January 28, 2021

Ms. Bridget Metz
Steel Wave
101 California Street, Suite 800
San Francisco, California 94111

Subject: Seismic Hazards Evaluation
Proposed Parking Structure
2221 Fourth Street
Berkeley, California

Dear Ms. Metz,

This letter presents the results of our seismic hazards evaluation for the proposed parking structure to be constructed at 2221 Fourth Street in Berkeley. Our seismic hazards evaluation is based on our review of the subsurface data in the following two documents:

1. Report titled *Geotechnical Investigation, Allston Way Lofts, Allston & Fifth Street, Berkeley, California*, prepared by Rockridge Geotechnical, Inc. (RG), dated June 3, 2016.
2. Report titled *Preliminary Geotechnical Investigation, Peerless Greens Mixed-Use Development, Berkeley, California*, prepared by Treadwell & Rollo (T&R), dated May 23, 2008.

The site for the proposed parking structure extends between Fourth and Fifth streets between Alston and Bancroft Ways. It is a relatively level L-shaped site with a length of 249 feet and a width varying from about 120 to 150 feet. The site is currently occupied by two commercial/warehouse buildings and a vacant two-story residence.

Plans for the proposed parking structure are to demolish the existing buildings on the site and construct a 3 to 4-level at-grade parking structure that will have plan dimensions of 122 by 248.33 feet.

Subsurface Conditions

For our previous investigation for a proposed residential development of the adjacent lot at Allston and Fifth streets, we drilled two test borings to a depth of 40 feet below the ground surface (bgs) and performed three cone penetration tests (CPTs), each to a depth of 50 feet bgs. The T&R investigation included drilling one boring to a depth of 50 feet on the subject property.

Regional geologic information indicates the site is underlain by Holocene-age alluvial fan and fluvial deposits (Qhaf). Based on the available subsurface data, we conclude the subject property is blanketed by undocumented fill. The T&R boring drilled on the site indicates the fill is about 10 feet thick and consists of stiff to hard clay with some gravel. On the adjacent lot to the north, up to three feet of fill consisting of stiff clay with sand was encountered. Below the fill is native alluvium consisting of stiff to hard clay with varying sand and gravel content interbedded with medium dense to dense clayey sand that extends to the maximum depth explored of 50 feet bgs.

The depth to the historically high groundwater level at the site is estimated to be approximately five feet bgs.

SEISMIC CONSIDERATIONS

The San Francisco Bay Area is one of the more seismically active regions in the world. The results of our evaluation regarding seismic considerations for the project site are presented in the following sections.

Regional Seismicity

The site is in the Coast Ranges geomorphic province of California that is characterized by northwest-trending valleys and ridges. These topographic features are controlled by folds and faults that resulted from the collision of the Farallon and North American plates and subsequent strike-slip faulting along the San Andreas fault system. The San Andreas Fault is more than 600 miles long from Point Arena in the north to the Gulf of California in the south. The Coast Ranges province is bounded on the east by the Great Valley and on the west by the Pacific Ocean.

The major active faults in the area are the Hayward, Calaveras, and San Andreas faults. These and other faults in the region are shown on Figure 4. For these and other active faults within a 50-kilometer radius of the site, the distance and direction from the site, and characteristic moment magnitude [Petersen et al. (2014) & Thompson et al. (2016)] are summarized in Table 1 below. These references are based on the Third Uniform California Earthquake Rupture Forecast (UCERF3), prepared by Field et al. (2013).

TABLE 1
Regional Faults and Seismicity

Fault Segment	Approximate Distance from Site (km)	Direction from Site	Characteristic Moment Magnitude
Total Hayward + Rodgers Creek (RC+HN+HS+HE)	4.1	East	7.58
Hayward (North, HN)	4.1	East	6.90
Hayward (South, HS)	14	Southeast	7.00
Mount Diablo Thrust North CFM	22	East	6.72
Total Calaveras (CN+CC+CS+CE)	23	East	7.43
Calaveras (North, CN)	23	East	6.86
Mount Diablo Thrust	23	East	6.67
Concord	26	East	6.45
Green Valley	27	Northeast	6.30
Total North San Andreas (SAO+SAN+SAP+SAS)	27	West	8.04
North San Andreas (Peninsula, SAP)	27	West	7.38
Clayton	32	East	6.57
San Gregorio (North)	30	West	7.44
West Napa	34	North	6.97
North San Andreas (North Coast, SAN)	33	West	7.52
Mount Diablo Thrust South	36	East	6.50
Rodgers Creek - Healdsburg	36	Northwest	7.19
Greenville (North)	37	East	6.86
Great Valley 05 (Pittsburg - Kirby Hills alt1)	40	East	6.60
Great Valley 05 (Pittsburg - Kirby Hills alt2)	43	East	6.66

Since 1800 four major earthquakes have been recorded on the San Andreas Fault. In 1836, an earthquake with an estimated maximum intensity of VII on the Modified Mercalli (MM) scale occurred east of Monterey Bay on the San Andreas Fault (Toppozada and Borchardt, 1998). The estimated moment magnitude, Mw, for this earthquake is about 6.25. In 1838, an earthquake occurred with an estimated intensity of about VIII-IX (MM), corresponding to an Mw of about 7.5. The San Francisco

Earthquake of 1906 caused the most significant damage in the history of the Bay Area in terms of loss of lives and property damage. This earthquake created a surface rupture along the San Andreas Fault from Shelter Cove to San Juan Bautista approximately 470 kilometers in length. It had a maximum intensity of XI (MM), an Mw of about 7.9, and was felt 560 kilometers away in Oregon, Nevada, and Los Angeles. The Loma Prieta Earthquake of October 17, 1989 had an Mw of 6.9 and occurred approximately 99 kilometers south of the site.

In 1868, an earthquake with an estimated maximum intensity of X on the MM scale occurred on the southern segment (between San Leandro and Fremont) of the Hayward Fault. The estimated Mw for the earthquake is 7.0. In 1861, an earthquake of unknown magnitude (probably an Mw of about 6.5) was reported on the Calaveras Fault. The most recent significant earthquake on this fault was the 1984 Morgan Hill earthquake (Mw = 6.2).

As a part of the UCERF3 project, researchers estimated that the probability of at least one Mw ≥ 6.7 earthquake occurring in the greater San Francisco Bay Area during a 30-year period (starting in 2014) is 72 percent. The highest probabilities are assigned to sections of the Hayward (South), Calaveras (Central), and the North San Andreas (Santa Cruz Mountains) faults. The respective probabilities are approximately 25, 21, and 17 percent.

SEISMIC HAZARDS

During a major earthquake on a segment of one of the nearby faults, strong to very strong shaking is expected to occur at the project site. Strong shaking during an earthquake can result in ground failure such as that associated with soil liquefaction, lateral spreading, and cyclic densification. We used the results of our borings and CPTs we advanced on the adjacent site and the T&R boring drilled on the site to evaluate the potential of these phenomena occurring at the project site. The results of our analyses and evaluation are presented in the following sections.

Ground Shaking

The ground shaking intensity felt at the project site will depend on: 1) the size of the earthquake (magnitude), 2) the distance from the site to the fault source, 3) the directivity (focusing of earthquake energy along the fault in the direction of the rupture), and 4) subsurface conditions. The site is about four kilometers from the Hayward Fault. Therefore, the potential exists for a large earthquake to induce strong to very strong ground shaking at the site during the life of the project.

Fault Rupture

Historically, ground surface displacements closely follow the trace of geologically young faults. The site is not within an Earthquake Fault Zone, as defined by the Alquist-Priolo Earthquake Fault Zoning Act, and no known active or potentially active faults exist on the site. We therefore conclude the risk of fault offset at the site from a known active fault is very low. In a seismically active area, the remote possibility exists for future faulting in areas where no faults previously existed; however, we conclude the risk of surface faulting and consequent secondary ground failure from previously unknown faults is also very low.

Liquefaction and Associated Hazards

Strong shaking during an earthquake can result in ground failure such as that associated with soil liquefaction and lateral spreading. Soil susceptible to liquefaction includes loose to medium dense sand and gravel, low-plasticity silt, and some low-plasticity clay deposits. Flow failure, lateral spreading, differential settlement, loss of bearing strength, ground fissures and sand boils are evidence of excess pore pressure generation and liquefaction.

The site has been mapped inside a zone of liquefaction potential on the map titled *Earthquake Zones of Required Investigation, Oakland West Quadrangle*, dated February 14, 2003, prepared by the California Geological Survey (CGS. The California Geological Survey (CGS) has provided recommendations for procedures and report content for site investigations performed within seismic hazard zones in Special Publication 117 (SP-117), titled *Guidelines for Evaluating and Mitigating Seismic Hazard Zones in California*, dated September 11, 2008. SP-117 recommends subsurface investigations in mapped liquefaction hazard zones be performed using rotary-wash borings and/or CPTs.

We evaluated the liquefaction potential of soil using data collected from our CPTs on the adjacent site. Our liquefaction analyses were performed using the methodology proposed by P.K. Robertson (2009). We also used the relationship proposed by Zhang, Robertson, and Brachman (2002) to estimate post-liquefaction volumetric strains and corresponding ground surface settlement; a relationship that is an extension of the work by Ishihara and Yoshimine (1992).

Our analyses were performed using the approximate in-situ groundwater depths measured in our CPTs and a "during earthquake" groundwater depth of five feet bgs. In accordance with the 2019 CBC, we used a peak ground acceleration of 0.88 times gravity (g) in our liquefaction evaluation; this peak ground acceleration is consistent with the Maximum Considered Earthquake Geometric Mean (MCE_G) peak ground acceleration adjusted for site effects (PGA_M). We also used a moment magnitude 7.58 earthquake, which is consistent with the mean characteristic moment magnitude for the Hayward Fault, as presented in Table 1.

Based on our analysis, we conclude the potential for liquefaction and associated hazards, including lateral spreading, occurring at the site during a major earthquake is low due to the cohesion and/or relative density of the alluvium underlying the site.

Cyclic Densification

Cyclic densification (also referred to as differential compaction) of non-saturated sand (sand above groundwater table) can occur during an earthquake, resulting in settlement of the ground surface and overlying improvements. The soil encountered above the groundwater table at and adjacent to the site is not susceptible to cyclic densification due to its cohesion. Therefore, we conclude the potential for cyclic densification to occur at the site is low.

If you have any questions regarding this letter, please call.

Sincerely yours,
ROCKRIDGE GEOTECHNICAL, INC.

REGISTERED PROFESSIONAL ENGINEER
CRAIG S. SHIELDS
GE2116
3/31/21
GEOTECHNICAL
STATE OF CALIFORNIA

Craig S. Shields, P.E., G.E.
Principal Geotechnical Engineer