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April 30, 2017

Mr. Mike O'Connell
900 Rosita Road
Pacifica, CA 94044

Subject: **San Pedro Terrace Road Property**
Off the West End of San Pedro Terrace Road
Pacifica, California
RESPONSE TO PEER REVIEW

Mr. O'Connell:

This letter has been prepared to respond to the issues raised in the Peer Review letter issued by RGH Consultants in their letter of March 8, 2017. The general categories of the RGH issues are presented in **BOLD UNDERLINED CAPITALS**, with our responses to their review comments in the paragraphs following these headings.

LIQUEFACTION

The primary issues raised by RGH were generally associated with liquefaction potential at the site. To address their concerns, we returned to the site and advanced 3 CPT soundings (at the locations shown on Figure 1) to better identify the potential zone of liquefaction, and potential consequences of the liquefaction.

Supplemental Subsurface Investigation

On April 10, 2017 a total of 3 CPT soundings were advanced around the site. The CPT soundings were hydraulically advanced pushing a 1.4 inch diameter cone-tipped probe into the ground. Gauges in the probe measured both tip resistance and frictional resistance (along with pore water pressures) to provide engineering information used to assess soil type and strength characteristics. The accumulated data was computer processed to provide further information on liquefaction potential and settlement potentials associated with liquefaction. The logs of the CPT soundings are shown on Figure 2.

Subsurface Conditions

The CPT soundings indicated that the site is generally underlain by clays and silty clays which extend to depths of 30 to 45 feet below grade (there is a thin roughly 2 foot thick layer of sand in CPT 2 at a depth of 4 feet). Sandy soils were generally encountered at depths below 28 feet.

Laboratory Testing

To further evaluate the liquefaction potential of the upper soils, Atterburg Limit testing was conducted on three samples of the upper soils from Boring 1. The testing indicated that the clays and silts are highly plastic, so are unlikely to be subject to liquefaction (see Appendix A).

Liquefaction Analysis

Liquefaction is the temporary change in a soil from a solid condition (inter-granular contact) to a liquid condition (particles of soil suspended in water). This condition can occur where predominantly **granular** soils are in a relatively **loose** and **saturated** condition. Liquefaction typically does not occur in cohesive, dense, or non-saturated soil conditions. Therefore, in order to evaluate the potential for liquefaction to occur at any location, it is necessary to be able to identify several important factors, including: type of soil; relative density of soil; elevation of water table; and seismic accelerations and magnitude. Variations in any of these factors can have a dramatic impact on the potential for liquefaction to occur, or in the magnitude of the results if it does occur.

Soil Type and Relative Density – the type and density of the soils penetrated by the CPT sounding are assessed from the CPT testing based upon correlations between resistance along the cone's sleeve and resistance at the cone's tip. Logs of the soil types and relative densities encountered in the CPT soundings are attached to this report in Figure 2, indicating that the upper soils are typically clays or silty clays and clayey silts.

Depth to Water Table –The ground water elevations at the subject site are currently on the order of 10 feet below grade, despite the recent extremely heavy rains, so we have assumed the water table elevation is at a depth of 10 feet in our analyses.

Seismic Accelerations – The US Seismic Design Maps from the USGS website indicates that the design earthquake may induce a highest Probable Ground Acceleration of up to 0.85g.

Liquefaction Analysis – We have performed our seismic analysis in conformance with the recommendations specified in the State of California Special Publication 117 and ASCE 7-10. The CPT data collected from our recent field investigation was analyzed using the CLiq program (version 1.3.1.104) issued by Geologismiki and Gregg Drilling. The program uses the tabulated results from the CPT soundings to assess the potential for liquefaction to occur at the site, as well as estimate the potential ground movements associated with liquefaction. Ground accelerations and ground water levels as discussed above were used as the input parameters along with the raw data from the CPT sounding for our analysis. The plots of the liquefaction analysis results at the CPT locations are attached to this report in Appendix A.

Analysis Results

Factor of Safety – The factor of safety against liquefaction occurring is calculated by comparing the forces tending to induce liquefaction to those resisting liquefaction. When the factor of safety against liquefaction falls below a value of 1.0 (i.e. inducing factors are stronger than resisting factors), the material is considered to have the potential to liquefy.

In our analysis, the CLiq program calculated that there is a potential for liquefaction (FS<1) to occur in various soil layers (see Figure 3), with shallower depths to liquefiable layers in CPT-1 with progressively greater depths to liquefiable soils progressively to the west (towards CPT-3) where liquefaction was generally confined to depths below 28 feet.

Settlements – The settlement analysis (Figure 5) indicated that the site soils may experience settlements between about 1.5 and 4 inches across the site, with less than 1 inch occurring in the upper 20 feet. This would suggest that differential settlements due to liquefaction are likely to be felt as more regional tilts over larger areas, than as abrupt differences in elevation over short distances.

Liquefaction Potential – Although the soil can be determined to have a potential to liquefy (FS<1), the relative probability of the liquefaction actually occurring is based upon the value of the factor of safety as well as the depth at which the liquefaction is potentially occurring. Values below 5 indicate that there is a low risk of these materials actually experiencing liquefaction. Values between 5 and 15 indicate a high risk, and over 15 is a very high risk of the soils actually liquefying. Calculated values on these 3 CPT soundings resulted in generally low to moderate risk levels (see Figure 4). Again, the values were low to depths of over 20 feet, again suggesting that differential movements at the site are likely to be expressed as overall tilts, rather than abrupt changes in elevation.

In summary, the design earthquake has a relatively low (10 percent) probability of occurring during the next 50 years. Even if the maximum seismic event actually occurs, there is less than a 10 to 15 percent chance that liquefaction will occur at most of the CPT locations. Although this represents a very low probability that liquefaction will occur at the site, the potential ramifications are likely to be significant and should be addressed by the use of appropriate foundation elements.

LATERAL SPREADING

RGH correctly notes that we omitted liquefied soils as potentially subject to lateral spreading. During our return visit to the site for the CPT testing, we measured the creek channel at several points along the project's northern border and found that the depth of the channel below the site grade ranges from 6 to 8 feet. This is above the elevation of the water table, and above the elevation of anticipated most of the liquefaction projected by the CPT data. Further, the high variability in the boring and CPT data suggests that any shallow potentially liquefiable layers are unlikely to be laterally continuous, reducing the potential for lateral spreading further. However, we have assumed lateral continuity and included this shallow "free face" in the computer analysis to provide potential lateral deformations associated with liquefaction.

The analysis projects that lateral movements on the order of 3.5 and 10 inches may occur at the site, but across a very thin seam (at 11 to 13 feet below grade). It is our opinion that the proposed waffle style foundation should be adequate to address the spreading and confine the ground surface distortions under the residence. Should supplemental protection be desired, then a row of 16 inch diameter, drilled shear pins extending to a depth of 20 feet below grade, spaced at 6 feet on center may be used to further limit lateral displacements.

CBC SEISMIC DESIGN VALUES

We have again used the USGS Java ground Motion Calculator (ASCE 7-10 standard) and have used a location directly in the center of the site (37.59009N by -122.50164W) to obtain the following parameters:

Site Class - D	SM_S = 2.171	SM_1 = 1.396	SD_S = 1.447	SD_1 = 0.930

DRILLED PIER FOUNDATIONS

Due to the variability in the site subsurface soils, potential confusion to contractors doing different foundations on different units, and potential for some differential settlements from potential liquefaction, we now recommend that all of these residential buildings (no commercial structures are planned for the site), be supported on the waffle foundations as discussed on Page 9 of our original report.

PREVIOUSLY GRADED PAD

Attached to this letter (after Figure 6) is a sheet of historic aerial photographs taken from Google Earth showing previous grading work on the subject site. As the site has been provided with an asphalt surfaced cul-de-sac and the site proximate to the cul-de-sac is relatively level, we termed it a graded pad. Based upon the photographs, we believe that the site should be considered to have a thin layer of fill across the entire area from the cul-de-sac to the edge of the storm drain bank.

We trust that the above responses and supplemental investigative work and analysis now adequately address the issues of concern raised by RGH in their peer review letter.

Should you have any questions please contact the undersigned.

Respectfully Submitted;
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