February 22, 2018

Mr. Jose McNeill
City of Vallejo
555 Santa Clara Street
Vallejo, CA 94590

Subject: North Mare Island - Specific Plan Development Area (157 Acres)
Vallejo, Mare Island, California

OVERVIEW OF GEOLOGIC HAZARDS AND GEOTECHNICAL ENGINEERING LAND DEVELOPMENT CONSIDERATIONS

Dear Mr. McNeill:

This report presents an overview of geologic hazards and geotechnical engineering land development considerations for the specific plan development area (157 acres) at North Mare Island in Vallejo, California. The site location is shown on the Vicinity Map, Exhibit A.

We understand that the commercial development of 157 acres on North Mare Island has an approved Specific Plan allowing up to 1.2 million square feet of commercial, office, retail, or industrial space. Redevelopment is anticipated to include modifications of site grades with cuts and fills to meet land development requirements and provide proper drainage. The grading concepts have not been developed at this time; however, preliminary grading concepts indicate that design modifications may involve cuts and fills on the order of 5 feet.

1.0 BACKGROUND INFORMATION

Mare Island was originally developed starting in 1853 as the first Navy base on the Pacific Coast. As part of the development, roads, rail systems, and numerous buildings were constructed and many low-lying marshy areas around the island were filled to create additional buildable land and dock facilities. This is particularly the case for the project site on the northern part of Mare Island, where the historic fills were used to raise the land and increase the usable surface area in the marshy regions along both sides of the narrow spit that connected the Strait. The original extent of the northern half of Mare Island, as mapped in 1851, was considerably narrower than the current island footprint, about 700 to 1,000 feet in 1851 compared to about 6,500 feet in the present day. With the Naval base closure in the 1990s, the majority of specific plan development area has remained dormant and largely inactive until present.

A major portion of site lies in an area that was originally submerged mud flats along the Napa/Mare Island Strait and San Pablo Bay. As San Pablo Bay and the Mare Island Strait lie within the zone of tidal influence in San Francisco Bay and the Sacramento River, mid-Holocene to modern deposits along the margins of San Pablo Bay and on the west side of Mare Island Strait are generally fine-grained, representing the deposition from slack water in the intertidal zone. In contrast, deposition of coarser grained (sandier) materials likely occurred along the banks of a through-going river present when sea level was lower during the latest Pleistocene.
LAND DEVELOPMENT CONSIDERATIONS

The current topography of the site is relatively flat lying, with surface Elevations ranging from about +10 to +15 feet (NAVD 88 Datum) across most of the site, with local higher areas up to Elevation +20 feet. The easternmost portion of the site, within about 500 feet of the current shoreline along the Mare Island Strait, grades from Elevation +10 feet down to mean sea level elevation. At the northwest corner of the site, near Q Street, the site Elevations range from about +5 to +8 feet. In addition, there are some “man-made” berms and roadways, which are elevated several feet from the surrounding ground.

2.0 REGIONAL GEOLOGY, GEOLOGIC HAZARDS, GEOTECHNICAL INFORMATION

2.1 PREVIOUS EXPLORATION DATA AND SUBSURFACE CONDITIONS

The previous geotechnical studies have included drilled borings and cone penetrometer tests (CPTs). Exhibit B presents the Site Plan including the location of explorations performed by ENGEO and others at the project site. This section provides an abbreviated summary of subsurface conditions encountered in previous geotechnical studies compiled at North Mare Island. The studies were generally preliminary in nature and covered large areas of property.

- Previous borings encountered a surface layer of existing “man-made” fill associated with historic land reclamation activities by the US Navy. The existing fills are undocumented and generally extend to depths ranging from approximately 3½ to 11 feet below the ground surface. Previous exploratory borings and CPTs indicate the existing fill deposits are variable and include soft to very stiff, cohesive fine-grained soils intermixed with loose to medium dense coarse-grained granular soils. Portions of the existing fill are intermixed with varying amounts of debris, such as construction rubble, bricks, concrete, metal, etc. The existing fill include areas of buried structures, utilities, asphalt and concrete pavement, and foundation remnants (including timber piles) from previous site development. Previous studies included laboratory test results, which indicate that the near-surface soils are moderate to highly expansive. Preliminary soil corrosivity testing showed resistivity measurements of 920 to 1,720 ohm-cm, classified as extremely corrosive. Exhibit D depicts thickness of undocumented fill based on interpolation of previous exploration data.

- Directly beneath the near-surface existing fill deposits, previous exploratory borings and CPTs encountered natural tidal marshland deposits comprised of highly compressible “organic rich” clayey soils; these tidal marshland soils are locally known as Young Bay Mud (YBM). These compressible clayey soils vary in thickness ranging from approximately 20 to 50 feet. Exhibit E depicts thickness contours of YBM based on interpolation of previous exploration data.

- Underlying the natural tidal marshland YBM strata, previous borings and CPTs encountered approximately 45 feet of high plasticity, clay deposits with varying site and sand, locally known as Old Bay Clays (OBC). The OBC strata is comprised of medium stiff to very stiff, clay with varying amounts of silt and sand.

- Beneath the OBC layer, the exploratory borings and CPTs encountered sedimentary bedrock units, Sandstone and Claystone, at approximately 96 to 108 feet below ground surface across the project site. The Sandstone and Claystone bedrocks encountered was intensely weathered and fractured, and friable.
LAND DEVELOPMENT CONSIDERATIONS

- Relatively shallow groundwater has been encountered in the previous exploratory borings and CPTs ranging from depths of approximately 4 and 10 feet below the existing ground surface. It should be noted that near waterfront margins, where tidal influences are present, water levels may vary significantly, on the order of 10 feet, and these conditions can influence and affect water levels of existing utility corridors, etc. Additionally, fluctuations in the groundwater conditions may be expected to occur with variations in seasonal rainfall, irrigation on the site and adjacent parcels, and variations in subsurface stratification.

2.2 REGIONAL GEOLOGY

The site is located on the eastern side of the San Francisco Bay in Coast Range Province of northern California. The Coast Ranges are comprised of several mountain ranges and structural valleys formed by tectonic processes commonly found around the Circum-Pacific belt. The basement rocks that have been sheared, uplifted and metamorphosed are separated by thick blankets of Cretaceous and Cenozoic sediments that fill the structural valleys and line continental margins. The San Francisco Bay Area has several ranges that trend north-west-southeast, parallel to strike-slip faults such as San Andreas, Hayward, Calaveras, and Rogers Creek faults that form them. Exhibit C provides regional geology map.

2.3 GEOLOGIC AND SEISMIC HAZARDS

The main geologic hazards and development concerns at the project site for future land development are compressible soils, undocumented fills, slope stability, flooding and sea level rise, and seismic hazards.

2.3.1 Compressible Soils

Settlement occurs from consolidation of fine-grained compressible soils when subject to increased loads. This property is underlain by relatively thick natural clayey soils/marsh deposits, locally known as Young Bay Mud (YBM). Consolidation and settlement of normally consolidated YBM occurs when these soils are subject to load increase; load increase may result from applying new structural loads, or the placement of additional fill to raise grades. To reduce consolidation of YBM, unloading areas with cuts, minimizing added fills, and use of compensation loading (depressed structures) may be considered in design. It should be pointed out that even minor grading (plus or minus a few inches) may induce settlement of YBM. The degree and rate of consolidation settlement depends on several factors, including actual loads applied, and the thickness and specific characteristics of the YBM immediately under the applied new loads. Because of the variable nature of the YBM, there is a potential for differential settlement over relatively short distances.

Many of the existing structures at North Mare Island are supported on driven timber piles, and/or driven precast concrete piles. The ground surface grades surrounding the older buildings and pile-supported infrastructure show evidence of on-going settlement, which displacements total approximately several feet over many years. Based on previous geotechnical explorations, we have compiled and interpolated thickness contours of YBM on Exhibit E. One mitigation measure that has been used successfully at Mare Island and in other areas surrounding the San Francisco Bay margins is “pre-consolidation” induced by a combination of temporary surcharge fills over areas combined with closely spaced vertical drains (i.e. wick drain). Foundation support even over pre-consolidated YBM may require the use of deep foundations.
to support moderate to heavily loaded structures. Such determination needs to be evaluated on a case-by-case basis and with a design-level geotechnical study.

### 2.3.2 Undocumented Fills

Previous borings encountered a surface layer of existing “man-made” fill associated with historic land reclamation activities by the US Navy. The existing fills are undocumented and generally extend to depths ranging from approximately 2½ to 11 feet below the ground surface, as presented on Exhibit D. Previous exploratory borings and CPTs indicate the existing fill deposits are variable and include soft to very stiff, cohesive fine-grained soils intermixed with loose to medium dense coarse-grained granular soils. Portions of the existing fill are intermixed with varying amounts of debris, such as construction rubble, bricks, concrete, metal, etc. The existing fill includes areas of buried structures, utilities, asphalt and concrete pavement, and foundation remnants (including timber piles) from previous site development. Undocumented fills and unsuitable debris may result in excessive total and differential settlement. Excessive total and differential settlement may occur from undocumented fills. To mitigate the risk of settlement, undocumented fills may be completely or partially overexcavated and cleared of unsuitable materials, and design grades restored using properly compacted engineered fill material. If cleared of unsuitable materials and debris, the overexcavated undocumented fills could be re-used as engineered fill.

### 2.3.3 Slope Stability

The ground surface at North Mare Island is relatively level across the majority of the site, and slopes downward slightly along the east side and northwestern portion of the property. The future development at North Mare Island is anticipated to be set back 200 feet from the San Francisco Bay Conservation and Development Commission (SF-BCDC) tidal marsh boundary. As such, slope stability and related potential deformation along the channel margin is not expected to extend close to the area of planned developments. However, the relatively low strength of Young Bay Mud in the top 40 to 50 feet of the site may lead to some instability immediately along the channel in areas not improved previously by Navy, especially during seismic events. If permanent or heavy temporary facilities are planned within 200 feet of the channel, these facilities should be evaluated for stability under both static and seismic loading.

### 2.3.4 Flooding and Sea-Level Rise

Flood risks are based on local hydrology, topology, precipitation, flood protection measures such as levees, and other scientific data. Concentrated flow of water from flooding may cause acute erosion of stream banks, slopes, and swales, possibly resulting in landsliding. Acute erosion around shallow building foundations may undermine the foundation and damage buildings or other structures. The project site is located on relatively level ground, and there are no lakes, reservoirs, water storage tanks, or water retention facilities upslope and near to the site that could fail and result in flooding at the site.

According to the Federal Emergency Management Agency published Flood Insurance Map (FIRM), a portion of the project site is situated within a special flood hazard area subject to inundation by the 1% annual chance flood. Specifically, the north area of the site, north of J Street, is located in “Zone AE”, shows base elevation of +10 feet (NAVD 88) as shown on Exhibit F.
LAND DEVELOPMENT CONSIDERATIONS

Recent publications and maps showing sea-level rise projections in the San Francisco Bay estimate sea level rise by the year 2100 (Heberger et al. 2012) may range from 39 to 55 inches. While there is significant uncertainty in the expected sea-level rise over the next 100 years, the estimated rise is based on scenarios in which the rate of global warming is reduced from the present rate. If the rate of global warming is not reduced, the sea-level rise could be much higher. Where portions of the site front the San Francisco Bay, appropriate measures and adaptive measures may be warranted to mitigate potential sea-level rise.

Although it is possible to mitigate flood hazard for future proposed buildings by raising the base elevation of the structures, access to and operations of the buildings could be significantly affected by inundation of the surrounding portions of the island. In the future development and civil plans, measures should be considered to address the sea rise.

2.3.5 Seismic Hazards

No active faults cross the subject project site, and the site is not located within a Alquist Priolo Special Study Zone; therefore, it is our opinion that ground rupture in unlikely at the project property. Numerous earthquakes occur every year in the region, and large (>Mw 7) earthquakes can be expected to occur in the future. As with all projects in the region, the development should take into account the potential for moderate to strong earthquake ground shaking. Major active faults near the project site include Concord-Green Valley, Calaveras, and Hayward-Rodgers Creek faults as shown on Exhibit H.

According to the Association of Bay Area Governments (ABAG) maps, the site is located within an area that may have low to very high susceptibility to liquefaction. Liquefaction is a phenomenon in which saturated, loose or medium dense, cohesionless soils are subject to a temporary, but essentially total loss of shear strength because of pore pressure build-up under the reversing cyclic shear stresses associated with earthquakes. Soils most susceptible to liquefaction are clean, loose, saturated, uniformly graded fine sands below the groundwater table. According to a previous study by Amec Foster Wheeler (2017), using the methodology of Idriss and Boulanger (2014) and using the data obtained from Cone Penetration Tests (CPTs), for the majority of the site, the soils are not susceptible to liquefaction. As presented on Exhibit I, there are a few limited zones of liquefiable soils, specifically at some locations in the Fill at depth between about 5 and 12 feet, and in a deeper layer, which approximately follows the old shoreline at a depth of about 25 to 35 feet. Based on the CPT data and because of the relatively flat topography, we judge that lateral spreading is unlikely to occur at the Mare Island site.

Tsunami inundation maps have been prepared for San Francisco Bar, San Pablo Bay, and the Mare Island Strait by the California Emergency Management Agency, California Geologic Survey, and University of Southern California (2009). The mapping by these groups shows that expected maximum inundation areas do not extend into the project area (Exhibit G). However, this inundation area does not account for potential sea-level rise as described in the previous section. Based on this information, we judge that the potential for tsunami inundation at the project site is low. Moreover, there are no dams that could fail and result in flooding at the site; therefore, the potential for inundation or acute erosion from seismically induced failure of water-retention facilities is judged negligible.
3.0 GEOTECHNICAL ENGINEERING LAND DEVELOPMENT CONSIDERATIONS

Based on previous studies, from a geotechnical standpoint, future land development within the Specific Plan Development Area (157 Acres) is feasible provided that appropriate geotechnical recommendations are followed and mitigation is performed, and that these measures are incorporated into the project planning and implemented construction.

In general, design-level geotechnical studies should be undertaken at future times once development details have been determined to provide specific design criteria for grading, structures and related site improvements. Exhibit J depicts development constraints presenting areas with lesser constraints, where existing grades are relatively higher and the YBM is relatively thinner (preferable development areas) and areas with greater constraints in terms of existing elevation and YBM thickness. Table I summarizes the identified geologic hazards and various geotechnical engineering corrective measure that may be considered in planning and design concepts. Table II provides typical construction unit rate costs for various geotechnical engineering corrective measures.

We are pleased to be of service to you on this project and will continue to consult with you and your design team as project planning progresses. If you have any questions or comments regarding this letter, please call and we will be glad to discuss them with you.

Sincerely,

ENGEO Incorporated

Bahareh Heidarzadeh, PhD
bh/tpb/jf

Theodore P. Bayham, GE, CEG

Attachments:
- List of References
- Table I – Geological and Geotechnical Hazard Summary and Potential Corrective Measures
- Table II – Typical Construction Unit Rate Cost
- Exhibits A through J
REFERENCES

Amec Foster Wheeler; Geotechnical Investigation Report, Project Zeus, May 1, 2017, Project No. 6166150082.

California Emergency Management Agency, California Geologic Survey, and University of Southern California, 2009, Tsunami Inundation Maps for Emergency Planning, State of California, San Francisco Bay Area, County of Solano, Mare Island and Cuttings Warf Quadrangles, Scale 1:24,000, July 15.

ENGEo; Geotechnical Exploration, Mare Island Infrastructure Improvements, Vallejo, California, February 21, 2003; Project No. 4804.2.004.01.

ENGEo; North Mare Island, Preliminary Geotechnical Cost Summary, March 2006, Project No. 4804.204.001.

ENGEo; Review of Improvement Plans, North Mare Island, Vallejo, California, October 31, 2006; Project No. 4804.2.003.07.

ENGEo; Initial Geotechnical Comments Regarding Preliminary Geotechnical Study for North Mare Island redevelopment, Vallejo, California, latest revision April 15, 2008; project No. 4804.200.037.

ENGEo; Foundation Report, Causeway Bridge, Span Replacement, Vallejo, California, December 5, 2011; project No. 9345.000.000.

ENGEo; Summary of Geotechnical and Geologic Considerations for Planned Earthquake Protection System (EPS) Development, March 30, 2015, Project No. 11971.000.000.


GEOCON Consultants Inc.; Preliminary Geotechnical Investigation, North Island Redevelopment, Mare Island, Vallejo, California; January 2008.

Harding Lawson and Associates; Geotechnical Consultation, Telephone Ductline Repair, Mare Island Naval Shipyard, Vallejo, California; March 1982; Job No. 8172.024.03.


J.H. Kleinfelder & Associates; geotechnical Engineering Investigation, Mare Island Sewer Replacement, Sewer North of A Street, Phase I, Mare Island, California, June 10, 1987; File No. 40-1820-1.

11971.001.000
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REFERENCES (Continued)

Krove Engineering; Plans for Mare Island North Roadway Improvement Project, Railroad Avenue & G Street: 65% Progress set; October 21, 2001.

Krove Engineering; G Street X-Sections Between Railroad and Causeway, Mare Island North Roadway Improvement Project; September 28, 2001.

Levine Fricke; Preliminary Geotechnical Engineering Study and Consolidation Evaluation, proposed North Mare Island Business Park, Vallejo, California, July 20, 2001; Project No. 8019.00-05.

LRF; Reimer, Utility Plans, Mare Island North Roadway Improvement Project, Railroad Avenue & G Street: 35% Progress Set; October 21, 2001.

LRF; Reimer, Utility Plans, Mare Island North Roadway Improvement Project, Railroad Avenue & G Street: 65% Progress Set; July 23, 2001.

Ninyo & Moore; Caltrans Initial Site Assessment Checklist, Highway 37/Walnut Avenue Interchange, Vallejo, California, January 30, 2001.

Ninyo & Moore; Preliminary Subsurface Conditions and Geotechnical Design Issues Report, Mare Island North Roadway Improvement Project, Vallejo, California, October 8, 2001.

Ninyo & Moore; Geotechnical and Environmental Sciences Consultants; Final Geotechnical Design report, Mare Island North Roadway Improvement project, Vallejo, California, February 12, 2002; project No. 400430002.

Woodward Clyde Consultants; geo technical Study, Boiler Plant Cal Conversion project, Mare Island Shipyard, Vallejo, California, May 26, 1981.
<table>
<thead>
<tr>
<th>GENERAL LOCATION</th>
<th>HAZARD SUMMARY</th>
<th>CORRECTIVE MEASURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undocumented Fill (Exhibit E)</td>
<td>Historic areas of grading and previous development. The thickness of the undocumented fill varies from about 3½ to 11 feet across the site. Undocumented fill at the site is variable in composition, and contains many abandoned utilities, abandoned foundations, some cobble-sized material, and organics. The fill may be susceptible to excessive settlement and liquefaction is some areas.</td>
<td>Design-level geotechnical exploration should be undertaken to characterize depth, areal limits of undocumented fill. Corrective measures may include: complete or partial removal, replacement with engineered fill, and/or other ground improvement. Portions not affecting future development are anticipated to be left in place.</td>
</tr>
<tr>
<td>Highly Compressible Soils Young Bay Mud (YBM) (Exhibits F-1 and F-2)</td>
<td>YBM varies in thickness from less than one foot to 53 feet with the shallower section generally to the west and south and deepening to the north and east. Compressible YBM may be considered susceptible to excessive total and differential settlement when subject to increased loads.</td>
<td>Corrective measures may include preconsolidation using temporary surcharge fills combined with closely spaced vertical drains (wick drains). Foundation loads and appropriate foundation system selected depending on structural loads.</td>
</tr>
<tr>
<td>Liquefiable Zones (Exhibit J)</td>
<td>Overall risk for liquefaction and seismic induced settlement at North Mare Island is generally considered to be low. There are local zones of potentially liquefiable layers along historic buried shoreline. In local areas, potential risk of liquefaction induced settlement in event of strong ground shaking.</td>
<td>Design-level geotechnical exploration should be undertaken to define limits and depths if present. Corrective measures if warranted may include foundation recommendations and/or ground improvement.</td>
</tr>
<tr>
<td>Flooding, Sea Level Rise, and Tsunami (Exhibits G and H)</td>
<td>The northern portions of North Mare Island defined by FEMA 2010. Site elevations range from +8 to +15 feet ([NAVD 88 Datum). Base flood elevation is approximate +10 feet (FEMA, 2010). Seal level rise by 39 to 55 inches by the year 2100 (Heberger, 2012). Based on the current FEMA flood inundation mapping, and the potential sea level rise, there is risk of flooding and sea level rise.</td>
<td>Corrective measures include raising the grades and/or raising the base elevation of the structures. Area fronting the San Francisco Bay may require protective measures and adaptive measures in Civil design.</td>
</tr>
<tr>
<td>Shrink Swell Potential</td>
<td>Previous areas of grading and development where undocumented fill exists. Based on the Atterberg Limits test results, the fill material may be prone to moderate volume change due to shrinkage and swelling.</td>
<td>Corrective measure may include supporting floor slabs on non-expansive fill to reduce the likelihood of slab damage from heave or shrinkage, or for lighter buildings (e.g. townhomes, post-tensioned mat foundation)</td>
</tr>
<tr>
<td>CORRECTIVE MEASURE</td>
<td>TYPICAL CONSTRUCTION COST</td>
<td>NOTES</td>
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<tr>
<td>Undocumented and Liquefiable Fills (Exhibit E)</td>
<td></td>
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<tr>
<td>Complete or partial removal, replacement with engineered fill</td>
<td>$32,000 per acre</td>
<td>Reworking 5 feet of undocumented fill</td>
</tr>
<tr>
<td>Lightweight fill placement</td>
<td>$50 cubic yard</td>
<td></td>
</tr>
<tr>
<td>Other ground improvement (Vibro-compaction-deep dynamic compaction)</td>
<td>$100,000 for an acre of improvement</td>
<td>To the depth of 25 feet</td>
</tr>
<tr>
<td>Compressible Young Bay Mud (YBM) Deposits (Exhibit F)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preloading without installing wick drains</td>
<td>$200,000 per acre</td>
<td>6 feet of surcharge Duration: 18 months</td>
</tr>
<tr>
<td>Preloading with Surcharge plus wick drains at 5 foot spacing</td>
<td>$400,000 per acre</td>
<td>6 feet of surcharge Duration: 6 months</td>
</tr>
<tr>
<td>Deep foundation</td>
<td>$75 square foot</td>
<td>Pile foundation supported in stiff deposits below YBM</td>
</tr>
<tr>
<td>Mat foundation</td>
<td>$35 square foot</td>
<td>Assumes 12-foot-thick mat foundation</td>
</tr>
<tr>
<td>Conventional slab and footings</td>
<td>$15 square foot</td>
<td></td>
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<tr>
<td>Flooding, Sea Level Rise, and Tsunami (Exhibits G and H)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raising grades and importing fill</td>
<td>$10 per cubic yard for imported</td>
<td>Assumes private arrangement with available source of suitable fill</td>
</tr>
</tbody>
</table>
EXHIBITS

Exhibit A: Vicinity Map
Exhibit B: Site Plan
Exhibit C: Regional Geology Map
Exhibit D: Undocumented Fill Areas - Thickness
Exhibit E: Compressible Young Bay Deposit Areas - Thickness
Exhibit F: Flood Insurance Rate Map
Exhibit G: Tsunami Inundation Map
Exhibit H: Regional Faulting and Seismicity
Exhibit I: Local Fills with Liquefaction Potential
Exhibit J: Development Constraints
EXPLANATION

ALL LOCATIONS ARE APPROXIMATE

CPT-30

CONING PENETRATION TEST SHOWING LIQUEFACTION ANALYSIS RESULTS IN INCHES (AWES 2015)

LOCAL FILLS WITH LIQUEFACTION POTENTIAL

BASE MAP SOURCE: GOOGLE EARTH MAPPING SERVICE