Land/
Marine
Geotechnics

August 30, 2006
Project No. 103.003

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Geotechnical Report in Support of Seismic Assessment
Hazardous Waste Facility, Part B Permit Renewal
CO Boilers and Bio Treater Tank 12038
Shell Martinez Refinery
Martinez, California

Dear Mr. Johnson:

This letter transmits the report presenting the results of the geotechnical consultation provided by Land Marine Geotechnics for the seismic assessment of the CO Boilers and Bio Treater Tank T-12038 at the Shell Martinez Refinery in Martinez, California. The tank and boilers are regulated by the California Department of Toxic Substance Control (DTSC) and are currently subject to a Hazardous Waste Facility Part B Permit Renewal Application Process.

Accordingly, HPA is conducting a Seismic Assessment of these facilities pursuant to the State of California's guidance document titled "Guidance for California Accidental Release Prevention (CalARP) Program Seismic Assessment", dated January 2004. Our consultation is directed at providing the information outlined in Section 2-Determination of Seismic Hazards and in providing foundation design criteria to aid in HPA's structural evaluation of the subject facilities.

It has been a pleasure working with you on this interesting project. If you have any questions please call.

Yours very truly,

Land Marine Geotechnics

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Prepared for:
HPA Inc.
Oakland, California

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DISTRIBUTION

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Shell Martinez Refinery
Martinez, California

1. INTRODUCTION

This revised report presents the results of the geotechnical consultation and seismic assessment provided by Land Marine Geotechnics for the seismic assessment of the CO Boilers and Bio Treater Tank T-12038 at the Shell Martinez Refinery in Martinez, California. The tank and boilers are regulated by the California Department of Toxic Substance Control (DTSC) and are currently subject to a Hazardous Waste Facility Part B Permit Renewal Application Process. The location of the CO Boilers and the Bio Treater Tank are shown on Figure 1, Site Location Map.

Accordingly, HPA is conducting a Seismic Assessment of these facilities pursuant to the State of California's guidance document titled "Guidance for California Accidental Release Prevention (CalARP) Program Seismic Assessment", dated January 2004. Our consultation is directed at providing the information outlined in Section 2-Determination of Seismic Hazards and in providing foundation design criteria to aid in HPA's structural evaluation of the subject facilities.

We evaluated subsurface conditions at the site by reviewing the results of previous geotechnical engineering studies conducted for the existing refinery structures. For the CO Boilers these references included:

> Woodward-Clyde-Sherard & Associates. Report: *Soil Investigation for a Proposed Refinery Expansion Tank Farm and Vine Hill Area 1A Shell Oil Company Refinery,* Martinez, California, May 18, 1964
>
> Woodward-Clyde-Sherard & Associates. Report: Supplemental *Soil Investigation for a Proposed Refinery Expansion Tank Farm and Vine Hill Area 1A Shell Oil Company Refinery,* Martinez, California, December 15, 1964

For the Bio Treater Tank site the existing data included:

Bechtel Corporation. Report: *Subsurface Investigation and Foundation Report Shell Martinez Manufacturing Complex, Pond Closure Project and Effluent Treatment Plant, Volumes 1 and 2,* Martinez, California, December 1991

Dames and Moore: *Foundation Investigation, Proposed Storage Tank, ,* Martinez, California, November 1958

Dames and Moore: *Foundation Investigation, Proposed Waste Chemical Tanks and Emulsion Treatment Tanks,* Martinez, California, December 1961

Dames and Moore: *Report: Foundation Investigation, 150,000 Barrel Floating Roof Storage Tank,* Martinez, California, November 1958

Woodward-Clyde-Sherard: *Soil Investigation for the Proposed Wharf Area Pipe Racks, Shell Oil Company Refinery,* Martinez, California, March 1965

2. SURFACE AND SUBSURFACE CONDITIONS

2.1 Surface Conditions

CO Boilers

The CO Boilers are located in the Light Oil Processing (LOP) area of the Shell Refinery in Martinez, California. The initial site investigation was conducted in 1964 prior to grading of the LOP area. This area was a sloping grass covered hill at the time and subsequently was cut up to 70 feet in order to provide a level site for construction of several tanks and associated structures. Currently, the area is covered with equipment, pipeways and pipelines, a railroad spur to the north, electrical lines, roadways, and the CO Boilers structures themselves. The structures consist of three separate units; a boiler unit, an electrostatic precipitator, and an exhaust stack. Figure 2 shows the CO Boilers site plan.

Bio Treater Tank T-12038

The Bio Treater Tank is located in the area of the Shell Refinery designated as the Effluent Treatment Plant. This area was studied by Bechtel in 1991 as part of a plan to close the existing bio-treatment ponds and construct an effluent treatment facility. The effluent treatment plant area consists of approximately 11 acres to the north of the Shell Martinez Manufacturing Complex. The area where the subject tank is located is a former marsh area that was filled over and used to create bio-treatment ponds. These ponds were eventually closed and replaced with above ground storage tanks used as bio-treatment structures. There are approximately 10-15 tanks in the area used for this and other purposes. In addition, there are associated pipeways and pipelines, asphalt roads, support structures, electrical lines, equipment, parking lots and a railroad line to the south of the area. Elevations in the area range from approximately +8 to +15 (Shell Datum). Figure 3 shows the Bio Treater Tank site plan.

2.2 Existing Subsurface Data

CO Boilers

The existing subsurface data we were able to review for the CO Boilers site included two reports by Woodward-Clyde-Sherard & Associates completed in 1964 which evaluated the feasibility of excavating the bedrock to depths of up to 70 feet. Subsurface conditions were investigated by conducting a geophysical seismic survey and by drilling test borings. Two bore holes designated Hole 2 and Hole 11, were advanced in the area as shown on the Site Plan - CO Boilers, Figure 2. Copies of the boring logs for these bore holes are attached in Appendix A.

Bio Treater Tank T-12038

The original geotechnical report for the Bio Treater Tank was written in 1961 by Dames and Moore. Five borings were advanced in the area of the tank. In addition, two borings were advanced in a separate investigation for the nearby API Separator. Subsurface conditions in the Bio Treater Tank T-12038 area were also investigated by Bechtel in 1991, as part of a comprehensive geotechnical investigation for the design of the Effluent Treatment Plant (ETP). Selected geotechnical data from all of these reports, relevant to the Bio Treater Tank design is presented in Appendix B. Numerous test borings and cone penetration test (CPT) probes were conducted in the area as shown on the attached site plan from the Bechtel Report. The logs of selected borings near the Bio Treater Tank are attached for reference in Appendix B and their locations are shown on the Site Plan – Bio Treater Tank, Figure 3.

2.3 Subsurface Conditions

CO Boilers

The original soil reports indicate that the area of the CO Boilers was originally at about elevation +120 to +130 feet. Prior to grading, the area was blanketed by a soil mantle of about 0.5 to 5 feet of medium dense fine sandy silt to silty sand. The soil was underlain by interbedded friable sandstone, siltstone and shale of the Martinez formation.

Grading in the area consisted of cutting to about elevation +60 feet. As a result, cuts into bedrock up to 60 to 70 feet deep were made in the CO Boilers area. The cuts removed all soil deposits and exposed dense to very dense bedrock throughout the CO Boilers site.

Appendix A presents selected geotechnical data relevant to the CO Boilers site. We have attached the original site plans from the Woodward-Clyde-Sherard & Associates Reports. Boring B-11 from this report was drilled directly upon the CO Boilers site. This site description is considered representative of subsurface conditions in the CO Boilers area. Figure 4, Subsurface Cross Section – CO Boilers graphically shows the site stratigraphy.

Bio Treater Tank T-12038

The test borings in the area indicate that the Bio Treater Tank is underlain by sequentially deeper layers of fill, fine grained Bay Sediments and alluvium. The alluvium is in turn underlain by bedrock of the Menanos and Domengine formations. The fill in the tank area is about 8 to 13 feet thick and is highly variable, ranging from silty and clayey sand to fat clay. The fill is underlain by Bay Sediments which consist of Young Bay Mud, Bay Sand and Peat. The Bay Mud consists of soft, highly compressible, elastic silts and organic clays. The Bay Sand is found discontinuously at the base of and within the Young Bay Muds. The sands are generally loose and are up to 5 feet thick in the tank area. As identified on Bechtel's Figure 10 – Contours on the Top of Stiff to Hard Clay, the tank site is located along the alignment of a buried Paleochannel where peat deposits exist in layers up to 10 feet thick. Bechtel's Figure 9 - Isopach Map of Peat shows about 10 feet of peat in the tank area. This agrees well with Boring 61-4 from the original geotechnical report for the tank which shows approximately 10 feet of peat at the location where the tank now sits.

Stiff to hard clays and dense to very dense clayey sands underlie the Bay Sediments at the tank site. The top of the clay layer is at about elevation -20 feet at the tank location. These stiff to hard clays and alluvium are underlain by bedrock. Insufficient boring data exists to accurately estimate the thickness of the hard clays and alluvium and hence the top of the bedrock. The shallowest bedrock elevation in the borings which extended to

rock in the area is about elevation 40 feet. The bedrock is highly weathered and was typically classified on the boring logs as clayey sand with gravel or as fat clay.

Groundwater in the tank area is located at about elevation +6 feet. Groundwater levels vary seasonally due to pumping in the area. Figure 5, Subsurface Cross Section – Bio Treater Tank graphically shows the site stratigraphy.

2.4 Foundation Conditions

CO Boilers

The CO Boilers structures consist of three separate units; the boilers, the electrostatic precipitator, and the stack. Based on the drawings provided by HPA (copy attached in Appendix A), the precipitator and stack are elevated and structurally connected; however, the boiler foundation is structurally isolated from the other units by a flexible duct connection. The structures each appear to be supported on spread footings bearing on native bedrock with the top of the footings typically 3.5 feet below grade. The footings are interconnected with grade beams with typical thickness of 15" height and 18" depth.

Bio Treater Tank T-12038

Based on the drawing provided by HPA (copy attached in Appendix B) the Bio Treater Tank is supported on a pile foundation. The piles appear to consist of 12-inch butt diameter timber piles with six piles 60' in length, four piles 55' in length, and two piles 50' in length. Pile tip elevations are estimated to vary from elevation -33 to -43 feet[1]. At this depth we anticipate that the piles extend approximately 14 to 22 feet into competent soils, specifically the stiff and dense soils below the Bay Sediments. Pile driving specifications stipulated that the piles were to be driven with a 15,000 lb hammer with a minimum blowcount of 12 blows per foot or to a refusal blowcount of 50 blows per foot.

[1] Pile tip elevation estimate taken from foundation plans. Piles may have been cut off above grade depending on driving conditions. Please see foundation plans in Appendix B as well as Figure 5, Subsurface Cross Section – Bio Treater Tank, for further detail.

The pile cap appears to be typically 9 inches thick and thickened at the pile locations to accommodate a minimum of 4 inches of pile embedment. The center roof column support is founded on a thickened pile cap section.

3. SEISMIC HAZARDS ASSESSMENT

The assessment of seismic hazards was conducted consistent with the Guidance for CalARP Program Seismic Assessments, dated January 2004. In accordance with the guidance document we have considered the following site specific seismic hazards:

1. Ground shaking, including local site amplification effects
2. Fault rupture
3. Liquefaction and lateral spreading
4. Seismic settlement
5. Landslides
6. Tsunamis

3.1 Seismicity

Major active faults in the area include the Concord and Green Valley Faults which are located less than 5 kilometers northeast of the site. However, there are several other active faults located in the region. For each of the active faults within 100 kilometers (km) of the site, the distance from the site and estimated maximum Moment magnitude[2,3] events are summarized in Table 1.

TABLE 1

Regional Faults and Seismicity

Fault Name	Distance (km)		Direction from Site	Maximum Moment Magnitude
	CO Boilers	Bio Treater Tank		
Concord	4.1	4.4	Northeast	6.5
Southern Green Valley	5.5	5.1	Northeast	6.5
Northern Greenville	15.5	16.7	East	6.6
Mount Diablo Thrust	17.2	18.5	Southeast	6.7

[2] Moment magnitude is an energy-based scale and provides a physically meaningful measure of the size of a faulting event. Moment magnitude is directly related to average slip and fault rupture area.

[3] California Division of Mines and Geology, 1996, *Probabilistic Seismic Hazard Assessment for the State of California*, CDMG Open-File Report 96-08.

Northern Calaveras	18.8	18.6	Southwest	6.6
Northern Hayward	18.9	18.6	Southwest	7.1
Hayward - Total	18.9	18.7	Northwest	6.5
Great Valley - 6	19.4	20.0	West	7.1
West Napa	20.0	20.1	Southeast	7.0
Rodgers Creek	21.2	20.4	East	6.7
Great Valley - 5	22.0	22.4	Northeast	6.5
Southern Hayward	25.7	26.5	South	6.9
Northern Green Valley	28.4	27.3	North	6.3
Great Valley - 4	29.7	29.1	Northeast	6.6
Central Greenville	33.8	35.2	Southeast	6.7
San Andreas - 1906 Rupture	47.6	47.2	Southwest	7.9
San Andreas - Peninsula	48.1	47.7	Southwest	7.2
San Andreas - North Coast South	48.1	47.7	Southwest	7.5
Hunting Creek - Berryessa	49.1	48.0	North	6.9
San Gregorio North	50.7	50.1	West	7.3
Southern Greenville	53.4	54.8	Southeast	6.9
Great Valley - 7	59.1	60.5	Southeest	6.7
Point Reyes	61.0	60.1	West	6.8
Hayward - South East Extension	64.0	65.2	South	6.4
Monte Vista	65.3	66.1	South	6.8
Great Valley - 3	68.8	67.8	North	6.8
Central Calaveras	68.9	70.2	Southeast	6.6
Maacama - South	79.9	78.5	Northwest	6.9
San Andreas - Santa Cruz Mnts.	93.7	94.8	South	7.2
Collayomi	97.9	96.5	Northwest	6.5
Sargent	98.6	99.7	South	6.8

In 2002, the Working Group on California Earthquake Probabilities at the U.S. Geologic Survey (USGS) predicted a 62 percent probability of a magnitude 6.7 or greater earthquake occurring in the San Francisco Bay Area by the year 2034. Smaller earthquakes (between magnitudes 6.0 and 6.7), are capable of considerable damage if

[4] Working Group on California Earthquake Probabilities (WGCEP), 2002, *Earthquake Probabilities in the San Francisco Bay region; 2000 to 2032 – A Summary of Findings*, Open File Report 99-517.

they occur in proximity to urban areas, and have about an 80 percent chance of occurring in the Bay Area by 2032.

3.2 Ground shaking

Earthquake ground motions at the two sites were evaluated using values obtained from the United States Geological Survey (USGS) National Seismic Hazard Mapping Program website located at http://earthquake.usgs.gov/research/hazmaps/design/. This resource presents the results of Probabilistic Seismic Hazard Analyses and is based on the current California Geologic Survey Statewide fault model. This source was used to obtain Peak Ground Acceleration (PGA) and spectral acceleration values of both a structural periods of 0.2 seconds (S_s) and 1.0 seconds (S_1). These values are for 5 percent critical damping and were determined for probabilities of exceedence of 10% in 50 years and for the Maximum Considered Earthquake (MCE), which is the 2% in 50 years earthquake, with a deterministic cap for characteristic earthquakes on known active faults in high seismic areas. The USGS values are appropriate for a site classified on the boundary between site class S_B and S_C. Accordingly, for the Bio Treater Tank, we have adjusted to account for the soil profile effects on ground shaking. The values used in our assessment are summarized in Table 2.

TABLE 2

Earthquake Ground Motion Parameters for Response Spectra Development

Shell Refinery Waste Boiler-CO Boilers		
Latitude 38.016N	**Longitude 122.115W**	**Site Class B-C[5]**
Adjustment not required for Site Class B-C		
Event Frequency	**10% in 50 Years**	**2/3 of MCE**
PGA	0.54	0.42
S_S	1.28	1.04
S_1	0.45	0.40

Shell Refinery Waste Boiler-Bio-Treater Tank		
Latitude 38.02N	**Longitude 122.125W**	**Site Class E**
Adjusted for Site Class E		
Event Frequency	**10% in 50 Years**	**2/3 of MCE**
PGA	0.45	0.37
S_{ES}	1.13	0.91
S_{E1}	1.05	0.96

3.3 Site Class

Site classification for seismic design based on the soil profile, as specified in CalARP, is defined in 1997 UBC and is consistent with that outlined in FEMA 356 (Seismic Rehabilitation Prestandard). Various soil parameters are used to categorize a site, and a summary of the relevant profile types from 1997 UBC are listed in Table 3.

[5] We have assumed site class B for seismic design purposes. The site class is on the borderline between B and C, however, the NEHRP procedure for developing a design spectrum does not interpolate.

TABLE 3

Soil Profile Types for Site Categorization.

Site Class	Soil Profile Type
S_A	Hard rock with measured shear wave velocity, V_s>5,000 ft/s.
S_B	Rock with 2,500 ft/sec < V_s ≤ 5,000 ft/s.
S_C	Very dense soil and soft rock with 1,200 ft/s < V_s ≤ 2500 ft/s.
S_D	Stiff soil with 600 ft/s ≤ V_s ≤ 1,200 ft/s.
S_E	A soil profile with V_s < 600 ft/s. Or any profile with more than 10 ft of soft clay.
S_F	Soils requiring site-specific evaluation: 1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. 2. Peats and/or highly organic clays (H > 10 ft of peat and/or highly organic clay where H = thickness of soil). 3. Very high plasticity clays (H > 25 ft). 4. Very thick soft/medium stiff clays (H > 120 ft).

The CO Boilers site is underlain by bedrock which has an estimated shear wave velocity varying from 1,500 to 5,000 feet per second. Accordingly, the CO Boilers site is a borderline S_B to S_C site class.

The Bio Treater Tank T-12038 site is underlain by up to 25 feet of soft and compressible Bay Mud. The Bay Mud contains peat layers up to 10 feet thick. The Bay Mud also contains loose sand layers which are up to 5 feet thick. These sand layers are susceptible to liquefaction, as discussed in a subsequent section of this report. Accordingly, the Bio Treater Tank site is a borderline S_E to S_F site class.

3.4 Adjustments for Soil Profile

For the CO Boilers site, no adjustment to the PGA or spectral acceleration values based on the soil profile was conducted, since the site is classified as S_B to S_C. Site amplification effects for the tank site were taken into account using the procedures described in FEMA 356 1.6.1.4 for a site classification of S_E. The adjusted values are also presented in Table 2.

3.5 General Response Spectrum

The general horizontal acceleration response spectra for the each site were developed in accordance with FEMA 356 1.6.1.5 and are presented on Figures 6 and 7. The spectrum recommended for an Earthquake Hazard Level BSE-1 (Basic Safety Earthquake 1) is the lower of the spectra associated with the 10% in 50 years values or 2/3 of the MCE. As shown on Figures 6 and 7, the BSE-1 Hazard Level is governed by the 2/3 MCE earthquake event.

3.6 Fault Rupture

In accordance with the Alquist-Priolo Special Study Zone Act of 1972, the State Geologist is required to delineate "special studies zones" along known active faults in California. The latest fault maps were reviewed on the California Geological Survey web site at http:/www.consrv.ca.gov/cgs/rghm/ap/index.htm. Review of theses maps indicates that neither site is within a special studies zone. In May of 1989, Shell Oil Company, Martinez, California retained Woodward Clyde Consultants, who prepared a report, *Evaluation of Holocene Faulting in the Vicinity of the CO Boiler Waste Feed*, which treats the area where the Bio Treater Tank is currently situated. No evidence of Holocene fault displacement near the site was found at this time. A copy of the report is included in Appendix B as evidence.

In a seismically active area, the 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 is low. We therefore conclude the risk of fault offset at the site from a known active fault is very low.

3.7 Liquefaction

Liquefaction is a phenomenon in which saturated (submerged), cohesionless soil experiences a temporary loss of strength because of the buildup of excess pore water pressure, especially during cyclic loadings such as those induced by earthquakes. Soil most susceptible to liquefaction is loose, clean, saturated, uniformly graded fine-grained

sand. Flow failure, lateral spreading, differential settlement, loss of bearing, ground fissures, and sand boils are evidence of excess pore pressure generation and liquefaction.

The CO Boilers site is underlain by bedrock which consists of dense cemented sandstone and siltstone and shale. The rock has standard penetration blow counts typically in excess of 100 blows per foot. These materials are not susceptible to liquefaction. In addition, a subsurface drainage system was installed throughout the entire LOP area to prevent the build up of groundwater within the engineered fill placed to develop the site. While the engineered fill in the LOP area is not only dense, it is also unlikely to become saturated due to the presence of the subsurface drainage system. Both of these factors lead us to conclude that the engineered fill is not susceptible to liquefaction. Therefore, we conclude the risk of liquefaction at the CO Boilers site is nil.

The Bay Sediments underlying the Bio Treater Tank T-12038 site contain layers of loose, fine to medium grained sand that are situated below the local groundwater table. Using the guidelines outlined in Special Publication 117, we conclude that these sand layers are susceptible to liquefaction during a moderate to strong earthquake. A numerical analysis of liquefaction triggering in these layers is presented in Appendix C using the Special Publication 117 referenced procedures.

Liquefaction of these materials may result in ground surface settlement due to volumetric strain. We estimate this settlement will be on the order of one inch as shown in Table 4.

TABLE 4

Liquefaction Induced Volumetric Strain and Associated Ground Surface Settlement[6]
Bio Treater Tank

Ishihara/Yoshimine (1990)							
Boring ETP 32							
Sublayer	Depth Range [ft]	(N1)60cs [blows/ft]	1.1x(N1)60cs [blows/ft]	FS[7]	Volumetric Strain	Sublayer Thickness [ft]	Delta H [in.]
1	0 to 3	104	115	-	Negligible	3	-
2	3 to 9	23	25	0.78	1.5%	6	1.1
3	9 to 15	12	13	-	Negligible	6	-
4	15 to 19	63	69	-	Negligible	4	-
5	19 to 24	28	30	-	Negligible	5	-
6	24 to 32	30	33	-	Negligible	8	-
7	32 to 35	23	25	-	Negligible	3	-
8	35 to 37	22	24	-	Negligible	2	-
9	37 to 50	49	54	-	Negligible	13	-
10	50 to 52	48	52	-	Negligible	2	-
						Total	1.1

The risk of tank settlement is mitigated by the pile foundations which support the tanks. For structures in the Effluent Treatment Plant area, which include the Bio Treater Tank area the 1991 Bechtel report concludes that:

"If liquefaction develops in this area, it is expected to be local in extent, and will not be a design concern for pile-supported structures. Potential effects would be some local surface settlement. Permanent lateral movements or ground lurching is not anticipated."

We concur with Bechtel's assessment provided that the pile foundations supporting the tanks are designed to accommodate downdrag forces due to settlement. In this case Liquefaction settlement is expected to be small in comparison to settlement caused by Bay Mud and Peat compression, which have likely been taken into account in pile design.

[6] Calculations based on 2% in 50 years level earthquake event.
[7] Factor of Safety for non-susceptible materials not calculated. Factor of safety for liquefiable layer based on average layer soil properties.

3.8 Lateral Spreading

Since the risk of liquefaction at the CO Boilers site is nil, lateral spreading is not a risk at this site. Additionally, the Bio Treater Tank site is essentially level and there are no shorelines, creek banks or other topographic depression near the tank site. Therefore we conclude the risk of lateral spreading at this site is very low.

3.9 Seismic Densification Settlement

Seismic densification can occur during strong ground shaking in loose, clean granular deposits above the water table (non-saturated), resulting in ground surface settlement. The sandstone and shale bedrock encountered at the CO Boilers site is very dense and cemented. As a result, it is not susceptible to seismic densification settlement. At the Bio Treater Tank site the soil layers above the groundwater table are typically less than 5 feet thick and consist primarily of clayey soils which are not susceptible to seismic densification settlement. Therefore, we estimate that the risk of seismic densification settlement at the Bio Treater site is very low and at the CO Boilers Site is nil.

3.10 Seismically Induced Landsliding

Both sites are relatively level and there are no significant topographic features in the vicinity. Accordingly we conclude that the risk of seismically induced landsliding is nil.

3.11 Tsunamis

A tsunami is a sea wave produced by an offshore earthquake, volcanic eruption, or landslide. Tsunamis are difficult to observe in the open ocean because they have relatively low wave heights (typically less than 10 feet) and travel extremely quickly (up to 500 miles per hour). Tsunamis can be exceedingly destructive when reaching coastlines and are capable of rising to 100 feet in height and moving at 30 miles per hour. The San Francisco Bay coastline is partially protected from inundation and damage associated with tsunamis because of the restricted hydraulic access at the Golden Gate. Wave energy that enters the mouth of the Gate would be expected to attenuate as it moves into the open water of the Bay. Estimates of wave run-up at Martinez have not

been made; a 2-foot run-up has been estimated at the mouth of Carquinez Strait near Vallejo[8]. The Contra Costa County General Plan indicates that wave run-up east of the mouth of Carquinez Strait is considered insignificant. As a result we conclude that the risk of tsunamis impacting either site is nil.

[8] Ritter, J., Dupre, W., 1972. Maps Showing Areas of Potential Inundation of Tsunamis in the San Francisco Bay Region, California, Department of the Interior, US Geological Survey, Misc. Field Studies, MF480.

4. RECOMMENDATIONS

4.1 CO Boilers

Foundation design criteria for the CO Boilers are presented in the Soil Investigation Report for the Tank Farm and Vine Hill Area 1A prepared by Woodward-Clyde-Sherard and Associates in 1964 (Reference 1). We recommend acceptance of the foundation design criteria as specified in the original soils report.

The site is in a cut area and the following foundation criteria are applicable from the original soil report.

Foundation type:	Spread footings or mat foundation
Minimum footing embedment:	2 feet

Allowable Bearing Pressure

Dead Load:	7500 psf
Dead plus Live Loads	10,000 psf
All loads including wind or seismic:	13,000 psf

The original soils report does not present criteria for evaluating the lateral resistance of foundations. However, given the subsurface conditions we have developed the following criteria assuming that the foundations are supported on bedrock and are backfilled with compacted fill.

Lateral loads can be resisted by a combination of passive pressure acting on the vertical faces of the footings and friction along the bases of the footings. Passive resistance may be calculated using an equivalent fluid weight (triangular distribution) of 350 pounds per cubic foot (pcf). The upper one-foot of soil should be ignored unless it is confined by slabs or pavement. Frictional resistance should be computed using a base friction coefficient of 0.40. These values include a factor of safety of about 1.5. Calculations for these parameters are given in Appendix D.

4.2 Bio Treater Tank

The Bio Treater Tank is supported on pile foundations as shown on the foundation plans by Shell in Appendix B. The foundations consist of tapered 12-inch diameter driven timber piles. Based on the soil conditions in the Bio Treater Tank area, we have computed vertical downward pile capacities for the timber piles as shown on Figure 8. The pile capacity chart presents anticipated downdrag loads due to settlement of the peat and bay mud layer as well as accounting for liquefaction related settlement during an earthquake event. Ultimate capacity values without a factor of safety are given.

Lateral capacities of the piles were also evaluated. The attached Figure 9 presents the results of lateral pile analyses using the program COM 624P. A commercial pre- and post- processing program was used to manage the input and output of the data. The program models the structural properties of the pile, as well as soil response using a family of nonlinear curves, termed p-y curves, which relate soil resistance and pile deflection at various depths along the pile shaft. In developing the p-y curves for the sands within the Bay Sediments we used residual strengths associated with liquefaction to account for seismic effects. A full set of input parameters and associated results for these pile calculations are included in Appendix E. The capacity values are given without a factor of safety.

5. PROFESSIONAL SERVICES

Our services consist of professional opinions, conclusions, and recommendations that are made in accordance with generally accepted geotechnical engineering principles and practices. This report is based on our review of limited existing subsurface investigation and variations may exist and conditions not observed or described in this report. This report is intended for use by HPA, Shell Oil, and DTSC for specific application to the proposed Hazardous Waste Facility Permit Part B Permit Renewal CO Boilers and Bio Treater Tank T-12038 at the Shell Martinez Refinery in Martinez, California as described herein.

6. BIBLIOGRAPHY

California Department of Transportation, Federal Highway Administration

1995 Supplemental Draft Environmental Impact Report/Environmental Impact Statement. Benicia-Martinez Bridge Project. Contra Costa and Solano Counties, California. March 1995.

1997 Final Environmental Impact Report/Environmental Impact Statement. Benicia-Martinez Bridge Project. Contra Costa and Solano Counties, California. August 1997.

California State Lands Commission (CSLC)

2002 Marine Oil Terminal Engineering and Maintenance Standards (MOTEMS), May 2002. (Proposed)

California Department of Conservation, Division of Mines and Geology, 1997, "Guidelines For Evaluating and Mitigating Seismic Hazards in California," CDMG Special Publication 117.

Caltrans

1996A Technical Report to Accompany the Caltrans California Seismic Hazard Map 1996 (Based on Maximum Credible Earthquakes).

Contra Costa County

1975 "Seismic Safety Element," Public Hearing Draft, Prepared by Contra Costa County Planning Department, August.

Dames & Moore

1955 "Preliminary Site Investigation Proposed Land Development Between Martinez and Avon, California for the Utah Construction Company."

Ben C. Gerwick

2001 "MOTERP, Seismic Evaluation of Shore Terminal, Martinez, California." Prepared for California State Lands Commission, January 2001.

Harold B. Goldman

1969 "Geology and Engineering Aspects of San Francisco Bay Fill," Special Report '97, California Division of Mines and Geology, San Francisco.

Hart, E.W. and Bryant, W. A.

1997 "Fault-rupture hazard zones in California," Alquist-priolo earthquake fault zoning act with index to earthquake fault zones maps, Div. of Mines and Geology, Sacramento, California, Special publication 42.

Petersen, M. D., Bryant, W.A., Cramer, C.H., Cao, T., Reichle, M.S., Frankel, A.D.,

Lienkaemper, J.J., McCrory, P.A., and Schwartz, D.P.
1996 Probabilistic seismic hazard assessment for the State of California: California Division of Mines and Geology Open-File Report issued jointly with U.S. Geological Survey, CDMG 96-08 and USGS 96-706.

Ritter, J.R. and Dupre, W.R.
1972 Maps Showing Areas of Potential Inundation by Tsunamis in the San Francisco Bay Region, California, Department of Interior, United States Geological Survey, Miscellaneous Field Studies MF 480.

Toppozada, T.R., C.R. Real, and D.L. Parke
1986 Earthquake History of California: California Geology, February 1986, 27-33, 1986.

Trask, P. and Rolston, J. W.
1951 "Engineering geology of San Francisco Bay, California," Geol. Soc. America Bull., V. 62, pp. 1079-1109.

Treasher, R.C.
1963 "Geology of the sedimentary deposits in San Francisco Bay, California, "California Div. Mines and Geology Spec. Report 82, pp. 11-24.

Woodward-Lundgren & Associates
1973a "Preliminary Soil Investigation Report, UCO Terminal, Martinez, California", for Hallanger Engineers, Orinda, California, Project S-12785, April 2.

1973b "Soil Investigation for the Proposed Wharf and Trestle Structures, UCO Terminal, Martinez, California", for Hallanger Engineers, Orinda, California, Project S-12785, November 7.

1974a "Supplemental Foundation Recommendations Trestle Structure, UCO Terminal, Martinez, California", for Hallanger Engineers, Orinda, California, Project S-12785, January 16.

1974b "Geotechnical Investigation for the Proposed UCO Crude Oil Refinery, Martinez, California", for Hallanger Engineers, Orinda, California, Project S-12785B, May 31.

1974c "Evaluation of Dredged Materials UCO Terminal, Martinez, California", for Hallanger Engineers, Orinda, California, Project S-12785D, October 23.

Working Group on California Earthquake Probabilities
1990 Probabilities of Large Earthquakes in the San Francisco Bay Region, California: U.S. Geological Survey. Circular, 1053, 51 pp.

Working Group on Northern California Earthquake Potential
1996 Database of potential sources for earthquakes larger than magnitude 6 in northern California, U.S. Geological Survey, Open-File Report 96-705.

Federal Emergency Management Agency, FEMA-356, Nov. 2000, "Prestandard and Commentary for the Seismic Rehabilitation of Buildings," Washington, D.C.

California Geological Survey (formerly Division of Mines and Geology), 1998, "Probabilistic Seismic Hazard Map of California," (website: www.consrv.ca.gov/dmg/rghm/psha/index.htm), Sacramento, CA.

Southern California Earthquake Center (SCEC), March 1999, "Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California," University of Southern California, Los Angeles.

Stark, T.D., and Mesri, G., 1992, Undrained shear strength of liquefied sands for stability analysis, Journal of Geotechnical Engineering, American Society of Civil Engineers, v118, n11, pp 1727-1747.

Makdisi, F.I. and Seed, H.B., "Simplified Procedure for Estimating Dam and Embankment Earthquake-Induced Deformations", ASCE Journal of the Geotechnical Engineering Division, Vol 104, No. 7, pp. 849-867

Youd, T. L., Hansen, C. M., and Bartlett, S. F., Revised Multilinear Regression Equations for Prediction of Lateral Spread Displacement," J. Geotech. and Geoenvir. Engrg., Volume 128, Issue 12, pp. 1007-1017.

Youd, T. L., Chair, Member, ASCE, Idriss, I. M. Co-Chair, Fellow, ASCE; Andrus, Ronald D.; Arango, Ignacio; Castro, Gonzalo; Christian, John T.; Dobry, Richardo; Liam Finn, W. D.; Harder Jr. Leslie F.; Hynes, Mary Ellen; Ishihara, Kenji; Koester, Joseph P.; Liao, Sam S. C.; Marcuson III, William F.; Martin, Geoffrey R.; Mitchell, James K.; Moriwaki, Yoshiharu; Power, Maurice S.; Robertson, Peter K.; Seed, Raymond B.; and Stokoe II, Kenneth H, October 2001, "Liquefaction resistance of soils: Summary report from the 1996 NCEER and 1998 NCEER/NSF workshops on evaluation of liquefaction resistance of soils," ASCE Journal of Geotechnical and Geo-environmental Engineering, Vol 127, No. 10, pp. 817-833.

Shell Martinez- Geological Report

Disclaimer- The attachments are not posted at this time due to their large file size. These are available through the DTSC project manager.