GeoEngineers
8410 154th Avenue NE
Redmond, Washington 98052
425.861.6000

March 13, 2013

City of Burien
400 SW 152nd Street, Suite 300
Burien, Washington 98166-1957

Attention: Maiya Andrews, PE
Public Works Director

Subject: Letter Report
Eagle Landing Landslide Evaluation
Burien, Washington
File No. 3416-053-00

## INTRODUCTION AND SCOPE

This letter provides a summary of our review of readily available information and a site reconnaissance on February 12, 2013 to evaluate a landslide located on a west facing slope along the shoreline of the Puget Sound in Eagle Landing Park in Burien, Washington. Our services were requested by Maiya Andrews of the City of Burien Public Works Department during a telephone conversation with Galan McInelly of GeoEngineers, Inc. on February 6, 2013.

Our scope of work is as follows:

1. Research local geologic conditions by reviewing available resources including digital data from public sources and pertinent maps, reports, and other documents that are in our files.
2. Review information provided from City records that may have relevance to the construction of the stormwater system or slope failure issues at or near the site, including a map of the local stormwater drain system and two videos created by members of the public (also provided to us by the City).
3. Conduct a site reconnaissance to assess site conditions and a large tree that is of concern. Evaluate the role stormwater discharge may or may not play in landslide activity within the park boundaries.
4. Prepare a short report documenting our observations and opinions regarding the cause of the landslide and any conceptual recommendations for additional investigations or measures that are appropriate. Any engineering design or analyses will be done under separate contract.

## BACKGROUND AND DOCUMENT REVIEW

GeoEngineers reviewed the following reports regarding landslide activity and tree evaluation at Eagle Landing Park in Burien, Washington:

- Shannon & Wilson, Inc., 2002. Evaluation of Mass Wasting, Branson Property, Burien, Washington.
- Shannon & Wilson, Inc., 2003. Design Statement Regarding Branson Park Stairway.
- Shannon & Wilson, Inc., 2003. Geotechnical Report Branson Park, Burien, Washington.
- Gilles Consulting, 2013. Evaluation of Trees at Eagle Landing Park.

Based on our review of the documents above, it is our understanding that the subject landslide discussed in this memorandum was previously identified, described and mapped by Shannon & Wilson in a 2002 report. In 2002, the City of Burien requested Shannon & Wilson's services to assess the Branson property. At that time the City of Burien was proposing to purchase a portion of the property. In their report, Shannon & Wilson presented their evaluation of the mass wasting processes on the Branson property and addressed the City's concern regarding contribution of sediment from the upland part of the slope to the beach along Puget Sound. Shannon & Wilson found that the subject site was not a "large supplier of sediment to the beach environment" compared to other Puget Sound bluffs, but the report did note that the Branson slope is a "regular and consistent supplier of coarse to fine sediment due to mass movement processes." Shannon & Wilson identify a "chute" on the south edge of the property, and notes "the coarse sediment is primarily supplied by debris flows in the chute on the south edge of the property and from periodic erosion of the toe of the very steep slope just north of the debris chute." Subsequently, Shannon & Wilson conducted shallow, hand-excavated subsurface explorations at the park and provided geotechnical recommendations for the stair case that the City of Burien constructed and maintains at the site.

The debris chute discussed in Shannon & Wilson's report appears to be the same chute that the subject landslide of this report occupies. Based on our review of the map provided by Shannon & Wilson, it appears as though the chute has eroded farther back into the slope and has produced an expanded landslide scar since the time of Shannon & Wilson's evaluation in 2002. We discuss the subject landslide in more detail in the Site Reconnaissance section below.

In February 2013, Gilles Consulting (Gilles) was requested by the City of Burien to conduct an evaluation of a large Douglas fir tree located upslope of the landslide. According to the report produced by Gilles, the landslide occurred sometime before Christmas in December 2012, and the scarp of the landslide was approximately 30 feet downslope from the base of the tree. Gilles reported that "the tree is the lone conifer on the slope surrounded by Maples and Alders," and that it is approximately 164 feet tall and has a circumference over 13 feet. The tree has been identified by the State Fish and Wildlife Department as a Bald Eagle Perch Tree. Gilles determined that if the tree fails it is within striking distance of the park trail and stairs in multiple locations, and toppling of the tree could trigger a much broader landslide. Recommendations in the Gilles report to avoid damage to the trail or possible personal injury to trail occupants is to reduce the height of the tree by at least 40 feet (height of 124 feet); this height would then allow for the tree to remain as an eagle perch. Alternatively, the tree could be reduced to approximately 50 feet tall but that would relinquish its function as an Eagle Perch Tree. In our Site Reconnaissance section below, we discuss the slope conditions near the tree.

Based on information provided during a phone conversation with Maiya Andrews on March 4, 2013, it is our understanding that the eagle perch tree and a section of the landslide (near the current head of the landslide scarp) are not located on park property, but are located on private property immediately south of the park boundary.

At the request of Maiya Andrews, we also reviewed two home videos that were recorded by a neighboring property owner, John White, and submitted to the City of Burien. The videos show the subject stormwater drain discharge during a period of high precipitation; the date and time of the recording were not provided in the video. The footage is brief and shows select segments of the drainage channel between the discharge point of the storm drain to just downstream of the trail crossing of the associated drainage channel. The first video (17 seconds long) shows water flowing out of the stormwater drainage pipe located along 25th Avenue SW, at Eagle Landing Park. The water flow is mainly contained within the rock-lined channel with the exception of a small streamlet of overflow water that drained from near the head of the stream to approximately 30 feet down the adjacent trail. The second video (23 seconds long) briefly shows the stream flowing downstream from a second 12-inch concrete culvert (that goes under the park trail) and a view upstream.

At the time of our site visit, water was not flowing from the storm drain or through the culvert beneath the park trail. See our observations regarding the stormwater drainage system below in the Site Reconnaissance section.

## SITE GEOLOGY

We reviewed a published map of the area (Waldron, 1962). The mapped geologic unit in the area is identified as advance outwash (Qsa) which Waldron (1962) describes as sand, and sand and pebble to cobble gravel with very fine sand and laminated silt. This unit was deposited by proglacial streams formed at the front of advancing glaciers in the Puget Sound. As described by Shannon & Wilson, these deposits are covered by colluvium. Colluvium is loose material that accumulates on slopes due to gravity; it is commonly attributed to root loosening, freeze-thaw action, animal burrowing or from landslide or other erosion processes that originate from higher elevations (in this case, the upper portions of Eagle landing Park). Shannon & Wilson also documents interbedded hard clay, silt and sand exposures at the beach.

During our site reconnaissance, near surface soils were observed in eroded slope exposures and in the scarp of the landslide. We generally found that approximately the upper 2 to 3 feet of slope deposits are colluvium, and is composed of fine to medium sand with silt, gravel and occasional cobbles. At the base of the slope, on the beach we encountered an outcrop of laminated silt, likely part of interglacial deposits or interbeds near the base of and within the glacial advance outwash mapped in the area.

## SITE RECONNAISSANCE

We completed a site reconnaissance at Eagle Landing Park on February 12, 2013 to evaluate the December 2012 landslide and Douglas fir tree upslope from the slide, and the stormwater drainage system (see Figure 1, Site Map). This evaluation was conducted to develop a preliminary opinion regarding the cause of the landslide, the potential risk for future slope failure and its relationship, if any, to the stormwater drainage system.

Beginning from the parking lot we observed the stormwater drainage system, a concrete, 12-inch drain pipe exposed under the western edge of 25th Avenue SW. The culvert drains to a rock lined channel running roughly parallel to the trail entering the park and continues downslope for about 150 feet, from there it flows into a culvert under the park trail and continues west (downslope). The channel includes channel-grade control structures spaced about 15 to 20 feet apart. Midway down the rock-lined drainage it appears as though grade control structures were once in place but have degraded from recent/past high flows. We also observed minor erosion on the park trail (about 6 inches wide, 3 inches deep), parallel to the rock-lined channel (see Figure 2). From the culvert placed under the trail we followed the drainage and could see that limited erosion has occurred in some areas immediately down slope of the culvert, including areas of incision up to 2 feet deep. The drainage is approximately 1 foot wide downslope of the culvert and becomes progressively shallower with distance downslope of the trail. Evidence of the surface flow is visible for approximately 50 feet downslope from the culvert and then evidence of channelized flow disappears as the water apparently infiltrates into the surface soils.

After investigating the stormwater drainage system we continued downslope toward the beach, taking the main trail that begins from the parking lot. The upland topography was generally irregular with variable slope gradient (about 40 to 100 percent). The park is generally forested by deciduous trees including Maple and Alder trees with a dense understory of ferns, ivy, and blackberry. The majority of the trees are bowed and leaning downhill. The slope gradient abruptly steepens about 30 to 40 feet vertically above the beach and the trail leads to a staircase that goes down to the beach. The top of the stair case begins at about elevation 150 feet and ends just above the beach; the slope gradient along this segment of the park trail is between 70 to over 100 percent.

Along the beach we observed multiple seeps, exposed tree roots, bowed and leaning trees, and evidence of active beach erosion along the toe of the slope (see Figure 3). At the base of the stairs there is an approximately 4-foot vertical drop to the beach and the toe of the slope adjacent to the stairs is undercut with vertical relief from about 1½ to 3 feet. In the exposed slope we observed colluvium in the upper 2 feet, underlain by silty sand. We used a soil probe in an eroded side wall of the slope to estimate the density of the material and found that it easily penetrated at least 3 feet into the slope. What appears to be a recent slope failure just south of the staircase is about 30 feet wide and 12 feet at its maximum height (see Figure 3). The small failure we observed to the south of the staircase is perhaps as little as 20 feet from the second stair landing upslope from the beach.

The larger subject landslide, located at the southern edge of the park boundary, measures approximately 88 feet (slope length) from the headscarp to the toe of the landslide. The toe of the failure was about 34 feet wide; the head had a maximum width of about 40 feet. A narrow debris shoot leads from the wider head of the failure to the toe of the feature. A bench is located approximately 30 feet (slope length) above the beach where the chute narrows to about 6 feet wide (see Figure 4). A second bench is located another 45 feet upslope of the first bench (75 feet upslope from the beach). At the second bench, the landslide widens into a bowl shape, forming the head of the landslide. The scarp at the head of the landslide exposes nearly 10 vertical feet of the underlying stratigraphy. Exposed in the scarp were inter-bedded silt and sand layers, with seepage emanating from the sandier strata.

Portions of the scarp are covered by dense foliage that has draped over the slope and edges of the chute (see Figure 5). At the time of our visit, we observed seepage from the body and toe of the landslide debris flowing at approximately 30 gallons per minute. The debris at the toe of the slide is composed of sand with gravel, cobbles, and woody debris.

Near the head of the landslide there are multiple tiers of near-vertical steel pipe and lumber that appear to have been installed to retain sediment and debris; these features were still partially intact on the south edge of the landslide but were apparently damaged by recent landslide activity.

We also evaluated the slope conditions around the base of the Douglas fir (eagle perch) located approximately 15 feet upslope from the headscarp. The tree is severely back tilted (about 55 percent), and roots are bare and exposed on the downslope side of the tree.

## DISCUSSION AND CONCLUSIONS

### General

Based on our review of available information and our site reconnaissance, it is our opinion that the landslide will likely continue to fail in the short and long term (i.e., within months to years). The eagle perch tree located upslope of the landslide is back-tilted, has exposed roots and is likely to fail as a result of headward retreat of the landslide headscarp, or because of windthrow. We also found that the base of the tree was about 15 feet from the top of the slide which is less than the observed 30 foot distance reported by Gilles, indicating that the headscarp has retreated approximately 15 feet over a period of a few weeks. In addition to the eagle perch tree, there were several trees with undercut root systems observed along the shoreline area that may, over time, present a safety hazard to the public. The small failure located south of the staircase could encroach on the second landing. Depending on the foundation details, this failure could undermine the landing foundation.

The stormwater drainage system has caused minor erosion in the upland area of the park boundaries but it appears as though the flow infiltrates, and signs of erosion dissipates about 225 feet downslope from where the discharge begins near the parking lot.

It is our opinion, based on the previous work and on our surface reconnaissance that the landslide activity is a natural, ongoing process resulting from groundwater seepage at the interface of underlying or interbedded silty strata and highly permeable advance outwash deposits. It is apparent that the failure has been ongoing since before 2002, based on the Shannon & Wilson report. It is also our opinion that beach erosion plays a significant role in the initiation of landslide activity in the vicinity of the park, as demonstrated by the small slump located immediately south of the stairway on the beach. The current landslide activity appears to have originated at the beach, probably as a small slump, and has continued as a result of natural groundwater discharge, piping and winnowing of sandy layers, and subsequent failure of the bluff face.

### Stormwater Contribution

Discharge from the stormwater drain near the top of the park does appear to contribute to groundwater recharge in the underlying advance outwash. Videos provided to the City by Mr. White showed water flowing from the storm drain outlet near the street into a rock-lined channel and through the culvert under the trail.

Regional recharge to groundwater likely occurs within the large upland area extending up to a half mile to the east.

We do not have data regarding the rate of discharge from the drain pipe; however, the stormwater basin, personal communication from City of Burien) contributing runoff-related recharge to groundwater upslope of the seeps and landslide area(s) is from approximately 2 to 3 city blocks (City of Burien personal communication, 2013). To gain a better understanding of runoff volumes from developed areas, a detailed study would be needed to evaluate how runoff from individual parcels is or is not routed to the City's stormwater system in the street.

The net increase (increase due to impervious surfaces versus pre-development conditions) in recharge from local stormwater flows likely increased discharge at the seeps above the beach for periods of time during and shortly following precipitation events. It is our opinion that the effect is transient and likely not significant, in terms of slope stability over the long term (years in decades), since seeps flow year round and will continue to emanate from the bluff as the result of groundwater flows originating from upland recharge areas well to the east of the park.

Determining the incremental increase in recharge from the storm drain system will require a significant watershed study to model flow from all of the contributing basin area and would include large uncertainties in terms of mapping the contributing basin.

### Conceptual Risk Reduction Alternatives

We considered conceptual mitigation alternatives to stop the landslide activity at the site. The most reasonable and probably least expensive option would be to remove loose material within the body of the landslide and fill the landslide scar with light loose rip rap and/or large quarry spalls placed over a filter fabric. This would allow the water to continue to drain from the slope face, but prevent future collapse of the slope surrounding the landslide scar. Construction would be difficult because of limited access to the site (which would be difficult for any alternative), difficulties associated with moving material into and out of the landslide, and tidal action on the beach. It is likely that any alternative will be fairly costly (more than $100,000).

Other options, such as retaining walls would be more expensive and perhaps infeasible due to the difficulty of getting large construction equipment and materials to the site, potential interference from tidal action, and other construction considerations.

Constructing a tight-line drainage system from the drain outlet to the beach would be expensive and require significant impacts to the park to construct manholes, thrust blocks and a pipe to convey the water to the beach. Constructing the tight-line would eliminate any contribution to groundwater flow from the stormwater drain. However, the probability of stopping the existing, and possible future, failure(s) by

simply tight-lining the storm drain flow to the base of the hill as the only mitigation measure is at best low, in our opinion.

Another alternative may be to connect the storm drain system to an existing tight line located south of the park, but it is not known if that is a feasible option at this point, nor do we have a good idea of potential costs. This alternative would also likely require some significant impacts to the park, at least in the short term.

### Eagle Perch Tree

It is our opinion that the eagle perch tree described by Gilles will topple if left as is, due to windthrow or loss of support from landslide activity (based on the recent rate of regression of the headscarp upslope). Though the tree is not located on park property, it is our opinion that the tree still represents a significant health and safety liability to the City due the potential of the tree to fall on park visitors on the trail or beach. Even if the tree were shortened, there is a significant chance that the trunk and root wad could tumble or slide down the steep slope and impact the beach if it falls. It is therefore our recommendation that the tree be removed as soon as possible to minimize the risk to park visitors.

## LIMITATION

We have prepared this report for the City of Burien and their authorized agents and regulatory agencies for evaluation of a landslide and stormwater drainage concerns at Eagle Landing Park in Burien, Washington.

Our services were provided to assist in the evaluation of a landslide and the stormwater drainage system. Our recommendations are preliminary and are intended to provide guidance to further evaluate and manage the potential for continued failure of the slope and potential impacts to the property. Qualified engineering geologic, engineering and construction practices can help mitigate these risks if implemented in a timely manner.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the field of engineering geology in this area at the time this report was prepared. The conclusions, recommendations, and opinions presented in this report are based on our professional knowledge, judgment and experience. No warranty or other conditions, express or implied, should be understood.

## REFERENCES

Gilles, B.K., "Evaluation of Trees at Eagle Landing Park," Gilles Consulting, February 8, 2013.

Laprade, W.T., "Evaluation of Mass Wasting, Branson Property, Burien, Washington," Shannon & Wilson, Inc., March 18, 2002.

Shannon & Wilson, Inc., "Design Statement Regarding Branson Park Stairway," Burien, Washington, November 14, 2003.

Shannon & Wilson, Inc., "Geotechnical Report," Branson Park, Burien, Washington, March 20, 2003.

Waldron, H.H., "Geology of the Des Moines Quadrangle, Washington." 1:24,000. U.S. Geological Survey Geologic Quadrangle Map GQ-159. 1962.

We trust that this letter report meets your needs at this time. Please do not hesitate to contact us if you have questions or require additional information.

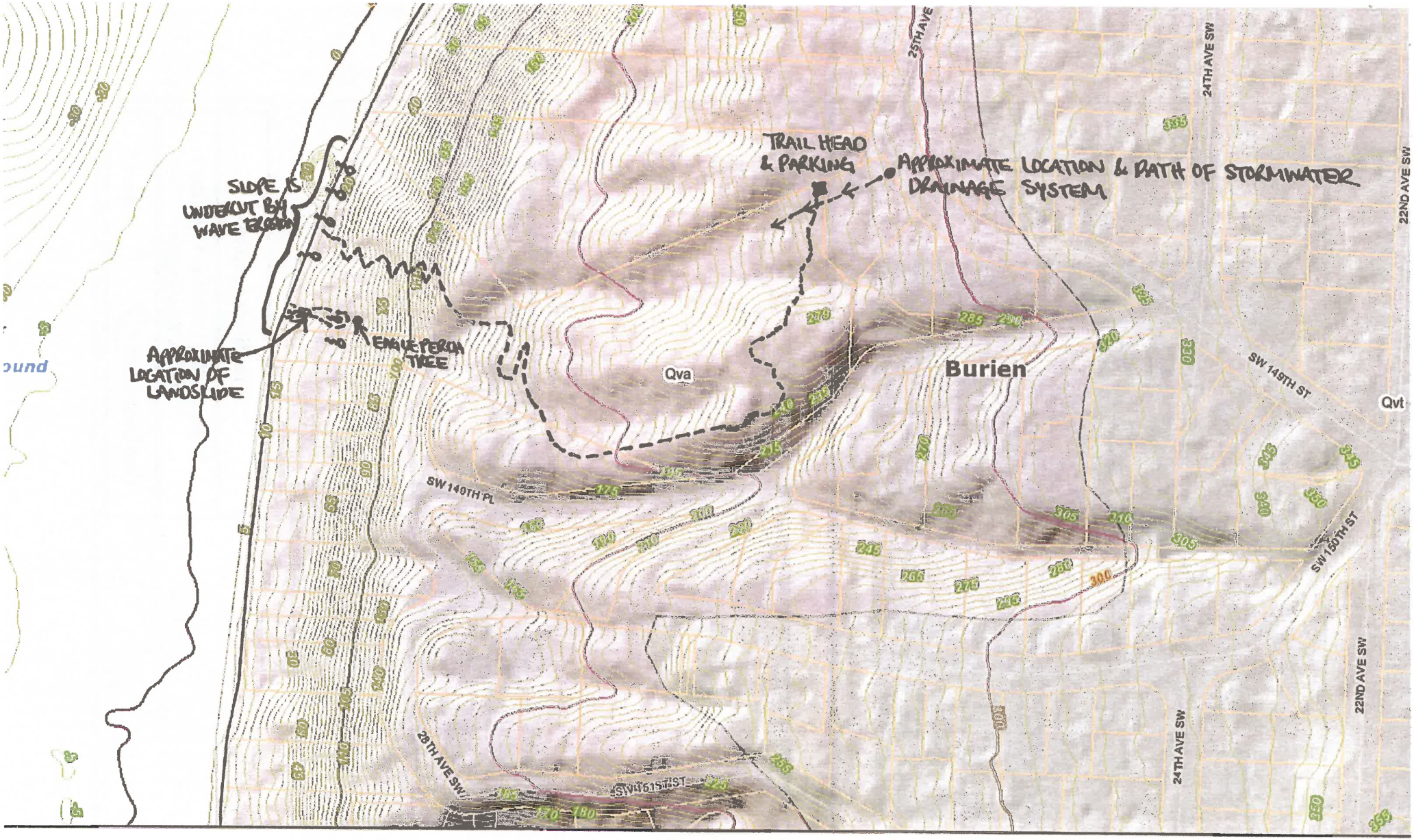
Sincerely,
GeoEngineers, Inc.

Tabitha A. Trosper
Staff Geologist

Galan W. McInelly, LG, LEG
Principal

TAT:GWM:lc

List of Figures
Figure 1. Site Map
Figures 2 through 5. Photo Log




: Mapping provided by King County GIS, 2006. Other digital GIS data acquired 2013.

N

es. It is intended to assist
ched document.

View of the 12-inch concrete stormwater drainage pipe where it begins to drain into Eagle Landing Park, located on western edge of 25th Avenue SW.

View upslope of the drainage and minor erosion in the trail (outlined in red). The drainage is rock lined and appears to contain grade-control structures (red arrow) that have begun to degrade. Photo taken facing toward the east.

| Site Photographs | |
|---|---|
| Eagle Landing Landslide Evaluation<br>Burien, Washington | |
| GeoEngineers | Figure 2 |

File No. 03416-053-00

Wave erosion on the beach is undercutting the base of the slope. Note about 1½ feet of vertical beach erosion at base of the slope. Tree roots are exposed and trees are bowed and leaning.

View from the beach at Eagle Landing Park. Note undercutting of the slope, about 3 to 4 feet of vertical erosion, and slope failure to the right of the staircase (outlined in red). Photo taken facing toward the east.

| Site Photographs | |
|---|---|
| Eagle Landing Landslide Evaluation<br>Burien, Washington | |
| GeoEngineers | Figure 3 |

File No. 03416-053-00

View of the toe of the landslide, debris are actively being down cut by seepage flow. Photo taken facing west-southwest.

View of the landslide debris located about mid-way up the landslide. Photo taken facing towards the east.

File No. 03416-053-00

| Site Photographs | |
|---|---|
| Eagle Landing Landslide Evaluation<br>Burien, Washington | |
| GeoEngineers | Figure 4 |

Partial view of the landslide headscarp (outlined in red) and straw- covered head of the landslide. Photo taken facing east.

View of the headscarp in background, and what remains of the pipe and wood feature that is placed across the slope (red arrow points to pipe sticking out of slope). Photo taken facing north.

| Site Photographs | |
|---|---|
| Eagle Landing Landslide Evaluation<br>Burien, Washington | |
| GeoEngineers | Figure 5 |

File No. 03416-053-00