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October 23, 2023

Driftwood Heights Association
ATTN: Randy Barry
VIA Email: president@driftwoodheights.net

Geotechnical/Geologic Bluff Evaluation
Driftwood Heights Bluff Evaluation
Parcel Nos. S6505-00-0000A-0, S6505-00-0000B-0
Island County, Washington
NGA File No. 1453923

Dear Mr. Barry:

NELSON GEOTECHNICAL ASSOCIATES, INC. (NGA) is pleased to present the results of our recent geotechnical/engineering geologic bluff evaluation located at **Parcel Nos. S6505-00-0000A-0 and S6505-00-0000B-0 in Island County, Washington.**

INTRODUCTION

The purpose of this letter is to present our findings, opinions and conclusions regarding existing geologic conditions, and our recommendations for the proposed trail development on and within the vicinity of the bluff, including drainage and site improvements. Specifically, we have evaluated the existing condition of the bluff slopes and provided recommendations for site development and management.

The site consists of two adjacent and undeveloped shoreline parcels covering a total area of approximately 5 acres. The lots are owned by the Driftwood Heights Association and primarily consist of shoreline and steep east-facing bluffs. The northern parcel and a portion of the southern parcel are occupied by an access easement roadway spanning along the top of bluff. We understand the Association is considering improving the trail that leads to the beach, as needed, as well as improving the drainage across the subject sites. Additionally, selective pruning, tree removal, or topping is being considered to maintain vegetation along or near the steep bluff slopes.

SCOPE

The purpose of this study is to explore and characterize the site surface and subsurface conditions within the vicinity of the steep east-facing bluff slopes and provide geotechnical recommendations for vegetation management and slope maintenance. Our scope of services includes the following:

1. Reviewing available soil and geologic maps of the area as well as other relevant geotechnical information, as provided.
2. Visiting the site to observe and document the conditions along the steep bluff slopes as well as the current drainage systems along the existing access road.
3. Preparing representative geologic cross sections through the bluff slopes to aid in qualitatively evaluating stability conditions.
4. Exploring the subsurface soil conditions, as needed, with hand tool explorations to characterize geologic conditions.
5. Providing recommendations for site drainage and erosion control.
6. Providing general recommendations for vegetation management and hazard mitigation.
7. Providing our opinions on current slope stability conditions.
8. Documenting the results of our findings, conclusions, and recommendations in a written geotechnical letter.

SITE CONDITIONS

Surface Conditions

The evaluated site consists of two adjacent and undeveloped shoreline parcels covering a total area of approximately 5 acres. The ground surface within the upper western portion of the property is terraced and slopes gently to moderately down from the west to the east with a steep east-facing bluff within the central portion of the subject sites. The existing trail traverses down the 40-foot bluff to the beach below. Brush vegetation exists along the upper portion of the property and along the top of the bluff with young to mature trees. The bluff slopes steeply to very steeply down to the toe of the slope at inclinations in the range of 45 to 85 degrees (100 to 189 percent of slope, respectively) as shown in Cross-Sections A-A’ and B-B’ in Figures 3 and 4, respectively. The bluff is traversed by a narrow trail that was cut into the slope. Block failures along with relatively minor erosional features were observed within the near vertical till faces encountered within the bluff. These block failures and erosional features appear to be a normal condition for the area and bluff conditions, created primarily due to local surface erosion and saturation from surface water flow.

The southern portion of the toe of bluff is protected by a timber bulkhead while the northern area is mostly protected from erosional effects of wave erosion and longshore current. No seawall has been constructed along this portion of the shoreline, but we observed minor wave toe erosion in this area. Due to the minimal amounts of bluff toe erosion, presence of driftwood and prevailing finer-grained beach deposits in this area. It is our opinion that the wave energy is believed to be low to moderate, as might be expected in this portion of the island.

Subsurface Conditions

Geology: Landforms within this region comprise a system of glacially sculptured features, which have been exposed by post-glacial erosion. Locally, the terrain of this area is interpreted to have been glacially modified, and the soils are thought to have been placed either just prior to, or during the latest glaciation of the Puget Lowland area. Glacial ice is thought to have last occupied the region during the late Pleistocene epoch, some 11,000 to 13,000 years before present. The latest glacial advance over the area is referred to as the Vashon Stade of the Fraser Glaciation, from which the glacial materials on site are believed to be deposited.

The geologic units for this area are shown on Geologic Map of the Juniper Beach 7.5-Minute Quadrangle, Island and Snohomish Counties, Washington by Polenz, Michael, Schasse, H.W., and Kalk, M.L., (WSDNR, 2009). The Site is mapped as mostly glacial till (Qgtv). Glacial till (Qgtv) is described as a compact diamict of sand, silt, gravel, and cobbles. Exposures within the steep to very steep east-facing bluff slope generally consisted of fine to medium sand with varying amounts of silt and gravel that we interpreted as native glacial till soils.

Hydrogeologic Conditions

We did not observe groundwater seepage emitting from the steep bluff during our visit on August 18, 2023. If groundwater is encountered during trail development, we would interpret this to be perched groundwater. Perched water conditions may occur on the site during periods of wet weather. Perched water occurs when surface water infiltrates through less dense, more permeable soils and accumulates on top of underlying, less permeable soils. Perched water does not represent a regional groundwater "table" within the upper soil horizons. Perched water tends to vary spatially and is dependent upon the amount of rainfall. We would expect the amount of perched water to decrease during drier times of the year and increase during wetter periods.

Seismic Hazard

The 2018 International Building Code (IBC) seismic design section provides a basis for seismic design of structures. Since medium dense or better glacial soils were encountered underlying the site, the site conditions best fit the IBC description for Site Class D. **Table 1** below provides seismic design parameters for the site that are in conformance with the 2018 IBC, which specifies a design earthquake having a two percent probability of occurrence in 50 years (return interval of 2,475 years), and the 2008 USGS seismic hazard maps.

Table 1 – 2018 IBC Seismic Design Parameters

Site Class	Spectral Acceleration at 0.2 sec. (g) S_S	Spectral Acceleration at 1.0 sec. (g) S_1	Site Coefficients		Design Spectral Response Parameters (g)	
			F_a	F_v	S_{DS}	S_{D1}
D	1.265	0.453	1.00	Null	0.843	Null

The spectral response accelerations were obtained from the USGS Earthquake Hazards Program Interpolated Probabilistic Ground Motion website (2008 data) for the project latitude and longitude. Hazards associated with seismic activity include liquefaction potential and amplification of ground motion by soft deposits. Liquefaction is caused by a rise in pore pressures in a loose, fine sand deposit beneath the groundwater table. The medium dense or better native glacial soils interpreted to underlie the site at depth have a low potential for liquefaction or amplification of ground motion.

Erosion Hazard

The criteria used for determination of the erosion hazard for affected areas include soil type, slope gradient, vegetation cover, and groundwater conditions. The erosion sensitivity is related to vegetative cover and the specific surface soil types, which are related to the underlying geologic soil units. The Soil Survey of the Island County Area, by the Natural Resources Conservation Service (NRCS), was reviewed. The mapped erosion hazard unit within the site is Aquic Dystroxerepts-Oxyaquic Xerorthents complex, 15 to 75 percent slopes. The erosion hazard rating for this soil unit is listed as severe. Based on our experience in the area we would interpret the erosion hazard for these soils to be low to moderate in areas where soils remain vegetated and undisturbed. If the ground surface becomes denuded or disturbed, we would anticipate a moderate to high erosion hazard. During the wetter periods of the year, we would expect some erosion of exposed soils, especially on steeper slopes within the property. This type of erosion is usually associated with weathering processes, including direct precipitation, wind, and freeze-thaw conditions.

Slope Stability

The criteria used for evaluation of landslide and steep slope hazards include soil type, slope gradient, groundwater conditions, as well as vegetative and geomorphological indicators. The ground surface within the subject parcel generally slopes gently to steeply from the existing residence towards the northwest. The slope descends at gradients in the range of 45 to 85 degrees (100 to 189 percent, respectively), resulting in a vertical relief of approximately 40 feet. We did not observe evidence of recent deep seated slope instability within the site slopes or within the immediate vicinity of the bluff during our investigation. We also did not observe seepage emitting from site slopes during our visit on August 18, 2023. In our opinion, the site and core of the steep slope appear to be relatively stable with respect to deep seated landslide activity.

Local surface slides and sloughing observed during our site visit and known to exist on the steep bluff slopes within this area, indicate a potential for surface sloughing over time and even large-scale slides during extreme weather. Backwasting (movement of near-surface soil) through exposed soil erosion processes or local surface slides are common to steep slopes, particularly where exposed to weathering, such as rain, wind, and freeze-thaw, perched groundwater flow within the steep slope area and wave erosion effects at the slope toe. As normally expected within similar areas, this area is backwasting from weathering conditions and seasonal surface saturation on steep slopes. Based on our observations, it is our opinion that the site is not backwasting significantly at this time, but block failures, shallow slides, and surface erosion will occasionally occur on the steep slopes within this area. This condition can be exacerbated by allowing surface water to flow over the top of slope, and over-steepening caused by erosion and surface sliding. Normal local surface sliding and erosion should be expected to continue to occur due to the prevailing conditions. If recommendations for vegetation management and drainage mitigation are utilized, we anticipate that the planned trail development area should not be affected for many years by normal slope activity.

CONCLUSIONS AND RECOMMENDATIONS

General

It is our opinion that the site is relatively stable, from a geologic and geotechnical standpoint, within the vicinity of the relatively small trailhead down to the beach. It is also our opinion that the proposed maintenance of the trailhead is feasible provided that no additional cuts or fill take place near the bluff slopes. The inferred underlying glacial deposits typically have high strength and are considered currently stable with regard to deep-seated earth movement. Long-term surface backwasting of the steep slope is considered on going for this site, due to natural processes and overall gradients of the bluff slope. This is considered a normal risk in this area. Minimal toe erosion and littoral drift exist and are expected to continue within this area.

We understand you desire to maintain the trailhead down to the beach, which will include placing new gravel surfacing along with installing a shallow perforated drain along the uphill side of the trail to mitigate ongoing erosion. We recommend that the trail footprint be maintained and not widened with the use of cuts or fills within the steep bluff face. If cuts or fills are needed to maintain the trail, we should be retained to provide recommendations for retaining walls to protect the bluffs during development. Developments to the trail should be performed in a manner that results in minimal disturbance to the bluff. During our visit to the site on August 18, 2023, we observed ongoing erosion along the uphill side of the trail where water from the bluff and trail had focused causing rills. This could be mitigated with the use of a shallow perforated pipe that could collect the water and transport it down slope to the beach. This is further discussed in the **Drainage Improvements** section of this report.

Development Considerations

The surficial slope soils are subject to backwasting due to weathering, creep, shallow sloughing, local erosion, and significant storm events. More significant surface sliding and sloughing events can occur during periods of heavy precipitation, overland surface runoff and undermining of the slope toe. This would result in slow to random surface recession of the slope face. We expect that recession associated with these types of processes can be accommodated with the proposed trail developments, provided our recommendations for maintaining vegetation and drainage are followed.

The slopes across this portion of Camano Island have receded slowly to sporadically fast over the past centuries, due to slope erosion and surface wasting processes. This is highly dependent on the prevailing soils and ground water conditions. Local near surface perched water and surface flow over the bluff slope can increase surface sliding activity within and in the vicinity of the site during the wet season. These processes should be expected to persist at their current rate if drainage on the slopes is not altered. Development-related improvements, such as drainage control systems and slope protection, could lessen the impact in this area. These techniques are commonly performed and should be utilized to aid in site improvement.

Vegetation Management

Selective pruning and thinning of vegetation should be acceptable within the steeper portions of the site but should be subject to review and County approval. We recommend that the vegetation be cut so that they remain alive, and that all pruned materials and debris should be removed from the area, and not allowed to remain on the ground. Any disturbed areas should be immediately restabilized through vegetation planting or other approved means. Placement of soil, sod, clippings or other matter on the slope is not recommended. Vegetation clearing within the proposed development area should not affect slope stability, provided that exposed soil areas are immediately revegetated and protected from erosion.

We anticipate that some trees may need to be removed from the bluff area in close proximity to the existing trail. In our opinion, this should be feasible and not adversely impact the existing slope stability conditions provided that the tree stumps remain at least 2-feet in height above the ground surface. This vegetation removal plan will leave the roots in place so they can continue to maintain stability and erosion protection, promoting the vegetation growth, while preventing the slope from becoming overloaded or shallow-rooted trees from becoming top-heavy. Limbs should not be allowed to fall on the nearby steep slopes during the removal process. Any other tree trimming within the property should be performed in a way that ensures that the trees remain alive. Tree removal and tree trimming should also be performed in accordance with Island County Code. All removed vegetation, cut trees, and resulting debris should be removed from the surface of steep slopes after cutting.

Best management practices should be followed to minimize disturbance to the slopes during tree and debris removal. If any portion of the site slopes are denuded from groundcover, they should be stabilized by plantings and erosion control measures consisting of heavy-duty jute netting or coconut coir grid. The erosion control measures should be staked at the top of the slope with 2- to 3-foot-long metal rebar that has a metal "T" welded to the end. The mat should be staked to the surface every five feet. After the matting is placed, we recommended that deep-rooted vegetation be planted. The vegetation should be maintained until established. If desired, existing invasive plants such as Himalayan Blackberry and English Ivy may also be removed and replaced with a mixture of native plants or shrubs to provide erosion control.

The vegetation should be maintained until established. We should be retained to provide specific recommendations for erosion control measures during tree and branch removal activities, as needed. Also, surface water should be directed away from the affected areas. This could be accomplished through the placement of berms/straw wattles and/or drains along the top of slope to route water away from the slope. Tree removal and tree trimming should also be performed in accordance with Island County code.

Erosion Control and Slope Protection

Best Management Practices (BMPs) should be used to control erosion within this site. Within exposed soil areas, vegetation planting, hydro-seeding and/or straw mulching are effective means to minimize erosion and allow the revegetation to begin rapidly. The bluff slope should be monitored and maintained on a regular basis to maintain current stability conditions and lessen the potential for large scale failures that could severely impact the area. Specifically, we recommend that no runoff generated on the property be allowed to reach the slope. Also, if sloughing and/or erosion is observed on the slope, the disturbed areas should promptly be covered with heavy-duty jute netting and hydroseeded. We should stress that due to the steepness of the bluff slope, the makeup of the soils exposed on the bluff, and severe weather the bluff could experience, that even with all the above measures implemented, large-scale sliding could still occur with little to no warning.

Drainage Improvements

We recommend the use of a curtain drain setback roughly 45 feet from the top of the slope. This will place the drain near an already established drainage trench and should catch runoff from the uphill residential properties. The drain should consist of a minimum 4-inch-diameter, rigid, slotted or perforated, PVC pipe surrounded by free-draining material wrapped in a filter fabric placed at the bottom of a minimum 4-foot-deep by 12-inch-wide trench. We recommend that the free-draining material consist of pea gravel or drain rock. The free-draining material should extend up to six inches below the finished surface. The top six inches of backfill should consist of sandy topsoil. The drain should be routed into the existing drain that extends down the slope. The existing drain that extends down the slope should be inspected for damage and functionality. If the drain is suspected or found to be damaged it should be replaced to ensure no water is focused on the steep slopes as this could exacerbate erosion and failures within the bluff. The drain should reach all the way down the bluff and end in a 'T' diffuser to mitigate any toe erosion of the bluff.

We also recommend a shallow perforated drain be installed along the uphill portion of the trail along the entire trail alignment. We understand a small trench will need to be excavated to install the drainpipe. We recommend that the trench be a maximum of 6 inches deep and be hand dug. The excavation spoils should be promptly removed from the site and not be stockpiled on the trail or be allowed to reach bluff slopes. The drain should consist of a 4-inch diameter, rigid, slotted or perforated, PVC pipe, surrounded by free-draining material. We recommend that the free-draining material consist of drain rock or 2-inch clean crushed rock. The drain should extend to the base of the bluff slope along the beach and be equipped with an energy diffuser to mitigate any toe erosion of the bluff slope. The drain should be routinely inspected for damage and blockage to abate water focusing on bluff slopes.

CLOSURE

NGA has prepared this letter for **Mr. Randy Barry** and his agents, for use in the planning and design of the development planned on this site only. The scope of our work does not include services related to construction safety precautions and our recommendations are not intended to direct the contractors' methods, techniques, sequences, or procedures, except as specifically described in our letter for consideration in design. There are possible variations in subsurface conditions between the explorations and also with time. Our letter, conclusions, and interpretations should not be construed as a warranty of subsurface conditions. A contingency for unanticipated conditions should be included in the budget and schedule.

All people who own or occupy homes on hillsides should realize that landslide movements are always a possibility. The homeowner should periodically inspect the slope, especially after a winter storm. If distress is evident, a geotechnical engineer should be contacted for advice on remedial/preventative measures. The probability that landsliding will occur is substantially reduced by the proper maintenance of drainage control measures at the site. Therefore, the property owner should take responsibility for performing such maintenance. Consequently, we recommend that a copy of our letter be provided to any future owners of the property if the area is sold.

Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted geotechnical engineering practices in effect in this area at the time this letter was prepared. No other warranty, expressed or implied, is made. Our observations, findings, and opinions are a means to identify and reduce the inherent risks to the owner.

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We appreciate the opportunity to provide service to you on this project. If you have any questions or require further information, please call.

Sincerely,

NELSON GEOTECHNICAL ASSOCIATES, INC.

Daniel J. O'Dell
Project Geologist

10.23.2023

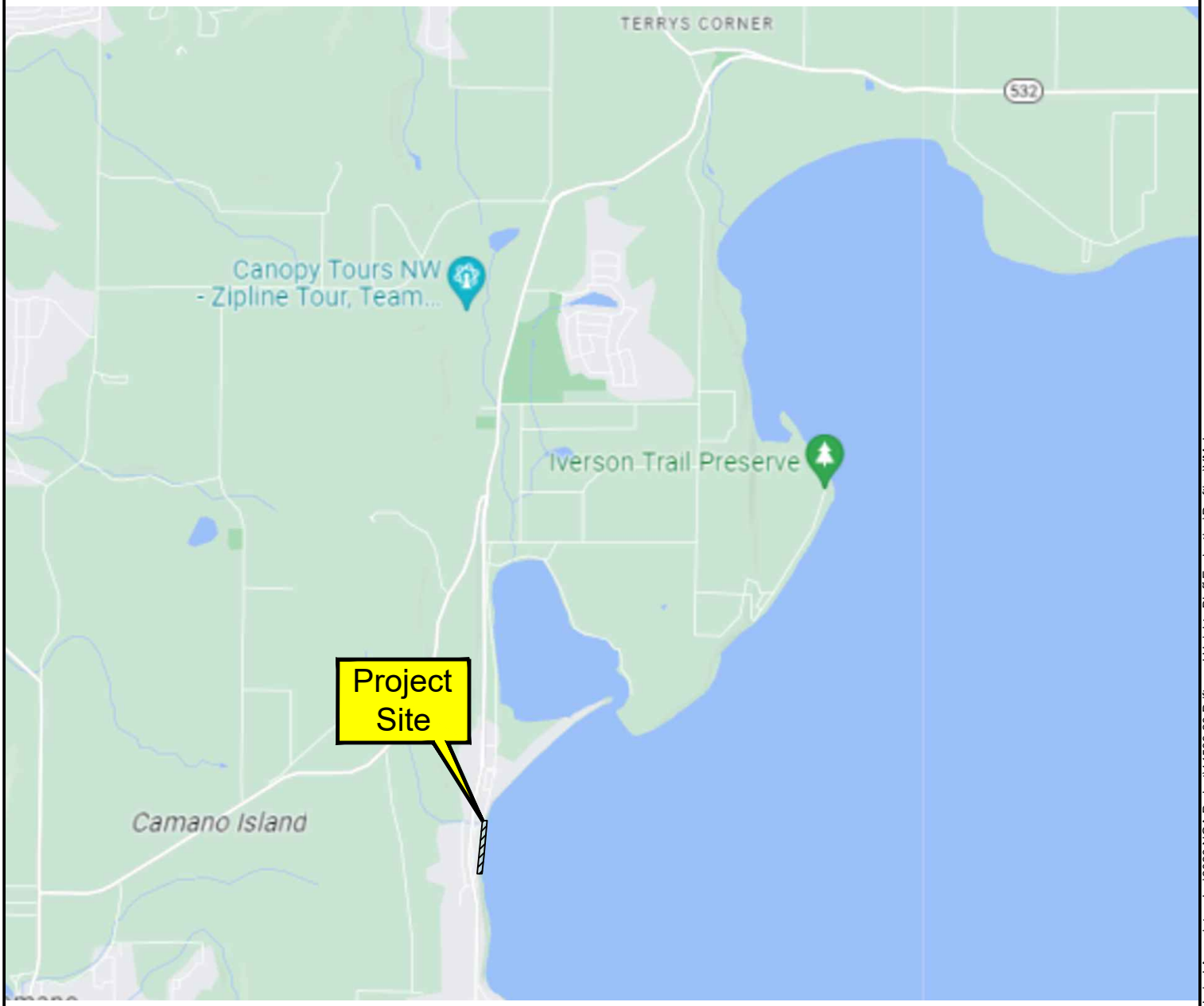
Khaled M. Shawish, PE
Principal

DJO:FKS:KMS:dy

Four Figures Attached

VICINITY MAP

Not to Scale



Island County, WA

Project Number 1453923	Driftwood Heights Bluff Evaluation Vicinity Map	NELSON GEOTECHNICAL ASSOCIATES, INC	No.	Date	Revision	By	CK
Figure 1			1	8/23/23	Original	ABT	DJO

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Site Plan

LEGEND

Property line

A A' Approximate location of cross-section

0 100 200

Approximate Scale: 1 inch = 100 feet

Reference: Site Plan based on field measurements, observations, and aerial parcel map review.

Project Number 1453923	Driftwood Heights Bluff Evaluation Site Plan	NELSON GEOTECHNICAL ASSOCIATES, INC
Figure 2		

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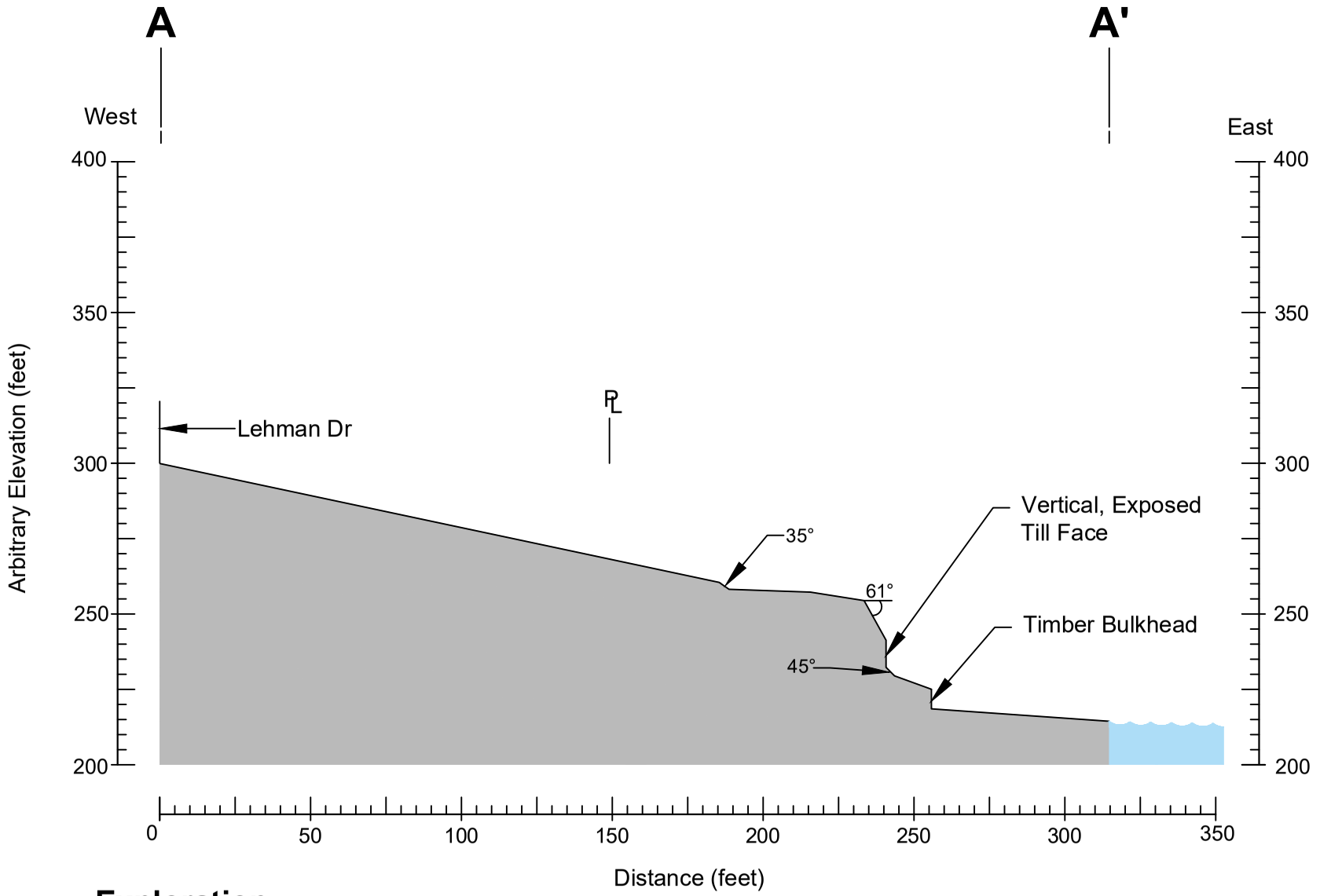

Exploration

Test Pit Designation → TP-1

Groundwater Level During Exploration →

Geologic Contact (approximate) → ? — — — ?

NOTES:
1) Stratigraphic conditions are interpolated between the explorations. Actual conditions may vary.
2) Elevations are arbitrary.

Reference: Cross Section is based on field measurements using a hand-held clinometer and 100-ft tape measure.

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Driftwood Heights
Bluff Evaluation
Cross-Section A-A'

Project Number
1453923

Figure 3

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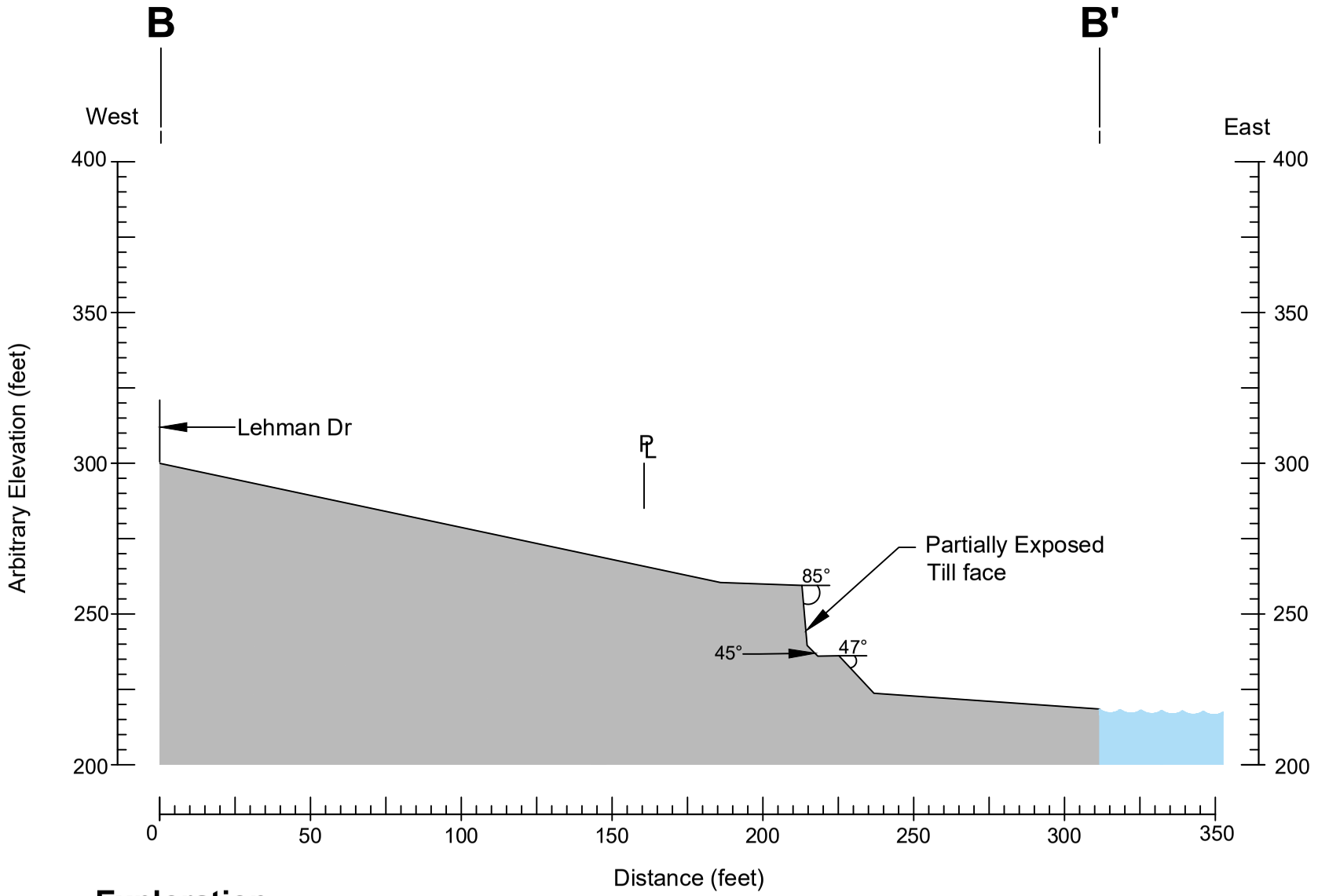

Exploration

Test Pit Designation → TP-1

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Driftwood Heights
Bluff Evaluation
Cross-Section B-B'

Project Number 1453923

Figure 4

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