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Project S14514

PROJECT: Copper Canyon Lane, Wandermere Estates, Spokane, WA
SUBJECT: Reconnaissance and evaluation of existing rock cuts

In accordance with our November 7, 2014 proposal, we visited the site on the afternoon of Sunday, March 22, 2015 to render an opinion as to the stability of rock and soil cuts on the upper *(east)* side of the subdivision.

Project

Copper Canyon Drive is cut into the upper reaches of the Wandermere Estates. The cuts in question extend from Copper Canyon's intersection with Rustic Lane and extend north to its end in a cul-de-sac at the northeast corner of the development (Lots 26, 27, & 28 in Block #1).

Geology

Prior to the Laramide Orogeny *(60 million years ago)*, pre-Cambrian *(600 million years ago)* sediments dominated the entire area around Spokane. Then, in an episode of mountain building, the area was intruded by semi-molten granite of the Idaho Batholith which uplifted the area, fused the sediments, and in some cases melted the sediments to be re-solidified. Later erosion has removed the overlying metamorphosed sediment from this site leaving the granite exposed. In some areas, the bedding planes of the older sediments are still visible. (right)

Soils

The surface soils overlying the granite and predominating in the area across from Lot 14, Block #1, comprise silty sands weathering from the decomposing granite. The material is moderately well-graded and sub angular, giving it relatively high strength.

Groundwater

In this wet season of a relatively dry winter water can be seen seeping out from the toe of the Redi-Rock™ retaining wall on the north side of the center cu-de-sac. It is likely perched on the underlying granite, exposed behind the wall, and will probably cease in dryer seasons. (right)

Encountered Conditions

Our visit found evidence of minor rock fall from relatively stable rock cuts. The granite displays numerous fractures and fissures with the potential for more serious rockfalls. The soil cut at the center cu-de-sac has raveled back to its repose angle 1½ horizontal to 1 vertical and, as such, has no margin of safety against deep-seated slope failure. (right)

Lots 26, 27, & 28, Block #1, at the cul-de-sac end, are on a newer fill over an older slope protected by rip rap. (left)

Geotechnical Principles

In order to better understand our conclusions, it would be helpful to discuss a few basic engineering principles that apply to this situation.

- ***Rock Cuts.*** Granite is by nature very solid. Where monolithic, it can stand nearly vertically as can be seen in the massive cut across Highway 395. Large granite blocks can slide on continuous, deep-seated fissures that are very rare. Localized fractures and fissures, however, can be a source of continuous rock fall. The most common cause of granite rock fall in cold climates is exfoliation, which we do not see in evidence here.

- ***Slope Stability.*** Slope stability is a function of soil or rock strength. The basic principles of slope stability involve a balance of forces. Weight of material at the crest of a slope tends to drive it downward. Weight of soil at the toe of a slope tends to resist movement. This balance of forces is defined by the "safety factor"(sf) which is determined by dividing the resisting forces by the driving forces.

  When the resisting forces exceed the driving forces, sf is greater than 1.0. When the driving forces predominate, the sf drops below 1.0 and the slope slides to correct the situation. Slopes with sf less than 1.0 will fail. Hence, a sf of 1.0 defines a slope in tenuous equilibrium that can be readily upset. In general, the target sf on slopes exceed 1.3; that is, resisting forces should exceed driving forces by 30 percent.

Cut slopes at or near their repose angles are very tenuous, and often hang on a delicate balance waiting for some force to upset that equilibrium and trigger a downhill slide. Safety factors can be modified in any one or more of the following ways:

- **At the Toe.** Where the toe slopes downward, the balancing surcharge is severely reduced. Excavation removing supporting material from the toe, reduces the sf. Fill at the toe increases it.
- **At the Crest.** Fill material placed at the crest or upper slope increases the driving forces and reduces the sf Likewise, removing material from the crest increases it.
- **On the Failure Plane.** As groundwater rises, it adds weight and hydrostatic pressure to the driving forces. It also weakens the material on the failure plane.

Conclusions

In view of the evidence apparent on our site visit, we arrived at the following conclusions:

- ***Rock Cut Slope Stability.*** Although fractured and fissured, the rock cuts appear quite sound, and are not likely to experience deep-seated slope failures. (right)

- ***Soil Cut Slope Stability.*** The cut slope at the center cul-de-sac is at its repose angle with a sf of 1.0. As such, it is likely to fail and take out a portion of the pavement. It is not likely to threaten homes on Lots 14, in either Block #1 or Block #9, but the head scarp will probably infringe on the neighboring property to the east. (mid-right)

- ***Major Rock Fall.*** There is the possibility that large segments of granite could slide or break loose on existing fractures or fissures and fall onto the road. This would probably be triggered by water freezing in the fissures, and most likely would show evidence of movement before a fall. (lower-right)

Recommendations

In view of the above stated conclusions, we recommend the following:

- ***Rock Cut Slope Stability.*** Although the rock cuts appear quite sound, they should be monitored for unlikely signs of mass movement.

- ***Soil Cut Slope Stability.*** The cut slope at the center cul-de-sac should be stabilized with a toe surcharge to increase resisting forces. This can be accomplished by simply extending the existing Redi-Rock retaining wall around the rest of the cul-de-sac and backfilling it. Where it will not interfere with neighboring property, backfill material should be taken from the crest of the slope so as to reduce the driving forces.

- ***Major Rock Fall.*** Where large segments of the granite could slide or break loose on existing fractures or fissures, slopes should be monitored for indications of movement. If and when such signs are observed, one or more of the following remediation methods can be engineered:
  - Breaking and removing the threatening rock.
  - Balancing forces with a toe surcharge behind a retaining wall.
  - Tying the threatening rock back with rock anchors drilled through the rock and into the parent granite.

- ***Minor Rock Fall.*** The potential for falling rocks to damage vehicles or injure pedestrians can be mitigated by one or more of the following methods:
  - Placing a wire mesh curtain over the cut face to contain falling rocks.
  - Constructing a wall along the curb to catch some of the rocks before they bounce onto the road.
  - Restricting parking, cycling, and walking where rock fall is to be expected.

- ***Groundwater.*** The water seeping from the retaining wall can be captured behind the wall and piped to the drop inlet farther up the road. (right)

- ***Fill Slope Stability.*** The entire slope *(new and old)* behind Lots 26, 27, and 28, Block #1, at the end cul-de-sac should be analyzed for stability, and remediated as may be necessary.

- ***Retaining Walls.*** Walls to retain earth or catch rocks can be constructed of several different materials as follows:
  - **Redi-Rock™**. This is the wall system used by the developer throughout the project. It is attractive and would show continuity. They are manufactured locally by Wilbert Vault.
  - **Ecology Blocks**. These are large concrete blocks that can be stacked in running bond to form walls in increments of 3 feet. They are manufactured locally by most of the concrete suppliers.
  - **New Jersey Barriers**. These are the triangular-shaped concrete blocks commonly used for traffic control on highways. They are manufactured locally by some of the concrete suppliers. As they cannot be stacked, their height is limited to 3 feet.
  - **Gabions**. These are large wire baskets that can be filled with small rocks and stacked running bond to form walls. They have a natural appearance and are readily adaptable to volunteer labor. They can be obtained through local suppliers.

LIMITATIONS

The conclusions and recommendations presented herein are based upon the results of field explorations and laboratory testing results. They are predicated upon our understanding of the project, its design, and its location as defined in by the client.

We endeavored to conduct this study in accordance with generally accepted geotechnical engineering practices in this area. This report presents our professional interpretation of investigation data developed, which we believe meets the standards of the geotechnical profession in this area; we make no other warranties, express or implied.

Attached is a document titled "*Important Information About Your Geotechnical Engineering Report*," which we recommend you review carefully to better understand the context within which these services were completed.