6/11/2020

James MacKay
810 N 36th St
Seattle, WA 98103

Subject: **MacKay - Critical Slope Consultation**
Parcel # 1455600052, Seattle, WA
QG Project No.: QG20-016

Dear Ms. MacKay:

At your request, Quality Geo, PLLC (QG) has completed a preliminary critical area review of the above referenced property's existing site conditions, including site visual reconnaissance, surface evaluation, slope analysis, and review of existing geologic literature for the site. The project site consists of an undeveloped residential property comprising a portion of a regional slope. It is our understanding that the client intends to determine the feasibility of constructing a new residence within an area designated a potential critical slope.

QG was requested to provide a geotechnical consultation to determine if current conditions are favorable, and to provide any additionally necessary recommendation regarding critical slope considerations including necessary setbacks and foundation recommendations. 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 is provided in Appendix A, and a site plan is presented in Appendix B. Typical slope conditions are shown schematically on the attached site slope profile in Appendix C. Photos showing general site features are provided in Appendix D.

GEOLOGIC LITERATURE REVIEW

QG reviewed available map publications to assess known geologic conditions and hazards present at the site location. The Washington Geologic Information Portal (WGIP), maintained by the Department of Natural Resources Division of Geology and Earth Resources, provides 1:24,000-

scale geologic mapping of the region. Geology of the site location and vicinity consists of pre Fraser glacial/nonglacial deposits (Qpf) described as: “Interbedded silt, sand, gravel, and diamicts of indeterminate age and mostly indeterminate origin; lightly to heavily oxidized. Discriminated from texturally similar younger deposits, particularly unit Qva, on the basis of stratigraphic position, oxidation, and commonly heterogeneous grain size. Above coastline of Puget Sound, mainly thinly laminated gray silt with neither organics nor drop-stones overlying and interbedded with oxidized sand and sandy gravel”.

According to the regional-scale interactive map, LiDAR, and available literature, the site appears to be the result of deposits from historic deep-seated landslide activity. Most of the residences in the area and along the coasts are founded in these deposits. No recent reactivations are known to exist within the site.

SITE INVESTIGATION METHODOLOGY

On 6/4/2020, a QG Licensed 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.

SURFACE OBSERVATION

QG performed general site reconnaissance to observe and document any indications of localized surface degradation or large-scale slope instability. The project site is roughly trapezoidal in shape and almost entirely slopes downward to the east towards other parcels. The subject critical slope typically grades around 25 to 35 degrees for about 60 vertical feet, with some minimally oversteepened portions near the crest of the slope. The slope is generally wooded, and heavily choked with low lying brush and few fallen trees across the property. Some trees were partially tilted or bowed indicating some localized shallow soil creep. There were no significant signs of advanced erosional hazards across the accessible areas of the site. The toe of the slope was generally inaccessible due to the thick brush cover and sloped conditions, however portions were visible from a distance, and did not reveal any additional concern.

QG performed reconnaissance to observe for and document indications of surface degradation or large-scale slope instability. No obvious features were observed that would indicate an active or

recent slope failure, such as headscarps or downslope accumulations. Topography was generally consistent across the site, lacking prevalent oversteepened areas, channelized runout zones, or hummocky deposits. No obvious evidence of rotational or translational failures or major toppling hazards was observed on the slope in the proximity of the potential building footprint. No obvious failure features were observed on adjacent slope areas visible from the subject property during our site visit.

SUBSURFACE CONDITIONS:

Soil exposures along the slope face appear generally consistent throughout, comprising interbedded horizons of sands with some gravels and a variable low fine-grained content. Existing borehole data for the neighboring southern parcel clearly indicate a 25-foot layer of loose to medium dense sand overriding a dense to very dense layer of similar sands.

SURFACE AND SUBSURFACE WATER CONDITIONS:

Site soils appear generally permeable to typical amounts of stormwater with no signs of significant channelized stormwater, perched water, or ground seeps within or immediately adjacent to the parcel. The closest surface water feature is Lake Washington, approximately 550 feet to the east. Groundwater appear to be significantly below the depth of concern regarding anticipated developments.

DISCUSSION & CRITICAL SLOPE RECOMMENDATIONS

The findings of QG's site reconnaissance at the subject site appear broadly consistent with available geologic literature and do not indicate any excessively prohibitive conditions exist for the site, assuming appropriate site management efforts are maintained. It appears that the designation as a landslide hazard area is based on mapped topography and mapped historic landslide deposits, rather than a known or existing pervasive landside hazard.

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, or erosional hazard area.** Due to the limitations of our scope, this study did not involve slope stability modeling, or subsurface explorations directly within the site. Based on the information herein, QG provides the following development- and site-specific recommendations that will minimize the inherent risks of developing in a sloped area.

Due to the reported loose nature of the upper soils, these soils present a significant risk of differential settlement. Additionally, critical area code requires specific foundation setbacks be maintained to protect slopes and structures. This can typically be achieved through the use of deep

foundation elements to increase the horizontal distance between the base of the foundation and the adjacent slope face.

QG recommends that at minimum all structural load-bearing elements of new slabs and foundation be supported by driven hollow-core steel pin piles attached directly to the footings. This may entail utilizing supporting grade beams on pin piles below or within a structurally-reinforced slab. It may be preferable to avoid slab-on-grade elements where feasible. We recommend final design and construction practices limit additional surface excavation to the smallest extent possible. Large excavations are generally discouraged.

For general foundation design considerations, QG recommends referring to guidelines and parameters of the *International Building Code* (IBC, 2015; or most recent edition adopted by the jurisdiction at the time of construction).

QG recommends that a local and reputable materials testing & inspection firm be retained for construction phase testing and observation in accordance with the local code requirements. A licensed geologist, professional engineer, or their representative shall oversee construction of the piles. QG recommends that we also be retained to perform periodic supplementary geotechnical observations and review the special inspectors reports during construction, and that all components cited on this letter be verified as suitably installed per these specifications and manufacturer recommendations. If conditions differ from those interpreted herein, QG recommends that we be contacted to provide supplemental recommendations for site and foundation construction.

Pin Pile Design Prescription:

As a conservative design assumption, QG recommends the contribution of pin piles to lateral foundation support be considered insignificant due to the reported low-strength soils present and the anticipated small diameter of pin piles. QG assumes the pin piles will be encased directly into concrete shallow foundation elements (footings or grade beams) and reinforced via rebar or similar tie-in (pile caps to be specified by the project engineer or pile installer/manufacturer). Therefore, the pin piles will be subject to a fixed-head scenario.

3-inch or 4-inch diameter pin piles (schedule 40 steel) may be used for any new foundation construction or underpinning. Corrosion-resistant pipe (galvanized or equivalent) should be employed. **For piles driven to refusal within the till soils, an allowable single-pile axial capacity of 9 kips and 16 kips maximum (respectively) is recommended for 3-inch and 4-inch diameter round hollow-steel pin piles, and assumes a 2.5x factor of safety**. We generally do not recommend 2-inch diameter piles be used for new construction applications. However, if some elements are well suited to low-capacity concentrated distribution, 2-inch schedule 80 pipe may be used with a 4-kip maximum axial capacity.

These pile capacities are provided taking into account the sensitive nature of the site soil conditions, as well as an assumption that load testing may not be required, as is common for small-residential projects using small-diameter pipe piles (depending on reviewing municipality). If load testing is elected as a discretionary measure by the client and designer, nominally higher axial capacities may be suitable for use assuming a correspondingly greater level of diligence in quality control inspection and observation is employed during construction. In this event, QG should be contacted to consult on final design capacities and the proposed schedule of load testing to verify installed conditions.

Actual pile locations, spacing, and foundation attachments shall be determined by the project engineer. QG anticipates that 3- to 4-foot on-center spacing of piles is feasible, given typical building loads for residential construction and common underpinning practices, to be confirmed or revised by the engineer according to the anticipated cumulative building loads and as needed during site preparations. Alternative layouts should also be determined by the project engineer for any concentrated loads if present. Pile grouping should be limited to avoid bearing reductions, with a minimum required separation of at least 3D (3 x Pile diameter).

Pin Pile Construction:

Except as noted, typical design elements and construction procedures shall be in accordance with manufacturer standards. Any discrepancies encountered that are not addressed herein shall be reconciled by the design engineers during construction. All piles shall be driven to refusal per the manufacturer/installer minimum criteria as determined based on the size of the pile and proposed mechanism of installation. Piles shall be driven straight and plumb, avoiding eccentricity as much as feasible. Piles angled near to or greater than 2 degrees may need to be abandoned.

We anticipate refusal will be reached after encountering sands of dense or hard consistency between 25 & 35 feet below the existing road grade. We recommend embedding piles within the dense sands to meet minimum refusal criteria, and to ensure proper seating and bearing support. Based on the existing adjacent bore hole log, it seems fair to assume pile embedment will be less than 50 feet.

If early pile refusal is encountered, pile acceptance shall be evaluated by the retained inspector in consideration of achieved depth, driving behavior, and adjacent pile conditions. If refusal is encountered at an excessively shallow depth (within upper deposits), QG recommends an alternative driving location be attempted at minimum 3*d (three times pile diameter) and at maximum 5*d on-center from the refused pile. Final acceptance of installed piles shall be at the discretion of the inspector, geotechnical consultant, and project engineer.

Setback Recommendations:

Considering the inclination and conditions of the lower slope specific setback requirements must be followed for successful construction at this location. The local critical area ordinance delineates minimum slope toe setbacks for slopes inclined greater than 40% (~22°), which may be further reduced upon review by a licensed geotechnical professional.

Horizontal setbacks were determined based on standard International Building Code (IBC) requirements as accepted by the State of Washington. The IBC details required setback delineations for slopes with an overall inclination less than or equal to 45 degrees. Structures in the vicinity of slopes shall maintain a minimum horizontal slope crest setback, the lesser of H/3 or 40 feet. QG made limited inclination measurements in the field and reviewed existing topographic data, in comparison to our general site observations made during our visit, to evaluate the adjusted setback requirements.

QG recommends that piles be embedded to a depth that maintains a minimum horizontal slope face setback of 20 feet between their base and the adjacent surface of the main slope (See Appendix C). This setback is detailed schematically in Appendix C. QG does not recommend reducing the setback unless further site-specific foundation design efforts are undertaken to ensure building and slope stability is maintained.

Erosion Controls:

Erosion is one of the most common driving forces leading to slope instability. In addition to the above commentary, 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:

- 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.
- Prior to construction, a silt fence and/or a continuous line of straw bales should be placed on the slopeward edge of the construction area. Heavy construction equipment, construction materials, or native and imported soils should not be placed behind the erosion control devices. Suitable temporary erosion and sediment control measures should be implemented at the construction site during and immediately after ground disturbance occurs. Temporary areas bare of vegetation should be protected from erosion via a blanket of straw or rolled erosion

control product (RECP) during prolonged breaks in site work and prior to reseeding or revegetation.

- At the end of the project, all bare surfaces and areas of disturbed vegetation should be replanted and maintained until fully reestablished. Concentrated surface water should not be allowed to traverse the slope during or after the construction phase of the project. Roof downspouts and footing drains should be routed into closed separate pipes which outfall into appropriate drainages. Outlets for these pipes should be protected from erosion through the use of rip-rap (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 top soil 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.
- Grading or excavation of soils during construction should be accompanied by grass reseeding and re-vegetation as the project is completed. According to "Vegetation Management: A Guide for Puget Sound Bluff Property Owners" (Manashe, 1993) the following types of vegetation provide good to excellent erosion control:

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

Limitations of Our Design:

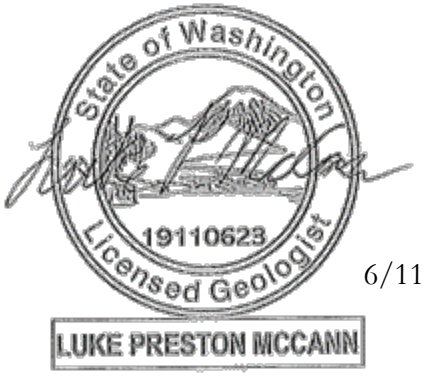
The client shall understand that the limitations of our scope do not allow for a comprehensive evaluation of subsurface conditions. The possibility remains that pile advancement will continue past these depths, especially if larger diameter piles and larger machinery are employed.

CLOSING:

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

Respectfully Submitted,

Quality Geo, PLLC



6/11/2020

Luke Preston McCann, L.G.
Principal Geologist

6/11/2020

Nick Taylor, P.E.
Subcontracted P.E. Review

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

LIMITATIONS

Upon acceptance and use of this report, and its interpretations and recommendations, the owner 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 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.

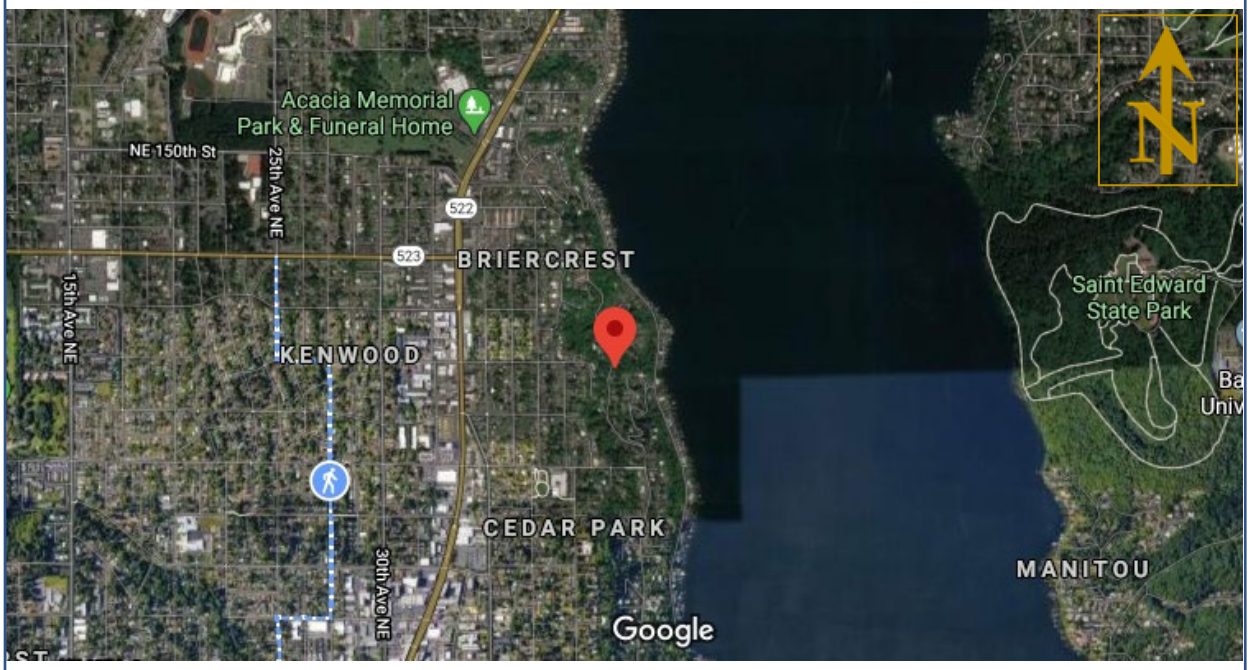
The findings of this study are limited by the level of scope applied. We have prepared this report in substantial accordance with the generally accepted geotechnical engineering practice as it exists in the subject region. No warranty, expressed or implied, is made. The recommendations provided in this 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.

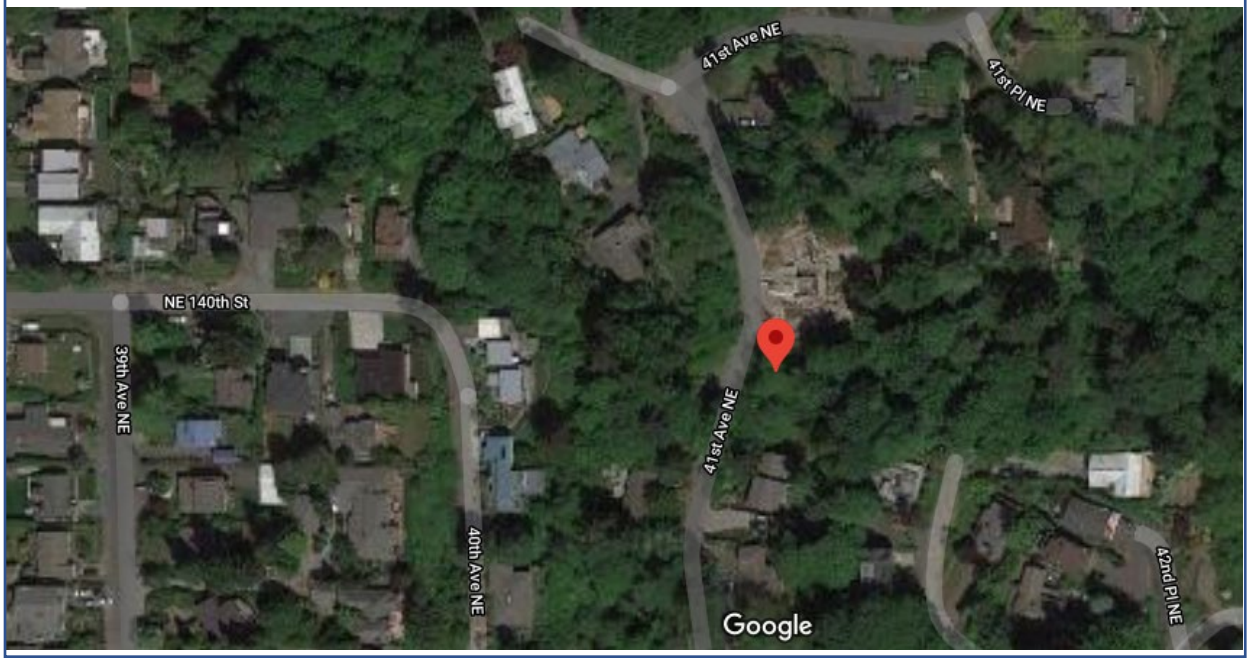
Land or facility use, on- and off-site conditions, regulations, or other factors may change over time, and additional work may be required. Based on the intended use of the report, QG may recommend that additional work be performed and that an updated report be issued. Non-compliance with any of these 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

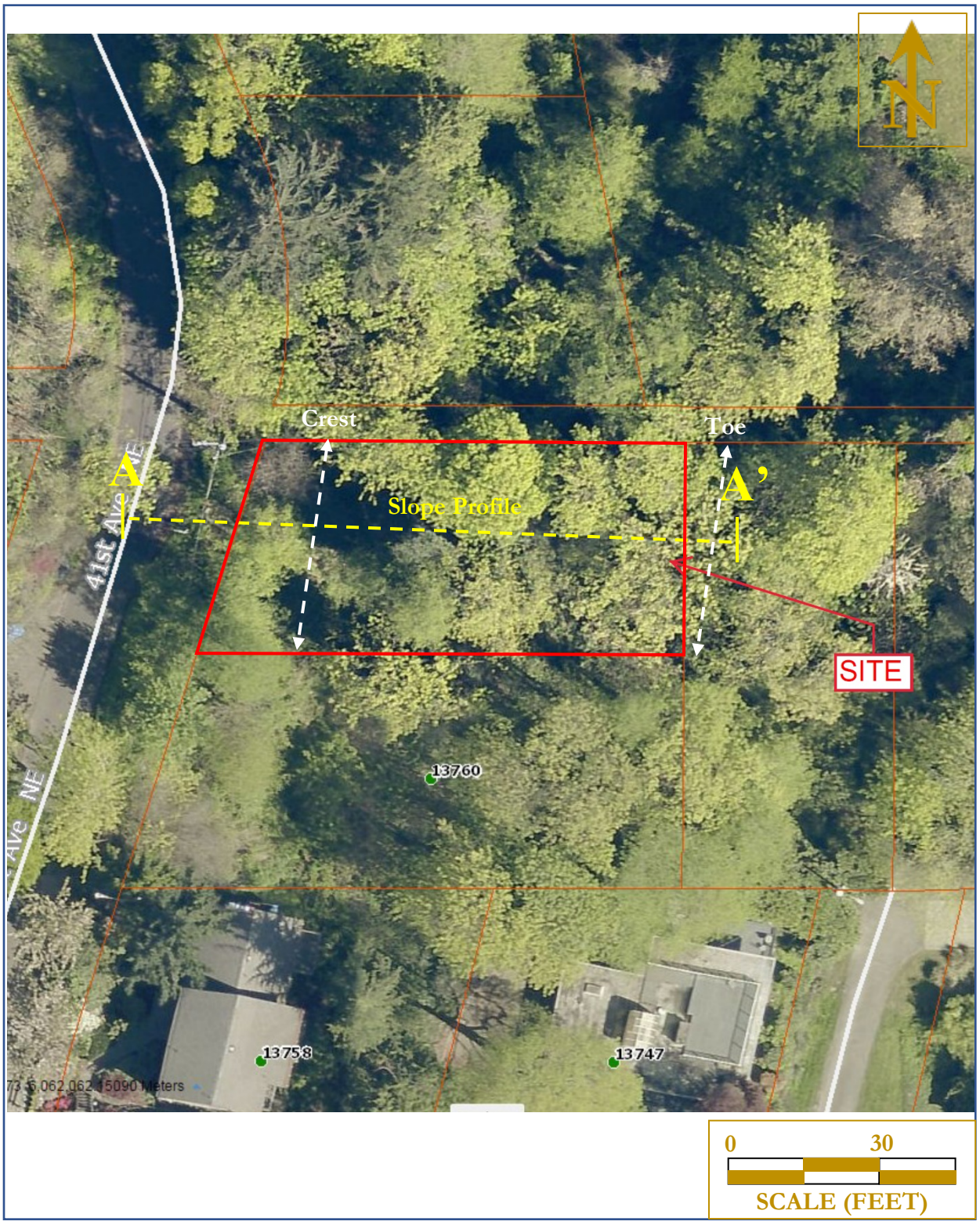


VICINITY



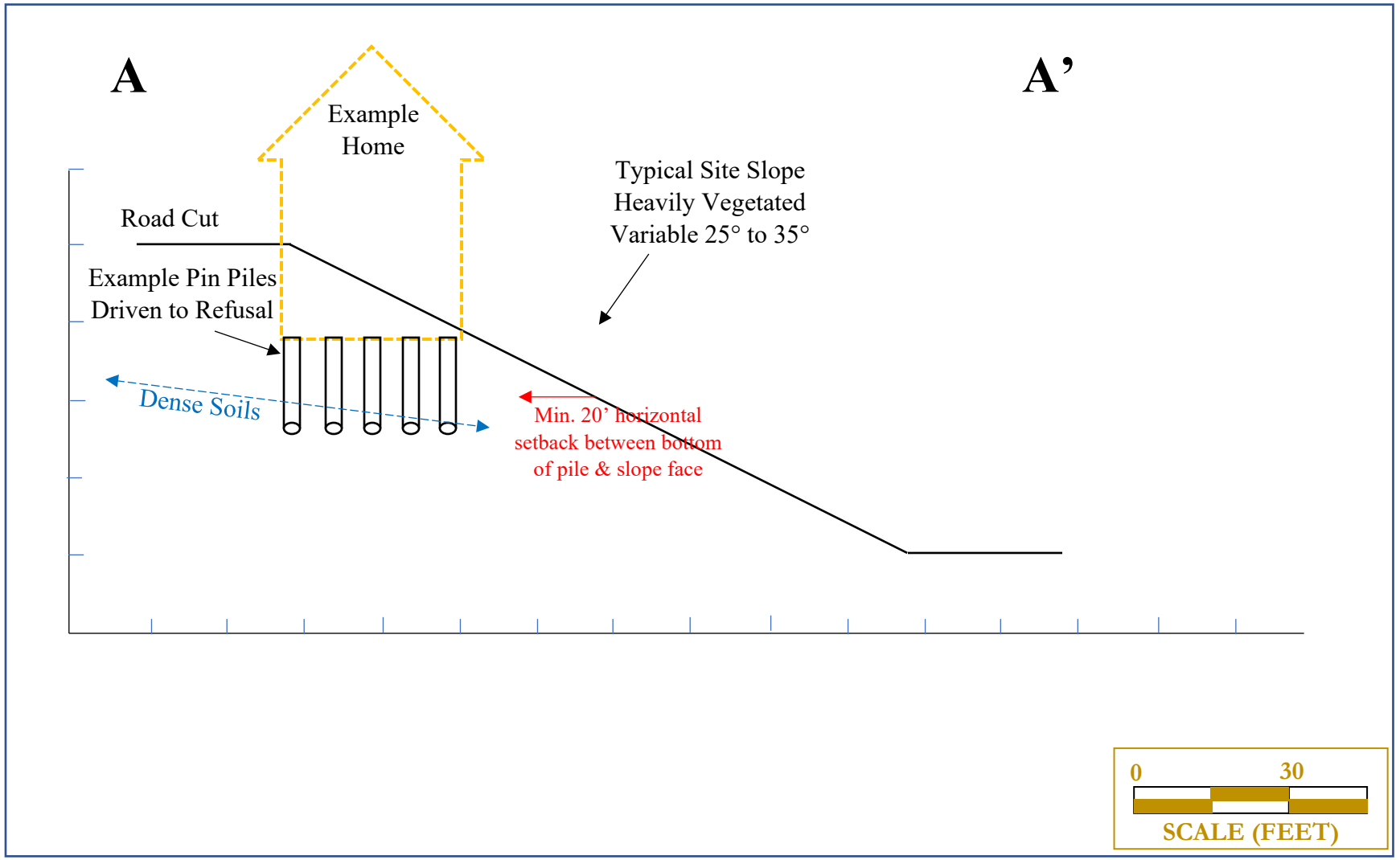
Quality Geo, PLLC	**Site Region** Schmidt CAO	Source: Google Imagery, 2020 **Scale & Locations are approx.** **Not for Construction**	**Figure 1**

Appendix B. Aerial Site Map



Quality Geo, PLLC	**Site Map** Mackay CAO	Source: King Co GIS, & Client Supplied Data Package **Scale & Locations are approx.** **Not for Construction**	**Figure 2**

Appendix C. Slope Profile



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

Appendix D. Site Photos

Photo 1. Typical upland site, adjacent to the road. Camera at west end of site facing north.

Photo 2. Typical slope conditions, well vegetated, lots of side cast debris.