Geo-Logic ASSOCIATES

September 9, 2015
Project No. 2015.0085

Ms. Robyn Cooper
Fall Creek Engineering
1525 Seabright Avenue
Santa Cruz, CA 95062

SUBJECT: *DRAFT* Geologic and Geotechnical Evaluation and Plan Review
Pedro Point Headlands
Trail Restoration
Pacifica, California

Dear Ms. Cooper:

As requested, we are pleased to present this geologic and geotechnical evaluation and plan review for proposed trail restoration work at the Pedro Point Headlands, managed by Pacifica Land Trust, in Pacifica, California. We understand the purpose of the project is to reduce erosion and subsequent sediment transport to nearby waterways through restoration of the existing trail network.

For this project we were provided with the following plans:

- An 11-page set of plans titled, "Pedro Point Headlands, Trail Improvement Plans, 30% Design Submittal" prepared by Fall Creek Engineering and dated July 2015.

- An 11-page set of plans titled, "Pedro Point Headlands, Restoration Plans, 30% Design Submittal" prepared by Fall Creek Engineering and dated July 2015.

PURPOSE AND SCOPE

This letter report is intended to evaluate geologic and geotechnical aspects of the proposed trail restoration and remediation. As detailed on the plans referenced above, some of the trails, including scars left by motorcycles, are to be remediated by placement of erosion control blanket, mulching, seeding, and revegetation. This remediation is primarily surficial, with minimal earthwork proposed. Other trails are to be restored by narrowing the existing trail to singletrack width and mulching and revegetating the periphery. This letter is intended to address geologic and geotechnical aspects of trail restoration, which involves earthwork, including partial filling of existing trails, and cutting of new trail in areas to be re-aligned.

For this report we completed the following tasks:

- Reviewed geologic literature pertinent to the study area, including geologic maps.
- Reviewed LiDAR hillshade image to look for evidence of slope instability, including landslides
- Field reconnaissance of select portion of the trail network
- Reviewed the plans referenced above
- Prepared this Letter Report, which presents our findings, conclusions, and recommendations.

GEOLOGIC SETTING

The Pedro Point Headlands are situated within the northernmost extension of the Santa Cruz Mountains on the coast side of the San Francisco Bay Peninsula. The Peninsula is bisected by the San Andreas fault, a major strike-slip fault zone located west of the project. Bedrock formations which lie west of the San Andreas fault are associated with the Salinian tectonic block, and include Cretaceous granitic rock and younger Tertiary sedimentary formations at the latitude of the subject site. Jurassic to Cretaceous metamorphic and sedimentary rocks of the Franciscan Assemblage form a tectonic wedge between the Salinian block and the San Andreas fault. The project site is underlain by an unnamed sedimentary formation of sandstone, shale, and conglomerate of Paleocene age (Brabb and others, 1998). This formation is faulted against Cretaceous granitic rock (Kgr) to the south and against Franciscan Assemblage rocks across the Pilarcitos fault to the north. Bedding within the unnamed Paleocene formation underlying the Pedro Point Headlands is tightly folded, with fold axes trending NNW to SSE.

We reviewed a LiDAR hillshade image of the site to look for evidence of landsliding. No major landslides were evident on the image. Bluffs on seaward exposures are steep and sheer. Bluff retreat in this area is likely to be an active and ongoing process in the long term.

GEOLOGIC RECONNAISSANCE

On August 13, 2015 our engineering geologist performed a field reconnaissance of trail segments that will be narrowed and restored for long term use by the public. We specifically looked for adverse geologic and geotechnical conditions that might directly affect the proposed improvements to the trail alignments, such as steep slopes, unstable soils, landslides, and adverse bedrock structure. Our findings and recommendations are presented below by trail name, and referenced by station number from the 30% Trail Improvement Plans. Our comments are restricted to portions of the trail where potentially adverse geologic/geotechnical conditions exist.

Southridge Trail

Findings

- At approximately Station 3+00 (Figure 1), steep slopes are present immediately downslope of the proposed trail realignment. While we could not access this location directly, the steep slopes shown on the plans are easily observed from the “Future California Coastal Trail” below. From this vantage point it is clear that the steep slopes form the scarp of a landslide that descends to the northeast. Based on slope geomorphology, the slide appears to be dormant, and could possibly be reactivated in wet conditions. Headward movement of the landslide could encroach on the proposed trail alignment (Figure 1).
- Between Stations 31+00 and 31+50 (Figure 2), outboard slopes to the west are inclined between 22 and 26 degrees. These slopes are sufficiently steep to preclude construction of fill slopes at 2:1 (horizontal to vertical) inclinations.
- Between Stations 33+00 to 33+50 (Figure 2), steep slopes are inclined between 28 and 52 degrees to the west on the outboard side of the trail. Sedimentary bedding locally dips 52 degrees to the west in a dipslope condition. This condition occurs where sedimentary bedding and the slope angle are coincident, and is often caused by slope failure along inherently weak sedimentary bedding planes. A “fin” of rock forms the outboard side of the trail along this trail segment, currently isolating the trail from the

steep outboard slopes. Removal of this fin for use as fill is unlikely to contribute to slope instability. However, movement of the trail to the west of its current location, as shown on the plans, may make the future trail alignment susceptible to failure along bedding planes in the long term (Figure 2).

Recommendations

- At approximately Station 3+00, we recommend that the proposed trail be setback horizontally from the top of the steep slopes (top of landslide scarp) by at least 10 feet. Discharge of water from the trail to this area should be minimized.
- Between Stations 31+00 and 31+50 we recommend that the final singletrack trail be biased toward the northeast to avoid placement of fills on steep slopes to the southwest. If fill is proposed on the west side some benching and keying may be required due to the existing steep slopes. Fills placed on slopes greater than 5:1 (horiz:vert) should be benched and keyed into native slopes (see Plan Review comments below for details on benching and keying).
- Between Stations 33+00 to 33+50 we recommend that the final trail alignment be biased toward the northeast side as it is narrowed. This will provide a setback from slopes that may be subject to instability due to a dipslope condition. However, if the fin of rock that forms the outboard side of the existing trail is left in place, final trail location anywhere in the existing alignment is feasible.

Bluff Trail

Findings

- Stations 9+50 to 11+00 (Figure 4) the trail grade is inclined steeply to the north-northwest at 18 degrees. Both sides of the trail are in cut, with existing cutslope profile inclinations of 50-60 degrees. Movement of the trail 10+ feet to the east over portions of this interval as proposed will entail cutting toward the east and backfilling to the west. Better topographic control will be needed to determine if fill slopes will "catch" on slopes to the northeast (if needed). This will depend on whether the final trail grade elevation will be raised as it is shifted eastward, as opposed to leaving it entirely in cut and maintaining its present elevation.
- At approximately Station 10+25 a 3 to 5 foot wide fin of severely weathered rock and soil separates the existing trail from very steep and exposed outboard (western) slopes.
- Between Stations 10+50 to 12+00 (Figures 4 and 5), steep slopes that descend to the ocean are inclined approximately 42 degrees to the west on the outboard side of the trail. Sedimentary bedding locally forms a dipslope condition over this trail interval. This condition appears to be the controlling factor for bluff retreat along the sheer cliffs that front the ocean along the Pedro Point Headlands. A "fin" of severely weathered rock and soil approximately 5 to 8 feet wide forms the outboard side of the trail along this trail interval, currently forming a buffer from exposed slopes. Removal of this fin for use as fill is unlikely to contribute to slope instability. However, bluff retreat is likely to be a continuing process over the long term.

Recommendations

- Between Stations 10+25 and 12+00 we recommend that final trail alignment be biased toward the eastern side of the alignment as it is narrowed. This will provide greater

setback from slopes undergoing bluff retreat and enhance longevity of the trail. While not necessarily a geotechnical concern, we would like to point out that exposed slopes may present a safety hazard during trail construction. Retaining at least a portion of the "fin" of rock and soil along this reach would maintain a buffer from exposed slopes for trail users. If this buffer is removed entirely, construction of a fence or railing over this interval is advised. Fill placed on slopes with inclinations greater than 5:1 should be benched and keyed as it is placed.

Arroyo Trail

Findings

- Between Stations 0+00 and 9+00 (Figure 3) the trail is proposed to be shifted to the north. This will entail cutting into the slopes north of the existing seasonal drainage. An existing 3-4 foot high erosional cut bank, standing at 60-70 degrees, currently forms the northern bank of this drainage along this interval. Soils in the cut were mostly concealed by duff and debris at the time of our visit, but in general, we observed sandstone bedrock fragments in a soil matrix in this cut. Bedrock may be shallow, based on nearby cuts for the Future California Coastal Trail downstream, but we were unable to confirm this. A colluvial fan is present between Stations 4+00 and 6+00, where soils can be expected to be deeper, unconsolidated, and relatively weak (Figure 3).
- The swale bottom is likely covered in alluvium and colluvial soils. Realignment of the seasonal drainage appears feasible pending proper drainage design and erosion control measures to be completed by others.

Recommendations

- This section of trail is the one portion of the project where deeper soils appear to exist. In order to reduce local instability and the resulting increase in trail maintenance that will likely be required, cut slope inclinations should be flattened in this area.
- In the area of the colluvial fan (Stations 4+00 to 6+00) we recommend proposed cut slopes be constructed at inclinations no greater than 2:1 (horiz:vert).
- For the portions of the proposed trail above and below the colluvial fan, and where deeper soils are found, cut slopes should be flattened as much as practically possible. Due to the steep slopes above the proposed trail (30 to 38 degrees) 2:1 cut slopes are not feasible (see slope inclinations on Figure 3 attached). If the resulting extent of grading is acceptable, we'd suggest considering maximum 1.5:1 cut slope inclinations for this area. Better topographic control may be needed in order to determine what cut slope inclination may be feasible.

Middle Ridge Trail (Option 2 Realignment)

Findings

- The proposed trail alignment traverses a landslide between stations 27+00 to 33+50 (Figure 3). Steep slopes of the landslide scarp range from 35 to 40 degrees, with subvertical slopes at some locales. Loose sandstone bedrock fragments are exposed in the upper portions of the scarp (stations 27+00 to 31+50, Figure 3). The landslide mass itself appears to be relatively thin and has likely been eroded out. Competent sandstone bedrock was observed in cuts for the Future California Coast Trail downslope

of the landslide, supporting our interpretation that the landslide mass is not deep-seated. The landslide appears to be inactive. Trail construction across the scarp will likely be difficult due to steep slopes and unstable bedrock. Remnant soils of the landslide mass in the lower portions of the slide are likely to be weak and unconsolidated.

Recommendations

- If this optional alignment is to be pursued we recommend the trail be re-aligned by extending the trail above the landslide scarp along contour to the northeast and then using a longer switch back to the southwest, crossing the lower, less steep portions of the landslide. Better topographic control would be necessary in this area to design this trail through the steep landslide terrain.

GEOTECHNICAL PLAN REVIEW

Our plan review comments below are tailored to the nature of this project, with the intent of maximizing the values and goals of esthetics and reducing the volume and impact of grading on native soils and vegetation as much as possible. They assume that no structures such as retaining walls, concrete or asphalt surfacing of trails are planned, or are desirable, and that trail maintenance will be regularly performed by hand crews.

Trail Improvement Plans, 30% Design Submittal

Sheet C3.0, Typical Trail Sections

- In order to reduce local instability and trail maintenance we suggest in general, a maximum cutslope (backslope) inclination of 3/4:1 in bedrock, and 1.5:1 in soil, be indicated on Details A and B of these typical trail sections. If this results in more extensive grading than desirable, and if increased trail maintenance is acceptable, then cut slopes could be constructed at steeper inclinations wherever bedrock is encountered.
- For the realignment of the Arroyo Trail, between Stations 4+00 to 6+00, proposed cut slopes will be in deep soil, and we suggest be constructed at inclinations no steeper than 1.5:1 (horiz:vert).
- Between Stations 0+00 to 4+00 and Station 6+00 to the end of the trail realignment, we suggest that cut slope inclinations in soil be flattened to 1.5:1, where feasible. If bedrock is encountered, cut slope inclinations could be increased to 3/4:1.
- Keying and Benching, Section B - We suggest that where fill is to be placed on existing slopes steeper than 5:1 (horiz:vert), that it be benched and keyed into the existing slopes. This section could show small keys and benches, on the order of 1 to 2 feet in depth and width, which could be constructed with excavators or small equipment.
- Fill Placement, Section B – We suggest that following specifications be considered for the details and/or notes on this sheet:
  - All fill to moisture conditioned to at least 2 percent above optimum moisture and lightly wheel or track rolled in place.
  - Maximum vertical fill depth of 4 feet to be indicated on the Detail B.
  - Maximum fill slope inclination of 1.5:1 to be indicated on Detail B

- Prior to fill placement, any existing fill is to be removed. All proposed fills to be placed on native soil subgrades.

Restoration Plans, 30% Design Submittal

Sheet C3.0, Throughcut Restoration

- In this detail we suggest the following notes be considered for addition:
  - All fill to moisture conditioned to at least 2 percent above optimum moisture and wheel rolled in place.
  - Maximum vertical fill depth of 4 feet to be indicated.
  - Prior to fill placement, any existing fill is to be removed. All proposed fills to be placed on native soil subgrades.
  - It appears to us that there may be cases where the throughcut restoration occurs with steep downhill slopes on the edge of the existing trail (Southridge Trail Stations 12+50 to 14+00 and 31+00 to 31+50, Bluff Trail Station 10+25 to 12+00). If so, we suggest a second Throughcut Restoration Detail be shown depicting this. The detail could show the singletrack positioned away from the steep downhill slopes and if fill is to be placed directly adjacent or on the downhill slope, specifications for maximum fill slope inclinations and benching and keying added.

LIMITATIONS

In preparing the findings and professional opinions presented in this report, we have endeavored to follow generally accepted principles and practices of the engineering geologic and geotechnical profession. This warranty is in lieu of all other warranties, express or implied. The conclusions contained in this report are based, in large part, on information that has been provided to us.

Should persons concerned with this project observe features or conditions at the site or surrounding area that are different from those described in this report, those observations should be reported immediately to Geo-Logic Associates for evaluation.

If you have any questions, please contact us.

Sincerely,

Geo-Logic Associates, Inc.

John Feltman
CEG #2530

Soma B. Goresky
GE 2252

Attachments: Figures 1 through 5: Geologic Field Notes

REFERENCES

Brabb, E.E., Graymer, R.W., and Jones, D.L., 1998; Geology of the Onshore Part of San Mateo County, California: Derived from the Digital Database Open-File 98-137, U.S. Geological Survey.