COLORADO GEOLOGICAL SURVEY

1801 19th Street
Golden, Colorado 80401

Karen Berry
State Geologist

January 2, 2019

Kari Parsons
El Paso County Development Services Dept.
2880 International Circle, Suite 110
Colorado Springs, CO 80910

Location:
SW of Sec. 28 / SE of Sec. 29,
T11S, R67W of the 6th PM
39.060, -104.8562

Subject: Forest Lakes Phase II PUD Amendment/Preliminary Plan – Additional Review
El Paso County, CO File No. PUDSP181; CGS Unique No. EP-18-0046

Dear Ms. Parsons:

The Colorado Geological Survey (CGS) has reviewed the following additional information provided for the Forest Lakes Phase II PUD Amendment referral:

- Debris Flow/Mudflow Analysis (CTL/Thompson, Revised 12/14/18)
- Geologic Hazards Evaluation and Preliminary Geotechnical Investigation (CTL/Thompson, 7/18/18)
- Preliminary Grading & Utilities Plan (Sheets 10-15; Classic Consulting, 10/24/18)
- Master Development Drainage Plan Amendment and Preliminary Drainage Report (Classic Consulting, November 2018)
- Letter of Intent (N.E.S., Inc., December 2018)
- PUD Development Plan and Preliminary Plan for Phase 2 (N.E.S., Inc., rev. 12/10/18)

The CGS previously provided comments in a letter dated February 6, 2018. In response to the CGS's comments in that letter, CTL/Thompson performed a debris flow/mudflow analysis and additional geotechnical investigation. The CGS understands that the proposed development layout was adjusted on the basis of CTL/Thompson's analysis and recommendations to avoid the mapped debris flow/mudflow inundation area as mapped by CTL/Thompson. CGS personnel visited the site on December 21, 2018 to observe conditions in the mapped debris flow inundation area. CTL/Thompson's debris flow/mudflow analysis and the resulting modifications to the proposed development layout, and CTL/Thompson's additional geotechnical investigation and recommendations have addressed the CGS's previous concerns regarding debris flow/debris flood, shallow groundwater, collapsible soils, potentially unstable slopes, and erosion. The CGS has the following specific comments:

Debris Flow/Mudflow Analysis

CTL/Thompson modeled bulked water flows using HEC-RAS software to prepare their debris flow/mudflow inundation area map. On the basis of our December 21, 2018 field observations, CTL/Thompson's mapped debris flow/mudflow inundation area appears reasonable. However, the CGS has several comments regarding the modeling process:

1. CTL/Thompson modeled water flow with increased estimated discharge (i.e. a bulked flow) in HEC-RAS software. Because of complex fluid properties and flow dynamics, mudflows and debris flows are best modeled using specialized software package specifically designed for that purpose (e.g. FLO-2D). The CGS would typically prefer to see debris flow modeling performed with a software package designed to account for debris-flow mechanics; however, as discussed by Travis et al. (2012), it is common practice to utilize bulked water flows with HEC-RAS up to bulking factors of 2.0.

CTL/Thompson's bulking factor of 1.4 is within that range.

2. CTL/Thompson states that they based their bulking factor of 1.4 on values recommended by Brunkal and Santi (2017); however, in the conclusion to that paper, Brunkal and Santi point out that the size of the supporting data set was limited and specifically caution against using the values for prediction purposes. Further, the bulking factor listed in Brunkal and Santi (2017) of 1.4 for >5 km^2 drainage basins is an average value (within a range of 0.14 to 4.4) for unburned drainage conditions. Under burned drainage conditions, the bulking factor for >5 km^2 drainage basins ranges from 0.3 – 9.1 with an average of 2.8.

   As stated above, on the basis of field observations, the CGS agrees that CTL/Thompson's mapped debris flow/mudflow inundation area is reasonable under the current conditions. However, the CGS cautions that significant changes associated with wildfire in the contributing drainage could lead to generation of debris flows that are significantly larger than those modeled by CTL/Thompson. **In the event of a wildfire in the North Beaver Creek drainage, additional debris flow mitigation may be necessary to protect the development.**

North Beaver Creek Culvert Design
In the debris flow/mudflow analysis (page 9), CTL/Thompson expressed concern that the then-proposed culvert at the road crossing over North Beaver Creek may not be capable of passing the estimated 100-year flood event as used in their analysis. **The applicant's engineering consultant should confirm that the most up-to-date culvert design has been prepared to pass the most up-to-date 100-year flood discharge.**

Shallow Groundwater, Potentially Unstable Slopes, and Erosion
CTL/Thompson has identified areas where shallow groundwater may occur. CTL/Thompson's recommendations to keep basements at least 3 feet (and preferable 5 feet) above anticipated groundwater levels should be followed. As stated previously, CTL/Thompson's recommendations regarding cut and fill slopes, individual lot slope stability analyses, engineered retaining systems, and erosion control and prevention should be carefully followed in this area.

On the basis of the information provided, the CGS does not object to the proposed development.

Thank you for the opportunity to review and comment on this project. If you have questions, please contact me by phone at 303-384-2632 or e-mail kemccoy@mines.edu.

Sincerely,

Kevin McCoy
Engineering Geologist

References Cited

Brunkal, H., and Santi, P., 2017, Consideration of the validity of debris flow bulking factors: Environmental & Engineering Geoscience, p. 1078- 7275.EEG–1774, doi:10.2113/EEG-1774.

Travis, B., Teal, M., and Gusman, J., 2012, Best Methods and Inherent Limitations of Bulked Flow Modeling with HEC-RAS, in World Environmental and Water Resources Congress 2012, Albuquerque, New Mexico, United States, American Society of Civil Engineers, p. 1195–1202, doi:10.1061/9780784412312.121.