8.4 GEOLOGICAL HAZARDS AND RESOURCES

This section presents an evaluation of potential impacts to geological resources and the potential geological hazards that might result from construction and operation of the Russell City Energy Center (RCEC) and the Advanced Wastewater Treatment (AWT) Plant and the associated linear facilities. Section 8.4.1 describes the existing environment that the project may affect. Section 8.4.2 identifies potential impacts on the environment associated with development of the RCEC. Section 8.4.3 discusses potential cumulative impacts, and Section 8.4.4 addresses proposed mitigation measures. Section 8.4.5 presents the laws, ordinances, regulations, and standards applicable to geological resources and hazards. Section 8.4.6 describes the agencies involved and provides agency contacts, and Section 8.4.7 describes permits required. Section 8.4.8 provides the references used to develop this section.

8.4.1 Affected Environment

8.4.1.1 Geologic Location

The project area, including the project site and associated linear facilities, is located along the eastern shore of South San Francisco Bay (Bay), which lies centrally within the Coast Ranges Physiographic Province of California. The Bay fills a northwest-trending structural depression in the central Coast Ranges and lies roughly between the San Andreas Fault to the west and the Hayward Fault to the east (Figure 8.4-1). The RCEC is located approximately 14 miles (22 km) from the San Andreas Fault and 3 miles (5 km) from the Hayward Fault.

8.4.1.2 Regional Geologic History

Basement rocks underlying the Bay area are those of the Franciscan Assemblage (50 to 200 million years old) and the Great Valley Sequence (65 to 150 million years old). These are generally overlain by rocks of Miocene age and younger that were deposited at the continental margin during the past 15 million years. Most of the rocks in the Bay area were folded and faulted as a result of early convergence of the North American and Pacific plates. About 10 million years ago, the tectonic regime in the Bay area changed from convergent to a transform boundary between the North American and the Pacific plates. In the Bay area, the relative horizontal (strike-slip) movement along this boundary is about 47 mm/yr, and is being distributed among the various faults of the San Andreas system. Over geologic time, the San Andreas Fault accommodates about 24 mm/yr of this movement, while the Hayward Fault accommodates about 9 mm/yr at Fremont (Petersen *et al.,* 1996).

In general, the Hayward Fault forms the boundary between two distinctly different geologic and geographic provinces. The hills on the east side of the fault are up to 10 million years old, but the flatlands on the west side are barely 10,000 years old. The Bay lies in a structural depression marked by downbowed and/or down-faulted sediment as young as middle Pleistocene. The Bay was formed during the Quaternary (last 2 million years). During the last major glaciation approximately 15,000 years ago, sea level was 330 feet (100 meters) lower than it is currently. At that time, the Bay contained no standing water, and the fluvial systems draining the surrounding hills emptied directly into the Sacramento-San Joaquin River, which flowed to the Pacific Ocean. The sea level began to rise as the ice from the great continental glaciers began to melt. The sea entered the Bay approximately 10,000 years ago, reaching its present level about 6,000 years ago.

After the Early Holocene sea level rise, sediments formerly carried far into the Pacific Ocean began to be deposited in and around the margins of the Bay. Most of the alluvial sediment in the vicinity of the project site was derived from Alameda Creek. Alameda Creek, with a drainage area of 633 square miles

(1640 kilo-meters), is the largest drainage basin contributing to the alluvial plains along the east side of the Bay and displays a well developed alluvial-fan system (Helley and Miller 1992). This system is the largest alluvial fan along the east side of the Bay and is up to 750 ft (225 m) thick. The fluvial system of Alameda Creek generated a complete, progressive suite of deposits: fan, levee, floodplain, flood basin, and Bay mud. At the turn of the century, Alameda Creek had two main distributary channels that bifurcated at the Coyote Hills, which lie approximately 4.6 miles (7.4 km) south of the project site. One channel flowed north and west around the north end of Coyote Hills, and the other flowed south and west, and reached the Bay south of Coyote Hills. Currently, only the north channel (Alameda Creek), is active, and is located approximately 2 miles (3.2 km) south of the site.

Over time, the rock basin of the Bay has been filled with silt, sand, and clay. "Older Bay mud" is the earliest material at the bottom of the Bay; it ranges in thickness from less than one foot to more than 200 feet (BCDC 1967). The older Bay mud consists of dark, plastic, semi-consolidated, organic-rich clay and silty clay, and interfingers with older alluvial fan deposits. The thickness of the older Bay mud increases toward the central portion of the Bay (BCDC 1967).

Overlying the older Bay mud is a sand layer and a layer of "younger Bay mud". The layer of younger Bay mud in some locales is as thick as 130 feet (BCDC 1967). Age of the younger Bay mud ranges from 2,500 to more than 7,000 years Before Present (BP).

8.4.1.3 Local Geology

The project site is located along the eastern shore of the Bay within the San Leandro and Newark 7.5 Minute U.S. Geological Survey (USGS) topographic quadrangles. This area is divided into four northwest-trending structural zones. From east to west, they are: (1) the Diablo Range, (2) a zone of alluvial fans grading west to alluvial plains, (3) the Coyote Hills, and (4) muds of San Francisco Bay (Helley and Miller 1992). The Hayward Fault separates structural zones 1 and 2, and faults inferred by Snetsinger (1976) bound both sides of the Coyote Hills. The site lies within Zone 4, the Bay Mud zone.

Coyote Hills (zone 3) is approximately 5 miles south of the site and appears as an elongate mass of contorted rocks that protrude through the sediments of the Bay plain. The Coyote Hills extend in a northwest-southwest direction for about 5 mi (8 km) and rise almost 300 ft (100 m) above sea level. The Hills represent a thin horst block of Franciscan Complex (bedrock) within the overall structural depression of the Bay (Helley and Miller 1992). The down-faulted block of bedrock on the northeast side of the hills is about 600 ft (200 m) deep under alluvial materials (Hazelwood 1976). The northern extension of the Silver Creek Fault was inferred by Snetsinger (1976) as the mechanism for down faulting. There is no other geomorphic or paleoseismic evidence for activity along this fault and consequently it is not considered to be active, i.e., there is no evidence of seismic activity within the last 11,000 years (Holocene).

The Hayward Fault is one of several northwest-trending strike-slip faults associated with right-lateral tectonic movement between the North American and Pacific Plates. The Hayward Fault forms the east boundary of the alluvial fans and plains (zone 3) in the Hayward and Newark quadrangles (Hall 1958; Lienkaemper *et al.* 1991).

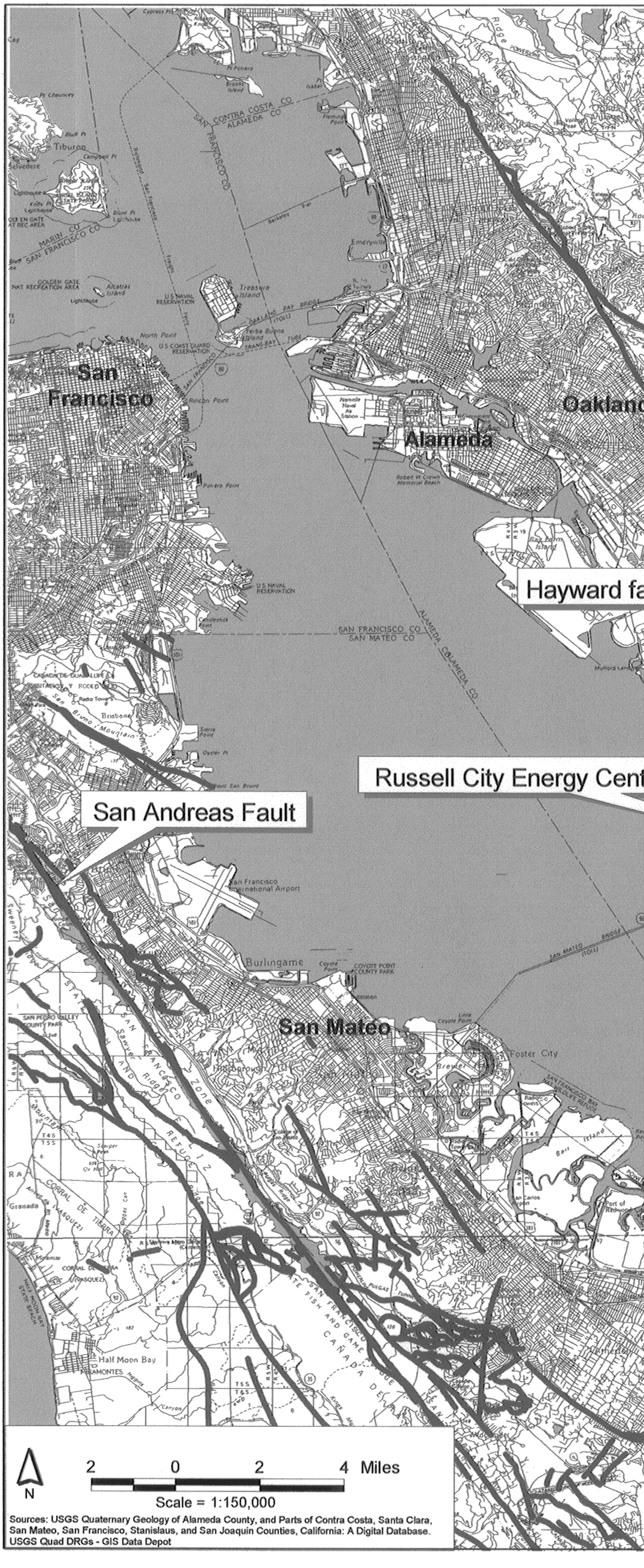

Figure 8.4-1

Earthquake Faults

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8.4.1.4 Seismic Setting

The project site is located in a seismo-tectonically active region. Table 8.4-1 identifies all active faults that may pose a potential geologic hazard to the RCEC (Petersen *et al.*,1996). Active faults are those that show evidence of displacement during Holocene time (11,000 years ago to present). In addition, Table 8.4-1 identifies the approximate distance from the RCEC, nature of displacement, slip rate, maximum moment magnitude (M), recurrence interval, location and various other characteristics unique to each fault.

As shown in Table 8.4-1, the San Andreas Fault and Hayward Fault are close to the site and are classified as "A" type faults. Faults with an "A" classification are capable of producing large magnitude events (M $\geq$ 7.0), have a high rate of seismic activity (i.e., having slip rates greater than 5 mm/yr), and have well constrained paleoseismic data (i.e., evidence of displacement within the last 700,000 years). Table 8.4-1 also lists "B" class faults, which lack paleoseismic data necessary to constrain the recurrence intervals of large-scale events. Faults with a "B" classification are capable of producing an event of magnitude 6.5 or greater. The San Andreas Fault and Hayward Fault systems are historically the most active of those listed in Table 8.4-1 and, because of their proximity to the site, they present the greatest seismic hazard.

Hayward Fault Zone

The project site is located approximately 3 miles (5 km) west of the Hayward Fault Zone. The Hayward Fault Zone consists of one known active strand and as many as three sub-parallel strands that generally lie east of the active strand. The active strand is marked by shutter ridges, offset streams, and cultural features such as offset railroad tracks, roads, sidewalks, and building foundations; and active creep. Evidence for parallel fault strands in the eastern part of the fault zone is less abundant. For the most part, the fault traces are defined by linear features such as topographic benches and narrow ridges (USGS 1970).

The Hayward Fault Zone is the southern segment of an extensive fracture zone consisting of the Hayward Fault and the Rodgers Creek, Healdsburg, and Macama fault segments. The zone extends northwest to Mendocino County, a total distance of 175 miles (280 km). A 53-mile- (86 km-) long Hayward Fault segment extends from San Pablo Bay to an obscure convergence with the Calaveras fault near Mount Misery east of San Jose, California.

Several segments of the Hayward Fault are undergoing fault creep, a very gradual horizontal displacement that occurs both episodically and continuously (Lienkaemper *et al.* 1991). While fault creep has been documented along many segments of the Hayward Fault between San Pablo and Fremont, it has not been observed along all segments throughout the fault's length. The displacement is almost purely right-lateral although small segments have a vertical component of displacement.

San Andreas Fault

The project site is located approximately 14 miles (22 km) northeast of the San Andreas Fault. The San Andreas Fault is part of a complex system of faults, isolated segments of the East Pacific Rise, and scraps of tectonic plates lying east of the East Pacific Rise that collectively separate the North American plate from the Pacific plate (Wallace 1990). Relative movement between the Pacific and the North American tectonic plates dominates the regional seismo-tectonic setting. The boundary between the Pacific and North American tectonic plates extends from the Rivera triple junction, south of Baja California,

Table 8.4-1. Active faults in the project area.

FAULT NAME AND GEOMETRY (ss) strike slip, (r)reverse, (n) normal (rl) rt. lateral, (ll) left lateral, (o) oblique	Distance from RCEC (km)**	Length (km)	Slip Rate (mm/yr)	Rank (1)	Mmax (2)	R.I. (3)	Rake	dip	Endpt. N	Endpt. S	Comment
A FAULTS											
SAN ANDREAS FAULT ZONE											
San Andreas (Peninsula) (rl-ss)	22	88	17.00	M	7.1	400	180	90	-122.60;37.81	-122.60:37.18	Slip rate is based on Clahan, et al. (1995) and assumptions by WGNCEP (1996). Max. magnitude base on 1.6 m displacement.
San Andreas (1906) (rl-ss)	22	470	24.00	M	7.9	210	180	90	-121.41;40.25	-121.51;36.82	Slip rate based on Neimi and Hall (1992) and Prentice, et al (1991). Assumption that 1906 events rupture North Cost, Pennisula, and Santa Cruz Mtns. Segments to San Juan Bautista. Max magnitude based on 1906 average 5 m dispacement (WGCEP, 1990: Liekaemper, 1996)
HAYWARD – RODGERS CREEK FAULT ZONE											
Hayward (total length) (rl-ss)	5	86	9.00	M-W	7.1	167	180	90	-122.41; 38.05	-121.81; 37.45	Well constrained slip rate for southern segment reported by Lienkaemper, et al. (1995) and Lienkaemper and Borchardt (1995). Recurrence (167 yrs) and slip per event (1.5 m) are based on WGCEP (1990). Model weighted 50%.
Hayward (south) (rl-ss)	5	43	9.00	W	6.9	167	180	90	-121.13; 37.73	-121.81; 37.45	Well constrained slip rate reported by Lienkaemper, et al. (1995) and Lienkaemper and Borchardt (1996). Recurrence (167 yrs) and slip per event (1.5 m) are based on WBCEP (1990). The southern segment can be projected to Calaveras fault along prominent zone of seismicity. Net slip rate of 9 mm/yr can be resolved into 3 mm/yr vertical and 7.6 mm/yr r.l. along postulated Mission Link blind thrust of Andrews, et al (1992) along with southern connection. Model weighted 50%.
Hayward (north) (rl-ss)	20	43	9.00	M	6.9	167	180	90	-122.41; 38.05	-122.13; 37.73	Well constrained slip rate for southern segment reported in Lienkaemper, et al. (1995) and Lienkaemper and Borchardt (1996). Recurrence (167 yrs) and slip per event (1.5 m) are based on WGCEP (1990). Model weighted 50%

Table 8.4-1. (continued).

FAULT NAME AND GEOMETRY (ss) strike slip, (r)reverse, (n) normal (rl) rt. lateral, (ll) left lateral, (o) oblique	Distance from RCEC (km)**	Length (km)	Slip Rate (mm/yr)	Rank (1)	Mmax (2)	R.I. (3)	Rake	dip	Endpt. N	Endpt. S	Comment
Rodgers Creek (rl-ss)	65	63	9.00	M	7.0	222	180	90	-122.77; 38.54	-122.34; 38.09	Slip rate is composite of slip rate reported by Schwartz, et al. (1992) and slip rate from Hayward fault (Lienkaemper and Borchardt, 1996). Recurrence (222 yrs) and slip per event (2.0 m) are based on WGCEP (1990).
B FAULTS											
SAN GREGORIO-HOSGRI FAULT ZONE											
Hosgri (rl-ss)	40	172	2.50	M-P	7.3	646	180	90	-121.73; 36.15	-120.69; 34.86	Slip rate based on San Simeon fault slip rate reported in Hanson and Lettis (1994).
San Gregorio (Sur region) (rl-ss)	40	80	3.00	P	7.0	411	180	90	-122.16; 36.81	-121.74; 36.18	Late Qt. Slip rate of 1-3 mm/yr based on assumed transfer of slip from Hosgri flt. Slip rate from San Simeon flt. (Hanson and Lettis (1994) and Hall et al (1994).)
San Gregorio (rl-ss)	50	129	5.00	P	7.3	400	180	90	-122.67; 37.89	-122.13; 36.81	Weber and Nolan (1995) reported Holocene slip rate of 3-9 mm/yr; latest Pleistocene slip rate of 5 mm/yr (min) and lt. Qt. Slip rate of about 4.5 mm/yr reported by Simpson, et al. (written communication to J. Lienkaemper, 1995).
CALAVERAS FAULT ZONE											
Calaveras (s. of Calaveras Reservoir) (rl-ss)	20	106	11	P-M	6.2	33	180	900	-121.79; 37.43	-121.18; 36.62	Includes Paicines fault south of Hollister. Slip rate is composite based on slip rate for a branch of Calaveras fault reported by Perkins & Sims (1988) and slip rate of Paicines fault reported by Harms, et al. (1987). Creep rate for fault zone approximately 15 mm/yr. Maximum earthquake assumed to about 5.2 (Oppenheimer, et al., 1990).
Calaveras (north of Calaveras Reservoir) (rl-ss)	15	52	5	M	6.8	146	180	90	-122.03; 37.86	-121.81; 37.45	Slip rate based on composite of 5 mm/yr rate reported by Kelson, et. al (1996) and 6 mm/yr creep rate from small geodetic net reported by Prescott and Lisowski (1983).

Table 8.4-1. (continued).

FAULT NAME AND GEOMETRY (ss) strike slip, (r)reverse, (n) normal (rl) rt. lateral, (ll) left lateral, (o) oblique	Distance from RCEC (km)**	Length (km)	Slip Rate (mm/yr)	Rank (1)	Mmax (2)	R.I. (3)	Rake	dip	Endpt. N	Endpt. S	Comment
BAY AREA											
Concord-Green Valley (rl-ss)	60	66	6.00	M	6.9	176	180	90	-122.20; 38.45	-121.98, 37.89	Moderately constrained slip rate for Concord fault based on Snyder, et al. (1995). Slip rate of 6 mm/yr should be considered a minimum. No slip rates reported for Green Valley fault.
Greenville (rl-ss)	40	73	2.00	P	6.9	521	180	90	-121.94; 37.98	-121.50; 37.42	Wright, et al (1982) reported a slip rate of about 1 mm/hr, based on an offset stream channel. A 10 km rl offset of a serpentinite body suggests a long term slip rate of 2-3 mm/yr.
Hayward (SE extension) (rl-r-o)	5	26	3.00	U	6.4	220	180	90	-121.90; 37.47	121.72; 37.28	Unconstrained slip rate based on slip budget between adjacent Calaveras flt. and assumed major slip junction of Calaveras and Hayward flt. (WGNCEP, 1996). Possible significant reverse component not considered.
Monte Vista-Shannon (r 45, E)	45	41	0.40	P-M	6.8	2410	90	45	-122.19; 37.38	-121.79; 37.21	Poorly constrained slip rate based on vertical separation of late Pleistocene terrace and assumptions of age of terrace (23-120 ka) and flt. Dip reported by Hitchcock, et al. (1994). Actual dip and fault width is variable. 15 km width approximates average.
Ortigalita (rl-ss)	45	66	1.00	P	6.9	1153	180	90	-121.28; 37.28	-120.91; 36.76	Poorly constrained slip rate based on vertical slip rate reported by Clark, et al (1984) (0.01-0.04 mm/yr), assumptions regarding H:V ratio, and geomorphic expression of flt. Consistent with about 1 mm/yr.
Point Reyes (r, 50 NE)	90	47	.030	P	6.8	3503	90	50	-123.24; 38.18	-122.83; 37.94	Poorly constrained long term (post-Miocene) slip rate based on vertical offset of crystalline basement (McCulloch, 1987).
Quien Sabe (rl-ss)	40	23	1.00	P	6.4	647	180	90	-121.36; 36.93	-121.21; 36.76	Poorly constrained slip rate estimated by authors based on vertically offset alluvial fan (Bryant, 1985) and assumptions regarding H:V ratio (6:1 to 14:1) based on 26JAN86 M5.8 earthquake (Hill et al, 1990) and age of fan surface based on soil profile development.

Table 8.4-1. (continued).

FAULT NAME AND GEOMETRY (ss) strike slip, (r)reverse, (n) normal (rl) rt. lateral, (ll) left lateral, (o) oblique	Distance from RCEC (km)**	Length (km)	Slip Rate (mm/yr)	Rank (1)	Mmax (2)	R.I. (3)	Rake	dip	Endpt. N	Endpt. S	Comment
Sargent (rl-r-o)	45	53	3.00	P	6.8	1200	180	90	-121.94; 37.14	-121.45; 36.87	Slip rate is rl. Creep rate reported by Prescott and Burford (1976). Nolan, et al. (1995) reported a minimum Holocene rl slip rate of 0.6 mm/yr in Pajaro River area, found evidence suggesting 0.8m of rl offset and a recurrence interval of about 1.2 ka. However, the penultimate event about 2.9 ka was characterized by about 1.7m of rl offset, suggesting max. earthquake of M 6.9. Recurrence of 1.2 ka used, but further work necessary to resolve maximum magnitude, slip rate, and recurrence.
West Napa (rl-ss)	55	30	1.00	U	6.5	701	180	90	-122.37; 38.41	-122.24; 38.16	Unconstrained slip rate based on assumption that geomorphic expression of fault is consistent with about 1 mm/yr slip rate (WGNCEP, 1996).
Zayante-Vergeles (rl-r)	48	56	0.10	P	6.8	8821	180	90	-121.97; 37.09	-121.46; 36.79	Slip rates reported by Clark, et al (1984).

(1) W = well-constrained slip rate; M = moderately constrained slip rate; P = poorly constrained slip rate.
(2) Maximum moment magnitude calculated from relationships (rupture area) derived by Wells and Coppersmith (1994)
(3) R.I. = recurrence interval
* Data from Petersen et al., 1996. Probabilistic Seismic Hazard Assessment for the State of Califonia.
** Approximate distance.

northwards to the Mendocino triple junction. Atwater (1970) and, more recently, Irwin (1990) describe the evolution of the Pacific-North American plate boundary. For much of the length of the plate boundary, and certainly for the site region, the San Andreas Fault functions as a transform fault (tectonic plate boundary) with strike-slip displacement (Wilson 1965).

Local Seismicity

Earthquakes in the San Francisco Bay area during the past 15 years are concentrated near the juncture of the San Andreas Fault and Calaveras faults, and in the East Bay area. Seismicity along the San Andreas Fault on the San Francisco Peninsula is relatively low compared to the Calaveras-Hayward-Rogers Creek Fault Zone. On the Hayward Fault, small earthquakes are common throughout most of the fault length through San Pablo southeast to Fremont. South of Fremont, the Hayward Fault is seismically quiet. The seismicity, however, continues along a zone trending more southeasterly, denoting an active connection with the Calaveras fault near the Calaveras Reservoir. On the Calaveras fault north of this juncture there is no obvious correlation between seismicity and the mapped trace of the Calaveras fault. This high level of seismic activity present along the Calaveras fault south of Calaveras Reservoir transfers to the Hayward Fault near Fremont (USGS 1987).

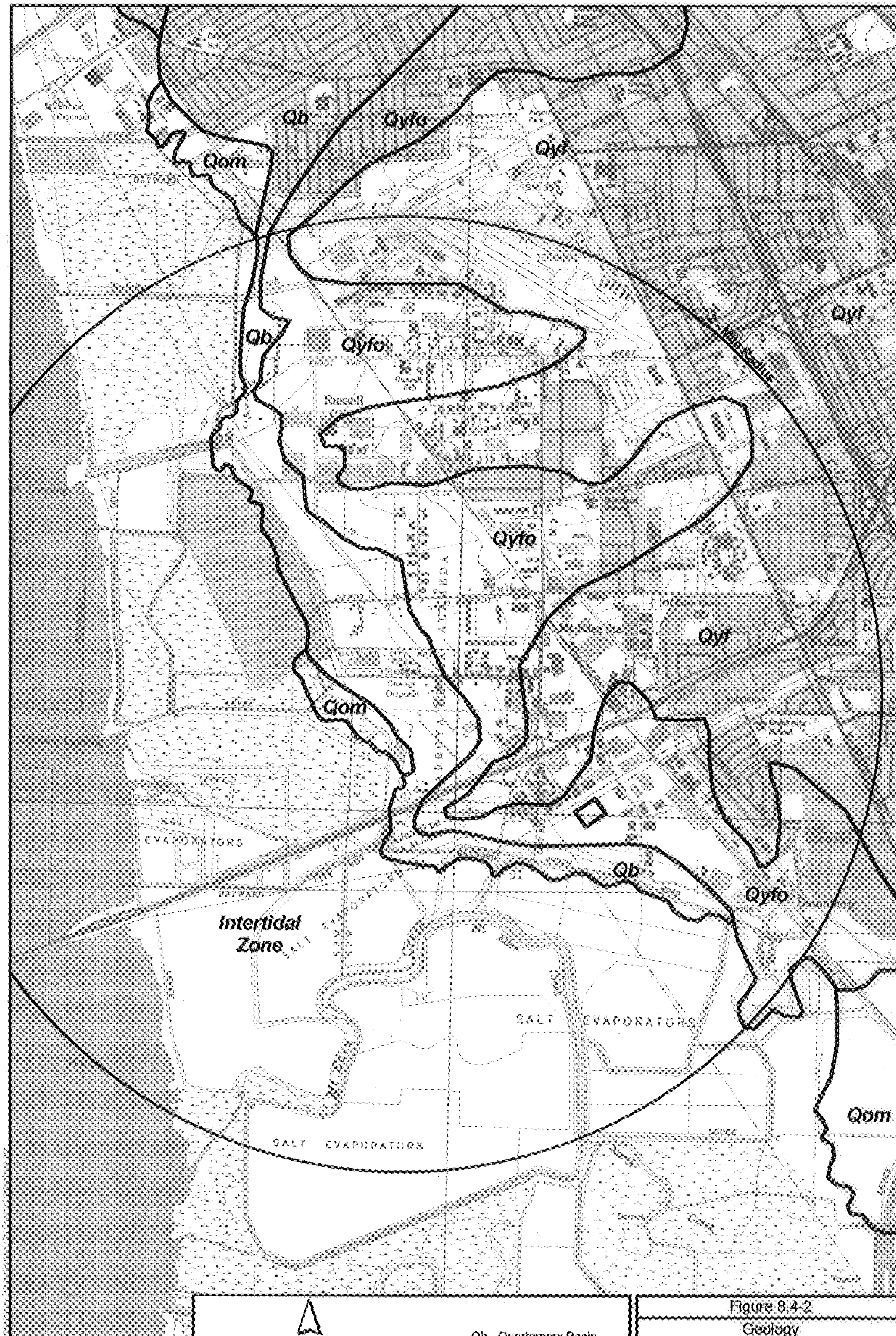
Earthquake History

A number of moderate to great earthquakes (greater than a M6) have affected the Bay Area; 22 such events have occurred in the last 160 years, averaging one every seven years. Earthquakes of magnitudes greater that 6 have occurred within 30 kilometers of the Hayward Fault in 1836, 1858, 1864, 1865, 1868, 1898, 1906, 1911, 1984, and 1989. Only the 1836 and 1868 events caused surface rupture of the Hayward Fault. Earthquakes of magnitude greater than 5.0 that have occurred within 62 miles (100 km) of the site are identified in Table 8.4-2. Historically, more earthquakes greater than magnitude 5 have occurred on the Calaveras-Hayward-Rogers Creek zone than on the adjacent segment of the San Andreas Fault.

8.4.1.5 Site Geology

Figure 8.4-2 is depicts the geology beneath the project site and transmission and gas pipeline routes (Helley, et al., 1972). On a regional scale, the project features are underlain by unconsolidated Holocene (Q) inter-tidal and alluvial fan, basin, and plain deposits, ranging from clay to gravel in particle size. As shown on Figure 8.4-2, the project site and electric transmission line, and water and gas pipeline routes are underlain by fine grain infterfluvial basin deposits (Qb), medium grain younger fluvial fan and plain deposits (Qyfo), coarse grain younger alluvial fan and basin deposits (Qyf), and fine grain older Bay Mud deposits (Qom). The RCEC is located in the flood basin zone and is underlain by Qb deposits.

The interfluvial basin fine grain deposits (Qb) consist of plastic, poorly sorted, organic-rich clay and silty clay and locally contains thin beds of well-sorted silt, sand, and fine gravel and that interfingers with the younger fluvial deposits (Qyfo). The Qyfo deposits consist of loose, moderately sorted fine to medium sand, silt, and silty clay and that interfingers with the younger alluvial fan deposits (Qyf). The Qyf deposits consist of unconsolidated, moderately sorted, permeable fine sand and silt with gravel becoming more abundant toward fan heads, located east of the site. The physical properties of the sediments underlying the project site and pipeline route are summarized in Table 8.4-3.



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2000 0 2000 Feet
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Sources: Helley, et al., 1972. USGS Quad DRG - GIS Data Depot

Qb - Quarternary Basin
Qom - Older bay mud
Qyfo - Younger fluvial fan
Qyf - Younger fan

Figure 8.4-2
Geology
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Table 8.4-2. Earthquakes within 100 km of the project area.

Distance[3] (Km)	Source[1]	Date						Location		Local Magnitude	Maximum[2] Intensity
		Year	Month	Day	Hour	Minute	Second	Latitude	Longitude		
3	DNA	1864	05	21	02	01	0.04	37.500	122.000	5.80	
11	DNA	1858	11	26	08	35	0.04	37.500	121.900	6.30	
14	CCN	1999	04	23	16	43	43.2	37.387	122.037	5.40	
20	DNA	1868	10	21	15	53	0.04	37.700	122.100	6.80	
23	USN	1955	09	05	02	01	18.0	37.400	121.800	5.8	VII
24	CCN	1989	04	03	17	46	34.2	37.432	121.770	5.00	
28	CCN	1988	06	13	01	45	36.5	37.393	121.740	5.00	
34	DNA	1838	06	--	--	--	4	37.600	122.400	7.00	
34	DNA	1836	06	10	15	30	0.04	37.800	122.200	6.80	
34	DNA	1856	02	15	13	25	0.04	37.600	122.400	5.90	
36	ISC	1986	03	31	11	55	39.1	37.525	121.617	5.60	
36	SIG	1980	01	24	19	0	0	37.800	121.800	5.90	VII
36	BRK	1984	04	24	21	15	19.0	37.320	121.700	6.20	
37	ISC	1980	01	27	02	33	34.9	37.776	121.753	5.00	
37	SIG	1984	04	24	21	15	0	37.300	121.700	6.20	VII
38	T-A	1911	07	01	22	0	0	37.250	121.750	6.60	
39	CCN	1990	04	07	02	39	17.50	37.876	121/979	5.09	
41	DNA	1935	09	10	23	55	0.04	37.850	122.250	5.00	
42	CCN	1989	08	08	08	13	27.4	37.145	121.927	5.00	
45	BRK	1988	06	27	18	43	22.3	37.131	121.878	5.30	
46	USN	1957	03	22	19	44	21.0	37.700	122.500	5.30	VII
50	SIG	1989	10	18	0	04	0	37.100	121.800	7.10	IX
52	PDE	1989	10	25	01	27	26.6	37.078	121.832	5.00	
52	DNA	1808	06	21	0	0	0.04	37.800	122.500	6.30	

Table 8.4-2. (continued)

Distance[3] (Km)	Source[1]	Date						Location		Local Magnitude	Maximum[2] Intensity
		Year	Month	Day	Hour	Minute	Second	Latitude	Longitude		
53	USN	1955	10	24	04	10	44.0	38.000	122.000	5.40	VII
56	PDE	1989	10	18	0	25	04.9	37.043	121.807	5.0	
57	DNA	1926	10	24	22	51	49.54	37.020	122.200	5.50	
58	CCN	1998	10	14	02	22	53.1	37.620	121.371	5.50	
58	DNA	1840	01	16	0	0	0.04	37.000	122.100	6.33	
59	DNA	1919	09	04	20	15	45.04	38.000	122.330	5.00	
59	DNA	1964	11	16	02	46	41.74	37.060	121.690	5.00	
60	DNA	1866	03	26	20	12	0.04	37.100	121.600	5.90	
60	PAS	1967	12	18	17	24	31.9	37.010	121.788	5.20	
64	CCN	1989	10	18	0	7	43.4	36.989	121.737	5.09	
64	DNA	1979	08	06	17	5	22.44	37.109	121.511	5.90	
64	ROT	1964	11	15	02	46	43.0	37.000	121.717	5.20	
68	DNA	1881	04	10	10	0	0.04	37.300	121.300	6.00	
69	BRK	1990	04	18	15	46	3.5	36.951	121.702	5.09	
69	USN	1959	03	02	23	27	17.0	37.000	121.600	5.30	VI
72	GS	1999	08	18	01	06	18.9	37.907	122.686	5.00	V
74	BRK	1993	01	16	06	29	34.9	37.025	121.459	5.30	
74	PDE	1990	04	18	13	41	38.8	36.918	21.670	5.00	
74	USN	1949	03	09	12	28	39.0	37.000	121.500	5.10	VII
74	USN	1954	04	25	20	33	28.0	36.900	121.700	5.30	VIII
74	DNA	1897	06	20	20	14	0.04	37.000	121.500	6.30	
78	ISC	1990	04	18	13	53	50.5	36.872	121.670	5.30	
78	PAS	1974	11	28	23	01	21.8	36.902	121.607	5.00	
82	DNA	1898	03	31	07	43	0.04	38.200	122.400	6.50	

Table 8.4-2. (continued)

Distance[3] (Km)	Source[1]	Date						Location		Local Magnitude	Maximum[2] Intensity
		Year	Month	Day	Hour	Minute	Second	Latitude	Longitude		
83	BDA	1974	11	03	08	26	10.4	36.000	121.500	5.00	VI
83	DNA	1864	02	26	13	47	0.04	36.900	121.500	5.90	
87	DMG	1902	05	19	18	31	0	38.300	121.900	5.50	VIII
91	G-R	1926	10	22	12	35	11.0	36.700	122.000	6.10	VIII
92	DNA	1892	11	13	12	45	0.04	36.800	121.500	6.00	
92	PAS	1969	10	27	10	59	41.1	36.895	121.345	5.00	
94	DNA	1939	06	24	13	01	54.04	36.800	121.450	5.50	
97	BRK	1960	01	20	03	25	53.0	36.780	121.430	5.00	
98	GS	1998	08	12	14	10	25.1	36.755	121.464	5.30	
100	SIG	1906	04	18	13	12	0	38.000	123.000	8.30	XI

(1) BDS M. Bath and S. Duda (1979).
BRK Berkeley, Haviland, California, USA.
CCN Central California Network (See U.S. Geological Survey 1969-77).
DMG California Division of Mines and Geology (Real and others, 1978).
DNA Decade of North American Geology (DNA project).
G-R Gutenberg and Richter, 'Seismicity of the Earth'.
GS U.S. Geological Survey, Denver, CO, USA.
ISC International Seismological Centre, Newbury, UK.
NAO Norse Array Observatory, Norway
PAS Pasadena, California.
PDE Preliminary Determination of Epicentres from NEIS/CGS.
ROT Rothe, J.P. 'The Seismicity of the Earth', 1953-1965, UNESCO, 1969.
SIG Catalog of Significant Earthquakes (Dunbar, Lockridge, Whiteside, 1993).
T-A S. D. Townley and M. W. Allen (1939).
USN U.S. Network Catalog (Hays and others, 1975).

(2) "Maximum Intensity" is another measurement of perceptible ground movement. However, Local Magnitude was used whenever possible throughout the study.

(3) "Distance in kilometers" is equal to the radial distance from the site.

Table 8.4-3. Physical properties of local sedimentary deposits.

Geol. Unit	No. of Samples	Depth of Test (ft)	Natural Dry Density (lb/ft^3)	Natural Moisture Content (% dry wt.)	Penetrometer (blows/ft)	Infiltration Rate (in/hr$^+$)
Qyf	122	8.1 ± 5.2	115 ± 9	18.3 ± 8.1	35 ± 22	0.6 - 2.0
Qyfo	40	7.6 ± 5.9	118 ± 8	17.9 ± 7.9	50 ± 17	0.06 - 0.2
Qb	---	---	---	---	---	0.06 - 0.6
Qm	---	---	---	---	---	---
Qof (shallow)	76	4.2 ± 4.2	121 ± 7	16.6 ± 4.8	26 ± 19	0.2 - 2.0
Qof (deep)	21	7.7 ± 4.9	123 ± 7	14.2 ± 5.7	116 ± 50	---
Qom	---	---	---	---	---	<0.06
QTs (shallow)	39	2.5 ± 2.2	116 ± 8	22.6 ± 7.0	23 ± 15	---
QTs (deep)	17	7.2 ± 3.3	120 ± 4	19.5 ± 6.7	92 ±24	---

* From standard soil survey – State of California, Department of Public Works, Division of Highways.
\+ Modified from U.S. Soil Conservation Service. 1981. Soil Survey, Alameda County, California, Western Part. p. 103.

Soil boring logs from borings advanced at the eastern portion of the project site indicate fill material consisting of moist, fine to medium grain, clayey sand extending to a depth of approximately 3 feet below ground surface (bgs). Below a depth of 3 feet, a black, silty clay unit is encountered and extends to the total depth of the boreholes, approximately 15 feet. Groundwater was encountered at approximately 6 feet bgs within each boring.

The sediments that underlie the project site and linear project features will be referred to herein as "younger Bay mud." The younger Bay mud is between 20 and 60 feet in thickness and overlies the older Bay mud. The older Bay mud deposits are substantially different from the younger Bay mud. Since it is more deeply buried, the older Bay mud has been consolidated by lithostatic pressure from above and consequently contains less moisture. As a result, the older Bay deposits provide a good foundation for poles and similar structures (BCDC 1967).

The older Bay mud overlies bedrock of the Franciscan Formation, which consists of a sequence of greenstones, greywacke, radiolarian chert and serpentinite (Helley and Miller 1992). The unconformable contact between the older Bay mud and bedrock is approximately 400 feet below ground surface (bgs) in the vicinity of the project site (Hazelwood 1976).

The top layers of younger Bay mud are highly compressible and lose considerable strength when disturbed. As a result, the younger Bay mud creates foundation problems for construction. Special consideration as to design of structures and supporting foundation members must be taken into account when building on this material (BCDC 1967). When the younger Bay mud is overloaded by fill, it becomes increasingly unstable as the thickness of the fill increases and will ultimately fail if the slopes at the edge of the fill are steep (BCDC 1967). The strength of the younger Bay mud increases with depth as a result of the overlying pressure. Like the older Bay mud, the lower levels of the younger Bay mud have been consolidated and may provide a good foundation for poles and similar structures.

8.4.1.6 Geologic Hazards

This section analyzes the existing geologic hazards within and surrounding the project site. There are five hazards in this area that could be potentially significant. These hazards are:

- Seismic ground shaking
- Ground rupture
- Ground failure
- Subsidence and settlement
- Seismic seiches

Seismic Ground Shaking

The most important geologic hazard that could affect the project is the risk to life and property from an earthquake generated by the Hayward Fault or the San Andreas Fault, which are capable of producing magnitude 7.1 and 7.9 events, respectively.

The project site is located in Seismic Zone 4 according to the California Building Code (CBC) 1998. This location implies a minimum horizontal acceleration of 0.4g for use in earthquake resistant design. Mualchin and Jones (1992) produced a map of maximum credible earthquake accelerations for California; their figure for the site indicates a horizontal acceleration of 0.5g.

Ground motions can be estimated by probabilistic method at specified hazard levels. The intensity of ground shaking depends on the distance of the earthquake epicenter to the site, the magnitude of the earthquake, site soil conditions, and the characteristic of the source. The California Division of Mines and Geology (CDMG) and the USGS recently completed a study to identify the seismic hazard based on a review of these characteristics and historical seismicity throughout California (Petersen, *et al.* 1996). The results of these studies suggest there is a 10 percent probability that the peak horizontal acceleration experienced at the site would exceed 0.55g in 50 years. However, this value is based on firm rock site conditions ($V \geq 760$ m/s). Because the RCEC will be located on the younger Bay mud ($V \leq 360$ m/s), it is likely to experience greater amplification of seismic shaking during an earthquake. Studies from past earthquakes show that such "poor ground" poses a greater potential hazard than does proximity to the fault or to the center of the earthquake.

Recent observations of geodetic strain and fault creep indicate that the current rate of strain accumulation along the Hayward Fault is approximately 9 mm/yr. Whether this rate is representative of the entire fault zone for the entire 167-year recurrence interval is unknown. However, Coppersmith (1982) estimated a probability of 14 to 26 percent for a M7 event to occur within the next 50 years along the Hayward Fault assuming strain accumulations (slip) rates of 3mm/yr and 6 mm/yr, respectively.

Earthquake planning scenarios published by the USGS (1982 and 1987) were reviewed for the San Andreas Fault and Hayward Fault. The planning scenarios contained predicted seismic intensity distribution maps (PSIDM) for a M8.3 earthquake on the San Andreas Fault (based on 1906 Earthquake) and a M7.1 for the Hayward Fault, based on a postulated rupture of the entire 53-mile (86 km) length of the fault. The PSIDMs depict severe shaking with partial or total destruction of some buildings. Both scenarios take into account the various ground (geologic) conditions and their impact on seismic wave fronts.

Ground Rupture

Three fault systems can affect the subject site: the northern extension of the Silver Creek Fault to the south, the San Andreas Fault to the southwest, and the Hayward Fault to the east, located approximately 5, 14, and 3 miles (8 km, 22 km, and 5 km) from the site, respectively. The northern extension of the Silver Creek Fault is an inferred fault with no reported recent (Holocene) activity and is not considered active. The active faults nearest to the project site are the Hayward Fault and San Andreas Fault. Surface rupture would likely occur immediately along the known trace of the Hayward Fault and San Andreas Fault, while severe shaking would occur at the project site. No known active faults cross the plant site or the water and natural gas pipelines and electric transmission line routes.

Ground Failure/Liquefaction

Liquefaction is a process by which water-saturated materials (including soil, sediment, and certain types of volcanic deposits) lose strength and may fail during strong ground shaking. Liquefaction is defined as "the transformation of a granular material from a solid state into a liquefied state as a consequence of increased pore-water pressure" (Youd 1992). This behavior is most commonly induced by strong ground shaking associated with earthquakes. In some cases, a complete loss of strength occurs and catastrophic ground failure may result. However, liquefaction may happen where only limited strains develop, and ground surface deformations are much less serious.

Sediments underlying the project site have a high liquefaction potential. The project site is located in a region designated as having a "high potential" for ground failure in the event of a major earthquake. This "high potential" is attributed to the seismic activity of the San Andreas Fault and Hayward Fault, the shallow depth to groundwater (between 5- and 10-feet bgs for the RCEC), and the unconsolidated to weakly consolidated younger Bay mud beneath the site.

There are four types of ground failure or collapse of soil structures that commonly result from liquefaction: lateral spread, flow failure, ground oscillation, and loss of bearing strength. Based on the site geology and topography, there is a moderate to high potential for the effects of lateral spread, ground oscillation and loss of bearing strength to be experienced in the event of a major earthquake. Each type is briefly defined below:

Lateral Spread

This term defines the lateral displacement of surficial blocks of sediment as the result of liquefaction in a subsurface layer. Once liquefaction transforms the subsurface layer into a fluidized mass, gravity plus inertial forces that result from the earthquake may cause the mass to move downslope towards a cut slope or free face (such as a river channel or a canal). Lateral spreads most commonly occur on gentle slopes that range between 0.3° and 3°, and commonly displace the surface by several meters to tens of meters. Such movement typically damages pipelines, utilities, bridges, and other structures having shallow foundations. During the 1906 San Francisco earthquake, lateral spreads causing displacement of only a few feet damaged many water supply pipelines. Thus, liquefaction compromised the ability to fight the fires that caused about 85 percent of the damage to San Francisco.

Ground Oscillation

When liquefaction occurs at depth and the slope is too gentle to permit lateral displacement, the soil blocks that are not liquefied may decouple from one another and oscillate on the liquefied zone. The resulting ground oscillation may be accompanied by opening and closing of fissures and sand boils, which may damage structures and underground utilities.

Loss of Bearing Strength

When a soil loses strength and liquefies, loss of bearing strength may occur beneath a structure, possibly causing the structure to settle and tip. If the structure is buoyant, it may float upward.

Subsidence and Settlement

Land surface subsidence can be induced by both natural and human phenomena. Natural phenomena include: subsidence resulting from tectonic deformations and seismically induced settlements; soil subsidence due to consolidation, hydrocompaction, or rapid sedimentation; subsidence due to oxidation or dewatering of organic-rich soils, and subsidence related to subsurface cavities. Subsidence related to human activity includes subsurface fluid or sediment withdrawal. Underground mining may also cause subsidence, but that is not a factor at this locality.

No evidence of subsidence has been documented in the region surrounding the RCEC. However, in the City of Newark, located approximately 10 miles (16 km) southeast of the site, documented subsidence has occurred. USGS reports indicate that land has subsided as much as 1 to 2 feet in the City of Newark and 13 feet in the region of San Jose as a result of excessive groundwater pumping. There is a potential for further subsidence in these areas because continued groundwater pumping is likely to occur.

Due to the loose, compressible nature of the younger Bay mud, there is a potential for soil settlement to occur at the site. Settlement would primarily be a consequence of an increase in overlying pressure from construction of structures associated with the project facilities. In the event of a major earthquake, subsidence and settlement will likely occur as a result of ground failure from liquefaction.

Seismic Seiches

Due to the relative proximity of the project site to the Bay, there is a potential for the project facilities to be impacted by seismic seiches resulting from the occurrence of a major earthquake along the San Andreas Fault and/or Hayward Fault. Earthquakes may affect open bodies of water in two ways: by creating seismic sea waves and by creating seiches. Seismic sea waves (often called "tidal waves") are caused by abrupt ground movements (usually vertical) on the ocean floor in connection with a major earthquake. A rise of water of even two or three feet in the Bay due to a seismic sea wave, if coupled with a high tide and onshore wind, could do serious damage to near-to-sea level developments. A seiche is a sloshing of water in an enclosed basin such as the Bay. It is caused by earthquake motion; the sloshing can occur for a few minutes or several hours. Seiches could be damaging in the Bay in the event of a large earthquake combined with a high tide and onshore winds.

8.4.1.7 Geologic Resources

The production of salt by means of a solar process using evaporation ponds is the only mineral resource in the vicinity of the project. Cargill Incorporated, located in the City of Newark, operates several salt evaporator ponds approximately 1.5 miles (2.5 km) south of the project site (CDMG SP 103, 1999) and gas and water supply and discharge pipelines, and electric transmission line routes. Soils exposed at the site and along proposed gas pipeline and transmission line corridors are unlikely to be a source of construction material because they contain too many fines-grained sediments for use as aggregate. No other geologic resources such as mines or pits were identified in the vicinity of the project site.

Recreational geologic resources typically include rock or mineral collecting, volcanoes, surface hydrothermal features, and surface expression of geologic features unique enough to generate recreational interests of the general public (e.g., natural bridges, caves, features associated with glaciation, and geomorphic features such as waterfalls, cliffs, canyons, and badlands). There are no known recreational geologic resources associated with the proposed site.

8.4.2 Environmental Consequences

The potential environmental effects from construction and operation of the RCEC on geologic resources and risks to life and property from geologic hazards are presented in the following subsections.

8.4.2.1 Significance Criteria

The project would cause a significant adverse impact to geological resources if it would:

- Significantly reduce access to geological or mineral resources of economic importance.
- Present a significant risk of injury by exposing people or structures unnecessarily to the consequences of major geologic hazards such as large seismic events.
- Cause large-scale erosion or land subsidence.

The potential for land subsidence, either seismically induced or by proposed building load factors will be further evaluated in a geotechnical investigation to be performed prior to the start of detailed design of the project facilities.

8.4.2.1 Construction Phase Impacts

RCEC Plant Site

Preparation of the ground surface at the power plant site will involve grading, leveling, and filling. The plant site is situated on interfluvial basin deposits (Qb). As noted in Table 8.4-3, underlying sediments are dense and have low infiltration rates. These sediments may require some additional drainage measures; otherwise, they present minimal problems for preparation of a level surface on which to construct the power plant. The plant site will occupy 12.55 acres of land. The site will be graded to achieve a minimum one percent slope to promote surface drainage, and areas adjacent to equipment will be surfaced with asphalt or concrete. If there is excess material that cannot be used, it will be disposed of at a suitable location offsite. Site grading will not result in large-scale erosion or adverse impacts to the geological environment.

Seismic hazards and potential adverse foundation conditions will be minimized by conformance with the recommended seismic design criteria of the CBC [CBC (1998)] Seismic Zone 4 requirements. The seismic requirements are further defined in Appendix 10-B titled, “Structural Engineering Design Criteria” and is found in Section 10-B titled, “Seismic Hazard Mitigation Criteria”. The facility arrangement is such that no major structures or equipment are within the projected trace of any active or potentially active faults.

Electric Transmission Line and Eastshore Substation Expansion—The net electrical power produced by the facility will be transmitted from the switchyard, through new overhead transmission lines to PG&E’s existing Eastshore Substation. Construction of the transmission towers and stringing the conductors will take place by helicopter crane, with ground support. Construction of the transmission line and expansion of the Eastshore Substation are not expected to negatively impact mineral resources since there are no known mineral resources associated with these sites. Also, these structures will be constructed in accordance with Seismic Zone 4 requirements contained in the CBC as further defined in Appendix 10-B, Section 5.1. No large-scale erosion is anticipated.

Natural Gas Pipeline—Land disturbance during construction of the 0.9 mile buried natural gas pipeline will be 3 feet wide, since the pipeline will be constructed within the roadway pavement. Pipeline excavation to a minimum depth of about 4 feet (1.3 m) in the younger alluvial fan deposits may be performed with a backhoe or trenching machine, and the soil temporarily laid in a windrow next to the trench. After the pipe is connected, it will be laid in the trench on a soil cushion and the trench backfilled with soil. Construction of the natural gas pipeline is not expected to negatively impact mineral resources since there are no known mineral resources along the pipeline route.

Wastewater Return Pipeline—Land disturbance during construction of the buried wastewater return pipeline will be 4 feet wide, since the pipeline will be constructed within the roadway pavement and will extend across Enterprise Avenue. Pipeline excavation in the younger alluvial fan deposits may be performed with a backhoe or trenching machine, and the soil temporarily laid in a windrow next to the trench. No large-scale erosion is anticipated. After the pipe is connected, it will be laid in the trench on a soil cushion and the trench backfilled with soil. Constructions of the pipeline is not expected to negatively impact mineral resources since there are no known mineral resources associated along the pipeline route.

AWT Plant

The AWT plant will be located next to the RCEC. Construction-related impacts would be the same or less than those associated with the power plant. Four water pipelines will cross Enterprise Avenue. The potential impacts will be the same for the RCEC wastewater return line described above.

Construction Laydown and Worker Parking Areas

These areas occur on developed land on previously disturbed ground. No significant adverse impacts to geological resources are expected. The Depot Road and Enterprise Avenue sites are surfaced in gravel. The PG&E substation site is open field, but disturbance due to parking and laydown would be minimal.

8.4.2.2 Operation Phase Impacts

RCEC Plant Site

The plant structures and equipment will be designed in accordance with CBC, Seismic Zone 4 requirements, which are further defined in Appendix 10-B, Section 5.1. Compliance with the CBC (1998), Seismic Zone 4 requirements will minimize the exposure of people to the risks associated with large seismic events. In addition, the major structures will be designed to withstand the strong ground motion of a design earthquake. A design earthquake is the postulated earthquake that is used for evaluating the earthquake resistance of a particular structure. Because the seismic hazard in the region of the project area is relatively well defined, the design earthquake would be established by the maximum, or characteristic, magnitude earthquake that can potentially occur on those faults identified on Table 8.4-1.

No major structures or equipment are within the projected trace of any active faults.

Electrical Transmission Line and Eastshore Substation Expansion—The pads for the transmission line towers will be founded on piles or piers in unconsolidated deposits of fine sand, silt and silty clay (Qyfo and Qyf). The tower pads will be designed and constructed in accordance with CBC, Seismic Zone 4 requirements and will be designed to withstand strong ground motion of a design earthquake. The transmission line will not cross the projected trace of any active faults.

Natural Gas Pipeline—The natural gas pipeline will be constructed in unconsolidated deposits of fine sand, silt and silty clay (Qyfo and Qyf). The pipeline will be designed to withstand the strong ground motion and ground failure (liquification) of a design earthquake.

Wastewater Return Pipeline—The wastewater discharge pipeline will be constructed in unconsolidated deposits of fine sand, silt and silty clay (Qyfo and Qyf). The pipeline will be designed to withstand the strong ground motion and ground failure (liquefaction) of a design earthquake.

AWT Plant

Design criteria for the AWT plant and any potential impacts will be similar to those described for the RCEC plant.

8.4.2 Cumulative Impacts

The project facilities will be constructed to the requirements of the CBC Seismic Zone 4. Site-specific geotechnical investigations will be performed prior to final design and construction. Since construction and operation of the project will not cause significant impacts to geological resources, it will not cause cumulative impacts to geological resources.

8.4.3 Proposed Mitigation Measures

Mitigation measures for the project are as follows:

- Perform geotechnical field surveys to locate geologic hazards at the plant site and natural gas pipeline route to evaluate their impact on the construction activities and the environment.
- Structures will be designed to meet seismic requirements of the 1998 CBCs. Moreover, the design of plant structures and equipment will be in accordance with CBC, Seismic Zone 4 requirements to withstand the strong ground motion of a design earthquake.
- An engineering geologist(s), certified by the State of California, will be assigned to the project to carry out the duties required by the CBC to monitor geologic conditions during construction and approve actual mitigation measures used to protect the facility from geologic hazards.
- Modifications of existing topography will not destroy any unique geologic or topographic features.

8.4.4 Applicable Laws, Ordinances, Regulations, and Standards

Design, construction and operation of the RCEC will be conducted in accordance with applicable laws, ordinances, regulations, and standards (LORS) pertinent to geologic resources and hazards during and following construction. The LORS are summarized in Table 8.4-3.

Table 8.4-3. LORS Applicable to geologic resources and hazards.

LORS	Applicability	Mitigation Effective?	AFC Reference
CBC (California Building Code)	Design and construction of manmade structures with respect to seismic safety features; design and construction of open excavations.	Yes	Section 8.4.5.2

8.4.5.1 Federal

The Uniform Building Code [UBC (1997)] specifies the acceptable design criteria for construction of facilities with respect to seismic design and load bearing capacity. However, the CBC incorporates by reference the UBC and contains additional requirements, and is the applicable code to be followed for the proejct.

8.4.5.2 State

The CBC (1998) specifies the acceptable design criteria for construction of facilities with respect to seismic design and load-bearing capacity.

8.4.6 Involved Agencies and Agency Contacts

There is one agency that is involved with geologic resources and hazards at the project site. The agency contact is listed in Table 8.4-4.

Table 8.4-4. Involved agencies and agency contacts.

Issue	Contact/Agency	Title	Telephone
Building Permit; Grading/Drainage/Erosion Control Permit	City of Hayward Department of Public Works	Planning and Permitting	(510) 583-4720

8.4.7 Permits Required and Schedule

Permits required for matters dealing with geologic resources and hazards for the project and the schedule to obtain each of these permits are provided in Table 8.4-5. Information required to obtain each permit is also included.

Table 8.4-5. Permits required and permit schedule.

Permit/Required Information	Schedule
Building Permit including Seismic Design Criteria: • 30 day review and approval process • Requires structural, civil, electrical and mechanical plans • Geotechnical/Geologic report • Identify geologic hazards and potentially conduct a seismic risk analysis • Architectural plans	Submit application 30 days prior to start of construction.
Grading/Drainage/Erosion Control Permit: • Engineered Grading Plan • Topographic Plan • Drainage controls • Surface Hydrology Report • Geotechnical/Geological Hazard Evaluation • Identify material source or disposal location and haul route • Erosion and Dust Control Plan • Traffic Control Plan	Submit application 30 days prior to start of construction activities.

8.4.8 References

Alameda County Flood control District, *Hydrology and Hydraulics Criteria Summary Western Alameda County*. Revised August 7, 1989.

Atwater, T. 1970. Implication of plate tectonics for the Cenozoic tectonic evolution of western North America. *Bulletin of the Geological Society of America* 81: 3513-3536.

San Francisco Bay Conservation and Development Commission (BCDC). 1967. Geology of San Francisco Bay. February, 1967.

Borcherdt, R.D., Gibbs, J.F., and K.R. Lajole. 1975. *Prediction of maximum intensity in the San Francisco Bay Region, California, for large earthquakes on the San Andreas and Hayward Faults.*

California Building Standards Commission. 1998. *California Building Standards Code. Title 24 of the California Code of Regulations.*

California Department of Conservation, Division of Mines and Geology. 1982. *Earthquake planning scenario for a magnitude 8.3 earthquake on the San Andreas Fault in the San Francisco Bay Area.* Special Publication 61.

California Department of Conservation, Division of Mines and Geology. 1987. *Earthquake planning scenario for a magnitude 7.5 earthquake on the Hayward Fault in the San Francisco Bay Area.* Special Publication 78.

California Department of Conservation, Division of Mines and Geology. 1996. Open-File Report 96-08 Probabilistic Seismic Hazard Assessment for the State of California (Also U.S. Geological Survey Open-File Report 96-706). This report was co-authored and published by both the DMG and USGS>

California Department of Conservation, Division of Mines and Geology. 1998. Maps of known active faults near-source zones in California and adjacent portions of Nevada. International Conference of Building Officials.

California Department of Conservation, Division of Mines and Geology. 1999. *Mines and mineral producers active in California.*

Mualchin L. and Jones A.L. 1992. Peak acceleration from maximum credible earthquakes in California (rock and stiff soil sites). CDMG Open-File Report 92-1.

Coppersmith, K.J. 1982. Probabilistic evaluations of earthquake hazards, edited by E.W. Hart, S.E. Hirshfeld, and S.S. Schulz. In: *Proceedings, Conference on Earthquake Hazards in the Eastern San Francisco Bay Area, California.* California Division of Mines and Geology Special Publication 62:125-134.

Hazelwood, R.M. 1976. Contour map and interpretive cross sections showing depth and configuration of bedrock surfaces, South San Francisco Bay Region, California. U.S. Geological Survey Miscellaneous Field Studies Map, MF-796, scale 1:62,500.

Helley, E.J., and D.M. Miller. 1992. Geologic map of the Newark 7.5 Minute Quadrangle, Alameda County, California. U.S. Geological Survey Open-File Report 92-312.

Helley, E.J., Lajoie, K.R., and Burke D.B. 1972. Geologic map of Late Cenozoic deposits, Alameda County, California. USGS Miscellaneous Field Studies Map MF-429.

Irwin, W.P. 1990. Geology and plate-tectonic development, edited by R.E. Wallace. In*: The San Andreas Fault System.* U.S. Geological Survey Professional Paper 1515:60-80. California.

Lienkaemper, J.J, Borchardt, G., and M. Lisowskie. 1991. Historic creep rate and potential for seismic slip along the Hayward Fault. *Journal of Geophysical Research* 96:18261-18283.

Petersen, M.D., Bryant, W.A., Cramer, C.H., Chao, T., Reichle, M.S., Frankel, A.D., Lienkaemper, J.J., McCrory, P.A., and D.P. Schwartz. 1996. *Probabilistic seismic hazard assessment for the State of California.*

San Francisco Bay Conservation and Development Commission (BCDC). 1967. *Geology of San Francisco Bay.*

Sieh, K.E. 1978. Slip along the San Andreas associated with the great 1857 earthquake. *Seismic Society of America Bulletin* 68:1421-1448.

Snetsinger, K.G. 1976. Rock types of the Franciscan Formation, Coyote Hills, Alameda County, California. *California Geology*, August 1976, pp. 174-177.

U.S. Department of Agriculture and the Soil Conservation Service. 1981. *Soil survey of Alameda County, California, Western Part.*

U.S. Geological Survey. 1970. Tectonic creep in the Hayward Fault Zone. Circular 525.

Wagner, D.L., E.J. Bortugno, and R.D. McJunkin. 1990. Geologic map of the San Francisco-San Jose Quadrangle. California Department of Conservation, Division of Mines and Geology.

Wallace, R.E. 1990. General features, edited by R.E. Wallace. In*: The San Andreas Fault System, California*. U.S. Geological Survey Professional Paper 1515: 3-12.

Webster, D.A. 1973. Map showing areas bordering the Southern Part of San Francisco Bay where a high water table may adversely affect land use. U.S. Geological Survey Miscellaneous Field Studies Map MF-530.

Wilson, J.T. 1965. A new class of faults and their bearing on continental drift. *Nature* 3207:343-347.

Youd, T. Leslie. 1992. Liquefaction, ground failure, and consequent damage during the 22 April 1991 Costa Rica earthquake. In: *Proceedings of the NSF/UCR U.S.*—Costa Rica Workshop on the Costa Rica Earthquakes of 1990-1991: Effects on Soils and Structures. Earthquake Engineering Research Institute, Oakland, CA.