Dan Zaich
Senior Director – Capital Facilities
San Rafael City Schools
310 Nova Albion Way,
San Rafael, CA 94903

June 26, 2020

Subject: Engineering Geology and Seismology Review for Terra Linda High School – Gymnasium Building 320 Nova Albion Way, San Rafael, CA CGS Application No. 01-CGS4424

Dear Dan Zaich:

In accordance with your request and transmittal of documents received on May 14, 2020, the California Geological Survey (CGS) has reviewed the engineering geology and seismology aspects of the consulting reports prepared for the subject project at Terra Linda High School in San Rafael, California. It is our understanding that this project involves construction of a new gymnasium building on the existing campus. This review was performed in accordance with Title 24, California Code of Regulations, 2019 California Building Code (CBC) and followed CGS Note 48 guidelines. We reviewed the following reports:

> **Design Level Geotechnical Investigation and Geologic Hazards Study Report, Terra Linda High School, 320 Nova Albion Way, San Rafael, Marin County, California:** A3GEO, Inc., 1331 Seventh Street, Unit E, Berkeley, California, 94710, company Project No. 1150-1B, report dated February 16, 2018, 36 pages, 10 appendices, 12 figures.
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> **Supplemental Geotechnical Recommendations, New Gymnasium, Terra Linda High School, 320 Nova Albion Way, San Rafael, Marin County, California:** A3GEO, Inc., 821 Bancroft Way, Berkeley, California, 94710, company Project No. 1150-1B, report dated March 25, 2020, 4 pages, 4 figures.

Based on our review, the data and reports presented by the consultants provide a thorough and well-documented assessment of engineering geology and seismology issues with respect to the proposed improvements. The principal concerns identified by the consultants are the potential for strong ground shaking, liquefaction, and dynamic-induced settlement. The consultants recommend a map-based design spectral acceleration parameter of $\mathbf{S_{DS} = 1.00}\boldsymbol{g}$ which is considered reasonable provided that the provisions of Exception 2 in ASCE 7-16, Section 11.4.8 are applied in structural design. Their evaluation indicates deep-seated slope instability is not design concerns for the project.

In conclusion, ***the engineering geology and seismology issues at this site are adequately assessed in the referenced reports, and no further information is requested***. If you have any further questions about this review letter, please contact the primary reviewer at Carla.Rosa@conservation.ca.gov.

Respectfully submitted,

Carla M. Rosa
Engineering Geologist
PG 9451

Chase White
Senior Geotechnical Engineer
PG 8530, CEG 2489, PE 73664, GE 2938

Concur:

Jennifer Thornburg
Senior Engineering Geologist
PG 5476, CEG 2240

Enclosures:

Note 48 Checklist Review Comments
Keyed to: *Note 48 - Checklist for the Review of Engineering Geology and Seismology Reports for California Public Schools, Hospitals, and Essential Services Buildings*

Copies to:

John N. Baldwin, *Certified Engineering Geologist*
A3GEO, Inc., 1331 Seventh Street, Unit E, Berkeley, CA 94710

Timothy P. Sneddon, *Registered Geotechnical Engineer*
A3GEO, Inc., 821 Bancroft Way, Berkeley, CA 94710

Steve Kwok, *Architect*
Quattrocchi Kwok Architects, 636 Fifth Street, Santa Rosa, CA 95404

Karen Van Dorn, *Senior Architect*
Division of State Architect, 1515 Clay Street, Suite 1201, Oakland, CA 94612

Note 48 Checklist Review Comments

In the numbered paragraphs below, this review is keyed to the paragraph numbers of California Geological Survey Note 48 (November, 2019 edition), *Checklist for the Review of Engineering Geology and Seismology Reports for California Public Schools, Hospitals, and Essential Services Buildings.*

Project Location

1. Site Location Map, Street Address, County Name: Adequately addressed.
2. Plot Plan with Exploration Data with Building Footprint: Adequately addressed.
3. Site Coordinates: Adequately addressed. Latitude and Longitude provided in report: 38.00001°N, 122.5534°W

Engineering Geology/Site Characterization

4. Regional Geology and Regional Fault Maps: Adequately addressed.
5. Geologic Map of Site: Adequately addressed.
6. Geologic Hazard Zones: Adequately addressed. The consultants report the site is located in an area that has not yet been evaluated for placement within a State-designated Liquefaction or Landslide Hazard Zone. They report USGS maps (Knudsen et al., 2000 and Witter et al., 2006) show the campus is in a location indicated to have a “moderate” liquefaction susceptibility.
7. Subsurface Geology: Adequately addressed. The consultants indicate the project site is underlain by artificial fill materials and alluvium (consisting mainly of clays and sands) overlying Franciscan Complex bedrock. They indicate groundwater was encountered at depths of 7 to 10 ft bgs at the time of their investigation in the vicinity of the proposed gymnasium. The consultants utilized information from four borings and two cone penetrometer tests (CPT) to a maximum depth of about 25 ft bgs.
8. Geologic Cross Sections: Adequately addressed.
9. Geotechnical Testing of Representative Samples: Adequately addressed.
10. Consideration of Geology in Geotechnical Engineering Recommendations: Adequately addressed. The consultants recommend **the gymnasium should be supported on deep drilled pier foundations** embedded at least 5 feet into the underlying bedrock (refer also to Item 11). Additionally, the consultants recommend the interior slab of the gym be designed as a framed structural slab to transmit dead and live loads to the framing and pile caps supported by the drilled piers. They further recommend **the interior slab and any grade beams/pile caps connecting drilled piers should be underlain by at least 18 inches of non-expansive fill materials (or a minimum 6-inch vertical void space)** to mitigate the expansion potential of existing soils. These recommendations appear to address the geologic conditions at the site.
11. Conditional Geotechnical Topics:
    B. Deep Foundations: Adequately addressed. The consultants recommended reasonable values of skin friction for the non-liquefiable soils and bedrock materials to be used in design of drilled piers. They also indicate the drilled piers will need to be designed to accommodate downdrag effects from potential liquefaction-induced settlement, and they recommend further consultation with the design team to determine the drag loads. The consultants’ geotechnical design recommendations appear reasonable based on

the information provided and under the assumption that final structural design of drilled piers incorporates reasonable values of potential drag loads due to seismic settlement.

Seismology & Calculation of Earthquake Ground Motion

12. Evaluation of Historic Seismicity: Adequately addressed. The consultants provide a summary of historical seismicity in the region.
13. Classify the Geologic Subgrade (Site Class): Adequately addressed. The consultants classify the site soil profile as Site Class D based on their subsurface investigation.
14. General Procedure Ground Motion Analysis: Adequately addressed. The consultants report the following parameters derived from a map-based analysis:
    S_S = 1.500 and S_1 = 0.60
    S_{DS} = 1.00 (and S_{D1} = 0.68, for the purpose of calculating T_s)
    T_s = not reported, but can be taken as S_{D1}/S_{DS}
    These seismic parameters are accepted **provided that C_S is calculated as required in 11.4.8, Exception 2, and that $T<1.5T_S$**. If otherwise, a site-specific ground motion hazard analysis should be prepared and submitted for CGS to review.
15. Site-Specific Ground Motion Hazard Analysis: Not applicable.
16. Deaggregated Seismic Source Parameters: Not applicable.
17. Time Histories of Earthquake Ground Motion: Not applicable.

Fault Rupture Hazard Evaluation

18. Active Faulting & Coseismic Deformation Across Site: Adequately addressed. The consultants report the site is not located within an Alquist-Priolo Earthquake Fault Zone, and do not report on any known active faults to cross the site.

Liquefaction/Seismic Settlement Analysis

19. Geologic Setting for Occurrence of Liquefaction: Adequately addressed. The consultants report shallow groundwater and potentially liquefiable were encountered beneath the footprint of the gymnasium. The data provided appear to support the consultants' conclusions.
20. Seismic Settlement Calculations: Adequately addressed. The consultants conducted a liquefaction analysis of the site utilizing their CPT data, applying a M_W of 8.05, PGA_M of 0.57g, and set groundwater to 2 ft below the ground surface. Based on their analysis, the consultants conclude potential liquefaction-induced settlement is estimated to be between 0.4 and 2.5 inches. The consultants additionally report that, without mitigation, **differential seismic settlement is anticipated to be up to about 1¼ inches over 30 horizontal feet**. The consultants provide foundation recommendations for mitigation of seismic settlement; see item #10. CGS notes the consultants did not provide their calculations for our review; however, the results appear reasonable given the subsurface data provided. For future projects, **the consultants should provide their liquefaction calculations for CGS review**.
21. Other Liquefaction Effects: Adequately addressed. The consultants report the potential for liquefaction and strength loss of soils at shallow depths beneath the proposed gym.
22. Mitigation Options for Liquefaction/Seismic Settlement: Adequately addressed. The consultants provide foundation recommendations to mitigate potential effects of seismic settlement and the loss of bearing capacity due to liquefaction at shallow depths below the gymnasium. See item #10.

Slope Stability Analysis

23. Geologic Setting for Occurrence of Landslides: Adequately addressed. The consultants report slope stability is not a design concern for the site as the campus has generally flat topography. Their conclusions appear reasonable.
24. Determination of Static and Dynamic Strength Parameters: Not applicable.
25. Determination of Pseudo-Static Coefficient (K_{eq}): Not applicable.
26. Identify Critical Slip Surfaces for Static and Dynamic Analyses: Not applicable.
27. Dynamic Site Conditions: Not applicable.
28. Mitigation Options for Landsliding/Other Slope Failure: Not applicable.

Other Geologic Hazards or Adverse Site Conditions

29. Expansive Soils: Adequately addressed. The consultants report **expansive soils may be present near the ground surface in portions of the site**.
30. Corrosive/Reactive Geochemistry of the Geologic Subgrade: Not addressed by the consultants and therefore not reviewed. The consultants do not report the sulfate exposure or the corrosion potential for concrete or ferrous metals in contact with surficial soils; **they should perform laboratory testing for corrosion prior to construction.**
31. Conditional Geologic Assessment: Adequately addressed. No significant conditional hazards of potential concern were identified by the consultants.

Report Documentation

32. Geology, Seismology, and Geotechnical References: Adequately addressed.
33. Certified Engineering Geologist: Adequately addressed.
    John N. Baldwin, Certified Engineering Geologist #2167
34. Registered Geotechnical Engineer: Adequately addressed.
    Timothy P. Sneddon, Registered Geotechnical Engineer #2809