APPENDIX D

LANDFILL SITING AND SEISMIC CRITERIA EVALUATION

TECHNICAL MEMORANDUM

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SUBJECT: Sonoma County Central Landfill Rock Extraction Area and Landfill 2 Seismic and Geologic Conditions

DATE: January 21, 2011

1.0 INTRODUCTION

This memorandum summarizes seismic and geologic characteristics of the Sonoma County Central Landfill as they may affect compliance with regulatory requirements and future cell construction at the site. The landfill property encompasses a 398.5 acre parcel, of which approximately 172 acres are currently permitted for Class III waste disposal. Ancillary facilities at the site include a recycling and reuse facility, a wood and yard waste chipping facility, a compost operations area, a landfill gas power plant and flare, scales, gatehouses, maintenance areas, surface impoundments, and an operations and administration building.

Three southerly-trending canyon areas characterize the areas of the property that have been developed or that have been identified for future development and waste placement. These canyon areas are identified as the "East," "West," and "Central" Canyons. Approximately 115 acres of the 130 acre Central Canyon area is covered by Landfill 1 (LF-1). The Rock Extraction Area (REA) abuts LF-1 to the west and occupies the remaining 15 acres of the Central Canyon. Both LF-1 and the REA are located in an area that is also known as the "1974 Permit Area" (Figure 1). Landfill 2 (LF-2) is located in the East Canyon area of the site; a relatively thin strip of undeveloped property in the East Canyon is located between LF-1 and LF-2. The West Canyon has not been developed and is not being contemplated for development as part of the current Central Landfill re-permitting effort.

1.1 PROPOSED DEVELOPMENT

Proposed future construction at the landfill will include new Subtitle D-compliant waste disposal cells in the REA and in the undeveloped area between LF-1 and LF-2. Base grading plans and liner details for these cells are currently being prepared by SCS Engineers (SCS) but are not yet available. The preliminary refuse fill grading plan developed based on this construction concept shows that new refuse will extend over refuse that is currently present in LF-1 and LF-2 (Figure 2). Because these new cells are proposed for development as Class III waste disposal areas, they are subject to the geologic siting criteria specified in §20260 of Title 27 of the California Code of Regulations (CCR).

1.2 PUPOSE AND SCOPE OF EVALUATION

A number of relatively detailed site studies, design evaluations, construction projects, and monitoring assessments have been completed or are ongoing at the site since it was developed in the 1970s. These projects have included surface mapping, subsurface exploration, observations during construction, field testing, laboratory testing, and a variety of engineering evaluations, among other items. As a result, an appreciable amount of site data are available and site conditions important to the evaluation of landfill performance and conformance with regulatory requirements are comparatively well understood. However, these data have been collected for a variety of purposes and a specific assessment siting criteria compliance for the area between LF-1 and LF-2 has not been completed to date (an assessment of siting criteria compliance for the REA was completed in by RMC Geoscience (RMC) in 2003).

As a result of the aforementioned limitations, the purpose of this memorandum was to review the available site information and evaluate the proposed new cell locations with respect to the Title 27 CCR Class III landfill siting criteria. The scope of work completed to meet this objective included:

- Review of the future cell locations and details as currently proposed;
- Review of available site data that address hydrogeologic, geologic, and seismologic conditions in the proposed expansion areas;
- Review of current seismic information relevant to the project site that is published or otherwise available from the United States Geological Survey (USGS), California Geological Survey (CGS), and others as warranted; and
- Preparation of this Technical Memorandum.

In addition to the evaluation of siting criteria compliance, this memorandum also addresses whether the seismic hazard evaluation that provided the basis for previous stability analyses captures the predominant period of interest for landfill stability (typically about 0.5 to 1 second) is suitable for design of the proposed expansion areas.

2.0 CONFORMANCE WITH SITING CRITERIA

The new cells proposed for the REA and the area between LF-1 and LF-2 are planned Class III waste disposal areas. Therefore, they are subject to the geologic siting criteria specified in 27 CCR §20260. Pursuant to these regulations:

- Class III landfills shall be located where site characteristics provide adequate separation between nonhazardous solid waste and waters of the state.
- New Class III and existing Class II-2 landfills shall be sited where soil characteristics, distance from waste to ground water, and other factors will ensure no impairment of beneficial uses of surface water or of ground water beneath or adjacent to the landfill.
- New Class III and existing Class II-2 landfills shall be designed, constructed, operated, and maintained to prevent inundation or washout due to floods with a 100 year return period. MSW landfills are also subject to any more-stringent flood plain and wetland siting requirements referenced in SWRCB Resolution No. 93-62.
- New Class III and expansions of existing Class II-2 landfills shall not be located on a known Holocene fault. However, existing landfills assigned a Class II-2 designation under previous versions of the SWRCB regulations may be located on a known Holocene fault, provided that the Unit's containment structures are capable of withstanding ground accelerations associated with the maximum probable earthquake.
- New Class III and un-reclassified existing Class II-2 landfills can be located within areas of potential rapid geologic change only if the RWQCB finds that the Unit's containment structures are designed, constructed, and maintained to preclude failure. MSW landfills are also subject to any more-stringent unstable area siting requirements referenced in SWRCB Resolution No. 93-62.

As described in more detail below, the results of previous evaluations coupled with this update indicate the proposed development areas generally meet the 27 CCR siting criteria and are suitable for future development as waste disposal areas.

2.1 GROUNDWATER SEPARATION AND PROTECTION

2.1.1 Background Surface and Groundwater Information

Surface Water and Springs

The ridge along the eastern and northern property line represents a drainage divide that separates surface water within the site from surface water north of the site. Surface water within the site area flows south to southeast to Stemple Creek. Springs have been observed in each of the canyon areas during the course of previous investigations. For example, Terratech (1970) identified a spring located at the head of the central canyon that had reported flows on the order of 10 to 40 gallons per hour. Subsequent work by Hallenbeck & Associates (1988) identified spring areas in a side drainage channel extending up in a northwesterly direction from the main channel in the central canyon. In addition, springs have been identified in the east and west canyon areas. Huntingdon-Herzog Associates (HHA, 1993) reported west canyon flow rates for springs, seeps, and marshes for the period of April through August 1993 that ranged from about 1 gallon per minute (gpm) to 17 gpm in April to dry conditions in July and August. East canyon flow rates for the same period of time were on the order of 3 gpm to 25 gpm in April to flow rates less than 0.1 gpm in July.

Seepage was not observed in the sideslopes of the REA during previous mapping and site characterization studies (RMC, 2003a). However, the field work for this study was completed at the end of the dry season; the presence of occasional phreatophytic plants supports the occurrence of relatively high groundwater and/or seepage in this area. Previous mapping (RMC, 2003b) during excavation and construction of LF-2 in the East Canyon indicated seepage was common in the side walls and base of the excavation. An underdrain was constructed as part of Phase1 and Phase 2 of LF-2 and flow measurements from the drain for the period of 2005 through 2010 indicated an average flow of about 2.6 gpm for 20.9 acre landfill footprint.

Groundwater

Groundwater occurs within each of the geologic formations and units at the site, and within each of these formations, groundwater flow directions and hydraulic parameters are variable. Groundwater occurs at or within several feet of the ground surface in the base of the REA. Depending on location and depth of well, the depth to groundwater in the area between LF-1 and LF-2 varies from about 2 to 25 feet below the ground surface. The groundwater potentiometric surface generally mimic topography and the average hydraulic gradient as measured down the axes of the various canyons in a southerly direction typically ranges from about 0.06 to 0.20 feet/foot (ft/ft).

Although groundwater flow direction in the Franciscan Formation (the unit that underlies the active waste disposal areas, the REA, and the area between LF-1 and LF-2) is variable, previous studies (HHA, 1993; EBA, 1997; Mark Group, 1994a, 1994b) concluded that shallow groundwater flow in the Franciscan Formation is characterized by an upward hydraulic gradient towards the axes of the different canyons. Recent groundwater monitoring data confirms the presence of an upward hydraulic gradient at the margin of LF-1 in the undeveloped area between LF-1 and LF-2 (RMC, unpublished).

2.1.2 Conformance with Siting Criteria

> *Class III landfills shall be located where site characteristics provide adequate separation between nonhazardous solid waste and waters of the state.*
>
> *New Class III and existing Class II-2 landfills shall be sited where soil characteristics, distance from waste to ground water, and other factors will ensure no impairment of beneficial uses of surface water or of ground water beneath or adjacent to the landfill.*

Base grading plans for the proposed cells are currently being developed but are not yet available. As a result, the approximate depth from the base of the cells to the highest anticipated elevation of groundwater cannot be characterized. However, based on current site grading and topography, previous site observations (RMC, 2001; 2002; 2003a; 2003b; 2005), and available depth to groundwater information, the design for future waste disposal cells in the REA and the area between LF-1 and LF-2 will need to include an engineered alternative that incorporates a subdrainage system into the containment system designs (a subdrainage system is included as part of the existing LF-2 containment system).

An underdrain and a containment system that meets the requirements of CCR Title 27 and State Water Resources Control Board (SWRCB) Resolution 93-62 will protect beneficial uses of groundwater beneath and adjacent to the site. Proposed cells in the REA and in the area between LF-1 and LF-2 will not intersect any existing surface water drainage channels or features. Surface water drainage conveyance, detention, and storage design for the proposed expansion areas in accordance with standard engineering practices will protect beneficial uses of surface water and groundwater beneath or adjacent to the landfill.

2.2 FLOODPLAIN AND WETLANDS SITING REQUIREMENTS

> *New Class III and existing Class II-2 landfills shall be designed, constructed, operated, and maintained to prevent inundation or washout due to floods with a 100 year return period. MSW landfills are also subject to any more-stringent flood plain and wetland siting requirements referenced in SWRCB Resolution No. 93-62.*

The REA and the area between LF-1 and LF-2 are located in upland areas that are not subject to floods with a 100 year return period. State Water Resource Control Board (SWRCB) Resolution No. 93-62 (as amended on July 21, 2005) requires compliance with the floodplains requirements specified in 40 CFR §258.11 and §258.16 and with the wetlands requirements specified in 40 CFR §258.12. These requirements state:

- **Wetlands (§258.12)**. This provision states that new municipal solid waste landfill (MSWLF) units and lateral expansions shall not be located in wetlands unless certain specific exemption criteria are demonstrated. The REA and the area between LF-1 and LF-2 are not located in wetlands (Sonoma County, 1997; 1998).

- **Floodplains (§258.11)**. This provision states that new MSWLF units, existing MSWLF units, and lateral expansions located in 100-year floodplains must demonstrate that the unit will not restrict the flow of the 100-year flood, reduce the temporary water storage capacity of the floodplain, or result in washout of solid waste so as to pose a hazard to human health and the environment. The REA and the area between LF-1 and LF-2 are not located in a 100 year floodplain.

- **Closure Floodplain Criteria (§258.16)**. This provision requires the closure of existing landfills that cannot demonstrate compliance with airport, floodplain, and unstable area requirements. Both LF-1 and LF-2 currently comply with these requirements, and as a result, §258.16 does not apply to expansion in the REA and the area between LF-1 and LF-2.

2.3 FAULT SITING REQUIREMENTS AND CRITERIA

2.3.1 Background Faulting and Seismic Information

Regional and Local Faults

Regional active faults within about 60 km of the site are summarized in Table 1 and include the Healdsburg-Rodgers Creek, San Andreas, Maacama, Hayward, West Napa, Green Valley, and Concord faults.[1] In addition to the regional faults, several local Quaternary faults are located in relatively close proximity to the landfill, including the Tolay, Americano Creek; Bloomfield; Dunham; and an unnamed fault (Figure 3). None of the local faults are zoned as Holocene-active faults by the CGS. The most recent fault map of California (Jennings, 2010) indicates the local faults are less than 1.6 million years old but that there is no evidence of movement in the late Quaternary (i.e., the last 700,000 years).

Table 1 summarizes the maximum probable earthquake (MPE) associated with each of the regional active faults. The MPE is the design earthquake for Class III landfills and is typically defined as the maximum earthquake likely to occur in a 100 year period. As shown in Table 1, the MPE for the Healdsburg-Rodgers Creek fault is the governing seismic event for the Central Disposal Site and can generate an estimated peak horizontal ground acceleration (PHGA) of 0.32g in a hypothetical bedrock outcrop at the site (GeoSyntec Consultants, 2004a; 2004b).

Site Faulting

Several faults and geologic features identified as possible fault structures have been identified within the limits of the Central Disposal Site. These faults and structures include: (i) the Dunham fault; (ii) the unnamed fault shown at the southeastern corner of the property in Figure 3; (iii) a possible unnamed inactive fault trace north of the REA; and (iv) a geophysical anomaly suggestive of a fault or fracture zone at location northwest of the REA. None of these features intersect waste disposal areas or have been judged to be potential seismogenic sources for the following reasons:

- **Dunham Fault**. The Dunham Fault enters the southwest boundary of the landfill, and trends to the northwest. At its closest point, it is about 1,500 feet south of the REA. An evaluation of the fault by GeoLogic Associates (GLA) in 2002 included excavation of

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[1] Active faults are defined as faults which have had surface displacement in the Holocene epoch (in the past 11,000 years) based on CCR Division 2, Title 14, also known as the Alquist-Priolo Earthquake Fault Zoning Act. Potentially active faults are defined by this Act as faults showing surface displacement during Quaternary time (about 1.6 million years before present). Inactive faults are defined as faults without recognized Quaternary displacement.

trenches across the fault, geologic mapping, and radiocarbon dating of the samples. Based on these data, GLA (2002) concluded that the Dunham fault has not exhibited movement during the Holocene and is not active.

- **Unnamed Fault Trace**. The unnamed fault trace is located in the East Canyon area just north of Hammel Road. The trace trends east and slightly north. Trenching of the unnamed fault was performed by Taber Consultants (Taber) in 1993 and the unnamed fault trace was concluded to be pre-Holocene and likely pre-Quaternary. This conclusion was supported by the observed absence of geomorphic evidence such as fault scarps, closed depressions, offset streams, etc., and ground features including anomalous topography, springs, fissures, etc. (Taber, 1993a). Recent observations (RMC, 2003) supported the earlier conclusions.

- **Unnamed Fault Trace North of the REA**. Previous studies at the landfill indicated an unnamed, inactive fault trace may be present in the northwest portion of the site near the current compost area and about 1,000 feet north of the REA (EBA Wastechnologies, 1997, 1998). This fault was interpreted to be generally east-west trending, near vertical, and to offset units entirely within the Franciscan Formation. As originally mapped, the fault does not project through or near the REA. According to the previous investigators, the south side of the fault appeared to have moved upward relative to the north side, although the basis for this judgment was not included in the EBA 1997 or 1998 reports. The fault trace could not be located in the field during subsequent site mapping work (RMC, 2001) and evaluation of stereo-paired aerial photographs (RMC, 2003) did not show evidence of significant lineations or geomorphic evidence of active faulting on a local or regional basis that might be associated with an active fault in this area.[2] As a result, the presence of an active fault in this area was judged to be unlikely.

- **Geophysical Anomaly Northwest of the REA**. Geophysical studies performed as part of the Stage 1 Shallow Field Exploration Report and Stage 2 Deep Field Exploration Work Plan (EBA Wastechnologies, 1998) identified a geophysical anomaly suggestive of a possible fault or fracture zone was present at a location approximately 700 feet southwest of the unnamed fault trace. A southeasterly projection of this anomaly could intersect the REA. However, subsequent investigations (RMC, 2001; RMC, 2003) did not support the presence of an active fault in this area, but rather suggested the

[2] Such evidence typically includes offset stream channels, closed depressions, fault scarps, shutter ridges, and linear springs.

geophysical line may have intersected a zone of highly sheared shale that was weaker and softer than the relatively harder and more intact surrounding sandstone, and that this difference may have contributed to the observed geophysical anomaly.

Evaluation of Seismic Activity

Historic seismic activity data were previous reviewed (RMC, 2003) to evaluate whether measurable seismic activity may have occurred within or near the REA or the previously identified unnamed fault located at the northern end of the site. This assessment was updated using a database assembled and maintained by the Northern California Earthquake Data Center (NCEDC) to identify earthquakes with magnitudes greater than 1 that occurred between 1900 and the of 2010 within about 5 kilometers of the landfill. The results of this evaluation (Figure 4) show no historic seismic or microseismic activity has been recorded within the landfill boundaries.

2.3.2 Conformance with Siting Criteria

> *New Class III and expansions of existing Class II-2 landfills shall not be located on a known Holocene fault. However, existing landfills assigned a Class II-2 designation under previous versions of the SWRCB regulations may be located on a known Holocene fault, provided that the Unit's containment structures are capable of withstanding ground accelerations associated with the maximum probable earthquake.*

The fault data summarized above indicate that no Holocene active faults are located within 200 feet of the REA or the area between LF-1 and LF-2.

2.4 RAPID GEOLOGIC CHANGE REQUIREMENTS AND CRITERIA

2.4.1 Background Geologic Conditions

Geologic units in the vicinity of the Central Landfill include the Franciscan Formation, the Sonoma Volcanics, the Wilson Grove Formation, landslide deposits, and unconsolidated alluvium and colluvium. General characteristics of these units based on previous geologic mapping in the REA and the LF-2 area (RMC, 2001; 2003; 2005; GLA, 2003) include:

- **Franciscan Formation.** The Franciscan Formation is the basement rock of the region and consists of deformed, uplifted, and eroded marine sandstone and shale mixed with chert and basic igneous rocks. These rocks have been intensely folded and sheared and subjected to varying degrees of low-grade metamorphism. The REA, LF-1, and LF-2 are underlain by this formation. Franciscan Formation bedrock exposed immediately adjacent to LF-1 in the REA consists of variably cemented and silicified arkosic sandstone and quartzofeldspathic greywacke, with lesser amounts of sheared shale. The near surface arkosic sandstone is light brown to orangish-tan, moderately weathered, and moderately hard. The quartzofeldspathic greywacke is typically dark gray, moderately weathered where exposed at the ground surface, and moderately hard to very hard where intact. The shale horizons mapped at the site are typically dark gray to black, clayey, and variably sheared. Slickensides and polishing are apparent on many, though not all, of the discontinuity surfaces. The orientations of discontinuity surfaces are typically irregular, although a very indistinct northwesterly trend appears associated with some slickensided surfaces exposed in the northeast corner of the REA. Orthogonal joint sets and through-going fractures have been observed in the shale. The shale is generally soft to locally brittle and breaks into very small pieces under a very light hammer blow.

- **Sonoma Volcanics.** The Sonoma Volcanics consist of a series of volcanic flow and ash deposits that are locally interbedded with sand, gravel, and conglomerate. Sonoma Volcanics have been mapped in fault contact with the Franciscan Formation near the southwestern property boundary. However, Sonoma Volcanics have not been mapped underlying LF-1, LF-2, or the REA.

- **Wilson Grove Formation.** The Wilson Grove Formation is a marine sandstone that consists of massive sand and minor amounts of gravel and tuff. The formation was deposited on an erosional surface of low to moderate relief on the Franciscan Formation. Exposures within the landfill footprint were limited to thin patches overlying the Franciscan bedrock. According to EBA (1997), the thin patches of Wilson Grove Formation materials that were identified in the central canyon area during early site development studies were removed by landfill grading and the Mark Group (1994) notes that "Wilson Grove Formation materials are not in contact with refuse." No Wilson Grove materials were mapped in the REA or in the LF-2 area during construction.

- **Landslides.** Landslide deposits typically consist of surficial soils and weathered bedrock on steep slopes and creek embankments and have been identified in each of the canyon areas at the landfill. Early geologic mapping indicated that several landslides were present on the flanks of the LF-1 canyon prior to site development. It is assumed that these deposits were removed during landfill development, although it was not possible to confirm this assumption based on the available data. No active landslides have been mapped in the REA or in the excavation for LF-2 (RMC, 2003a; 2003b).

- **Alluvium.** Alluvial deposits occur within each of the canyon drainages at the landfill. The alluvium typically consists of layers of silt and clay with discontinuous layers of sand and gravel (EBA, 1997). Site observations during excavation for the LF-2 indicate the alluvium is relatively sandy and is saturated. Although EBA (1997) indicates most of the alluvium in the LF-1 area was removed during grading, previous studies (RMC, 2005) indicate as much as 40 feet of alluvium may be present in the drainage channel below the center of the LF-1 area.

2.4.2 Conformance with Siting Criteria

> *New Class III and un-reclassified existing Class II-2 landfills can be located within areas of potential rapid geologic change only if the RWQCB finds that the Unit's containment structures are designed, constructed, and maintained to preclude failure. MSW landfills are also subject to any more-stringent unstable area siting requirements referenced in SWRCB Resolution No. 93-62.*

In accordance with CCR Title 27, Article 2, §20164, rapid geologic change means the "alteration of the ground surface through such actions as landslides, subsidence, liquefaction, and faulting." These potential geologic conditions should not affect the REA or the area between LF-1 and LF-2 because:

- Both areas are underlain by bedrock of the Franciscan Formation that consists predominantly of fractured sandstone with lesser amounts of sheared shale. Loose, saturated sand is not present, and as a result, the potential for liquefaction is negligible. Soft, compressible deposits are not present in the proposed expansion areas; therefore, the potential for significant differential settlement of the expansion foundation areas is very low.

- Under certain conditions, subsidence due to groundwater withdrawal can occur on an area-wide basis. However, significant groundwater extraction in the landfill area is not known to occur and the Franciscan Formation bedrock underlying the site would not be susceptible to this type of subsidence.

- The results of site mapping and observations during various phases of construction have not indicated the presence of pre-existing landslides, significant shear zones, zones of weakness, or other structural factors that could significantly affect stability of the expansion areas.

- Faulting should not affect the proposed expansion for the reasons described previously.

3.0 SEISMIC CRITERIA USED FOR PREVIOUS DESIGN ANALYSES

In accordance with CCR Title 27 criteria, seismic design analyses for different phases of development at the landfill have been based on the MPE occurring on the Healdsburg-Rodgers Creek fault. For cases where the pseudostatic safety factor was less than 1.5, seismic stability has been evaluated using deformation analysis procedures. These deformation procedures were based on ground motions that were selected to be generally representative of the design earthquake and that were scaled to match target response spectra for spectral periods in the range of about 0.35 to 1 seconds which is the predominant period range of interest for typical landfill stability assessments.

3.1 PREVIOUS SEISMIC HAZARD EVALUATION

Development of the site seismic response and the associated deformation analysis procedures used for previous analyses in the REA are presented in GeoSyntec Consultant's (GeoSyntec) 2004 Seismic Site Response and Deformation Potential Evaluation report. As described in the report, a "decoupled" seismic response analysis procedure was used that included:[3]

- Selection of representative landfill cross sections;
- Identification of representative materials properties based on published information and site-specific data;
- Identification of representative one-dimensional columns for evaluation of site seismic response;

[3] A decoupled approach to seismic deformation analyses is frequently employed for the analysis of earth dams (Seed and Martin, 1966; Ambraseys and Sanna, 1967; Makdisi and Seed, 1978) and landfills (Augello, et al., 1995; Kavazanjian and Matasovic; Rathje and Bray, 1998). Lin and Whitman (1983), Gazetas and Uddin (1994), and Rathje and Bray (1998) have demonstrated that the decoupled approach is generally conservative and typically overestimates the permanent displacements by at least a factor of two compared to more rigorous fully coupled seismic deformation analysis methods.

- Completion of one-dimensional equivalent-linear seismic site response analyses using the computer program SHAKE; and

- Completion of Newmark-type seismic deformation analyses.

As described in the GeoSyntec (2004a) report, the geologic conditions, style of faulting, site-to-source distance, earthquake moment magnitude, significant duration of strong shaking, predominant period of the landfill, and target acceleration response spectra were considered in selecting representative accelerograms for use in seismic response and deformation analyses. These records included:

- The $M8^+$ synthetic accelerograms generated by Seed and Idriss (1969) to simulate a large earthquake on the San Andreas fault;

- The Tabas accelerogram recorded in bedrock during the 1978 M_w 7.4 Tabas-e-Golshan, Iran earthquake; and

- The Silent Valley - Poppet Flat accelerogram recorded on weathered granite during the 1992 M_w 7.4 Landers earthquake.

These records were scaled to the site PHGA of 0.32g and compared to the site-specific target response spectra as shown in Figure 5.

3.2 APPLICABILITY TO FUTURE EVALUATIONS

Review of the previous seismic hazard assessment indicates it should be relatively conservative and suitable for future design at the landfill because:

- As shown in Figure 5, the acceleration response spectra of the selected time histories fall between the mean and the 84th percentile bracket of target response spectra for spectral periods of 0.35 seconds to about 1 second. Therefore, these time histories are appropriate for the predominant period range of interest for landfill stability assessments and should be conservative; and

- The magnitudes of the selected time histories (7.4, 7.4, and 8^+) are all relatively higher than the magnitude of the MPE design earthquake (6.75). As a result, the duration of ground shaking associated with these time histories should be greater than the duration of shaking associated with the MPE.

It should be noted that the GeoSyntec seismic hazard evaluation was based partially on attenuation relationships that were developed in 1997 and these relationships were updated in 2008. The new relationships are collectively referred to as Next Generation Attenuation (NGA) relationships.[4] In general, however, use of the NGA relationships results in relatively lower PHGAs at most sites in northern California. As a result, use of the existing seismic hazard site PHGA should be conservate.

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[4] Five different NGA relationships were developed by different researchers. These relationships are described in Abrahamson and Silva (2008); Boore and Atkinson (2008); Campbell and Borzongnia (2008); Chiou and Youngs (2008); and Idriss (2008).

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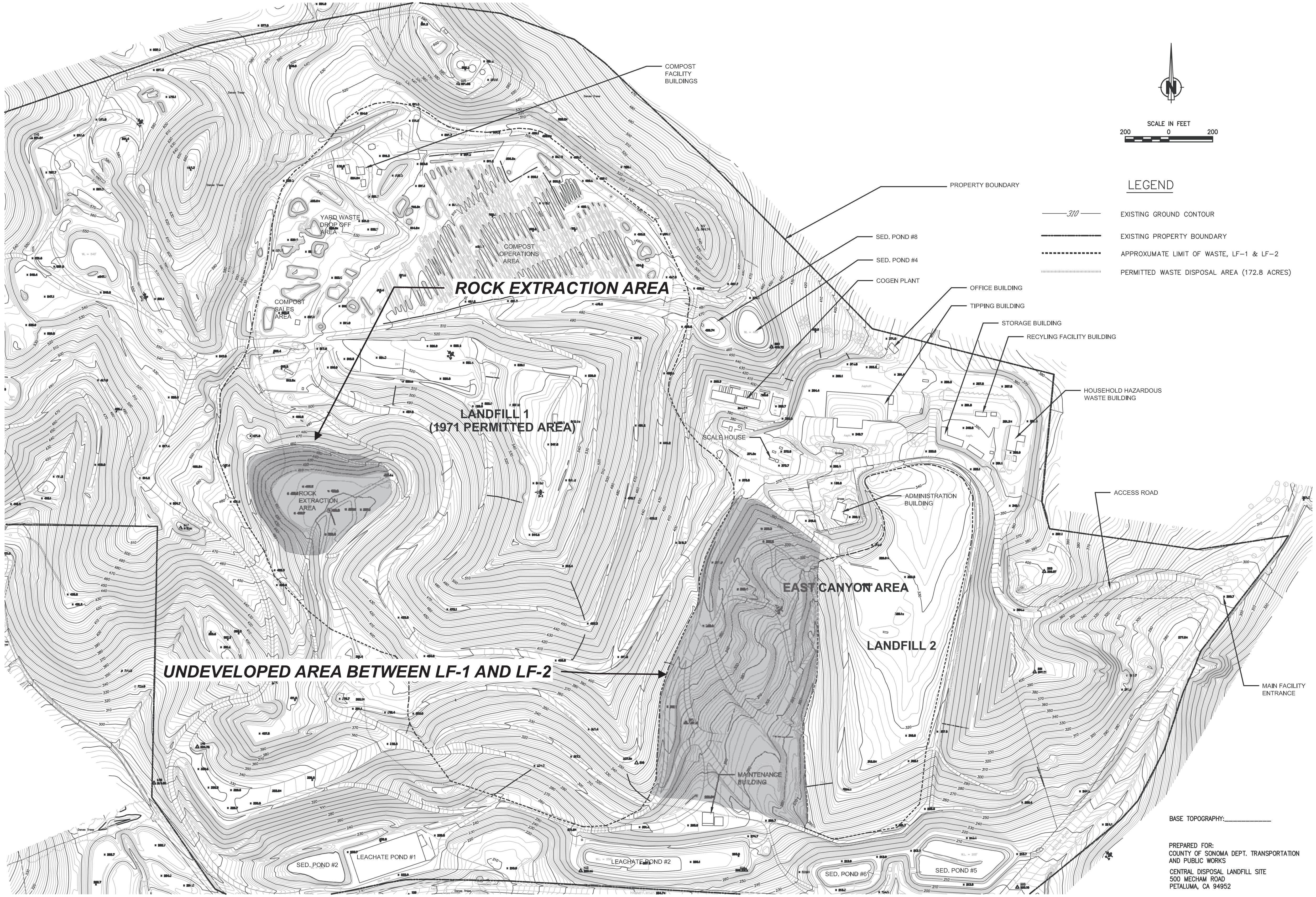
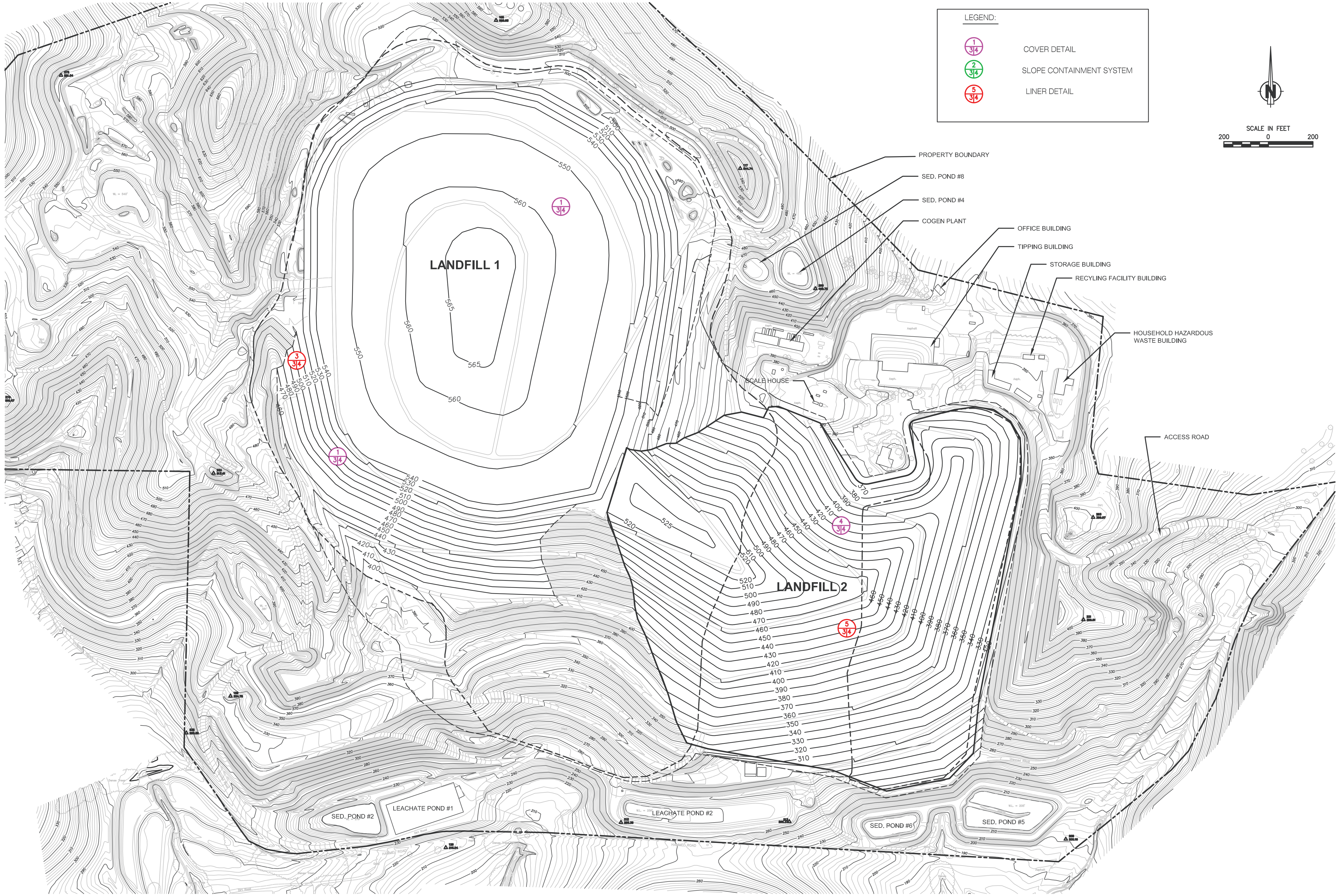
Table 1
SUMMARY OF ACTIVE FAULTS USED FOR PREVIOUS SEISMIC HAZARD EVALUATION
Rock Extraction Area and Landfill 2
Geologic and Seismic Siting Evaluation

FAULT	STYLE OF FAULTING	APPROXIMATE DISTANCE FROM SITE		MPE MAGNITUDE (M_w)	MPE PHGA (g)
		Miles	km		
Healdsburg-Rodgers Creek	Strike-Slip	5.7	9.2	6.75	0.32
San Andreas (Northern)	Strike-Slip	15	24	7.5	0.22
Maacama	Strike-Slip	15.5	25	7.1	0.18
Hayward	Strike-Slip	27	44	7.0	0.09
West Napa	Strike-Slip	20	32	6.0	0.08
Green Valley	Strike-Slip	28	46	6.5	0.06
Concord	Strike-Slip	36	59	6.2	0.04

Reference: GeoSyntec (2004a)



RMC Geoscience, Inc. Engineering Geology Environmental Geoscience 405 East D Street Suite 112 Petaluma, CA 94952 415-699-8073	Rock Extraction Area and Landfill 2 Geologic and Seismic Siting Assessment Central Landfill, Sonoma County, California **EXISTING SITE CONDITIONS**
January 2011	FIGURE 1



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PRELIMINARY SCS ENGINEERS GRADING PLAN

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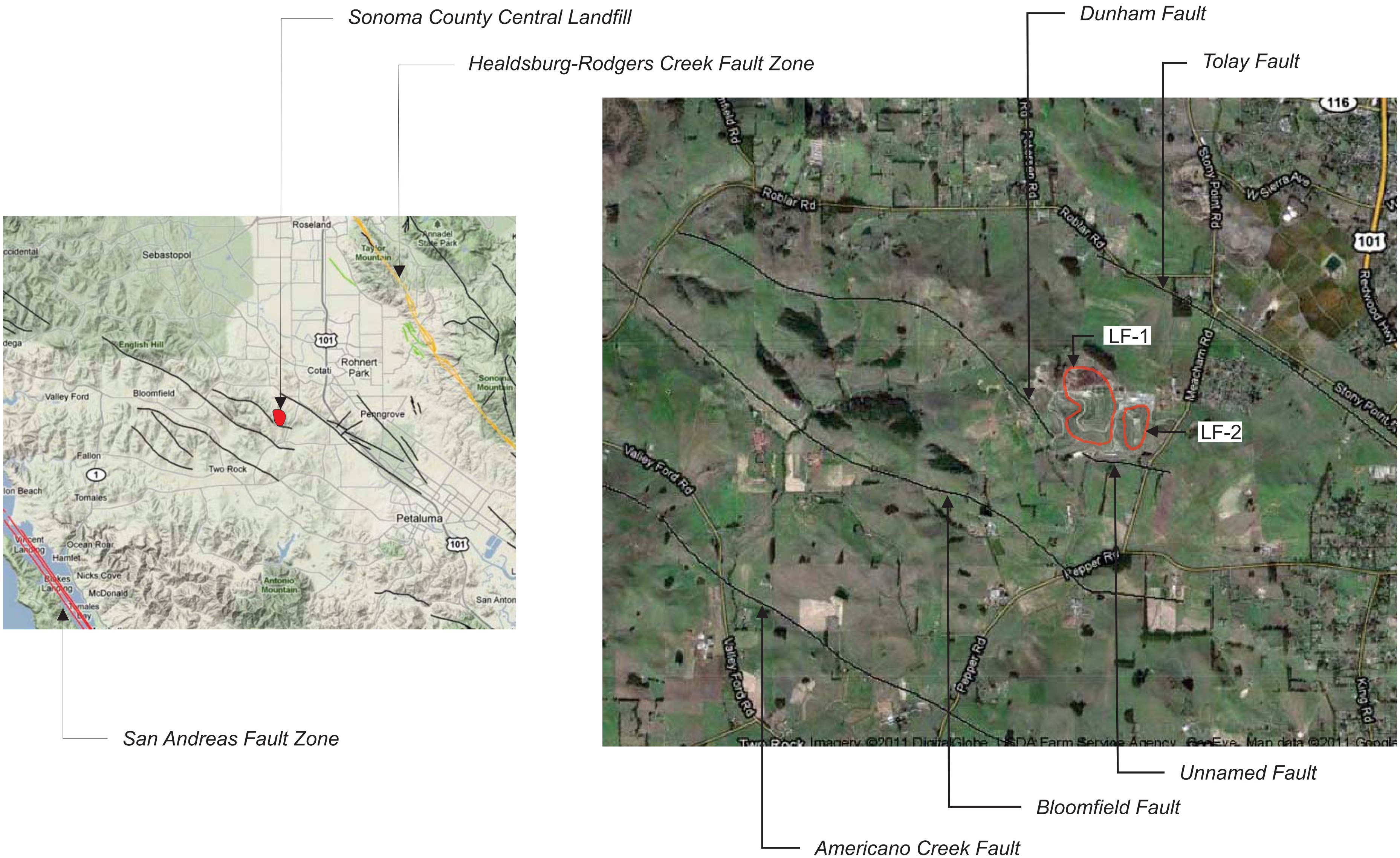
FIGURE 2



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LOCATIONS OF REGIONAL AND LOCAL FAULTS

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Figure 3

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Geologic and Seismic Siting Assessment
Central Landfill, Sonoma County, California

SEISMIC ACTIVITY WITHIN 5 KM OF THE LANDFILL

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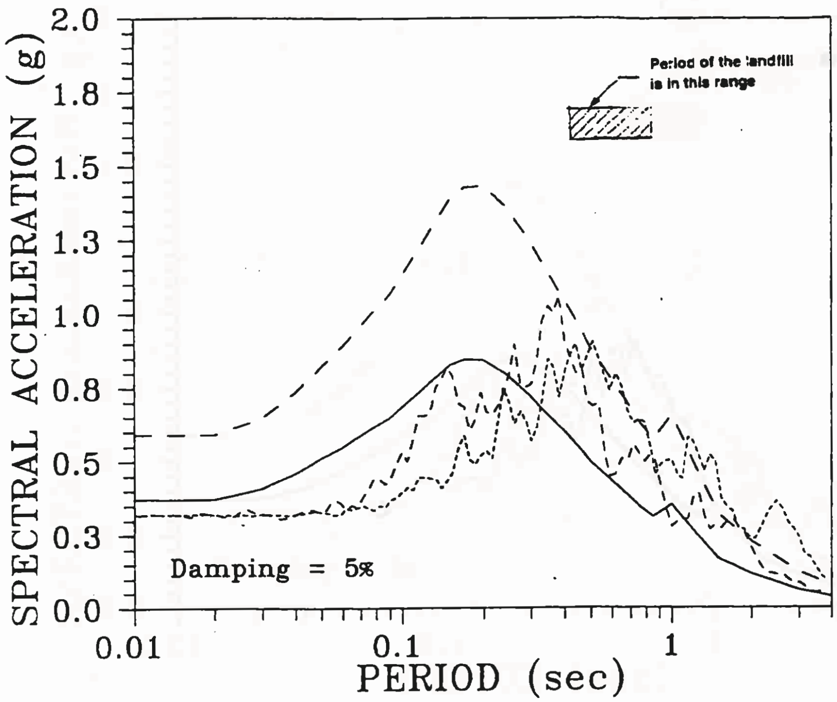
Figure 4

EAST CANYON EXPANSION, CENTRAL LANDFILL
SONOMA COUNTY, CALIFORNIA



—— median target spectrum by Abrahamson & Silva (1997) model
— — 84th percentile target spectrum by Abrahamson & Silva model
------ Indio (90 deg) accelerogram (1992 Landers Eq.)
- - - - M8+ Synthetic accelerogram (Seed and Idriss, 1969)

REFERENCE: GeoSyntec Consultants (2004a, 2008)

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ACCELERATION RESPONSE SPECTRA

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Figure 5