May 11, 2018

Dr. Eric D. Loucks, P.E.
Supervising Civil Engineer
Stormwater Treatment and Stream Restoration
City of Austin Watershed Protection Department
505 Barton Springs Rd
Austin, TX 78704

Re: Documentation of Slope Failure Along Shoal Creek at Pease Park

Dear Dr. Loucks:

Pursuant to the City of Austin's (City) request, HDR Engineering Inc. (HDR) completed a preliminary site assessment of a recent slope failure along the west side of Shoal Creek. The site reconnaissance was performed by two HDR staff (undersigned), in the presence of City Watershed Protection Department staff David Johns, PG and Clayton Ernst, PE.

Background

After heavy rains on May 4, 2018, a slope failure occurred along the existing hill on the west side of Shoal Creek just downstream of the Shoal Creek Boulevard bridge. The associated slip surface initiated on private properties located on top of the hill and extended into Shoal Creek. Figure 1 provides an aerial view of the site with the approximate limits of the failure identified.

Geometry

The approximated limits of the failure were determined from a drone video provided by the City and site reconnaissance with a geolocation enabled device (Figure 1). Based on the scaled aerial, the width of the slope failure is approximately 400 feet, as measured along Shoal Creek. The length of the slope failure, as measured from Shoal Creek to the hill top, ranges from approximately 150 to 200 feet.

Based on the 2-foot topographic contours from the City (Figure 1), the elevations along the crest (pre-failure) generally range from El. 552 feet to El. 574 feet (msl). The bottom elevation along Shoal Creek (within the impacted area) is approximately El. 492 feet (+/-). The total slope heights, as measured between Shoal Creek and the pre-failure crest, range from approximately 60 to 80 feet.

The surface grade prior to failure averaged approximately 42% to 46%, which equates to a slope angle of approximately 24 degrees. The average incorporates the surface elevations within the upper reaches (near the crest), where pre-failure slopes in excess of 65 degrees were measured from the topographic data provided on Figure 1.

Site Geology

The slope failure is in an area that is geologically characterized as Buda Limestone underlain by the Del Rio Formation. The Buda Limestone is present from the crest of the hill to a depth of approximately 20 feet. The limestone outcrop diminishes in thickness downslope, until the Del Rio

is fully exposed. The steep pre-failure grades noted in the upper reach of the slope are presumably associated with the Buda Limestone outcrop.

The Del Rio Formation typically consists of a high plasticity clay. It is often rich in the mineral montmorillonite, formed during the weathering process. The montmorillonite mineral is what makes the Del Rio clay highly plastic. High plasticity clays are prone to shrinkage and swelling during periods of dry weather and wet weather, respectively. The montmorillonite clay mineral in particular can absorb significant amounts of water (when available). Water adsorption can make the clay soft, reducing both the cohesiveness and frictional characteristics of the material.

Site Observations

A photo log of select field photos is provided as Attachment 1. Observations documented during our site visit include:

1. The slope failure has pushed the west bank of Shoal Creek (along the impacted area) into the creek, creating a near full constriction of the creek at several locations.

2. Along the toe of the failure, material “piled” up in Shoal Creek as the toe advanced east. This material is loose and unstable. Broken and displaced pieces of trail pavement along the west side of the creek are also unstable.

3. The material within the creek includes toppled trees, limestone boulders, and soil. In some cases it appears the boulders (former bank stabilization material) pushed forward in a near horizontal direction, while in other instances appears to have toppled into the creek.

4. In general, the toe of the slip surface appears to have daylighted at or near the creek bottom. Currently the toe of the slide does not appear to have impacted the east bank of the creek.

5. Numerous trees within the slope failure area were uprooted or leaning in the direction of the movement especially near the edges of the failure. Some trees appeared vertical, but with an appearance they had been transposed horizontally during the failure event.

6. Overall the surface is heavily vegetated with trees and understory making access by foot difficult.

7. The primary material visible within the failure mass is clayey soil, though containing notable amounts of limestone boulders and vegetation. The boulders, which are concentrated on the upper elevations, are mostly broken pieces of Buda Limestone that toppled and spread during the failure event.

8. An escarpment exists at the top of the slope failure. The escarpment has formed a shear wall or cliff along the crest of the hill top. The exposed height of the newly formed cliff ranges from approximately 20 to 35 feet. The exposed material consists of weathered Buda Limestone underlain by Del Rio clay. The surface of the newly formed cliff has a texture and appearance consistent with a very recent shear failure.

9. The face of the escarpment area or cliff includes loose limestone fragments and blocks, as well as overhanging material at the crest. Based on visual appearance, the escarpment area appears unstable. Evidence of older failures are present at both the north and south end of the current failure. Rock faces exist on one side of a grade break and soil has

partially in-filled the older failures. The current failure is roughly parallel to these older features and generally corresponds to the regional faulting along the Balcones Fault Zone.

10. The flow debris (i.e. failed material) appears unstable with voids, cracks, and deep crevasses present throughout.

11. The near surface/remolded Del Rio clay was often soft and wet at time of observation.

Potential Failure Mechanism

Slope Stability

Slope stability is the ability of an inclined land surface to maintain its original configuration. A failure occurs when the driving gravitational forces of a particular mass of earth are greater than the resisting forces. Resisting forces along a particular plane or surface within the earth material are obtained by the shear strength properties of the material, as well as the depth and weight of the material. The shear strength properties usually include the internal angle of friction and cohesion.

Reduced Shear Resistance

High plasticity clays (e.g. Del Rio Formation) have a tendency to weaken overtime due to wetting and drying cycles and become less resistant to slope failures, especially during or following a significant rainfall. As moisture increases, the clay has a tendency to swell or take on water. Contrary, during periods of hot and dry weather the clay tends to shrink, forming cracks or joints with the clay mass. When present, cracks or joints provide a conduits for water to be more readily adsorbed into the clay fabric during rainfall events. A reduced shear strength of the Del Rio clay is quite possibly the main contributing factor in the recent slope failure event.

Prior to failure, the Buda Limestone (near the crest) likely included fractures and joints, which may have provided an enhanced, though natural pathway for more precipitation to reach the underlying Del Rio clay. A network of naturally occurring near vertical fractures within the Buda Limestone could have also reduced the overall vertical shear resistance of the rock mass, a contributing factor in the development of the near vertical cliff observed at the escarpment.

Failure Geometry

The site reconnaissance primarily examined surface features, so it is somewhat difficult to postulate on the geometric configuration of the slip surface. However, given the vertical escarpment depth, noted movements at the toe, and site geology the failure/slip surface is likely moderately deep. In other words, the failure surface should not be considered a shallow or veneer type slide, at least not without more substantial geotechnical investigation.

Current Stability of Failure Area

Clay soils have a reduced shear strength once they are fully mobilized or over strained. The term most often used to describe this phenomena is “residual” shear strength. So while the failed slope is presumable at a flatter slope/grade, the Del Rio clays within the shear zone have a compromised strength. Adding to this concern are the observed cracks, crevasses, and voids throughout the failed mass. These now macro features provide direct conduits for precipitation to enter the Del Rio clay at depth, potentially resulting in a further degradation of shear strength. Consequently, the

current failed slope configuration could be in a delicate state of equilibrium, subject to additional or ongoing movements without advanced notice.

On a more localized basis, loose/unstable material exists at the toe and the escarpment area. Both of these areas should be considered a safety hazard independent of ongoing slope movements.

Preliminary Recommendations

It is recommended that no earth material (soil and rock) be removed from the toe of the slope, including material within the creek. This recommendation may be modified or adjusted once more is understood about the slope failure and the stability of the current configuration. Trees that have fallen in the creek may be removed with great caution. The base and root ball of the trees should remain in place.

Ongoing slope movements should be monitored. This can be accomplished by establishing and monitoring survey points or markers placed along the west side of Shoal Creek, as well as within the mid-sections of the slope and near the crest.

It is understood that at least one property owner at the crest is taking a proactive approach. It is recommended the owners of other properties impacted by the slope failure be made aware that the escarpment area is unstable and likely to experience more movement or failure in the near future.

Lastly, a slope failure of this significance requires a comprehensive and thorough geotechnical investigation, including a series of slope stability analyses. Results of the geotechnical investigation would be used to determine the engineering properties of the various materials, the potential cause of the failure, and the geometry of the slip surface. Such information will be critical in developing a short and long term action plan.

Sincerely,

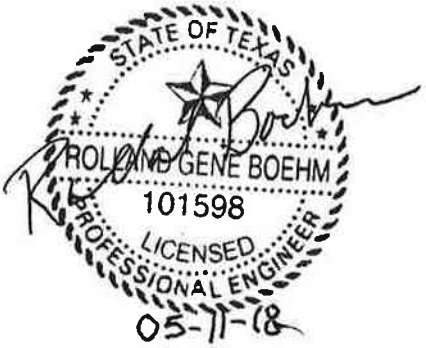
HDR Engineering, Inc.

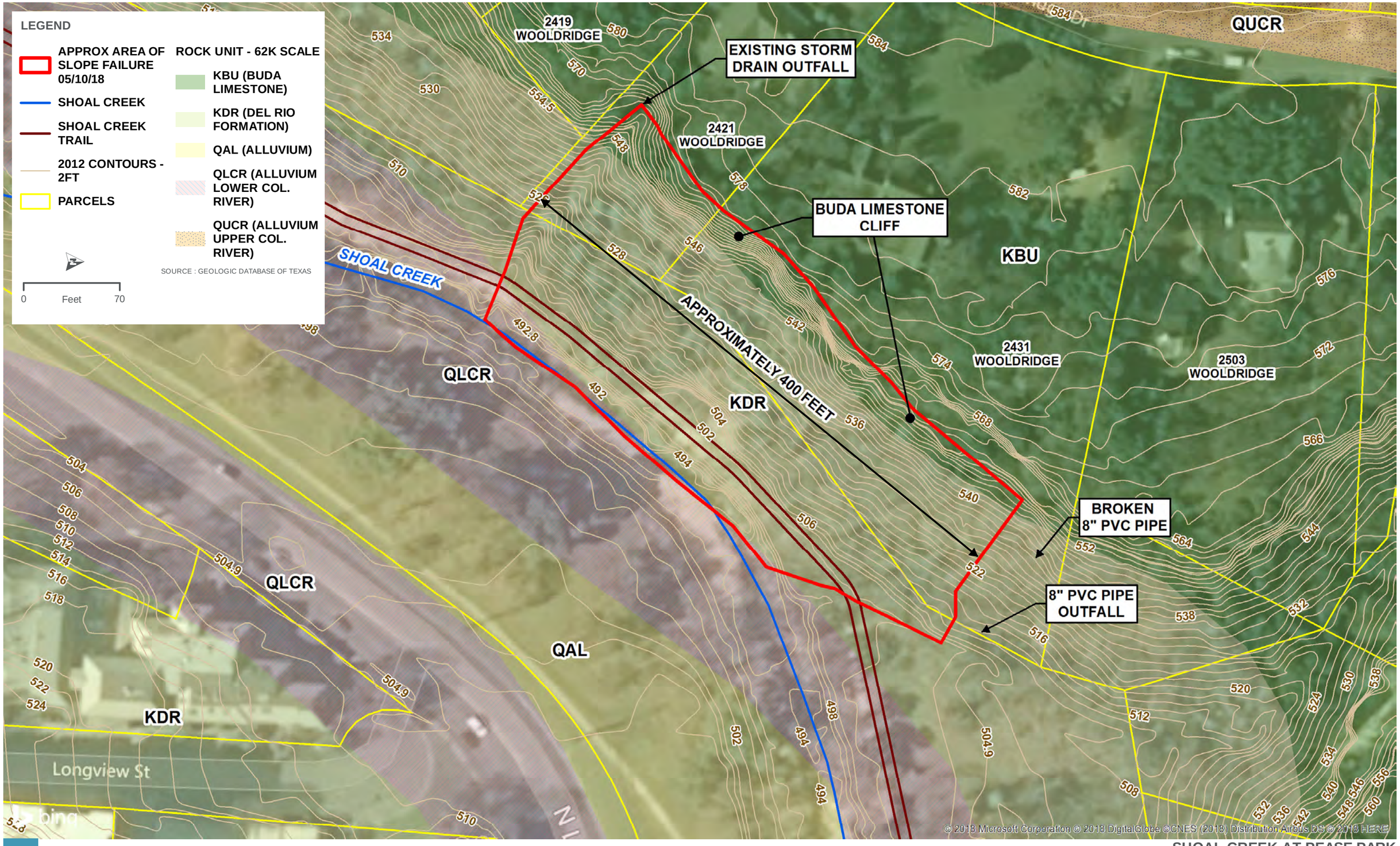
Eric J. Stewart, PE
Project Manager

Rolland G. Boehm, PE
Senior Geotechnical Engineer

Enclosures:
Figure 1 – Shoal Creek at Pease Park Approximate Area of Slope Failure
Attachment 1 – Photo Log May 10, 2018

Cc:
Mike Kelly, PE (Watershed Protection
Clayton Ernst, PE (Watershed Protection)





SHOAL CREEK AT PEASE PARK

FIGURE - 1

Attachment 1

Photo Log

May 10, 2018

Northern terminus of slide at Shoal Creek
Existing dry stack wall pushed horizontally into creek

Southern terminus of slide at Shoal Creek
Existing dry stack wall pushed horizontally into creek

D/S half of horiz. trail wall displacement at Shoal Creek
Creek bed material pushed up into pile in front of slide
Displacement greater in downstream (d/s) half compared to upstream (u/s) half

D/S half of horiz. trail wall displacement at Shoal Creek
Creek bed material pushed up into pile in front of slide
Displacement greater in d/s half compared to u/s half

Upstream (u/s) half of horiz. trail wall displacement at Shoal Creek
Displacement of bed material not as significant

Top view of trail at creek, along toe of slide looking d/s
Rough approximation of pre-event creek bottom width (shown by red line)

Along trail south of existing gabion wall
Some vertical displacement of pavement, mostly horizontal

Existing gabion wall
Note bulging displaced gabion toe at south end and heaving/thrusting of material at front face

Southern edge of slope failure along fence line at 2419 Wooldridge Drive
Deep crevasse and separation along fence line.
Upper right hand corner – existing storm drain

Southern edge of slope failure along fence line
Upper right hand corner – existing storm drain

Buda Formation at upslope edge of failure
Along 2421 Wooldridge Drive

Upslope edge of failure at between 2421 and 2431 Wooldridge Drive
Buda Formation (above) Del Rio (below) – contact location
Thickness of Buda approx. 20ft. Unstable slope.ft

Close up of Buda/Del Rio contact location
Along south end of 2431 Wooldridge Drive

Upslope edge of failure at between 2421 and 2431 Wooldridge Drive
Buda Formation (above) Del Rio (below) – contact
Note deep separation crevasse behind tree at bottom of pic

Upslope edge of failure at 2431 Wooldridge Drive
Looking north. Unstable slope.

At base of upslope edge of failure at 2431 Wooldridge Drive
Landscape wall fallen from yard above

NW corner of fence for 2431 Wooldridge Drive locally displaced
Near downslope and northern edge of slide

North end of upslope edge of failure at 2431 Wooldridge Drive
Buda formation above

Upslope edge of failure at 2431 Wooldridge Drive
Looking south near north end of failure. Unstable slope. Mortared natural ledge stone landscape wall at upper right corner

Upslope edge of failure at 2431 Wooldridge Drive
Mortared natural ledge stone landscape wall

Upslope edge of failure at 2431 Wooldridge Drive
Mortared natural ledge stone landscape wall
Looking west near north end of failure

Older failure along north edge of 2431 Wooldridge Drive
Soil on right and Buda rock face on left (looking north). Note slight separation at base parallel to new failure

North edge 2431 Wooldridge Drive
Potential older failure - parallel to new failure
Location of misc. natural ledge stone walls
Looking north

8” PVC at north edge of 2431 Wooldridge Drive

Break in pipe does not appear to be new

North edge 2431 Wooldridge Drive (looking south)

Near NW corner of fence for 2431 Wooldridge Drive locally displaced
Near downslope and northern edge of slide

Looking west at 2431 Wooldridge Drive (drone video from City)

Looking south along 2431 Wooldridge Drive (drone video from City)

Looking north along 2421 and 2431 Wooldridge Drive (drone video from City)