counts were recorded in 10-centimeter increments as a thirty-five-pound weight was dropped 15 inches. Blow counts were then converted to resistance (kg/cm2), standard penetration blow counts (N-values), and corresponding soil consistency, with complete results shown on the attached logs.

SURFACE OBSERVATION

QG performed general site reconnaissance to observe and document any indications of localized drainage issues or surface degradation. The site consists of a stormwater retention pond with two residential properties surrounding the north and south side of the parcel. Along the southern fence line, soils at the surface are being displaced resulting in damage to the residential property adjacent. Undercutting of the fence has extended to approximately 3 feet within the residential parcel, with uncompacted uncontrolled fill having been placed by the homeowner to remediate surface grade. The southern slope leading into the pond is graded just over a 3H:1V slope and does not have any further modifications for stabilization. The northern slope is graded to a 3H:1V with two lines of eco blocks embedded for stability.

No indications of impending or historic deep-seated movement were observed along the slopes. Topography was generally consistent, lacking features such as: significantly over steepened native slopes, apparent scarps, channelized runout zones, or hummocky zones. The fence to the south and the eco blocks to the north provide evidence of rotational or translational failures on site. No significant failure features were observed on adjacent slope areas visible from the subject property during the visit. No massive downslope accumulation, or tension cracks were observed. No significant areas of scouring from natural stormwater channelization were observed.

SUBSURFACE OBSERVATIONS

QG performed hand tool explorations on site, which revealed surface soils down to 2-foot depth to be brown poorly graded gravel with silt and sand across the site. The brown soils appear to correlate with the mapped glacial outwash unit in the region. The soil was very cobbly with no mottling and in a medium dense condition. Few organics were present aside from roots at the surface.

DISCUSSION & RECOMMENDATIONS

The findings of QG's limited reconnaissance at the subject site do not indicate that any excessively prohibitive conditions exist for the current level of slope development (from a geotechnical standpoint). In consideration of the available information, and our direct observations, at this time **QG does not consider the site to be within an active landslide hazard area.** Erosional hazards related to soil creep and loose soils may be mitigated per the following development and site-specific recommendations.

QG anticipates that the fence will need to be replaced or restored. QG recommends that the concrete for fence posts be embedded and buried a minimum of 18 inches to protect from frost heave. Additionally, the concrete for the fence post should be imbedded enough so that the is a horizontal distance of 5-feet from the base of the concrete to the slope face. See Appendix C, figure 3.

The most effective solution would be to install a small block wall to stabilize soils and prevent further degradation of the slope, similar to that found on the opposite slope of the retention pond from where settlement is being experienced. We offer the following basic construction recommendations to be considered by the property owner and their retained engineer or contractor.

Additionally, rotation and bulging of the existing eco blocks was noted on the opposite side of the retention pond. QG recommends that these walls are replaced concurrently to the addition of new walls to prevent failure in the future and reestablish good condition of the slope.

- **Subgrade Preparation:**
  QG recommends excavating and clearing any loose or saturated soils from areas of proposed wall foundations, down to firm bearing conditions and benching the final bottom of subgrade elevation flat. This may also require pumping water out of the excavations to prevent softening subgrade soils. Excavations should be performed with a smooth blade bucket to limit disturbance of subgrade soils. Vibratory compaction methods are suitable for densification of the native soils.

  After excavations have been completed to the planned subgrade elevations, but before placing fill or structural elements, the exposed subgrade should be evaluated under the periodic guidance of a QG representative. Any areas that are identified as being soft or yielding during subgrade evaluation should be brought to the attention of the geotechnical engineer. Where over excavation is performed below a structure, the over excavation area should extend beyond the outside of the footing a distance equal to the depth of the over excavation below the footing. The over-excavated areas should be backfilled with properly compacted structural fill.

- **Base Pad:**

  New walls shall bear directly on a structural base lift as follows:

  A minimum 6-inch-thick leveling structural fill pad composed of permeable railroad ballast per WSDOT Specification 9-03.9(2), or an approved alternative. The material shall be compacted with a small vibratory plate or hoe pack on top to allow for maximum compaction of the grains, while avoiding liquefication of the underlying soils. **This mat shall be separated from underlying and surrounding native soils by a layer of rugged nonwoven permeable geofabric**, with 24-inch overlaps at joints, to allow for water to escape and prevent the accumulation of fine-grained soils within the void space. Fabric shall be wrapped overtop of the mat following compaction.

  The total fill section shall extend beneath the entire footprint of the proposed wall and a minimum of 6 inches past the front and side edges of the wall base block. There shall be a perforated drainpipe running through the back of the base (within the ballast) and graded to gravity drain to an outfall pipe, to allow any accumulated water to be released in an existing approved drainage feature. The outfall point must be lower in elevation than the lowest point of possible water accumulation in the base, so as to allow any captured water within the base lift to completely drain away from the wall footprint preventing standing water from accumulating.

- **Excavations:**

  The duration of time that excavations behind walls remain open should be limited to only as necessary to prepare the base pad and placement of the wall features, backfilling with drain rock and approved fill immediately. Temporary worker protections such as trench boxes or temporary shoring may be required for entering excavations deeper than 4 feet, and all OSHA safety regulations should be observed. Extended open cut periods or work proceeding in wet weather may require surface coverings, lesser cut angles, and/or temporary bracing be applied. Shoring may be required to prevent the undermining of nearby existing structures, if excavations are within 5 feet of them, and should be considered by the designer or earthworker as needed.

- **Wall Drainage**:

  At minimum, a 12-inch-wide wall drain corridor shall be installed behind the wall, extending uninterrupted from the base, all the way to the last wall course and laterally across the entire retained face. Drain material shall conform to **WSDOT Spec 9-03.12(4) Gravel Backfill for Drains**, or **9-03.12(5) Gravel Backfill for Drywells.** Drain rock shall be vibratory plate

compacted to settle grains out to their most dense state. **Drainrock shall be wrapped on all sides with nonwoven fabric**. Perf pipes shall be installed along the length of the base to wick water out of the wall drain, and gravity flow to an outfall away from the walls. Surface soils behind the top of the wall shall be capped with native soils to minimize penetration of sheeting surface stormwater into the drains.

- **Wall Embedment**

  The initial base rockery shall be embedded (keyed in) a minimum of 6 inches deep. Key backfill soils in front of the wall may consist of reused existing site soils. A flat bench shall be established to extend from in front of the base of the wall, outward a minimum of 4 horizontal feet, before descending no greater than 2H:1V.

Drainage Recommendations:

QG recommends proper drainage controls for stormwater runoff during and after site development to protect the site. The ground surface adjacent to structures should be sloped to drain away at a 5% minimum to prevent ponding of water adjacent to them.

QG recommends all stormwater catchments (new or existing) be tightlined (piped) away from structures to an existing catch basin, stormwater system, established channel, or approved outfall to be released using appropriate energy-dissipating features at the outfall to minimize point erosion. Roof and footing drains should be tightlined separately or should be gathered in an appropriately sized catch basin structure and redistributed collectively. If storm drains are incorporated for impervious flatworks (driveways, sidewalks, etc.) collected waters should also be discharged according to the above recommendations.

Erosion Controls:

Erosion is one of the most common driving forces leading to slope instability. In addition to the above commentary, if applicable the following general recommendations should be implemented in general to reduce long-term erosion potential of the slope below the project site and maintain slope stability:

- Stability of exposed slope faces are to be improved by planting and maintaining deep rooting vegetation coverage. Installing beneficial ground plantings is encouraged. Alternatives to vegetation may include erosion control measures such as a staked geotextile fabric and 6 to 8-inch rockery (quarry spall or rip rap) cover. This may be considered suitable for slopes at or greater than 3H:1V, but no steeper than 1H:1V. It may be preferable to incorporate rolled erosion control products (RECPs) on an as needed basis during replanting activities to increase the likelihood of successful vegetation or replace areas not receptive to vegetation.

- Adding vegetation will encourage rooting stabilization and in turn increase the erosional and hydrologic resistance of the slope. The slope inclination calls for careful plant selection, planning, and execution, to best achieve establishment and long-term surface stability.
- Minimize the volume and velocity of water that travels toward and down the slope face (via proper choice of site development features including stormwater controls discussed above).
- Avoid accelerating slope erosion and mass wasting due to human activity such as:
  - ✓ Adding side-cast such as dumping landscape debris or fallen trees on or above the slopes.
  - ✓ Using heavy construction equipment on or near steep slopes.
  - ✓ Excavating near adjacent steep slopes toe or on slope face.
  - ✓ Placing excavated soil near the steep slope crest.
- Roof downspouts and footing drains are currently routed into closed separate pipes which outfall into appropriate drainages. Outlets for these pipes should be protected from erosion through the use of riprap (quarry spalls) or some other energy dissipating device. Similarly, concentrated drainages should be captured in closed pipe systems and routed down slope to appropriate outfalls.
- Clearing of existing vegetation outside the proposed building area on and adjacent to the existing slopes should be avoided except as approved by a qualified professional. This provides additional stability to the loose topsoil and minimizes the effects of down-slope water movement. This is excepting removal of problem, dead, or dying, trees if posing a direct hazard to site installations or adjacent roadways.

Common Name	***Botanical Name***	***Deciduous/Evergreen***	***Mature Height (ft)***
Bigleaf Maple	Acer macrophyllum	Deciduous	60
Douglas Fir	Pseudotsuga menziesii	Evergreen	200+
Evergreen	Vaccinium ovatum	Evergreen	To 8
Oceanspray	Holodiscus discolor	Deciduous	10+
Oregon Grape	Mahonia spp.	Evergreen	To 6
Pacific Madrone	Arbutus menziesii	Evergreen	70
Red huckleberry	Vaccinium parvifolium	Deciduous	To 12
Rose	Rose spp.	Deciduous	2-10
Salal	Gaultheria shallon	Evergreen	To 4
Salmonberry	Rubus spectabilis	Deciduous	To 12
Serviceberry	Amelanchier alnifolia	Deciduous	12+
Snowberry	Symphoricarpos albus	Deciduous	3+
Vine Maple	Acer cricinatum	Deciduous	10+
Willow	Salix spp.	Deciduous	10+

CLOSING REMARKS

We trust this letter satisfies your project needs currently and greatly thank you for the opportunity to be of service. QG wishes you the best while completing the project.

Respectfully Submitted,
Quality Geo NW, PLLC

Prepared by:

Alexander Barnes, G.I.T.
Staff Geologist/Laboratory Supervisor

Approved by:

8/24/2023

LUKE PRESTON MCCANN

Luke Preston McCann, L.E.G.
Principal Licensed Engineering Geologist

Attachments: *Limitations*
Appendix A. Site Region and Vicinity Maps
Appendix B. Aerial Site Map
Appendix C. Site Slope Profile
Appendix D. Exploration Logs

LIMITATIONS

Upon acceptance and use of this report, and its interpretations and recommendations, the user shall agree to indemnify and hold harmless QG, including its owners, employees and subcontractors, from any adverse effects resulting from development and occupation of the subject site. Ultimately, it is the owner's choice to develop and live in such an area of possible geohazards (which exist in perpetuity across the earth in one form or another), and therefore the future consequences, both anticipated and unknown, are solely the responsibility of the owner. By using this report for development of the subject property, the owner must accept and understand that it is not possible to fully anticipate all inherent risks of development. The recommendations provided above are intended to reduce (but may not eliminate) such risks.

This report does not represent a construction specification or engineered plan and shall not be used or referenced as such. The information included in this report should be considered supplemental to the requirements contained in the project plans & specifications and should be read in conjunction with the above referenced information. The selected recommendations presented in this report are intended to inform only the specific corresponding subjects. All other requirements of the above-mentioned items remain valid, unless otherwise specified.

Recommendations contained in this report are based on our understanding of the proposed development and construction activities, field observations and explorations, and laboratory test results. It is possible that soil and groundwater conditions could vary and differ between or beyond the points explored. If soil or groundwater conditions are encountered during construction that differ from those described herein, or if the scope of the proposed construction changes from that described in this report, QG should be notified immediately in order to review and provide supplemental recommendations.

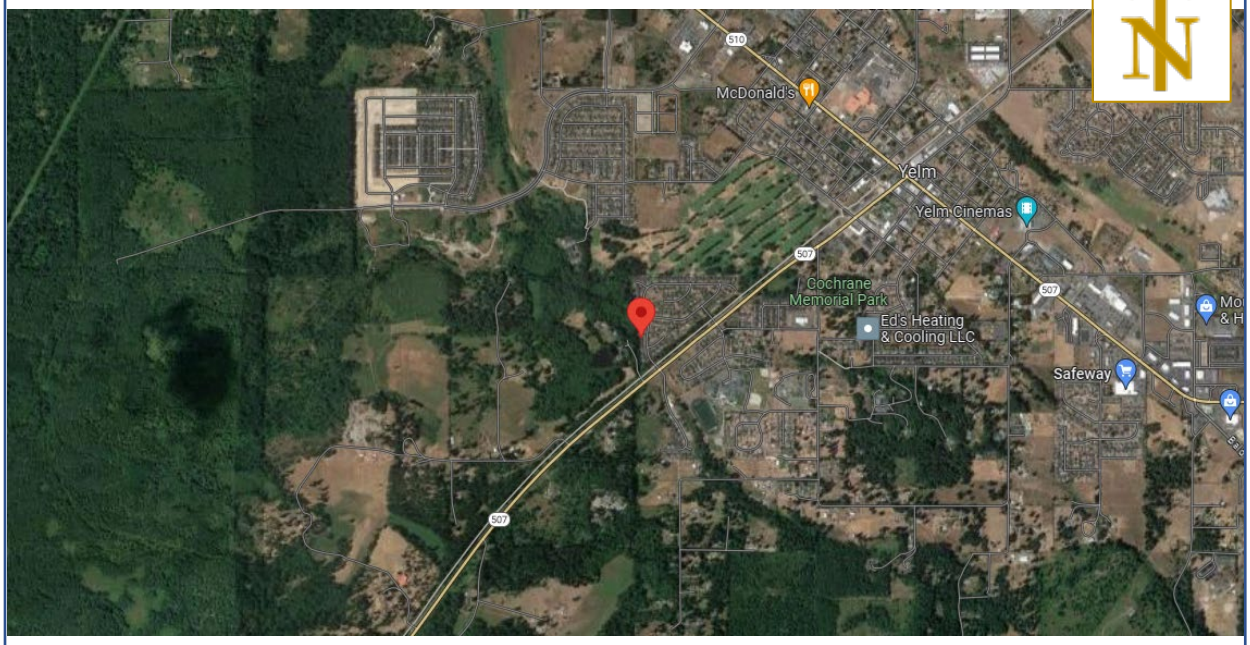
The findings of this study are limited by the level of scope applied. We have prepared this report in substantial accordance with the generally accepted geotechnical engineering practice as it exists in the subject region. No warranty, expressed or implied, is made. The recommendations provided in this report assume that an adequate program of tests and observations will be conducted by a WABO approved special inspection firm during the construction phase in order to evaluate compliance with our recommendations.

This report may be used only by the Client and their design consultants and only for the purposes stated within a reasonable time from its issuance, but in no event later than 18 months from the date of the report. It is the Client's responsibility to ensure that the Designer, Contractor, Subcontractors, etc. are made aware of this report in its entirety. Note that if another firm assumes Geotechnical Engineer of Record responsibilities, they need to review this report and either concur with the findings, conclusions, and recommendations or provide alternate findings, conclusions and recommendation.

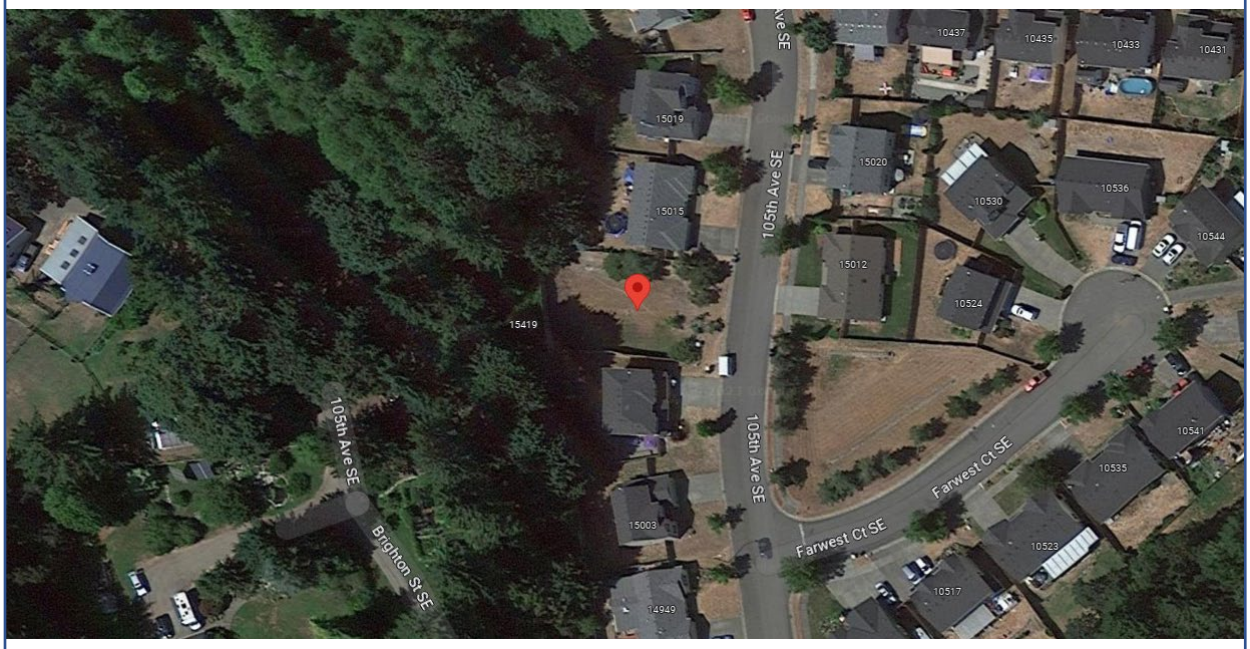
Land or facility use, on- and off-site conditions, regulations, or other factors may change over time, and additional work may be required. Based on the intended use of the report, QG may recommend that additional work be performed and that an updated report be issued. Non-compliance with any of these requirements by the Client or anyone else will release QG from any liability resulting from the use of this report. The Client, the design consultants, and any unauthorized party, agree to defend, indemnify, and hold harmless QG from any claim or liability associated with such unauthorized use or non-compliance. We recommend that QG be given the opportunity to review the final project plans and specifications to evaluate if our recommendations have been properly interpreted. We assume no responsibility for misinterpretation of our recommendations.

Appendix A. Site Region & Vicinity

REGION

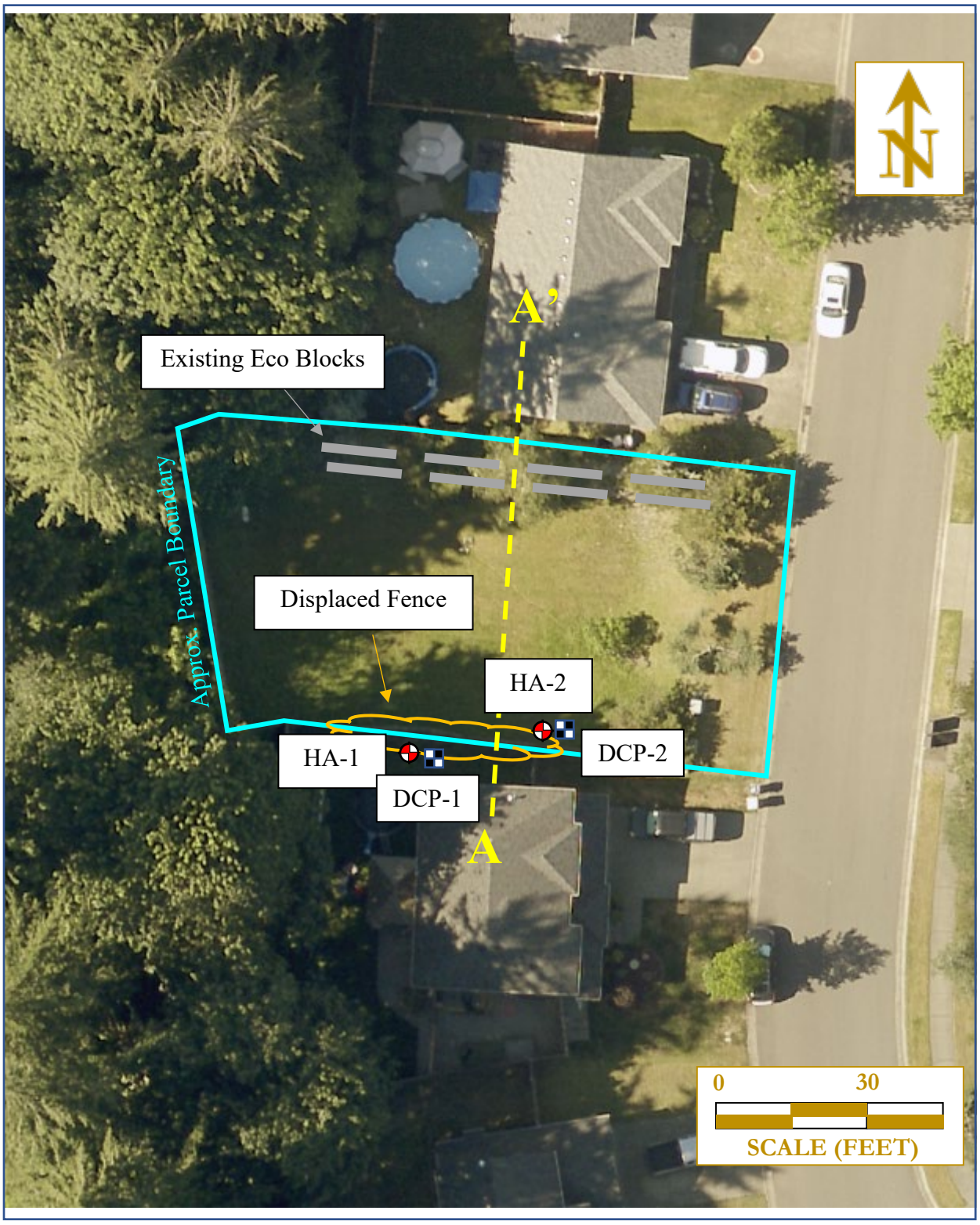


VICINITY



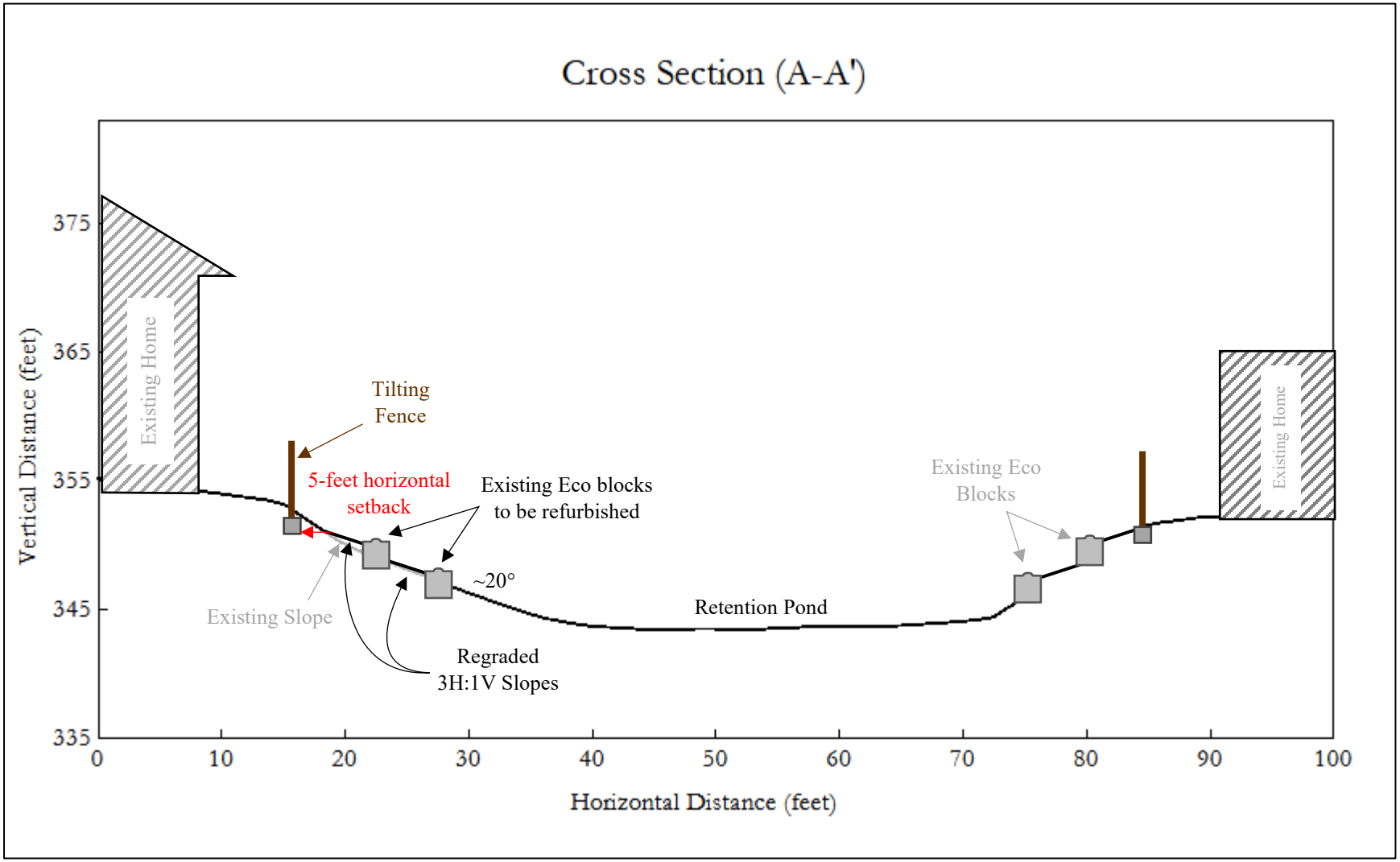
Quality Geo, PLLC	**Site Region** Nisqually Meadows Geo	Source: Google Imagery, 2023 **Scale & Locations are approx.** **Not for Construction**	**Figure 1**

Appendix B. Aerial Site Map



Quality Geo NW, PLLC	**Site Map** Nisqually Meadows Geo	Source: Thurston Co. GIS, 2023 **Scale & Locations are approx.** **Not for Construction**	**Figure 2**

Appendix C. Slope Profiles



Quality Geo NW, PLLC	**Slope Profile A – A'** Nisqually Meadows Geo	Source: Mapped Topo & Hand Measurements **Scale & Locations are approx.** **Not for Construction**	**Figure 3**

Appendix D. Exploration Logs

Hand Auger Log HA-1

PROJECT NUMBER QG23-122
PROJECT NAME Nisqually Meadows GEO
PROJECT LOCATION Yelm, WA

FIELD WORK DATE 7/14/2023
DRILLING METHOD Hand Auger Boring

BORING LOCATION TPN 65080002900; adjacent to tilted portion of fence
SURFACE ELEVATION Existing
LOGGED BY AB

COMMENTS

Depth (ft)	Samples	Is Analysed?	Graphic Log	USCS	Material Description
0				GP	POORLY GRADED GRAVEL with SILT and SAND Brown, dry, no mottling, few organics, abundant cobbles to 5-inches (rounded), medium dense condition. Gravel: 50% Sand: 40% Fines: 10%
0.5					
1					
1.5					
2					Terminated at equipment refusal and contracted depth. No groundwater encountered.

Quality Geo NW, PLLC - Ph: 360-878-9705, qualitygeonw.com, 4631 Whitman Lane SE, Ste D, Lacey, WA

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Hand Auger Log HA-2

PROJECT NUMBER QG23-122
PROJECT NAME Nisqually Meadows GEO
PROJECT LOCATION Yelm, WA

FIELD WORK DATE 7/14/2023
DRILLING METHOD Hand Auger Boring

BORING LOCATION TPN 650880300000; along slope to south by tilted fence
SURFACE ELEVATION Existing
LOGGED BY AB

COMMENTS

Depth (ft)	Samples	Is Analysed?	Graphic Log	USCS	Material Description
				TS	TOPSOIL Dark brown, high organic content (grass roots) Gravel: 50% Sand: 40% Fines: 10%
0.5				GP	POORLY GRADED GRAVEL with SILT and SAND Brown, dry, no mottling, few organics, abundant cobbles to 5-inches (rounded), medium dense condition. Gravel: 50% Sand: 40% Fines: 10%
1					
1.5					
2					Terminated at equipment refusal and contracted depth. No groundwater encountered.

WILDCAT DYNAMIC CONE LOG

Quality Geo NW, PLLC
Geotechnical Consultants
Lacey, WA

PROJECT NUMBER: QG23-134
DATE STARTED: 07-14-2023
DATE COMPLETED: 07-14-2023

HOLE #: DCP-1
CREW: AB
PROJECT: Nisqually Meadows Geo
ADDRESS: TPN 650800002900; 105th Ave, Yelm WA
LOCATION: Adjacent to tilted portion of fence towards north side of parcel

SURFACE ELEVATION: Existing
WATER ON COMPLETION: No
HAMMER WEIGHT: 35 lbs.
CONE AREA: 10 sq. cm

DEPTH	BLOWS PER 10 cm	RESISTANCE Kg/cm²	GRAPH OF CONE RESISTANCE 0 50 100 150	N'	TESTED CONSISTENCY NON-COHESIVE	COHESIVE
-	5	22.2	••••••	6	LOOSE	MEDIUM STIFF
-	17	75.5	••••••••••••••••••••	21	MEDIUM DENSE	VERY STIFF
- 1 ft	15	66.6	••••••••••••••••••	19	MEDIUM DENSE	VERY STIFF
-	23	102.1	•••••••••••••••••••••••••••••	25+	MEDIUM DENSE	VERY STIFF
-	11	48.8	••••••••••••••	13	MEDIUM DENSE	STIFF
- 2 ft	7	31.1	•••••••••	8	LOOSE	MEDIUM STIFF
-	5	22.2	••••••	6	LOOSE	MEDIUM STIFF
-	10	44.4	•••••••••••••	12	MEDIUM DENSE	STIFF
- 3 ft	50	222.0	••	25+	VERY DENSE	HARD
- 1 m						
-						
- 4 ft						
-						
-						
- 5 ft						
-						
-						
- 6 ft						
-						
- 2 m						
- 7 ft						
-						
-						
- 8 ft						
-						
-						
- 9 ft						
-						
-						
- 3 m 10 ft						
-						
-						
-						
- 11 ft						
-						
-						
- 12 ft						
-						
-						
- 4 m 13 ft						

WILDCAT DYNAMIC CONE LOG

Quality Geo NW, PLLC
Geotechnical Consultants
Lacey, WA

PROJECT NUMBER: QG23-134
DATE STARTED: 07-14-2023
DATE COMPLETED: 07-14-2023

HOLE #: DCP-2
CREW: AB
PROJECT: Nisqually Meadows Geo
ADDRESS: TPN 65080300000; 105th Ave, Yelm WA
LOCATION: Along slope by fence towards south side of parcel

SURFACE ELEVATION: Existing
WATER ON COMPLETION: No
HAMMER WEIGHT: 35 lbs.
CONE AREA: 10 sq. cm

DEPTH	BLOWS PER 10 cm	RESISTANCE Kg/cm²	GRAPH OF CONE RESISTANCE 0 50 100 150	N'	TESTED CONSISTENCY NON-COHESIVE	TESTED CONSISTENCY COHESIVE
-	8	35.5	••••••••••	10	LOOSE	STIFF
-	10	44.4	•••••••••••	12	MEDIUM DENSE	STIFF
- 1 ft	19	84.4	•••••••••••••••••••••	24	MEDIUM DENSE	VERY STIFF
-	18	79.9	••••••••••••••••••••	22	MEDIUM DENSE	VERY STIFF
-	23	102.1	•••••••••••••••••••••••••	25+	MEDIUM DENSE	VERY STIFF
- 2 ft	18	79.9	••••••••••••••••••••	22	MEDIUM DENSE	VERY STIFF
-	12	53.3	•••••••••••••	15	MEDIUM DENSE	STIFF
-	8	35.5	••••••••••	10	LOOSE	STIFF
- 3 ft	10	44.4	•••••••••••	12	MEDIUM DENSE	STIFF
- 1 m	10	44.4	•••••••••••	12	MEDIUM DENSE	STIFF
-	10	38.6	•••••••••••	11	MEDIUM DENSE	STIFF
- 4 ft	21	81.1	•••••••••••••••••••••	23	MEDIUM DENSE	VERY STIFF
-	50	193.0	••	25+	VERY DENSE	HARD
-						
- 5 ft						
-						
-						
- 6 ft						
-						
- 2 m						
- 7 ft						
-						
-						
- 8 ft						
-						
-						
- 9 ft						
-						
-						
- 3 m 10 ft						
-						
-						
-						
- 11 ft						
-						
-						
- 12 ft						
-						
-						
- 4 m 13 ft						