FUGRO WEST, INC.

PRELIMINARY GEOTECHNICAL REPORT
LOS OSOS WASTEWATER PROJECT EIR
SAN LUIS OBISPO COUNTY, CALIFORNIA

Prepared for:
MICHAEL BRANDMAN ASSOCIATES

May 21, 2008

FUGRO WEST, INC.

660 Clarion Court, Suite A
San Luis Obispo, California 93401
Tel: (805) 542-0797
Fax: (805) 542-9311

May 21, 2008
Project No. 3629.001

Michael Brandman and Associates
5280 Field Crest Drive
Camarillo, California 93012

Attention: Mr. Michael Houlihan

Subject: Preliminary Geotechnical Report, Los Osos Wastewater Project Environmental Impact Report, San Luis Obispo County, California

Dear Mr. Houlihan:

Fugro is pleased to submit this Preliminary Geotechnical Report as input to the Los Osos Wastewater Environmental Impact Report in San Luis Obispo County, California. This report was prepared in general accordance with the scope of services presented in our proposal dated March 5, 2008, and authorized by our subconsultant consultant agreement with Michael Brandman and Associates (MBA) dated April 1, 2008.

This report is a preliminary geotechnical study based on review of previous geotechnical studies, published geologic information, and project information provided by MBA. The purpose of this report is to provide input to the Environmental Impact Report and study being prepared by MBA. This report summarizes geologic hazards and geotechnical considerations that are likely to impact the design and construction of the project, and discusses mitigation measures that may be needed to address these items. Please contact the undersigned if you have questions regarding this report, or require additional information.

Sincerely,

FUGRO WEST, INC.

Jonathan

JONATHAN D. BLANCHARD
No. 2312
exp. 12-31-09

Jonathan D. Blanchard, G.E. 2312
Principal Geotechnical Engineer

Reviewed by:

Lori Prentice

LORI E. PRENTICE
EG NO. 2312
CERTIFIED ENGINEERING GEOLOGIST

Lori E. Prentice, C.E.G. 2312
Principal Engineering Geologist

Gresham D. Eckrich
Staff Engineer/Geologist II

Copies: 4 - Addressee

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1.0 PROJECT UNDERSTANDING

The work preformed for this study generally consists of a preliminary geotechnical evaluation that will provide input to the preparation of the Environmental Impact Report (EIR) for the proposed community-wide wastewater collection and treatment plant system for the unincorporated areas of Los Osos, Baywood Park and Cuesta-by-the-Sea in San Luis Obispo County, California. The project is currently in the preliminary design phase I and generally consists of the design and construction of a new wastewater treatment facility for the Los Osos community that will replace privately-owned individual septic systems (septic tanks and leach lines) that currently serve the residents of Los Osos. The locations of the proposed improvements and project alternatives considered for our evaluation are indicated on Plate 1 - Site Map.

The County of San Luis Obispo is overseeing the design and construction of the project. The proposed project will consist of a wastewater treatment facility, a disposal system for the treated effluent, a 30-acre storage reservoir for treated effluent, and a collection system comprised of a pipeline network with associated pump stations. The approximate limits of the collection system area are within the limits of the prohibition zone shown on Plate 1. MBA provided the proposed project and project alternatives being evaluated for the EIR in correspondence received May 1, 2008. A summary of alternatives is presented below:

Proposal Project and Alternatives

Project	Treatment Plant Site	Treatment Process	Effluent Disposal - Type	Storage	Collection System
Proposed Project 1	Branin-Giacomazzi-Cemetery	Facultative Ponds (Secondary Treatment)	Broderson – Infiltration Tonini – Spray Irrigation Conservation	30-acre feet at treatment plant	STEP/STEG and Gravity
Proposed Project 2	Giacomazzi	Oxidation Ditches/Bio Lac (Secondary Treatment)	Broderson – Infiltration Tonini – Spray Irrigation Conservation	30-acre feet at Tonini	STEP/STEG and Gravity
Proposed Project 3	Branin-Giacomazzi-	Oxidation Ditches/Bio Lac (Secondary Treatment)	Broderson – Infiltration Tonini – Spray Irrigation Conservation	30-acre feet at treatment plant	STEP/STEG and Gravity
Proposed Project 4	Tonini	Facultative Ponds (Secondary Treatment)	Broderson – Infiltration Tonini – Spray Irrigation Conservation	30-acre feet at treatment plant	STEP/STEG and Gravity

Project	Treatment Plant Site	Treatment Process	Effluent Disposal - Type	Storage	Collection System
Alternative 1	Turri Road	Oxidation Ditches (Secondary Treatment)	Broderson – Infiltration Tonini – Spray Irrigation Conservation	30-acre feet at Tonini	STEP/STEG and Gravity
Alternative 2	Mid-Town	MBR (Secondary Treatment)	Broderson – Infiltration Tonini – Spray Irrigation Conservation	30-acre feet at Tonini	STEP/STEG and Gravity
Alternative 3	Giacomazzi	Oxidation Ditches/Bio Lac (Tertiary Treatment)	Broderson – Infiltration Tonini – Spray Irrigation Conservation Ag and urban reuse	160-acre feet at Tonini	STEP/STEG and Gravity
Alternative 4	Branin-Giacomazzi-Cemetery	Facultative Ponds (Secondary Treatment)	Broderson – Infiltration Tonini – Spray Irrigation Conservation Agricultural Reuse Urban Reuse	30-acre feet at treatment plant site	STEP/STEG and Gravity
Alternative 5	Robbins 1-Robbins 2-Andre	Oxidation Ditches/Bio Lac (Secondary Treatment)	Broderson – Infiltration Tonini – Spray Irrigation Conservation	30-acre feet at treatment Tonini	STEP/STEG and Gravity

1.1 COLLECTION

A technical memorandum prepared for the County by Carollo Engineers (2008) discusses the likelihood that the sewer collection system will consist of a combination of lower pressure force mains and gravity flow piping. The proposed project and project alternatives would use a STEP/STEG and gravity flow system. The pipeline network will consist of approximately 45 miles of sewer and over 5,000 lateral connections to existing residences and property.

Alternatives for installation of the pipeline could consist of traditional cut and cover pipeline construction, or trenchless pipe installation performed using horizontal directional drilling. Cut and cover is typically selected in earthen areas and roadways, while trenchless techniques can be used to cross or install piping below heavily trafficked or environmentally sensitive areas. Trenchless installations are anticipated to cross the busier streets within the project limits, such as Los Osos Valley Road and South Bay Boulevard. However, we understand that no constraints have been identified that could preclude the use of cut and cover techniques in all areas of the project at this time.

The pipeline is designed to provide a minimum of 3 feet of soil cover over the top of the pipe on secondary roads, and 4 feet of soil cover over the pipe in primary roads. Pipe diameters are likely to range from about 2 to 12 inches. A previous gravity sewer design by Montgomery-Watson-Harza (MWH 2004) likely would have resulted in trench depths of up to approximately 15 to 30 feet. Carollo (2008) estimates that a low-pressure collection system, utilizing grinder pumps for residences in low lying areas, could be used to limit the trench depths to about 4 to 7 feet.

1.2 PUMP STATIONS

Pump stations are typically installed at the low points in the service area. Pump stations serve as collection points, typically located at the low point of a service area where the waste can flow into the pump station by gravity. The collected wastewater is then pumped to the treatment facility or is lifted to allow the wastewater to flow into an adjacent service area. The number and size of the pump stations depends on type of collection, terrain, and location of the treatment plant. Pump stations typically consist of a wet well, vault, electrical supply, and standby power building.

The MWH (2003) gravity sewer design plans show seven (7) primary pump stations and approximately 18 pocket-type pump stations at various locations. The pocket-type pump stations would help limit trench depths where the existing terrain is relatively low compared with adjacent areas. MWH estimates that the primary pump station wells would extend to 20 feet below the existing ground surface and that the pocket pump stations would be approximately 10 feet in diameter and extend to depths of approximately 10 to 15 feet below the existing ground surface.

Carollo (2008) estimates that about 3 to 4 pump stations would be needed to service a low pressure collection system, supplemented by grinder pumps installed at each customer location.

1.3 OUT OF TOWN CONVEYANCE

An out of town conveyance pipeline likely will be utilized to collect and pump wastewater from the entire collection area to a wastewater treatment facility located east of town. Also, it is anticipated that a pipeline returning reclaimed water to the community will be installed adjacent to the effluent disposal pipeline. Carollo (2008) mapped and discussed several options for pipeline routing, which may require crossing creeks by means of tunneling, trenching, or bridge-mounted piping. A number of the route options will border residential, agricultural, and sensitive habitat areas. Conveyance pipelines likely will consist of a 12- to 14-inch diameter pressurized force main that probably will be installed using a combination of conventional open-cut trenching and directional drilling to minimize excavation depth, project cost, and environmental impacts.

1.4 WASTEWATER TREATMENT PLANT SITES

The treatment plant generally will consist of a new wastewater treatment plant designed to accept an estimated peak flow of 1.6-million gallons per day. The components of the facility will depend on the treatment option selected for design. The proposed project will involve secondary treatment using facultative ponds or oxidation ditches/BioLac. The pond systems are likely to be excavated to depths of 10 to 20 feet below the existing ground surface. Oxidation ditches and treatment facilities likely will involve relatively large, heavily loaded concrete structures and tanks that may be constructed above or below grade. Additional improvements are likely to include an operations building, offices, septage receiving station, headworks, solids processing, and filter systems. Site improvements could also involve paving for parking and access roads, concrete flatwork, retaining walls, utilities, piping, drainage facilities, and landscaping.

1.5 EFFLUENT DISPOSAL AND REUSE

A combination of spray fields, agricultural reuse areas, urban reuse sites, leach line fields, storage ponds, and constructed wetlands may be incorporated into the disposal and storage of treated effluent discharged from the treatment plant. These locations will dispose of an estimated 1,290 acre-feet per year of effluent by means of general irrigation, percolation lines, evaporation ponds, and drywells. In addition, seasonal storage ponds will provide storage for treated effluent during the winter months when agricultural reuse capacity is at a minimum. Storage ponds likely will be located at or near the treatment plant and/or reuse sites. The effluent will be pumped to disposal, reuse and storage sites via pressured pipelines. The locations of proposed effluent disposal and reuse sites are shown on Plate 1.

According to Carollo (2008), spray fields will likely be utilized to dispose of effluent by means of evapotranspiration and percolation. Agricultural reuse consists of crop irrigation with treated secondary and tertiary effluent. Tertiary treated and disinfected effluent may also be disposed of through urban reuse by irrigating lawns and landscaping vegetation. Leach lines are buried perforated pipes placed on top of a gravel backfilled trench and covered with soil. The effluent is distributed through the perforated pipe and percolates into the subsurface though the gravel backfill. Constructed wetlands are an additional consideration for storage of effluent and disposal via evapotranspiration and percolation.

1.6 TREATMENT AND STORAGE PONDS

Facultative ponds and oxidation ditches are planned as a component of the treatment plant design. The proposed project and alternatives include 30 acre-feet of storage intended to hold treated effluent during periods of low disposal capacity (wet season). Alternative 3 would require a total of 160 acre-feet of storage, and more limited urban reuse of water. We understand from MBA that storage ponds likely will be lined earthen reservoirs. The reservoirs will be designed such that the retained height of water and/or capacity of the reservoirs is below the jurisdictional limits of the California Division of Safety of Dams (the ponds will not be considered a dam according to State definitions). The ponds are likely to consist of an earthen perimeter berm and an interior excavation to provide the required storage. Treatment and storage pond depths have not yet been determined. Storage ponds are typically lined to prevent percolation, and with 2 to 4 feet of free board above the water storage level. The proposed project alternatives show the storage ponds at one of the treatment plant sites or on the Tonini site.

2.0 WORK PERFORMED

2.1 PURPOSE

The purpose of this report is to provide geotechnical input to the preparation of the EIR. It is not intended for the design or construction of the project. This report presents a summary of geologic hazards and geotechnical considerations as input to the preparation of the EIR for the project.

2.2 SCOPE OF WORK

Work performed for this study consists of the following:

Aerial Photographic Review and Data Review. We reviewed site-specific historical aerial photographs to evaluate the site. We also reviewed readily available published geologic data available in our files, previous geotechnical reports and a technical memorandum prepared by Fugro (Fugro, 2004a, 2004b, 2007). A summary of the historical aerial photographs that we reviewed is presented in the following table.

Summary of Reviewed Aerial Photographs

Date	Scale	Flight	Frames
11-13-02	1:32,000	GS00999	16 and 17

Site Reconnaissance. We performed a site reconnaissance to assist in the evaluation of the site conditions on May 6, 2008.

Review of Previous Geotechnical Reports and EIRs. We have reviewed and referenced relevant information and data from two geotechnical reports (Fugro, 2004a and 2007), one technical memorandum (Fugro, 2004b) and two EIRs (The Morro Group, 1987; Crawford Multari & Clark Associates, 2000) addressing sites within the project limits.

Preliminary Geotechnical Report. This report summarizes geotechnical data reviewed for the project site and discusses potential geologic hazards, geotechnical considerations, and mitigations based on the data review. This report includes our opinions and recommendations regarding:

- Geologic and seismic setting;
- Predominant soil and formational units in the project area;
- Potential for the sites to be impacted by geologic hazards (such as strong ground motion, fault rupture, liquefaction, seismic settlement, landsliding, tsunami or seiche, or dam inundation);
- Potential for erosion, hydrocollapse, subsidence, expansive or collapsible soil conditions;

- Potential to encounter naturally occurring asbestos or radon gases;
- Areas (shown graphically) that pose geologic hazards;
- Potential for geologic conditions to cause site alterations (such as grading) to adversely impact the project;
- Construction or geotechnical considerations that could impact the project, such as the need for dewatering, excavation characteristics of the geologic materials, likely foundation support for structures, and anticipated grading;
- Impacts associated with potential geologic hazards related to liquefaction and seismic settlement and slope instability and landsliding); and
- Potential mitigation measures to address potentially significant impacts.

2.3 LIMITATIONS

This preliminary geotechnical report has been prepared for the exclusive use of Michael Brandman Associates and their agents as input to the preparation of the project EIR and is not intended for design of the project. In our opinion, the data collected and any findings, conclusions, professional opinions, and recommendations presented herein were prepared in accordance with generally accepted geotechnical engineering practice of the project region.

Although information contained in this report may be of some use for other purposes, it may not contain sufficient information for other parties or uses. If any changes are made to the project as described in this report, the conclusions and recommendations in this report shall not be considered valid unless the changes are reviewed and the conclusions and recommendations of this report are modified or validated in writing by Fugro.

In performing our professional services, in our opinion, we have used generally accepted geologic and geotechnical engineering principles and have applied that degree of care and skill ordinarily exercised, under similar circumstances, by reputable geotechnical engineers currently practicing in this or similar localities. No other warranty, express or implied, is made as to the professional advice included in this report.

3.0 SITE CONDITIONS

3.1 GEOLOGIC SETTING

The project is located in the Los Osos Valley and within the Coast Ranges geologic and geomorphic province. That province consists of north-northwest-trending sedimentary, volcanic, and igneous rocks extending from the Transverse ranges to the south into northern California. Rocks of the Coast Ranges province are predominantly of Jurassic and Cretaceous age; however, some pre-Jurassic, along with Paleocene-age to Recent rocks are present. The surficial geology in the project vicinity, as mapped by Hall et al. (1979), is shown on Plate 2 – Regional Geologic Map.

The Los Osos Valley and adjacent Irish Hills are the dominant geomorphic features within the project vicinity. The Los Osos Valley has formed in response to several tectonic processes that began prior to Pliocene time (more than 5 million years ago). Prior to the Pliocene, the bedrock strata in the Los Osos area was folded into an east-west trending syncline (U-shaped fold) that has subsequently been filled with up to 1,000 feet of sediment during the Pliocene and Pleistocene periods. Concurrent with that deposition was uplift along the east-west striking Los Osos fault that forms the boundary between the Los Osos basin and adjacent Irish Hills.

As shown on Plate 2, Hall et al (1979) map the predominant geologic units exposed in the study area as surficial sediments comprised of dune sand deposits (Qs) and alluvium (Qal), and outcrops of Paso Robles Formation (Qpr) and Franciscan Formation. Hall indicates that the Franciscan Formation materials are composed of greywacke (KJfg), metavolcanics (KJfmv), and mélange (KJfm). The dune sand (Qs) mapped by Hall is referred to as eolian deposits (Qe) by Lettis and Hall (1994). The alluvial sediments are associated with the Los Osos Creek, the floor of the Los Osos Valley, and Warden Lake. Surficial sediments are primarily underlain by weakly consolidated units of the age-equivalent of Paso Robles Formation and Careaga Sandstone (Tca). The Paso Robles Formation and Careaga Formation are underlain by relatively impermeable basement rocks composed of Franciscan greywacke and metavolcanics; Pismo Formation (Tp) shale; and Cretaceous-age dacitic (Td) intrusives (California DWR, 1989). Units of the Pismo Formation (Tpm) and Franciscan Formation (KJfm, KJfmv, KJfg) are exposed on the Irish Hills south of Los Osos.

3.2 FAULTING

The majority of the faults within the Coast Ranges province and the Sierra de Salinas belt generally trend north-northwest. The California Geological Survey (CGS 1996, formerly the California Division of Mines and Geology) considers major faulting within the project vicinity to include the Los Osos fault, San Simeon fault, and the San Andreas fault. The CGS fault database consists of active and potentially active faults that are considered by the CGS to be capable of affecting regional seismicity in California. A summary of faulting in the Central Coast area is shown on Plate 3 – Regional Fault Map.

Fugro utilized the fault search routine in FRISKSP (Blake 2000) to identify active and potentially active mapped faults and fault segments within a 62-mile radius of the project vicinity. The site coordinates (latitude and longitude) for the Los Osos Wastewater Treatment Project vicinity were estimated to be 35.3128° latitude and 120.8375° longitude. Summarized below are nine (9) faults and fault segments that were considered to be the most capable of producing high ground motion within the project vicinity. Additional information is presented in the California Geological Survey (CGS, 2002) fault database.

Summary of Fault Characteristics

Fault	Approximate Distance From Site (mile)	Maximum Moment Magnitude (M_w)	Fault or Fault Segment Length (km)	Slip Rate (mm/yr)
Los Osos	0.6	7.0	44 ± 4	0.5 ± 0.4
Hosgri	7	7.5	169 ± 17	2.5 ± 1.0
San Luis Range (S. Margin)	9	7.2	64 ± 6	0.2 ± 0.1
Rinconada	16	7.5	190 ± 19	1.0 ± 1.0
Casmalia (Orcutt Frontal Fault)	28	6.5	29 ± 3	0.3 ± 0.2
Lions Head	33	6.6	41 ± 4	0.02 ± 0.02
San Juan	37	7.1	68 ± 7	1.0 ± 1.0
San Andreas (Cholame)	43	7.3	63 ± 6	34 ± 5
Los Alamos – Baseline	48	6.9	28 ± 3	0.7 ± 0.7

Los Osos Fault. The closest mapped active fault to the project vicinity is the Los Osos fault zone (PG&E 1988, Lettis & Hall, 1994; Asquith, 1997). The fault zone and associated structural features are shown on Plate 4 - Los Osos Fault Zone and Lineaments. Lettis & Hall (1994) describe the Los Osos fault zone as a series of discontinuous, subparallel and en echelon fault traces that extend from the offshore Hosgri fault zone to Lopez Reservoir, a distance of about 35 miles. Lettis & Hall (1994) subdivided the fault zone into four segments: Estero Bay, Irish Hills, Lopez Reservoir, and Newsom Ridge. The Irish Hills segment of the Los Osos fault is about 10 to 12 miles long and extends from the Pacific Ocean near Los Osos eastward to San Luis Creek. This segment of the fault forms the boundary between the Los Osos Valley and the Irish Hills and has documented Holocene offset (PG&E 1988). Portions of the fault east of Los Osos (east of study area) near the City of San Luis Obispo have been zoned active and are designated as an Alquist-Priolo earthquake fault hazard zone by the CGS.

Several authors, including the California Division of Water Resources (DWR, 1989) and Asquith (1997), mapped a northwest-trending strand (locally referred to as “Strand B”) of the Los Osos fault east of the project area. The presence of the Strand B fault mapped by DWR was interpreted by an inferred offset in relatively deep bedrock units and groundwater aquifers in the Los Osos area. Asquith (1997) presents a refined location for a portion of the Los Osos fault and the Strand B lineation based on differences in shallow groundwater elevations in the Los Osos area. As part of their 1999 geotechnical study, CFS Geotechnical Consultants, Inc. advanced various piezocone penetration tests (CPT) and borings to depths of about 30 to 40 feet across the inferred trace of Strand B as mapped by Asquith near Ferrell Road. This data, combined with Fugro (1997) and various County of San Luis Obispo well data, suggest that the shallow groundwater is perched on various shallow clay layers that pinch out in the vicinity of the presumed fault trace. The clay layers terminate near or east of Palisades Avenue. The inferred Strand B trace from these data is an arcuate-shaped feature and not linear as inferred by previous investigations.

Cleath & Associates (2003a, 2003b, 2003c personnel communication with Spencer Harris, 2003) performed additional studies that included reviewing the DWR and Asquith reports, and performing pump tests in existing wells near the inferred Strand B fault on Palisades Avenue. Cleath reports that the inferred Strand B fault is not needed to characterize the structure of Los Osos Valley geology or groundwater basin. Further, pump testing of a well on Palisades Avenue near the County library did not show deflection of the drawdown cone of depression across the mapped trace of the inferred fault. The lack of deflection within the cone of depression suggests that there is not a groundwater barrier that prevents the horizontal flow of groundwater. As such, the Strand B fault is not included in their groundwater model for basin, and there is a low potential that the inferred fault exists.

Nacimiento Fault. The Nacimiento fault zone is associated with relatively recent, significant seismic events; however, it is not included as a seismic source within the CGS database. Jennings (1994) suggests that the fault does not have surficial features suggestive of Quaternary movement, and is considered inactive. However, the Bryson earthquake of 1952 that is sometimes assigned to the Nacimiento fault zone, and the M6.5 2003 San Simeon earthquake that occurred within the fault zone, contradicts Jennings' inactive classification and would make the fault seismically active. The Bryson earthquake, which occurred in a rural area of northern San Luis Obispo County, is poorly understood and may be attributed to movement on other faults such as the active San Simeon or potentially active Rinconada fault zones.

The Nacimiento fault zone is described by Hart (1976) as an ill-defined, complex array of northwest trending faults of diverse types and ages. The Nacimiento fault zone separates the soft rocks of the Coastal Franciscan domain on the west from the primarily granitic rocks of the Salinian domain on the east. As discussed by Hart (1976), the fault zone "lies on trend, both locally and regionally with faults and fault zones generally identified as the Nacimiento fault" along the southeastern portion by Hall and Corbató (1967) and Vedder and Brown (1968), and the Sur-Nacimiento fault to the northwest by Jennings (1958). Based on mapping by several investigators, it appears that the Nacimiento fault zone is not a single fault line of specific age, but rather a complex zone of branching and discontinuous faults of diverse orientations, movements, and ages. The fault zone is more or less defined by a narrow sinuous outcrop band of Franciscan mélange.

3.3 GEOLOGIC UNITS

The following characterization of general subsurface conditions mapped within the prospective project sites is based on review of published geologic maps and soils encountered during previous exploration programs conducted by Fugro (2004a, 2004b, 2007).

Dune Sand Deposits (Qs). Dune sand deposits comprise the predominant geologic unit exposed at the ground surface over the collection system area. The areal extent of the dune sand deposits, as mapped by Hall et al. (1979), is indicated on Plate 2, and is generally consistent with units encountered in the explorations. Lettis & Hall (1994) characterize the dune sands as unconsolidated to moderately consolidated, undifferentiated late Pleistocene and Holocene wind blown deposits.

The dune sand encountered in previous exploration programs was typically weathered with a moderately developed topsoil horizon. The topsoil was generally classified as very loose to medium dense sand (SP), silty sand (SM) and sand with silt (SP-SM). The underlying dune sand typically consisted of loose to very loose fine sand (SP) to depths of approximately 5 to 10 feet below the ground surface. The sand dune deposits below that depth were typically medium dense to dense sand (SP) and are locally interbedded with zones and lenses of silty sand (SM), clayey sand (SC), sand with silt (SP-SM), and silt (ML).

Alluvium (Qal). Alluvium is generally present along the eastern edge of the Morro Bay estuary, along the floodplains associated with Los Osos Creek, within wetland areas including Warden Lake, and on generally flat topography within the Los Osos Valley drainage basin. Within the collection system area, the alluvium is similar in composition to the dune sand deposits, and is therefore difficult to distinguish from those deposits on the basis of soil classification. Undifferentiated units of alluvium may be present in areas mapped or logged as dune sand deposits, particularly in low lying interdunal depressions within the project vicinity. The limits of alluvium mapped by Hall et al. (1979) are indicated on Plate 2. Lettis & Hall (1994) characterize the alluvium as Holocene-age unconsolidated cobbles, pebbles, sand, and silt stream deposits.

The alluvium encountered in previous exploration programs generally consisted of very loose to dense fine sand (SP, SP-SM) with varying amounts of silt. The deposits are locally interbedded with layers and lenses of gravel, clay, clayey sand, and organics. Dense sand units were encountered below the dune sand deposits near the intersection of Mitchell Drive and Pine Street.

Paso Robles Formation (Qpr). The presence of the Paso Robles Formation within the project vicinity is unrecognized by Lettis & Hall (1994) and undifferentiated from dune sands by Hall et al. (1979) as the surficial deposits comprising the plateau east of the Los Osos Creek flood plain. While not exposed within the collection system area, Paso Robles Formation is mapped along areas of Los Osos Creek, and overlies Franciscan rocks at the treatment plant sites near the cemetery, along portions of the southern and southwesterly areas of the Tonini site, and the hills near the Turri Road site. Hall et al. (1979) describes the unit as consisting of weakly consolidated sandstone, siltstone, claystone, and conglomerate in the Los Osos Valley area. Although described in terms of rock designation because of the formational name, the sediments of the Paso Robles Formation are generally equivalent to stiff to hard cohesive soils and medium dense to very dense granular soils.

The age-equivalent of the Paso Robles Formation was encountered below dune sand deposits during previous exploration programs, and likely underlies most of the dune sand within the project area. The material locally referred to as Paso Robles Formation may include older wind blown sediment and is commonly of a similar grain size as the overlying dune sand, only denser. The relative density of the material encountered was used to differentiate between what we interpret to be Paso Robles Formation and the surficial dune sand and alluvial deposits, in addition to the presence of clay layers that would not be expected to be encountered within wind blown deposits. The contact between the Paso Robles Formation and dune sands appears to be relatively uniform and dip to the northwest toward Morro Bay.

The Paso Robles Formation encountered in our previous explorations generally consisted of dense to very dense sand (SP), silty sand (SM), and clayey sand (SC). The sand is locally interbedded with 1- to 5-foot thick layers of very hard lean clay (CL). Where encountered in the explorations, the Paso Robles Formation was overlain by approximately 10 to 40 feet of dune sand and/or alluvium. We estimate that up to 100 feet or more of dune sand overlies the Paso Robles Formation near Santa Maria Avenue.

Franciscan Formation metavolcanics (KJfmv) and mélange (KJfm). The Los Osos Valley is bounded to the north and south by the San Lucia and San Luis ranges, respectively. Within the project site vicinity, the bases of these ranges are composed of Cretaceous or Jurassic-age Franciscan greywacke and metavolcanics. Along the easterly side of the collection area, Franciscan rocks were encountered below the Paso Robles Formation in borings by Cleath (2003b). Cleath reported metavolcanic rocks below Paso Robles Formation in borings drilled at the east end of Santa Ysabel and along South Bay Boulevard. Franciscan rocks are exposed on the hillsides above the Tonini site, extensively along Turri Road, and in hillsides above the Turri Road site. Hall et al. (1979) describes the Franciscan metavolcanics as primarily consisting of metamorphosed basalt and diabase with localized, extensively sheared zones. The mélange is characterized by Hall et al. (1979) as pervasively sheared greywacke largely composed of sheared claystone, with exotic clast inclusions. The mélange typically weathers to a highly expansive soil at the ground surface, and is prone to soil creep, slope instability, and landsliding.

3.4 GROUNDWATER CONDITIONS

Previous studies by Fugro report groundwater depths ranging from approximately near or at the ground surface to greater than 80 feet below the existing ground surface (Fugro, 2004a) in the collection system area. Based on a boring drilled on Doris Avenue just south of its intersection with Lupine Street (Fugro, 2004a), groundwater conditions in areas near Morro Bay appear to be influenced by tidal changes. Groundwater data is shown on Plate 5a - Groundwater Contours, Collection System Area and Plate 5b - Depth to Groundwater Map, Collection System Area. In addition, groundwater depths ranging from 30 to 48 feet below the existing ground surface were recorded within the limits of the Los Osos Mortuary, Giacomazzi and Branin properties (Fugro, 2007). During an exploration of the Andre site (Fugro, 2004b); groundwater was not recorded in any of the explorations advanced to depths ranging from 20 to 60 feet. However, vegetation suggestive of groundwater seeps/near surface groundwater was observed on the northeast-facing slope above the Warden Lake area, although active seeping was not observed during Fugro's reconnaissance. Based on published mapping, the Warden Lake area can be a marshy environment and has contained surface water in the past. The Turri Road site also appears to be in a low-lying area with shallow groundwater. Marshy soil and evidence of flooding were observed at the west end of the Turri Road site during our May 2008 site visit.

The potential exists for groundwater to be encountered at different depths at other locations and times, above impermeable layers, and within fractures or discontinuities within the bedrock (if encountered). Groundwater and soil moisture conditions will fluctuate seasonally, and as a result of changes in precipitation, storm runoff, irrigation schedules, and other factors.

3.5 SEISMIC CONDITIONS

3.5.1 Historical Seismicity

The project is located in a seismically active region of central California. Historical records indicate that the area has been subject to various seismic events over the last 183 years (PG&E, 1988). A summary of Magnitude 2 and greater seismic events recorded from 1933 through March 2008 are presented on Plate 6 - Historical Seismicity Map. From these references, examples of relatively strong ground motion that has reportedly been experienced near the project area are the seismic events of 1830, 1857, 1913, 1916, 1917, 1966, 1980, and 2003.

The 1830 event is estimated to be an approximately M5 earthquake that occurred from a poorly located source near San Luis Obispo. The effects of the 1830 event were generally observed between the Los Osos and Rinconada faults. The 1857 event (the Fort Tejon earthquake) occurred on the Mojave segment of the San Andreas fault, and reportedly resulted in damage in central and southern California. The 1913 event is estimated to be an approximately M5 earthquake that occurred along the southwestern margin of the San Luis/Pismo block near Arroyo Grande. The 1916 event is estimated to be an approximately M5 earthquake that occurred near Avila, possibly along the Los Osos fault or faults along the southwestern margin of the San Luis/Pismo block. The 1917 event is estimated to be an approximately M5 earthquake that occurred near Lopez Canyon between the Rinconada and West Huasna faults. The 1966 event (the Parkfield earthquake) is estimated to be an approximately M6 earthquake that occurred on the San Andreas fault. The 1980 event is estimated to be an approximately M5 earthquake that occurred offshore near Point Sal along the Casmalia fault zone, and near its intersection with the Hosgri fault. The 2003 event (the San Simeon earthquake) is estimated to have been a M6.5 earthquake resulting in a ground acceleration of about 0.18g in the project vicinity (U.S. Geologic Survey 2004). The epicenter of the 2003 earthquake was located approximately 25 miles north of the site, near the Nacimiento fault zone.

3.5.2 Seismic Hazard Analysis

A preliminary probabilistic seismic hazard evaluation for the project vicinity was performed using the web-based interactive National Seismic Hazard Map program (U.S. Geologic Survey, 2008). The intent of our evaluation was to estimate the range of strong ground motions that could result from earthquakes occurring on active and potentially active faults. Crustal source and subduction source ground motions are calculated within a 200-kilometer (km) and 1,000-km radius of the project vicinity, respectively. Maps depicting the estimated peak horizontal ground motion and estimated spectral accelerations for 0.2 second (s) and 1.0s periods were used to estimate ranges within the project vicinity. Ground motions are calculated for a suite of attenuation relationships and combined using a weighted logic tree analysis (Peterson et al., 2008). The ground motions are approximated for a reference site corresponding to the boundary between NEHRP Site Classes "B" and "C" (average shear wave velocity of 760 meters per second in the upper 30 meters of the crust). Estimated ground motions corresponding to a 2 percent probability of being exceeded in 50 years (statistical return period ≈ 2,475 Years) are tabulated below.

Hazard Level	**Peak Horizontal Acceleration**	**0.2 Second Period Horizontal Acceleration**	**1.0 Second Period Horizontal Acceleration**
2% Probability of Exceedance in 50 years	0.4 – 0.6	1.01 – 1.6	0.31 – 0.5

Note: All acceleration values in units of g (32 ft/sec2 or 9.81 m/s2)

Based on the geology of the project vicinity and subsurface conditions encountered in previous exploration programs, we anticipate the majority of sites will be classified as site class "D". This soil profile type corresponds to a stiff soil profile according to the CBC (2007). A site class "D" assumes that the material in the upper 100 feet of the site has an average shear wave velocity ranging between 600 and 1,200 feet per second (180 and 360 meters per second). However, based on review of geologic maps (see Plate 3) portions of the collection area are underlain by sediments that have been identified as having a potential for liquefaction. Exploration has not been performed for the Tonini and Turri Road sites; however, the sites are mapped as being underlain by alluvium that can be vulnerable to liquefaction. According to the ASCE (2005) design code and the CBC (2007), "soils vulnerable to potential failure or collapse under seismic loading, such as liquefiable soils … and collapsible weakly cemented soils" shall be classified as site class "F" and require a site-specific response analysis. It should be noted that a site-specific response analysis is not required for structures having fundamental periods of vibration equal to or less than 0.5s, according to section 20.3.1 of the ASCE (2005) design code.

3.6 LIQUEFACTION CONDITIONS

Liquefaction is a sudden loss of soil strength due to rapid increases in pore water pressures caused by seismic shaking. Liquefaction typically occurs during an earthquake in unconsolidated loose to medium dense sandy soils that are below the groundwater table. The potential and severity of liquefaction will depend on the intensity and duration of the strong ground motion, the depth to groundwater, the soil type, and terrain in the area where liquefaction occurs. Seismically induced settlement, collapse, or lateral spreads can occur in soils that are loose, soft, or that are moderately dense and weakly cemented, or in association with liquefaction.

3.6.1 San Simeon Earthquake

We reviewed selected areas of the project site on the afternoon following the December 22, 2003 magnitude M6.5 San Simeon earthquake to observe whether or not there was evidence of liquefaction or other earthquake damage. The epicenter of the earthquake was located approximately 25 miles north of the site, and is estimated to have resulted in a ground acceleration of 0.18g in the project vicinity (USGS 2004). We visited the low-lying areas of the collection system, Mid-Town site, and pump station locations. Evidence of liquefaction was observed along shorelines of Morro Bay and Cuesta Inlet. Liquefaction was manifested as sand that had ejected around the pilings that support the Baywood T-pier, numerous sand boils and mud volcanoes on the shore of Morro Bay mainly below the high-tide line, and lateral spreads, pipes, and fissures along the shoreline of Cuesta Inlet. The liquefaction appeared to be constrained to near the shoreline, and did not visually appear to have seriously impacted the adjacent roadways or infrastructure such as may have been evidenced by cracks, fissures, or differential settlement.

The liquefaction appears to have occurred within a relatively shallow layer of loose sand that was encountered in previous exploration programs. We did not observe evidence of liquefaction or differential seismic settlement at the higher elevations of the prospective project sites such as at the Mid-Town, Broderson, effluent disposal sites, nor at the pump station sites that were typically located away from the shoreline.

The manifestation and damage that can be associated with liquefaction is strongly dependent on the duration of the ground motion. Larger magnitude earthquakes typically result in longer periods of shaking. Earthquakes that occur closer to a site generally result in higher ground motions than a similar magnitude earthquake that could occur away from the site. The design earthquake ground motion is likely to be higher than the San Simeon earthquake ground motion (0.4g to 0.6g vs. 0.18g).

3.6.2 Liquefaction

The Safety Element of the San Luis Obispo County General Plan (1999) identifies areas where the potential for liquefaction should be evaluated based on mapping of geologic formations that may contain soil types susceptible to liquefaction. Within the Los Osos area, the Safety Element identifies geologic units such as beach sand, dune sand, and younger alluvial deposits as having a high potential to contain sediments that may be prone to liquefaction. Based on review of geologic maps (see Plate 2), all the sites under consideration for the project are completely or partially underlain by geologic units that may contain sediments susceptible to liquefaction. The previous geotechnical data available for the sites and presented in the Fugro (2004a, 2004b, and 2007) reports was used to further characterize the potential for liquefaction to impact the project considering the soil types encountered within the various geologic units, the relative density of the soil, and the depth to groundwater. A summary of the liquefaction hazard for the project is presented on Plate 7 – Liquefaction Hazards Map. The varying potential for liquefaction shown on the map is presented below:

- Very High. Groundwater has been encountered within about 10 feet of the ground surface, soil units previously encountered are loose and vulnerable to liquefaction, and/or manifestation of liquefaction was observed following the 2003 San Simeon earthquake.
- High. Groundwater is present within about 50 feet of ground surface and previous explorations suggest sediments are loose and prone to liquefaction. The depth of potentially liquefiable material may be limited or near the groundwater table.

- Moderate. Groundwater is present within about 50 feet of ground surface, and previous explorations suggest sediments are medium dense and prone to liquefaction, or geologic units may contain sediments susceptible to liquefaction, but the area was not evaluated by the previous studies.
- Low. Groundwater likely not present within 50 feet of ground surface or sediments in this vicinity were previously evaluated and found to be dense and have a low potential for liquefaction.
- Not indicated. Bedrock or formation units that are not considered vulnerable to liquefaction.

4.0 GEOLOGIC HAZARD IMPACTS

The following sections present a summary of geologic hazards that we evaluated for the project, our opinion regarding the potential for the hazards to impact the project, and preliminary recommendations for mitigation of the hazard, if needed. Prospective agricultural and urban reuse sites were not evaluated for geologic hazard impacts, as irrigation with reuse water is not anticipated to represent a change in current land use or influence impacts from geologic hazards.

4.1 FAULT RUPTURE

Fault rupture is the displacement of the ground surface created by movement along a fault plane during an earthquake. A fault rupture hazard can exist when structures or facilities or are located directly on an active fault, and rupture of that fault could displace the ground surface upon which the building or facility is located. The State of California precludes building on active faults under the Alquist-Priolo Earthquake Fault Zoning Act. The Alquist-Priolo Earthquake Fault Zoning Act's main purpose is to prevent the construction of buildings used for human occupancy on the surface trace of active faults.

As shown on Plate 4, prospective project sites are not located within a designated Alquist-Priolo Earthquake Fault Hazard Zone. As discussed in Section 3.2 of this report, the closest mapped active fault to the project vicinity is the Irish Hills segment of the Los Osos fault mapped approximately ½ miles or more south of the project vicinity. Therefore, the potential for fault rupture to impact the project site is considered low, and no mitigation for fault rupture is needed.

Mitigation. None anticipated.

4.2 STRONG GROUND MOTION

Strong ground motion (shaking) can occur in response to local or regional earthquakes. The project site is located within a seismically active area. The potential exists for strong ground motion to affect the project during the design lifetime. In general, the primary effects will be those phenomena associated with shaking and/or ground acceleration. Those effects can be mitigated through appropriate design and construction procedures.

The building code requires that structures be designed to resist design earthquake strong ground motions. The ASCE (2005) design code and the California Building Code (CBC 2007) require buildings to be designed for earthquake effects that are two-thirds ($^2/_3$) of the corresponding Maximum Considered Earthquake (MCE) effects. As discussed in Section 3.5 of this report, the estimated MCE ground motions are site class-modified spectral accelerations corresponding to earthquakes estimated to have a 2 percent chance of being exceeded in 50 years, or a return period of about 2,475 years. Design earthquake ground motions for liquefaction and other geotechnical analyses are defined as two-thirds ($^2/_3$) of the corresponding MCE ground motions. Structural designs are based on the 0.2s and 1.0s period spectral accelerations corresponding to the MCE for a Site Class "B" (site class is defined per ASCE [2005], CBC [2007]) which are modified, if necessary, to account for different Site Class effects.

Mitigation. The proposed structures should be designed to resist the lateral forces generated by earthquake shaking in accordance with building code requirements. Seismic data and site classification for the design of structures should be provided in the design-level Geotechnical Report in accordance with applicable building codes and subsurface exploration. The report should also provide ground motion parameters (magnitude and peak ground acceleration) for use in geotechnical analyses, such as for evaluating slope stability, liquefaction, and seismic settlement.

4.3 SEISMIC-RELATED GROUND FAILURE

4.3.1 Liquefaction and Seismic Settlement

As noted above, all the sites under consideration for the project are completely or partially underlain by geologic units that may contain sediments susceptible to liquefaction. However, previous site-specific analysis of liquefaction shows that not all of the mapped units are potentially liquefiable. The potential for liquefaction hazards to impact each prospective site is summarized below, and shown on Plate 7. The following information is based on previous investigations by Fugro (2004a, 2004b, 2007), visits to particular sites, and review of geologic maps and literature.

Soils within the project vicinity vary from having a relatively low to high potential for liquefaction. Soils having a high to very high potential for liquefaction were typically encountered in the collection system area by our previous investigation (Fugro, 2004a). The greatest potential for liquefaction is within areas that are either low in elevation, such as the shoreline areas along Morro Bay and interdunal depressions along Morro Avenue, Paso Robles Avenue, Santa Ynez Avenue, and Ramona Avenue-Mitchell Drive. These areas are typically characterized as being underlain by relatively loose sand and shallow groundwater. The potentially liquefiable sand is typically less than 10 feet thick. The piping and pump stations that will be located in these areas are the most likely to be impacted by liquefaction. Soils having a low potential for liquefaction were generally encountered in the higher elevations of the site, such as the predominant dune ridges along Pismo Avenue, eastern Santa Maria-El Morro Avenue, and in the Broderson-Skyline Avenue area. These areas are typically characterized as being underlain by relatively dense sand, and/or areas where groundwater is deep relative to the presumed depth of the collection system.

In addition, soils having a moderate to high potential for liquefaction are mapped within the recent, unconsolidated dune sand and alluvial sediments associated with Los Osos Valley drainage, Los Osos Creek, and Warden Lake. Based on the low relief of these areas, we anticipate high groundwater elevations to augment the susceptibility of the alluvial soils to liquefaction. These areas are most likely to impact the conveyance pipelines that may traverse these low lying areas.

In general, dune sand and alluvial sediments are underlain by soils of the Paso Robles Formation within the project vicinity. The Paso Robles Formation is typically equivalent to stiff to hard and dense to very dense soil, thus, the majority of sites underlain by the Paso Robles Formation, have a low potential for liquefaction. Bedrock units of the Franciscan Formation are not considered susceptible to liquefaction. The treatment plant improvements and Broderson sites are located in areas that are considered to have a low potential for liquefaction, except for perhaps the Turri Road and Tonini treatment plant sites where subsurface exploration to help evaluate liquefaction hazards has not been performed. Based on site reconnaissance, the majority of the Tonini site appears to have relatively shallow soil cover overlying Paso Robles Formation or Franciscan rocks, and a site for the treatment facility could likely be selected in the bedrock areas and outside any areas that may be vulnerable to liquefaction.

4.3.1.1 Collection System and Conveyance Network

Liquefaction can result in ground mobility that impacts pipeline grades, or results in pipelines floating out of the ground in areas of liquefaction. The collection system will consist of approximately 45 miles of pipeline that will essentially be constructed through the Los Osos, Cuesta-by-the-Sea and Baywood communities. Loose sand blankets the upper 5 to 10 feet of the ground surface over most of the collection system area. Portions of the collection system network and prospective out-of-town/in-town conveyance routes traverse areas having a relatively high potential for liquefaction. The potential for liquefaction and seismic settlement to impact pipelines may be governed by the depth of the pipeline relative to the depth of liquefiable soils. For our previous investigation (Fugro, 2004), the seismic settlement within the collection area was estimated to be less than about 2 inches.

Mitigation. Liquefaction could impact the pump station and pipelines in portions (about 20 percent) of the collection system areas, and where the conveyance crosses low-lying areas or creeks. Mitigation for pump stations typically consists of site preparation and grading that will reduce the potential for liquefaction and seismic settlement to impact the pump station areas, or supporting the structure on deep foundations bearing below the liquefiable materials. Specific recommendations for designing pump stations considering liquefaction hazards should be provided in the design-level geotechnical report.

When practical, pipelines should be founded below liquefiable soils. Because of the difficulty of predicting pipeline performance relative to liquefaction and seismic hazards, pipelines are commonly not mitigated as part of the design and construction of a pipeline project. Alternatively, liquefaction and seismic hazards can be addressed in an Emergency Response Plan (ERP) for the wastewater facility. The ERP should recognize the potential for liquefaction and seismic hazards to impact the pipeline, and specific high hazard areas that should be inspected for damage following an earthquake. "Soft fixes" are sometimes incorporated in the ERP. Soft fixes typically consist of having a plan in-place to address the hazards, such as can be achieved by storing supplies and equipment associated with the pipeline and repair that can be difficult to obtain or have long lead times to obtain.

4.3.1.2 Wastewater Treatment Plant Sites

Los Osos Mortuary, Giacomazzi, Branin, Robbins 1, Robbins 2, and Andre Sites. Materials of undifferentiated Paso Robles Formation and/or alluvium were encountered in each of the explorations from our previous investigation (Fugro, 2007) at the sites. The upper 3 to 4 feet of materials appeared to be relatively loose/soft and likely represent topsoil/colluvial materials disturbed during previous agricultural/plowing activities. There appears to be a low potential for liquefaction to impact these sites based on currently available information.

Tonini Site. The lower, generally flat topography of the Tonini site is characterized primarily by alluvium, with queried deposits of dune sand and Paso Robles formation. The slopes along the western and northern portions of the site have been mapped as Franciscan mélange and metavolcanics. During a site visit on May 6, 2008, Fugro noted the presence of alluvial, surficial clayey soils on the generally flat portions of the site, and Franciscan units on the adjacent slopes. As shown on Plate 7, without site-specific geotechnical study the recent alluvial sediments are considered to have moderate to high potential for liquefaction if groundwater elevations are high. However, the presence of fine-grained, cohesive materials within the soil profile suggests a lesser potential for liquefaction and seismic settlement than that typically associated with cohesionless soils. The majority of the Tonini site appears to have relatively shallow soil cover overlying Paso Robles Formation or Franciscan rocks, and although further geotechnical analysis is needed to evaluate liquefaction potential for a treatment facility at this site, a site could likely be selected outside any areas that may be vulnerable to liquefaction.

Mid-Town Site. The site is underlain by a variable thickness of relatively loose to medium dense dune sand deposits that overlie relatively dense sand of the Paso Robles Formation (age-equivalent). During our previous investigation (Fugro, 2004a), the groundwater table was generally encountered within the denser sand and below the base of the dune sand deposits. Grading was recommended to remove the loose soil from improvement areas that may be vulnerable to seismic or static settlement. The denser sand within the Paso Robles Formation is estimated to have a relatively low potential for seismic settlement and liquefaction.

Turri Road Site. The Turri Road site is underlain by alluvium. As shown on Plate 7, without site-specific geotechnical data and given the recent alluvial sediments, low elevation of the site, and the likelihood of shallow groundwater, the site is considered to have a relatively high potential to be impacted by liquefaction. Fugro estimates a high potential for liquefaction and seismic settlement to impact the site.

Mitigation. The building code requires liquefaction and associated mitigation to be addressed in the design-level geotechnical report for design. With the exception of the Turri Road site, the treatment plant sites appear to have a moderate to low potential for liquefaction.

As discussed above, grading would remove loose soil from the Mid-Town site that is considered vulnerable to seismic settlement. A geotechnical study of the Tonini site should allow for a suitable site for the treatment facility to be selected outside areas where mitigation of liquefaction may be required. The Turri Road site should be further evaluated if selected for design; however, there is a relatively high potential that mitigation of liquefaction or seismic settlement would be needed to develop the site for the treatment plant.

The design-level geotechnical report should address liquefaction for the selected wastewater treatment site considering the treatment facility (structure vs. ponds), the storage reservoirs, and related site improvements. Mitigation for liquefaction and seismic settlement typically consists of either removing the soil that is prone to liquefaction and seismic settlement and replacing it with properly compacted (engineered) fill; deeply compacting the soil in-place; or supporting structures on deep foundations bearing below the settlement-prone soil. Deep compaction or deep foundations may be needed to support structures, or portions of the structures, if the estimated seismic settlement cannot be tolerated using shallow or mat foundations. The tolerable settlement and foundation design for the buildings should be further evaluated by the geotechnical professional and structural engineer during the design of the project.

4.3.1.3 Effluent Disposal Sites

Broderson. The proposed effluent disposal system at Broderson will be located on a relatively gently sloping hillside approximately 1,200 feet south of Highland Avenue. Based on previous investigations (Fugro, 2004a), the depth to groundwater is greater than 100 feet below the existing ground surface, and except for the near-surface loose dune sand deposits, the deeper soils encountered beneath the site are generally dense and not susceptible to liquefaction or seismic settlement. The near-surface loose dune sand would be considered potentially liquefiable in the event that they were saturated at the time of an earthquake; however, the groundwater depths will not be permitted to rise near to the ground surface at the site (Cleath and Associates, 2000). Therefore, Fugro (2004a) concluded there is essentially no change in the potential for liquefaction or seismic settlement to occur within the soils encountered as a result of the effluent disposal system and estimated mounding at the Broderson Site.

Tonini. The spray field irrigation at Tonini likely have little impact on the potential for liquefaction. Should liquefaction occur at the site, it is unlikely that the occurrence of liquefaction would impact the suitability of the site for spray irrigation. Clay soil mapped over most of the site likely limit the infiltration of irrigation water. Low lying areas along the southern end of the site, may contain liquefiable soil, but are likely to have an increased potential for liquefaction due to irrigation.

Mitigation. None anticipated.

4.3.2 Lateral Spreads

Lateral spreading is slope instability that can occur in response to liquefaction. Lateral spreading typically develops on sloping ground underlain by liquefiable soils or where free-face conditions can develop in a liquefiable soil, such as along a river bank or drainage. Prospective sites that include rivers banks or descending slopes that may allow for free-face conditions to develop within liquefiable soils, and the potential for lateral spreading to impact the sites during a seismic event are discussed below. As discussed in Section 3.6.1 of this report, lateral spreading was observed in areas along the perimeter of Morro Bay following the December 2003 San Simeon Earthquake. Observed lateral spreading was generally confined to inlets and shoreline areas, and not within the proposed collection system area. Stream bank areas along Los Osos Creek are also likely vulnerable, and could impact the conveyance pipes at creek crossing locations.

Above-ground treatment and storage ponds with earth berm perimeters likely would be susceptible to liquefaction-induced slope instability if founded on potentially liquefiable soil. The potential for berm instability is predominantly governed by the inclination of berm slopes and relative density of the underlying foundation support soil. Only the Turri Road and Tonini sites are likely to have foundation soils that may be prone to liquefaction. Design and construction of slopes should be further evaluated in subsequent design level geotechnical reports.

Mitigation. The design-level geotechnical report should address the potential for lateral spreading to occur in association with liquefaction, and whether or not the hazard could impact the design of the conveyance structures, storage reservoirs or other improvements. The ERP should consider the potential for lateral spreading in association with liquefaction along shoreline areas and creeks. Mitigations, such as lowering the conveyance pipelines below potentially liquefiable soils and the need to remove liquefiable soil from beneath the storage reservoir berm to maintain slope stability, should be addressed in the report.

4.3.3 Ground Lurching

Ground lurching occurs as the ground is accelerated during a seismic event. As evidenced by the Loma Prieta, Landers, Northridge, and San Simeon earthquakes, the effects of ground lurching can damage facilities and buried pipelines. Ground lurching occurs due to detachment of underlying stratigraphic units, allowing near-surface soil to move differentially from underlying soil. The site is within a seismically active region of Central California that is prone to moderate to large earthquakes. It is therefore our opinion that there is a potential for ground lurching to impact the site. Ground lurching is generally not a geologic hazard that can be prevented, and therefore is mitigated by implementing preparedness measures.

Mitigation. Address in ERP with other seismic hazards.

4.4 LANDSLIDING

The project sites are generally on relatively flat terrain and not in areas that would be subject to landslides. However, based on review of aerial photographs, site reconnaissance and review of geologic maps, the hills adjacent to the Tonini site and along Turri Road are underlain by Franciscan Mélange and show relatively extensive evidence of slope instability, landsliding and creep. The Tonini site is also an area proposed for disposal of treated effluent by spray field irrigation. However, the Tonini and Turri Road sites are generally located on flatter ground, off of the hillsides where the instability was observed. Landsliding is not expected to impact the treatment plant, collection system, conveyance or disposal system sites. Potential impacts from landsliding could be the potential for debris to move down slope and accumulate near the base of slopes. Improvements, particularly the spray field at the Tonini site, should not be sited upon sloping areas where slope instability may be a concern.

Mitigation. A California registered engineering geologist (CEG) should evaluate the limits of the spray fields during the design of the project to confirm that spray fields are not located in areas of known or potential slope instability, landsliding, or creep. The design plans for the spray field should be reviewed by the CEG, and the CEG should document the review in writing with any recommendations for modifying the limits of the spray field. The recommendations of the CEG should be incorporated into the design plans.

4.5 SUBSIDENCE AND COLLAPSE

The prospective sites are not in an area where the withdrawal of subsurface fluids is known to have caused ground subsidence. The greatest potential for subsidence would be if potentially compressible soils were impacted by lowering of the groundwater table during construction dewatering. The buoyancy of the soil above a specific depth decreases as groundwater levels are lowered. Lowering of the groundwater level therefore increases the effective weight of the soil above that depth, which can cause the soil to subside (settle) under the increased weight of the ground above it.

Previous investigations and geologic maps indicate that the majority of the collection system area is underlain with sand dune deposits that are generally granular. Granular soils are typically regarded as having a low potential for subsidence due to dewatering. With the exception of the Turri Road site, the treatment plants sites are not in areas where dewatering would cause ground subsidence. The Turri Road site is in a low-lying area where shallow groundwater and soft or organic soil may be present. If dewatering is planned at the Turri Road site, the potential for subsidence in association with lowering of the groundwater table should be evaluated.

Mitigation. The design-level geotechnical report should address whether there are potentially compressible soils that could be prone to subsidence by construction dewatering, and any mitigation that may need to be considered for construction dewatering.

4.6 EROSION

Graded cut and fill slopes associated with the site development will be subject to sheet and rill erosion. Erosion of soils can be accelerated where soils are exposed directly to runoff and/or areas of concentrated storm runoff, such as at culvert outlets. Site drainage and landscape improvements can be designed to reduce the potential for soil erosion.

Mitigation. Erosion control measures, such as hydro-seeding, erosion control matting, and maintenance, should be provided to reduce the potential for erosion while vegetation is being established on slopes. On-going maintenance of the slopes should be provided, as-needed, to assist in establishing appropriate vegetation and to repair erosion that occurs. Energy dissipation and erosion control devices should be provided at outlets of drainage pipes and in areas where there are concentrated flows of runoff to reduce the potential for erosion.

4.7 EXPANSIVE SOILS

Expansive soil generally consists of fine-grained soil of high plasticity (clay) that can damage near-surface improvements in response to shrinking and swelling associated with changes in soil moisture content. Expansion potential of soils within the project vicinity is depicted on Plate 8 – Soil Expansion Potential Map. Near surface soils at the prospective sites predominantly consist of dune sands having a generally low potential for expansion, and alluvial sediments having a low to high potential for expansion.

Highly expansive soils mapped within the limits of the prospective wastewater treatment plant sites belong to the Concepcion, Cropley, Diablo and Cibo series. These soils are characterized as having slow to very slow permeability and high shrink-swell (expansion) potential (Ernstrom, 1984). After swelling, water infiltration is typically low and surface water is more likely to runoff or pond.

Mitigation. Structures and foundations should be designed according to at least the minimum requirements of the building code. The building code provides criteria for the design of structure foundations and concrete flatwork for expansive soil conditions. The design-level geotechnical report should address whether or not expansive soil conditions should be considered for design of structures and concrete flatwork, and provide recommendations for mitigating expansive soil conditions using concrete reinforcement, deepened footings, control of drainage, or mats of non-expansive fill as-needed based on the expansion potential of the foundation support soil.

4.8 HYDROCOLLAPSE POTENTIAL

Hydrocollapse or hydroconsolidation describes soils that are prone to settling when subjected to wetting or saturation. Hydroconsolidation can result in differential settlement that can impact buildings, pipelines, flatwork, or pavement; particularly if the wetting or infiltration of water does not occur uniformly. Shallow near surface soil, such as the expansive clay soil and loose dune sand, may be vulnerable to collapse. Near surface soil that may be vulnerable to collapse is typically removed during site preparation and grading and is replaced with compacted (engineered) fill to provide suitable support for structures, or supporting structures on deep foundations bearing below the soil. Previous investigations and review of geologic literature indicate near surface soils encountered at the prospective sites may be vulnerable to hydrocollapse. Explorations performed for previous studies suggest the loose soil that is most prone to hydrocollapse is typically less than several feet thick. We therefore expect that the loose soil likely be removed by grading to remove the loose soil and replace it as compacted fill.

Mitigation. The design-level geotechnical report should provide recommendations for foundation design, site preparation and grading to provide suitable support for structures.

4.9 TSUNAMIS AND INUNDATION

Tsunamis, or long-period sea waves created due to seismic events or submarine landslides, have historically occurred in the project region. Tsunamis can range in height from a few feet to greater than 50 feet, and can result in run-ups, or bores, extending great distances up streams, rivers, and creeks. As evidenced by recent events around the world, tsunamis can have devastating impacts on coastal areas. The project vicinity is located at elevations (el) ranging from approximately sea level for the portions of the pipeline that bound Morro Bay to approximately el. +200 feet above mean sea level (MSL) at the Broderson and Tonini sites. The County of San Luis Obispo has prepared web-based tsunami inundation maps (http://www.sloplanning-maps.org/ed.asp?bhcp=1) that show coastal areas that may be vulnerable to inundation from tsunami below about el. +40 feet MSL. The inundation zones are generally the coastal areas along Morro Bay, and low lying areas along Los Osos Creek and the vicinity of Warden Lake. According to Kilbourne and Mualchin (1980), the following historical tsunamis have occurred in the project region:

Historical Tsunami Run-up

Year	Estimated Tsunami Generation Location	Estimated Impact Location	Estimated Tsunami Run-up (meters/feet)
1868[1]	Unknown	Morro Bay	Unknown
1878[2]	Unknown	Morro Bay	Unknown
1927	Local	Pismo Beach	1.8 meters/5.9 feet
1946	Aleutian Trench	San Luis Obispo Bay	1.2 - 1.5 meters/3.9 - 4.9 feet
1960	Chile-Peru Trench	Central Coast	>1.0 meters/>3.3 feet
1964	Gulf of Alaska	Central Coast	>1.0 meters/>3.3 feet
1	Speculative		
2	Reportedly overtopped the sand spit that separates the bay from the ocean (SLO County 1999).		

As noted in the above table, tsunamis generated from far-field sources have historically occurred in the project region. A study performed by Houston and Garcia (1978) estimated the 100-year and 500-year tsunami run-ups in the study area based upon far-field source generation locations (such as the Aleutian or Chile-Peru Trenches). On the basis of their study, the estimated tsunami run-up along the Cayucos/Morro Bay coastline is up to approximately 9.5 feet to 24.2 feet for the 100-year and 500-year events, respectively. Those run-ups were calculated using astronomical high tides, and compare well with recorded tsunamis that have occurred in Crescent City and other locations along the California coast. However, according to Kilbourne and Mualchin, the worst case scenario would occur if a tsunami occurred during a meteorological high tide (storm surge), which would add an estimated 15 feet to the run-up values calculated by Houston and Garcia (1978). Thus, with a worst case scenario, the estimated tsunami run-up for the 100-year and 500-year would be approximately 25 and 40 feet, respectively.

Houston and Garcia's (1978) study did not evaluate the tsunami run-up potential generated from local seismic events or local submarine landslides. It is difficult to model the tsunami run-up magnitudes based on local events; however, it is thought that local events can generate tsunamis of equal magnitudes as far-field tsunami sources (Kilbourne and Mualchin 1980).

The entire Turri Road Site and coastal areas of the collection system are below the estimated tsunami run-up elevations shown on the County website. As a result, tsunami run-ups may be considered a potential hazard to the Turri Road Site as a prospective location for the wastewater treatment plant. However, tsunami run-ups should not result in adverse impacts to the pipeline in areas where it is buried and protected from scour, or impact areas where the pipeline is above the run-up elevations. We would expect that there is a potential that locally the pipeline could be exposed and possibly damaged as a result of erosion associated with tsunami run-up.

Mitigation. None anticipated. Tsunami hazards are typically addressed by developing warning systems and evacuation plans for coastal areas. The San Luis Obispo County Office of Emergency Services is responsible for the emergency response plan.

4.10 NATURALLY OCCURRING ASBESTOS

Naturally occurring asbestos (NOA) is common in serpentine rock throughout San Luis Obispo County. The California Air Resources Board has identified serpentine rock as having the potential to contain asbestos. Serpentine rock is typically a constituent of Franciscan Formation mélange, which is mapped on the slopes along the northern limits of the Tonini site and north of the Turri Road site. Mélange has not been mapped or encountered at any of the remaining prospective sites. We do not anticipate components of the project will be planned for areas potentially containing serpentine rock. Therefore, it is our opinion that there is a low potential for NOA to impact the project.

Mitigation. None anticipated. The County will likely require a letter prepared by a geotechnical professional for project that specifically identifies whether or not NOA is an issue for the project.

5.0 GEOTECHNICAL CONSIDERATIONS AND IMPACTS

The following provides a summary of preliminary geotechnical considerations that are likely to affect the project. These items will need to be considered in the design and construction of the project.

5.1 SEISMIC DATA

San Luis Obispo County has adopted the 2007 California Building Code effective January 1, 2008. Buildings and structures for the new wastewater facility will be designed to the minimum requirements of Seismic Zone 4. The site preparation and foundation design should consider any associated impacts that could be associated with liquefaction, seismic settlement, or ground instability as discussed in this report. Seismic design criteria from the 2007 California Building Code are discussed in section 3.5.2 of this report.

5.2 COLLECTION SYSTEM

5.2.1 Excavation

Excavation for the collection system will generally consist of trenching to allow for placement of the new sewer pipes and service laterals from the existing residences. Improper excavation techniques and can result in instability of the trench sidewalls, unsafe working conditions, and damage to adjacent property, utilities, and streets. As part of the Fugro (1997) field exploration program, 7 backhoe trenches were excavated at the site. On the basis of the trenching, the main geotechnical considerations for the trench excavations will be:

- The soils encountered within the collection system area generally consist of sandy soils. The trenches that were excavated at the site were performed using a rubber-tire mounted backhoe with a 30-inch-wide bucket. The sand should be able to be excavated for pipeline trenches relatively easily using conventional backhoe or excavator type equipment typically used for pipeline construction.
- The sand encountered in the previous explorations generally has low or no cohesive strength. These materials generally will not stand unsupported in excavations with vertical sides. Depending on the soil moisture conditions at the time of construction, the soil may exhibit apparent cohesion for a time; however, even temporary unsupported excavations with vertical sidewalls should be considered to be potentially unstable and subject to collapse. Excavations should be sloped or shored in accordance with OSHA requirements.
- Groundwater was encountered at relatively shallow depths in the borings, trenches, and CPT soundings. Where groundwater was encountered in our trenches, we observed that the walls of the excavation typically became unstable and collapsed or flowed into the excavations. Excavations extending below the groundwater table should not be considered feasible without the use of dewatering prior to excavation. Areas of potentially high groundwater are shown on Plates 5a and 5b.
- Trenching for the collection system will mainly be performed in the existing streets. Placement of the pipe will typically involve saw cutting the existing pavement, removing pavement, excavating the trench, placing the pipe, placing backfill, and patching the street. Stockpile areas adjacent to the trench are typically needed to provide access for pipe delivery, stock piled material excavated from the trench, and to provide access for haul trucks delivering and hauling away trench excavation and backfill material. This system can easily occupy the width of the roadway and limit access of most residential streets.

Mitigation. Trench and excavation and shoring is the responsibility of the contractor. Trench walls should be supported in accordance with Cal OSHA requirements, and properly sloped, shored, and dewatered to prevent instability of the trench walls and damage to adjacent property.

5.2.2 Dewatering

Groundwater conditions are notoriously shallow in many areas of the communities of Los Osos, Baywood, and Cuesta-by-the-Sea. Construction dewatering will likely be needed to allow for construction of portions of the collection system. Improper construction dewatering can result in instability of trench walls, removal of insitu soil and subsequent subsidence of the ground along the trench, and flooding of the trench preventing proper construction. Groundwater depths based on previous studies within the collection area are summarized on Plates 5a and 5b. In some areas of the site, groundwater daylights on the surface, resulting in areas of ponding, springs, and seeps. Groundwater and surface water conditions along the coastal areas in Baywood and Cuesta-by-the Sea are likely influenced by tidal fluctuations. Groundwater changes will also fluctuate seasonally, and with variations in storm water runoff, irrigation schedules, rainfall, and other factors.

- On the basis of the groundwater conditions previously encountered within the collection area, it is our opinion that dewatering will be needed to construct the pipeline trenches. The contractor should be responsible for selecting the method of dewatering, and for maintaining the dewatering system, as-needed, to allow for the pipeline construction.
- Dewatering should consist of lowering groundwater levels below the bottom of the trench prior to excavation. Dewatering should be performed such that water does not seep through side walls of the trench, and is significantly below the invert of the pipe to allow for stabilization of the subgrade and compaction of the pipe zone bedding material.
- Dewatering facilities, such as sump pits, wells, and well points should be designed with filters such that sand and fine-grained materials are not removed from the soil during dewatering operations. Dewatering facilities should be installed in advance of beginning excavation, and time should be allowed for lowering of the groundwater table before beginning excavation. Prior to mobilizing equipment to the site, the contractor should be required to submit a dewatering plan for review by the design consultant and geotechnical engineer. A qualified registered professional should prepare the dewatering plan.
- Although the majority of soil conditions previously encountered generally consisted of sandy materials, layers of moderately cemented, dense sand and clay were encountered in some of the explorations at depth. It is our experience that these types of conditions can perch groundwater, and subsequently reduce the effectiveness of dewatering wells constructed at depth to drawdown the groundwater table. The contractor should perform field pump tests to evaluate the depth and spacing of dewatering points or wells prior to submitting the dewatering plan.

- Discharge requirements from the Regional Water Quality Control Board will need to be permitted to allow for construction dewatering.

Mitigation. Construction dewatering should be performed by a qualified contractor. Discharge permits and requirements for construction dewatering should be addressed in advance of beginning construction.

5.3 SITE PREPARATION AND GRADING

We anticipate that site preparation and grading will be needed to provide uniform support for building foundations, pavements, concrete flat work, and related structures. The near-surface soil is relatively loose, prone to hydrocollapse, and is not suitable for support of the improvements. Grading typically consists of removing the existing soil to a specific depth below the existing ground surface, and replacing the excavated materials as compacted fill. The specific depth of the removal will depend on the results of design-level geotechnical study, but likely be about 5 feet or less.

Mitigation. The design-level geotechnical report should provide recommendations for foundation design, site preparation, and grading to provide suitable support for structures.

5.4 FOUNDATION DESIGN

Foundations should be designed such that structural loads are transferred to the ground without exceeding the allowable bearing capacity of the soil, and such that the settlement of the ground in response to structural loading does not exceed tolerable limits for the structure. The project development is expected to consist of single-story buildings for the plant operation, pump station controls, and generators. Geotechnical considerations that could impact the design of the building foundations are differential settlement associated with liquefaction or seismic settlement, and the presence of potentially compressible soils that may be present below the depth of grading.

We expect that building and tanks associated with the wastewater project likely be supported on shallow foundations bearing in compacted fill. The exception may be the Turri Road site, where there is a potential for soft ground conditions, which may require that building or treatment facilities be supported on deep foundations, such as driven piles. At the remainder of the site, grading will likely be performed to provide uniform support for foundations and structures, and limit the potential for settlement due to the foundation load. Additionally, footings can be tied together with grade beams or designed as a single “mat” foundation to help distribute structural loads, reduce bearing pressures, and help to limit differential settlement.

If structural loads are relatively large, the footing size will need to be increased to accommodate the higher load, and the depth of soil that is influenced by the pressure of the footing will extend to a greater depth. In soft, liquefiable, or compressible soil, it may not be practical to design the grading deep enough to limit the settlement to within tolerable limits for the structure.

Mitigation. The design-level geotechnical report should provide recommendations for foundation design, site preparation, and grading to provide suitable support for structures. The type of foundation systems and tolerable settlement for structures will need to be addressed during the design phase of the project. Additional geotechnical evaluation and coordination with the structural engineer will be needed to select the appropriate foundation type and grading needed to support foundations.

5.5 SITE SELECTION FOR TREATMENT PLANT

With the exception of the Turri Road site, the treatment plant sites appear geotechnically feasible for design, have limited potential to be impacted by geologic hazards, and will likely be constructed using relatively conventional foundation support and grading methods. No site-specific geotechnical evaluation has been performed for the Turri Road site. Because the site has potential for shallow groundwater and soft ground, the design and construction of a treatment plant on this site could be geotechnically complex, costly, and prone to being impacted by geologic hazards such as liquefaction, seismic settlement, and inundation from a relatively catastrophic tsunami.

Mitigation. Further geotechnical evaluation and exploration of the Turri Road site should be performed to further evaluate geologic hazards and geotechnical considerations for the project, if this site is to be selected for design.

6.0 SUMMARY

Hazard/Geotechnical Consideration	Summary	Consideration/Mitigation
Fault Rupture	No known faults appear to impact the current sites.	None
Strong Ground Motion	Project site is likely to be impacted by strong ground motion. Historical earthquakes have impacted the Los Osos Community in the past.	Design and construction should be performed in accordance with minimum requirements of California Building Code (2007), as adopted by County of San Luis Obispo. A Geotechnical Report, prepared by a California registered Geotechnical Engineer and Professional Geologist, should be prepared for the design of the project to provide seismic data for use with the building code.

Hazard/Geotechnical Consideration	Summary	Consideration/Mitigation
Seismic-Related Ground Failure (liquefaction and seismic settlement)	Collection System and Conveyance Network: Portions of the collection system and the out-of/in-town conveyance pipelines traverse areas having a high potential for liquefaction. The greatest potential for liquefaction is within areas that are either low in elevation, such as the shoreline areas along Morro Bay and interdunal depressions along Morro Avenue, Paso Robles Avenue, Santa Ynez Avenue, and Ramona Avenue-Mitchell Drive, and along the drainages of Los Osos Creek. These areas are typically characterized as being underlain by relatively loose sand and shallow groundwater.	A Geotechnical Report should be prepared for the project to address liquefaction hazards, and provide recommendations for mitigation. When practical, pipelines should be founded below liquefiable soils. An Emergency Response Plan (ERP) should be prepared as part of the operation and maintenance plan for the wastewater facility. The ERP should recognize the potential for liquefaction and seismic hazards to impact the pipeline, and specific high hazard areas that should be inspected for damage following an earthquake. "Soft fixes" are sometimes incorporated in the ERP. Soft fixes typically consist of having a plan in-place to address the hazards, such as can be achieved by storing supplies and equipment for repair.
	Wastewater Treatment Plant Site: Previous studies suggest that the Los Osos Mortuary, Giacomazzi, Branin, Robbins 1, Robbins 2, Andre and Mid-town Sites have a low potential for being impacted by liquefaction. Additional exploration and geotechnical evaluation would be needed to evaluate the liquefaction hazards at the Tonini and Turri Road site. Based on geologic review, portions of the Tonini site have a moderate potential to be underlain by potentially liquefiable soil. There is a relatively high potential for the Turri Road site to be underlain by potentially liquefiable soil.	A design-level Geotechnical Report should be prepared for the design of the project that addresses liquefaction hazards and any mitigation for the selected site in accordance with building code requirements. A preliminary geotechnical report should be performed in advance of design, if a treatment plant is to be sited at Turri Road or on the Tonini property. The preliminary study should address whether or not the sites being considered will require mitigation for liquefaction, and if they are geotechnically feasible and preferred for this project.
	Effluent Disposal Sites: The soils beneath the Broderson site that may be subject to a rise in groundwater level are generally dense and not prone to liquefaction. The Tonini site will have spray irrigation, is not a facility that would be expected to be significantly impacted by liquefaction hazards, if it were to occur.	None
Seismic-Related Ground Failure (lateral spread)	Lateral spreading is slope instability that can occur in response to liquefaction. Lateral spreading is most likely to occur along shoreline areas of inlets and the bay, and not within the proposed collection system area. Stream bank areas along Los Osos Creek are also likely vulnerable to lateral spreading in association with liquefaction, and could impact the conveyance pipes at creek crossing locations. Above-ground treatment and storage ponds with earth berm perimeters likely be susceptible to liquefaction-induced slope instability, if founded on potentially liquefiable soil. Only the Turri Road and Tonini sites are likely to have foundation soils that may be prone to liquefaction.	A design-level Geotechnical Report should be prepared for the design of the project that addresses liquefaction and lateral spreading hazards and any mitigation for the selected site in accordance with building code requirements.
Seismic-Related Ground Failure (ground lurching)	Ground lurching (detachment of near-surface soil layers or strata) can occur in variety of subsurface conditions, is not easily predicted, and cannot be avoided or mitigated.	Operation and emergency response plans should consider the potential for ground lurching to occur in response to seismic events, and the potential for lurching to damage lifelines, utilities, and structures.

Hazard/Geotechnical Consideration	Summary	Consideration/Mitigation
Landsliding (building areas)	Generally the improvements are not located on ground mapped as existing landslides or in areas of known slope instability. However, the hills adjacent to the Tonini site and along Turri Road are underlain by Franciscan mélange and show relatively extensive evidence of slope instability, landsliding, and creep.	A California professional geologist (PG) should evaluate the limits of the spray fields during the design of the project to confirm that spray fields are not located in areas of known or potential slope instability, landsliding, or creep. The design plans for the spray fields should be reviewed by the CEG, and the CEG should document the review in writing with any recommendations for modifying the limits of the spray field. The recommendations of the CEG should be incorporated into the design plans.
Subsidence and Collapse	The site is not in an area where extraction of fluids (such as groundwater or oil) is known to have resulted in subsidence or collapse.	Likely, none at existing groundwater levels. If dewatering or lowering of the groundwater level is expected, the associated impacts to the site and grading and foundation design should be addressed in the Geotechnical Report.
Erosion	Graded areas of the site will be prone to erosion.	Erosion control measures should be implemented during grading to minimize the impacts of erosion during grading. Graded cut and fill slopes should be vegetated or landscaped in a manner that will reduce the potential for soil erosion following construction. Site drainage should be provided to control surface water, direct water away from slopes, and control surface water discharge.
Expansive soils	Soils mapped at the Los Osos Mortuary, Giacomazzi, Branin, Robbins 1, Robbins 2, Andre Tonini and Turri Road sites have a moderate to high potential for expansion.	Structures and foundations should be designed according to at least the minimum requirements of the building code. The design-level geotechnical report should address whether or not expansive soil conditions should be considered for design of structures and concrete flatwork, and provide recommendations for mitigating expansive soil conditions.
Hydrocollapse	Near surface soils (less than about 5 feet in thickness) are likely to be relatively loose and vulnerable to collapse (hydroconsolidation) when subject to wetting and surface loads.	Soils prone to hydroconsolidation should be removed from building sites during grading, and be replaced with properly compacted fill, or as otherwise recommended in the design-level Geotechnical Report.
Flooding, Tsunamis or Inundation	The County of San Luis Obispo has prepared web-based tsunami inundation maps (http://www.sloplanning-maps.org/ed.asp?bhcp=1) that show coastal areas that may be vulnerable to inundation from tsunami below about el. +40 feet MSL. The inundation zones are generally the coastal areas along Morro Bay, and low lying areas along Los Osos Creek and the vicinity of Warden Lake. The San Luis Obispo County Office of Emergency Services has a program for tsunami hazard warnings and evacuation independent of this project.	None

Hazard/Geotechnical Consideration	Summary	Consideration/Mitigation
Trench Excavations	Excavation for the collection system will generally consist of trenching to allow for placement of the new sewer pipes and service laterals from the existing residences. Improper excavation techniques within the dune sand and shallow groundwater areas can result in instability of the trench sidewalls, unsafe working conditions, and damage to adjacent property, utilities, and streets.	Trench and excavation and shoring is the responsibility of the contractor. Trench walls should be supported in accordance with Cal OSHA requirements, and properly sloped, shored, and dewatered to prevent instability of the trench walls and damage to adjacent property.
Dewatering	Groundwater conditions are notoriously shallow in many areas of the communities of Los Osos, Baywood, and Cuesta-by-the-Sea. Construction dewatering likely be needed to allow for construction of portions of the collection system. Improper construction dewatering can result in instability of trench walls, removal of insitu soil and subsequent subsidence of the ground along the trench, and flooding of the trench preventing proper construction.	Construction dewatering should be performed by a qualified contractor. Discharge permits and requirements for construction dewatering should be addressed in advance of beginning construction.
Site Preparation and Grading	Site preparation and grading is needed to provide uniform support for building foundations, pavements, concrete flat work, and related structures. The near-surface soil is relatively loose, prone to hydrocollapse, and is not suitable for support of the improvements. Grading typically consists of removing the existing soil to a specific depth below the existing ground surface, and replacing the excavated materials as compacted fill. The specific depth of the removal will depend on the results of design-level geotechnical study, but will likely be about 5 feet or less.	The design-level geotechnical report should provide recommendations for foundation design, site preparation, and grading to provide suitable support for structures.
Foundation Design	Foundations should be designed such that structural loads are transferred to the ground without exceeding the allowable bearing capacity of the soil, and such that settlement of the ground in response to structural loading does not exceed tolerable limits for the structure. Structures likely be supported on conventional spread footing foundations. The exception may be the Turri Road site, where there is a potential for soft ground conditions, which may require that building or treatment facilities be supported on deep foundations, such as driven piles.	The design-level geotechnical report should provide recommendations for foundation design, site preparation, and grading to provide suitable support for structures.
Site Selection for the Treatment Plant	With the exception of the Turri Road site, the treatment plant sites appear geotechnically feasible for design, have limited potential to being impacted by geologic hazards, and can likely be constructed using relatively conventional foundation support and grading methods. No site-specific geotechnical evaluation has been performed for the Turri Road site. Because the site has potential for shallow groundwater and soft ground, the design and construction of a treatment plant on this site could be geotechnically complex, costly, and prone to being impacted by geologic hazards such as liquefaction, seismic settlement, and inundation from a relatively catastrophic tsunami.	Further geotechnical evaluation and exploration of the Turri Road site should be performed to further evaluate geologic hazards and geotechnical considerations for the project, if this site is to be selected for design.

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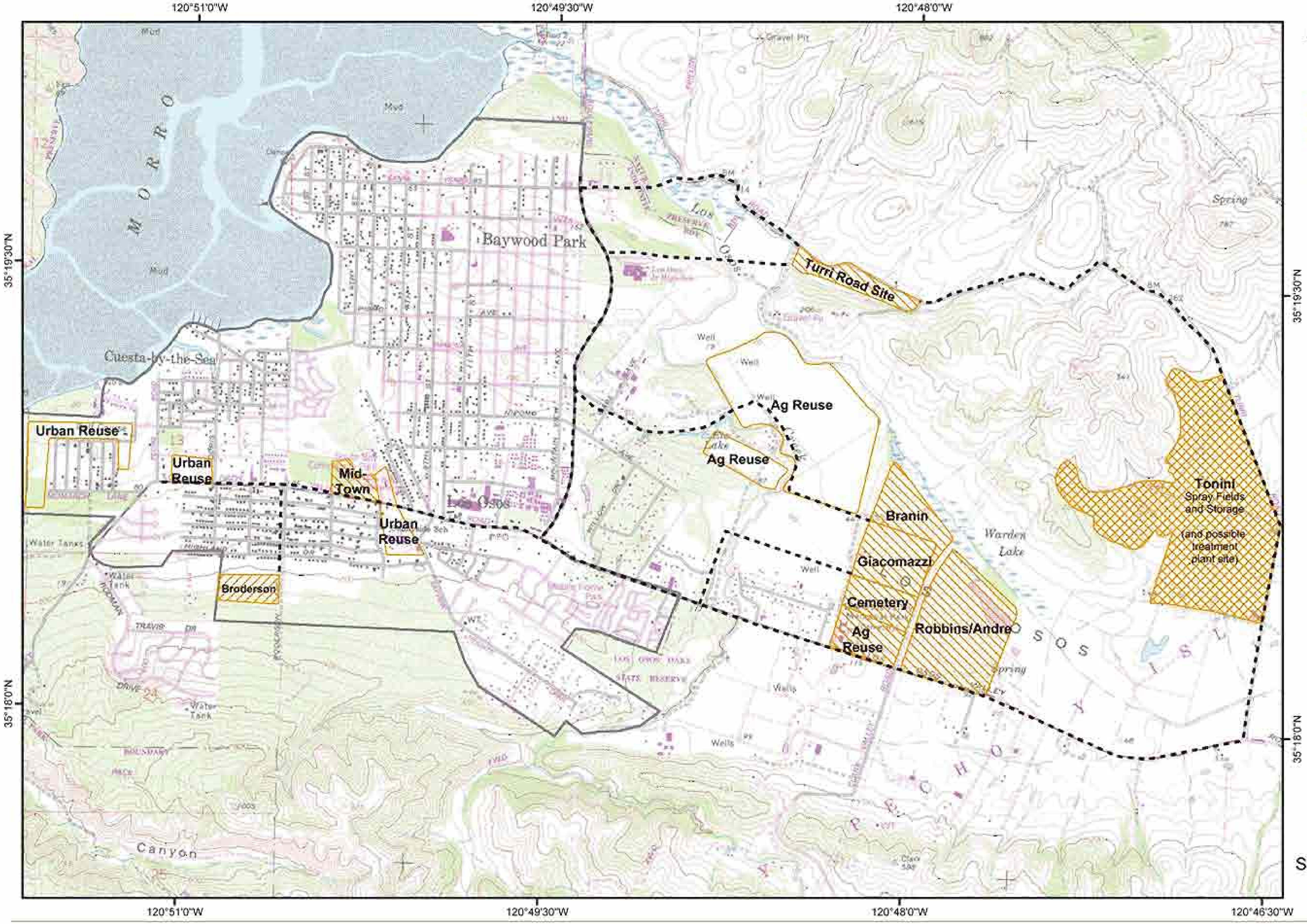
PLATES

Michael Brandman Associates
Project No. 3629.001

FUGRO



SITE MAP
Los Osos Wastewater Project
San Luis Obispo County, California

PLATE 1

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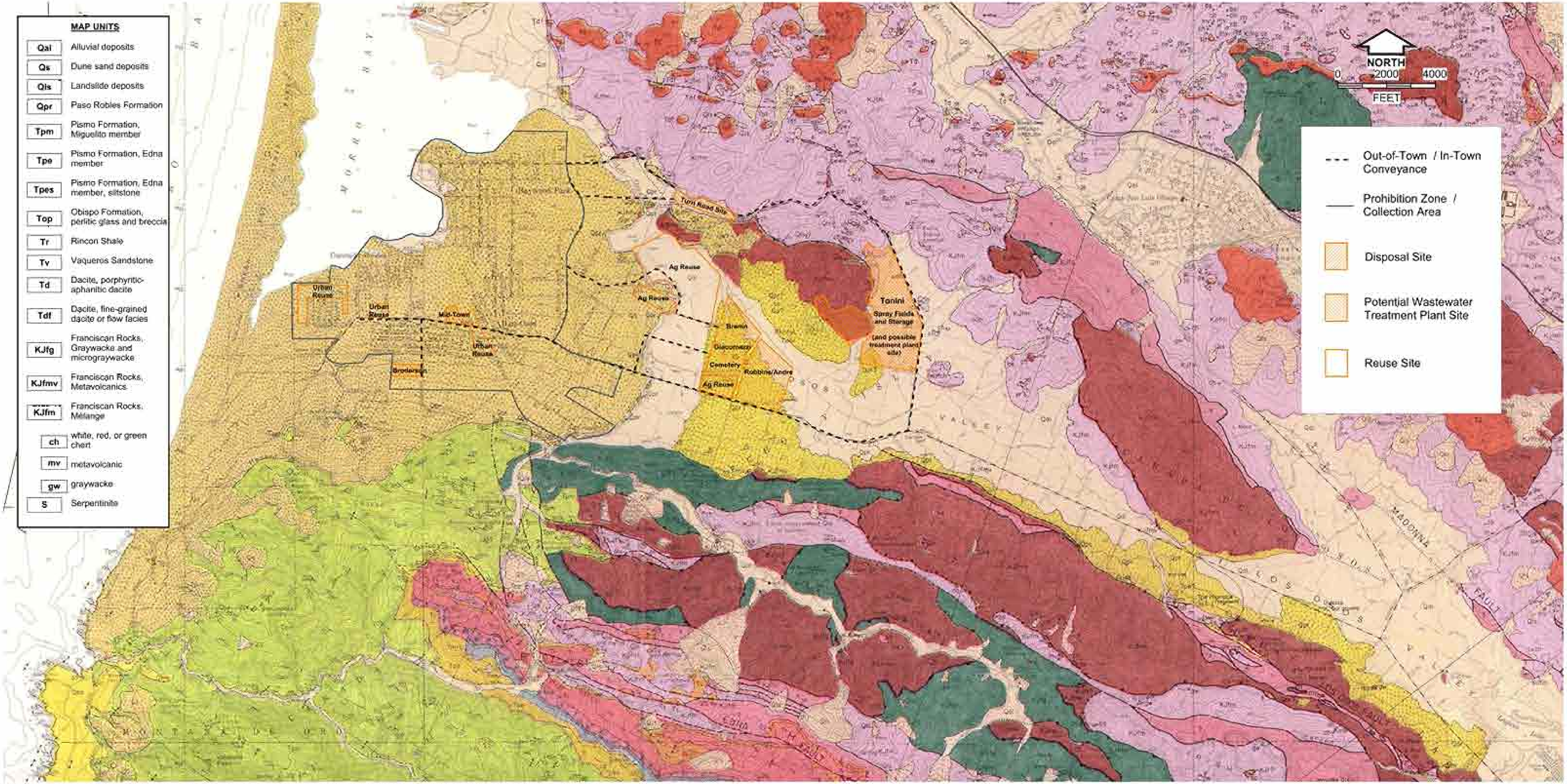


MAP UNITS

Qal	Alluvial deposits
Qs	Dune sand deposits
Qls	Landslide deposits
Qpr	Paso Robles Formation
Tpm	Pismo Formation, Miguelito member
Tpe	Pismo Formation, Edna member
Tpes	Pismo Formation, Edna member, siltstone
Top	Obispo Formation, perlitic glass and breccia
Tr	Rincon Shale
Tv	Vaqueros Sandstone
Td	Dacite, porphyritic-aphanitic dacite
Tdf	Dacite, fine-grained dacite or flow facies
KJfg	Franciscan Rocks, Graywacke and micrograywacke
KJfmv	Franciscan Rocks, Metavolcanics
KJfm	Franciscan Rocks, Mélange
ch	white, red, or green chert
mv	metavolcanic
gw	graywacke
S	Serpentinite

- - -	Out-of-Town / In-Town Conveyance
—	Prohibition Zone / Collection Area
▨	Disposal Site
▨	Potential Wastewater Treatment Plant Site
☐	Reuse Site

BASE MAP SOURCE: Geologic Map of the the San Luis Obispo-San Simeon Region, USGS Misc. Investigations Series Map I-1097, Sheet 3 of 3 (Hall, et al., 1979).

LEGEND

Contact - Dashed where approximately located or inferred; queried where doubtful; dotted where concealed

High-angle fault - Dashed where approximately located or inferred; dotted where concealed and inferred; queried where uncertain. Arrows show relative direction of movement on cross sections when known; queried where uncertain.

Thrust or reverse fault - Dashed where approximately located or inferred, dotted where concealed and inferred; queried where concealed or doubtful. Sawteeh on upper plate. Dip of fault plane between 30° and 80°

Photo lineament - Queried where uncertain

Synform - Trace of axis at surface. Dashed where approximately located. Flanks coverate downward in folds and in rocks whose stratigraphic sequence is unknown.

Antiform - Trace of axis at surface. Dashed where approximately located. Flanks diverge downward in folds and in rocks whose stratigraphic sequence is unknown.

Strike and dip of beds uncertain

Marker beds

Conglomerate or gravel bed

Sandstone

Siltstone or diatomaceous siltstone

Tuff

Breccia

30 Strike and dip of flow banding

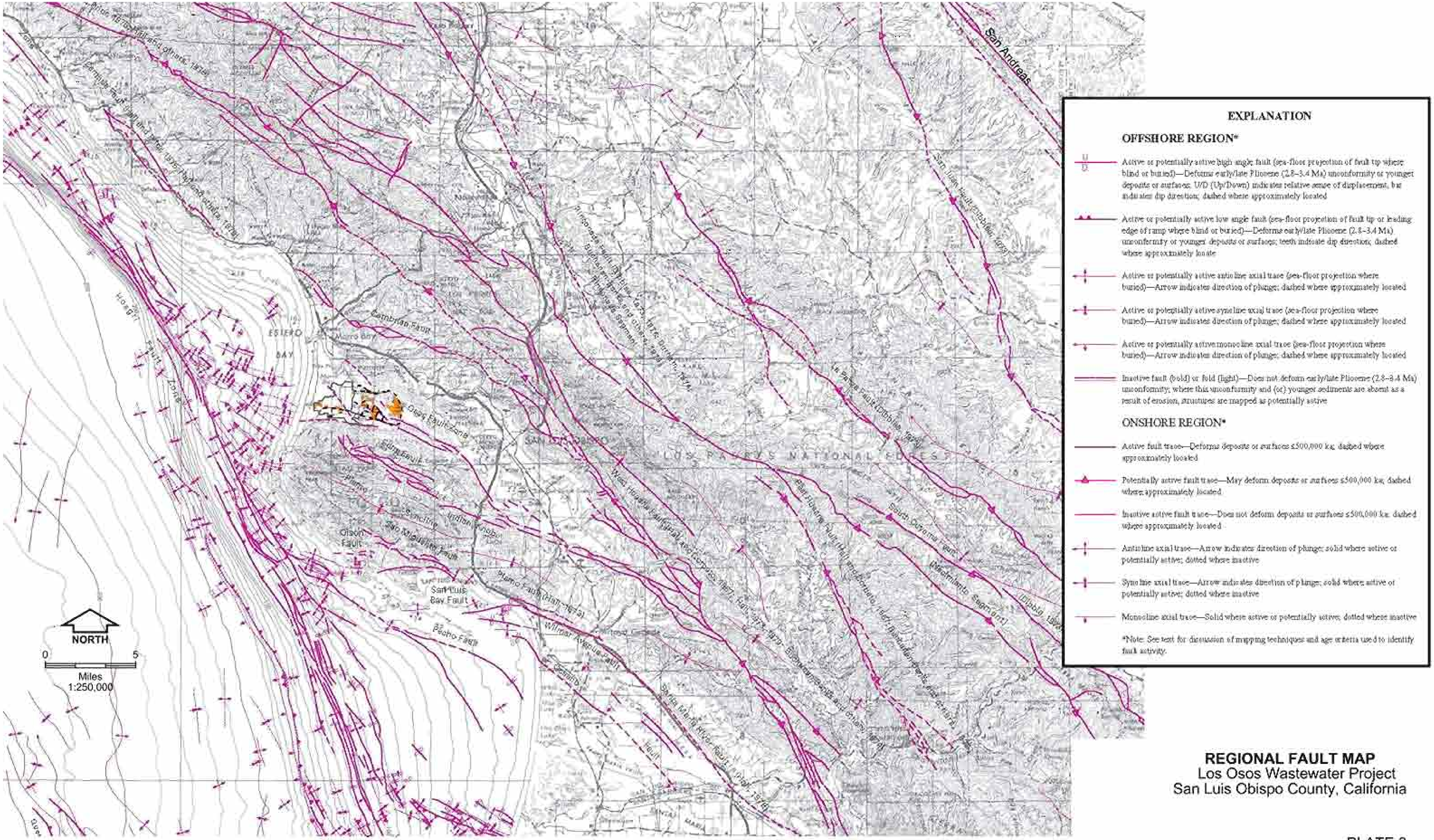
x 6193 Megafossil locality - U.C.L.A. locality number

Vollmer Ranch name/property owner

REGIONAL GEOLOGIC MAP

Los Osos Wastewater Project
San Luis Obispo County, california

PLATE 2



EXPLANATION

OFFSHORE REGION*

Active or potentially active high angle fault (sea-floor projection of fault tip where blind or buried)—Deforms early/late Pliocene (2.8–3.4 Ma) unconformity or younger deposits or surfaces. U/D (Up/Down) indicates relative sense of displacement, but indicates dip direction; dashed where approximately located

Active or potentially active low angle fault (sea-floor projection of fault tip or leading edge of ramp where blind or buried)—Deforms early/late Pliocene (2.8–3.4 Ma) unconformity or younger deposits or surfaces; teeth indicate dip direction; dashed where approximately locate

Active or potentially active anticline axial trace (sea-floor projection where buried)—Arrow indicates direction of plunge; dashed where approximately located

Active or potentially active syncline axial trace (sea-floor projection where buried)—Arrow indicates direction of plunge; dashed where approximately located

Active or potentially active monocline axial trace (sea-floor projection where buried)—Arrow indicates direction of plunge; dashed where approximately located

Inactive fault (bold) or fold (light)—Does not deform early/late Pliocene (2.8–3.4 Ma) unconformity; where this unconformity and (or) younger sediments are absent as a result of erosion, structures are mapped as potentially active

ONSHORE REGION*

Active fault trace—Deforms deposits or surfaces ≤500,000 ka; dashed where approximately located

Potentially active fault trace—May deform deposits or surfaces ≤500,000 ka; dashed where approximately located

Inactive active fault trace—Does not deform deposits or surfaces ≤500,000 ka; dashed where approximately located

Anticline axial trace—Arrow indicates direction of plunge; solid where active or potentially active; dotted where inactive

Syncline axial trace—Arrow indicates direction of plunge; solid where active or potentially active; dotted where inactive

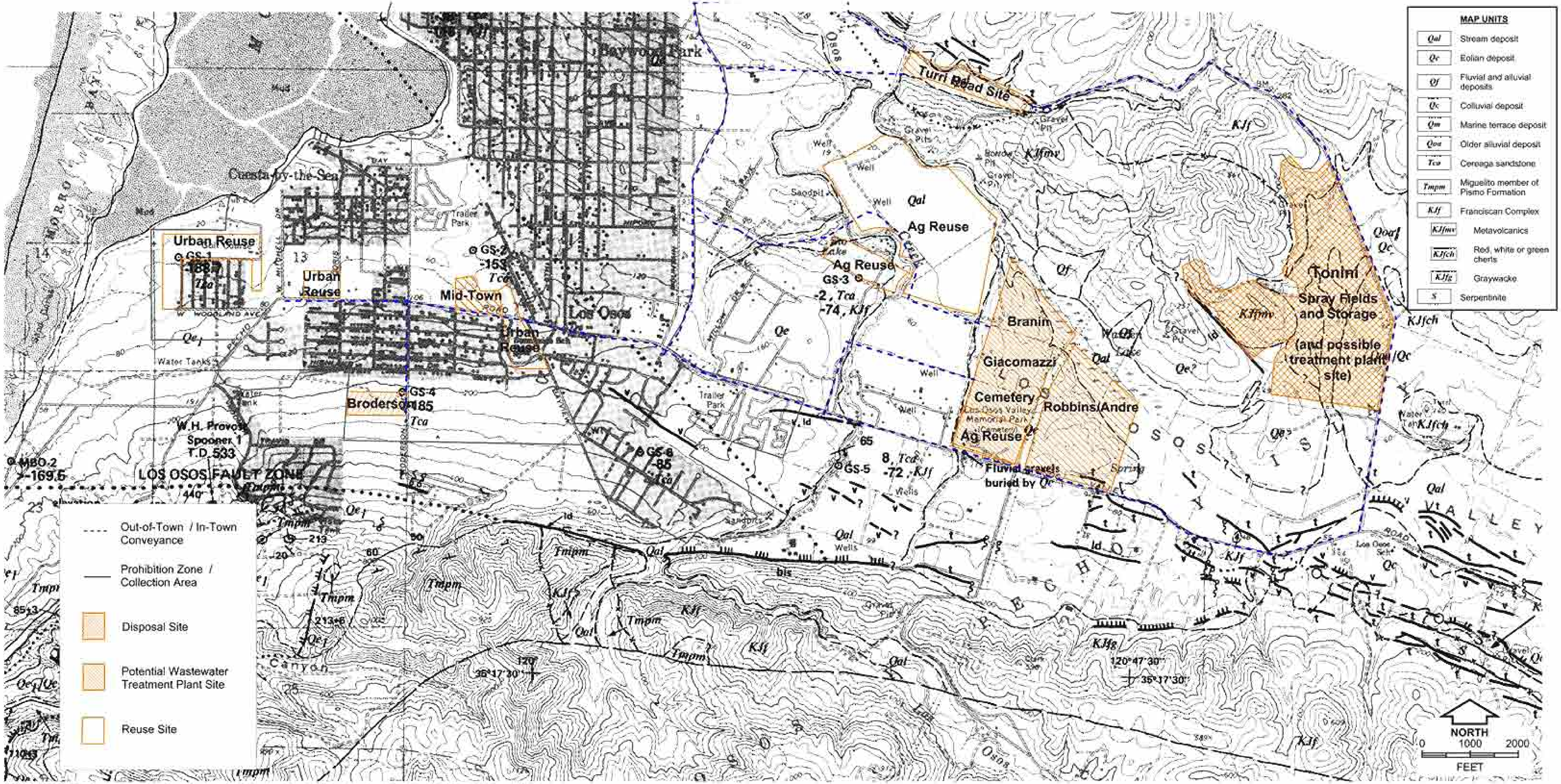
Monocline axial trace—Solid where active or potentially active; dotted where inactive

*Note: See text for discussion of mapping techniques and age criteria used to identify fault activity.

BASE MAP: Lettis et al. (2004), Faults and Folds in Onshore and Offsore Regions of South-Central California.

REGIONAL FAULT MAP
Los Osos Wastewater Project
San Luis Obispo County, California

PLATE 3



BASE MAP SOURCE: Quaternary Geologic Map of Los Osos Fault Zone, Los Osos Fault Zone, San Luis Obispo County, CA, Plate 5 (Lettis and Hall).

LEGEND

Fault - Dashed where approximately located; dotted where concealed; U = up/D = down indicates relative sense of displacement; small arrow and number indicate strike and dip of fault exposed in outcrop

Aerial photo lineament - Or fault-related feature; dashed where less distinct; queried where uncertain; hachures indicate topographic scarp and show direction; ld = linear drainage, tc = tonal contrast, v = vegetation lineament, dd = deflected drainage, bis = break in slope, s = saddle, shb = side hill bench

Los Osos fault of Hall (1973) - Dashed where approximately located; dotted where concealed
Edna fault
Indian Knob fault
Other faults

Shoreline angle - Solid where well constrained; double dot dash where concealed; dotted where eroded; altitude shown in meters

Contact - Dashed where approximately located or inferred; queried where uncertain

Strike and dip of bedding

Syncline - Showing trace of axial surfaces and direction of plunge

Anticline - Showing trace of axial surface and direction of plunge

Borehole - GS-1 - U.S. Geological Survey (unpublished data, G. Yates, Water Resource Division); MBO-2 - California Department of Water Resources (1972); altitude of subsurface of formations shown in meters

Borehole - Completed during this study

Exploratory oil well - Producer, name of well, and depth (meters) are indicated

Closed depression

Spring

Glick Trench T-1 Trench location

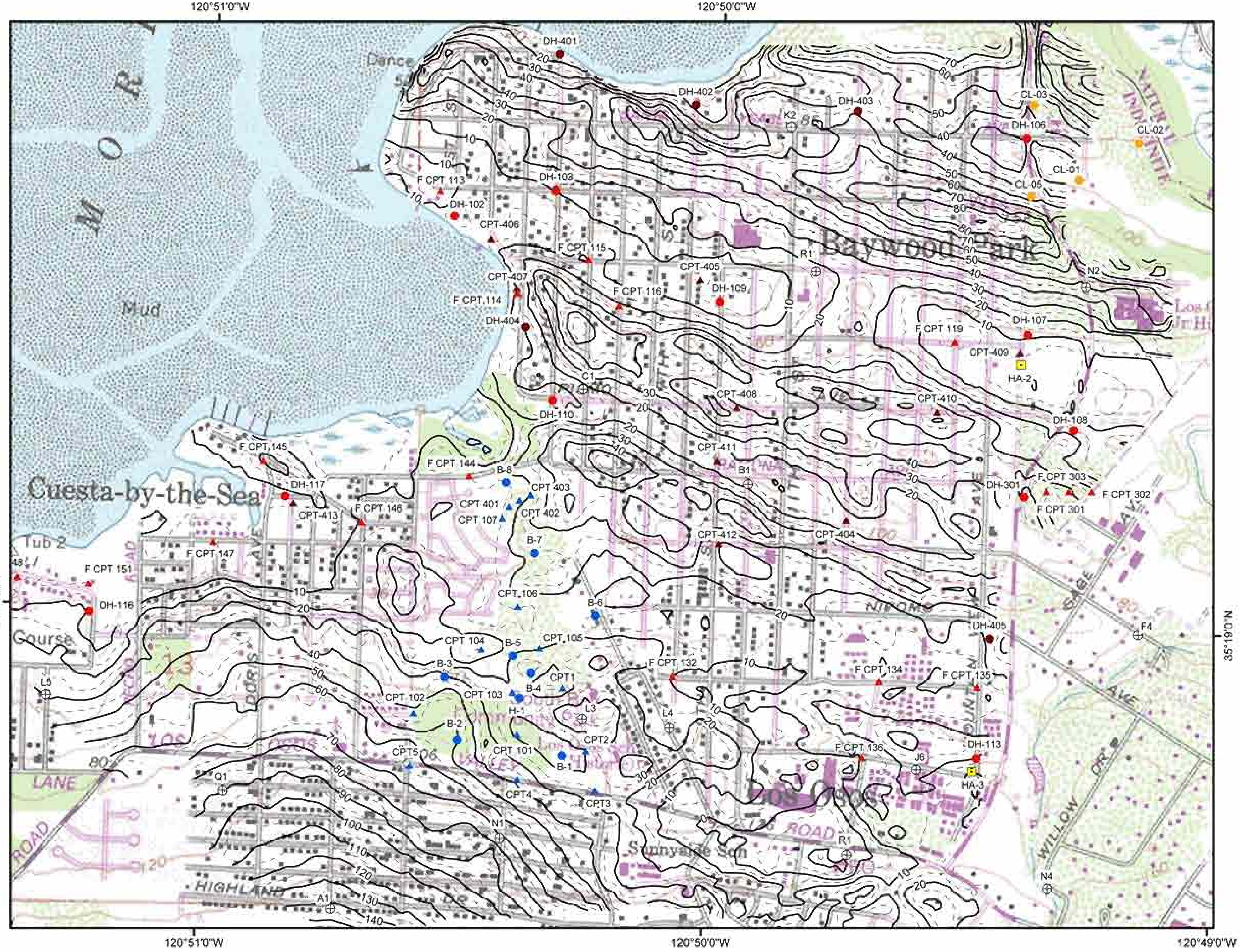
Bedrock exposure

Limit of mapping

LOS OSOS FAULT ZONE AND LINEAMENTS

Los Osos Wastewater Project
San Luis Obispo County, California

PLATE 4



Legend

- ● Hollow Stem Auger Boring Site (Fugro, 2003)
- ▼ CPT Site (Fugro, 2003)
- ● Hollow Stem Auger Boring Site (Fugro, 1997)
- ▼ CPT Site (Fugro, 1997)
- ● Hollow Stem Auger Boring Site (Cleath, 2003)
- ● Boring Site (CFS, 1999)
- ▼ CPT Site (CFS, 1999)
- ⊕ County Engineering Monitoring Well
- ▣ Hand Auger Site

Depth to Groundwater Contours

- —— Contour Interval = 10 feet
- - - - Contour Interval = 5 feet

Note: Depth to groundwater is approximate and varies seasonally. Depth calculated as difference between surface topography obtained from Montgomery Watson Harza and groundwater levels and contours estimated from explorations.

N

0 500 1,000 2,000 Feet

GROUNDWATER CONTOURS, COLLECTION SYSTEM AREA

Los Osos Wastewater Project
San Luis Obispo County, California

PLATE 5a

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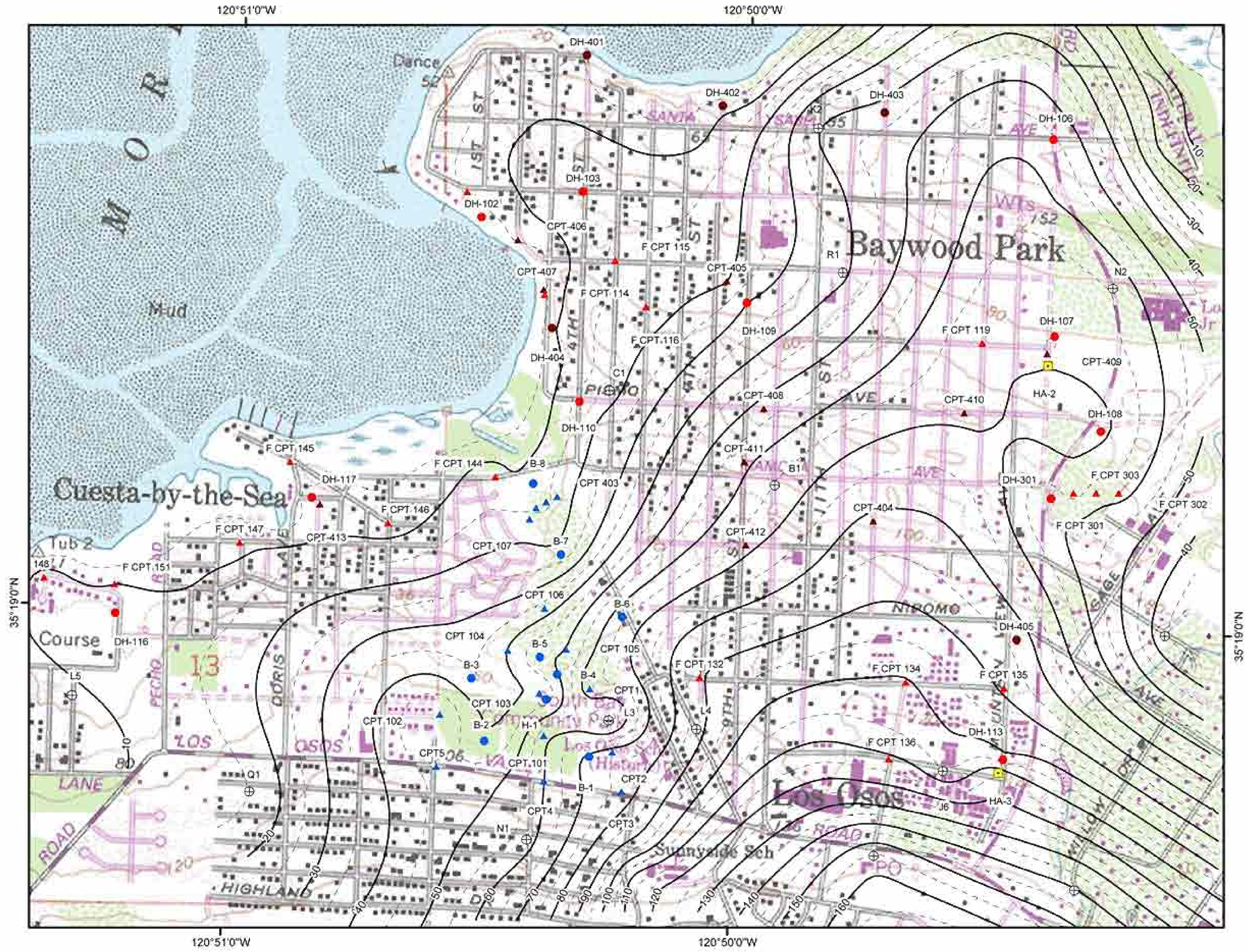
Michael Brandman Associates
Project No. 3629.001



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Legend

●	Hollow Stem Auger Boring Site (Fugro, 2003)
▼	CPT Site (Fugro, 2003)
●	Hollow Stem Auger Boring Site (Fugro, 1997)
▼	CPT Site (Fugro, 1997)
●	Hollow Stem Auger Boring Site (Cleath, 2003)
●	Boring Site (CFS, 1999)
▼	CPT Site (CFS, 1999)
⊕	County Engineering Monitoring Well
▣	Hand Auger Site

Depth to Groundwater Contours

—	Contour Interval = 10 feet
- - -	Contour Interval = 5 feet

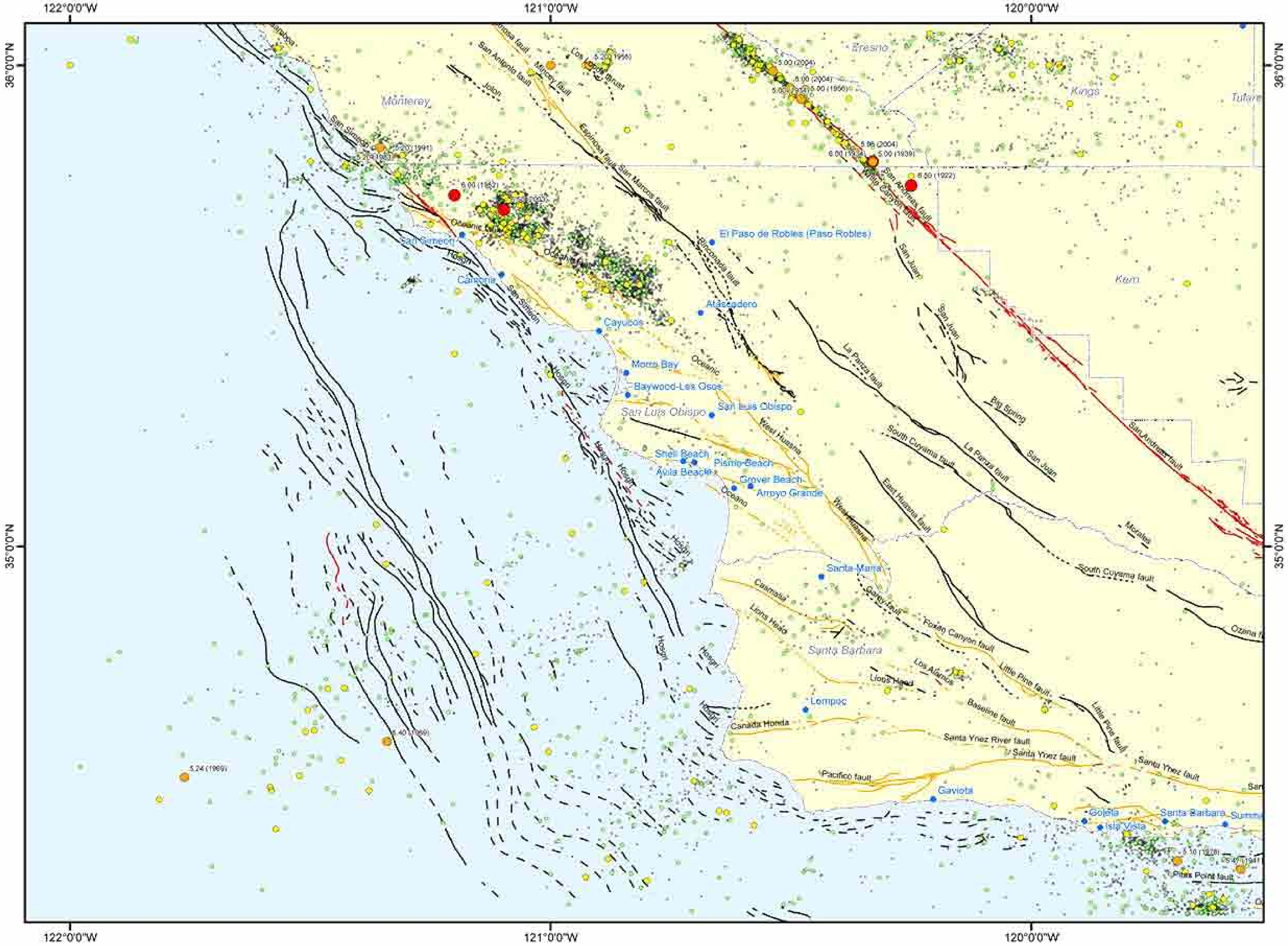
N

0 500 1,000 2,000 Feet

DEPTH TO GROUNDWATER MAP, COLLECTION SYSTEM AREA

Los Osos Wastewater Project
San Luis Obispo County, California

PLATE 5b



Legend

Earthquake Magnitude
Magnitudes equal to and greater than 5 are labeled.

·	2.0 - 2.9
•	3.0 - 3.9
●	4.0 - 4.9
●	5.0 - 5.9
●	>6.0

Faults (dashed where inferred, dotted where concealed)

—	Active Fault
—	Potentially Active Fault
—	Inactive Fault

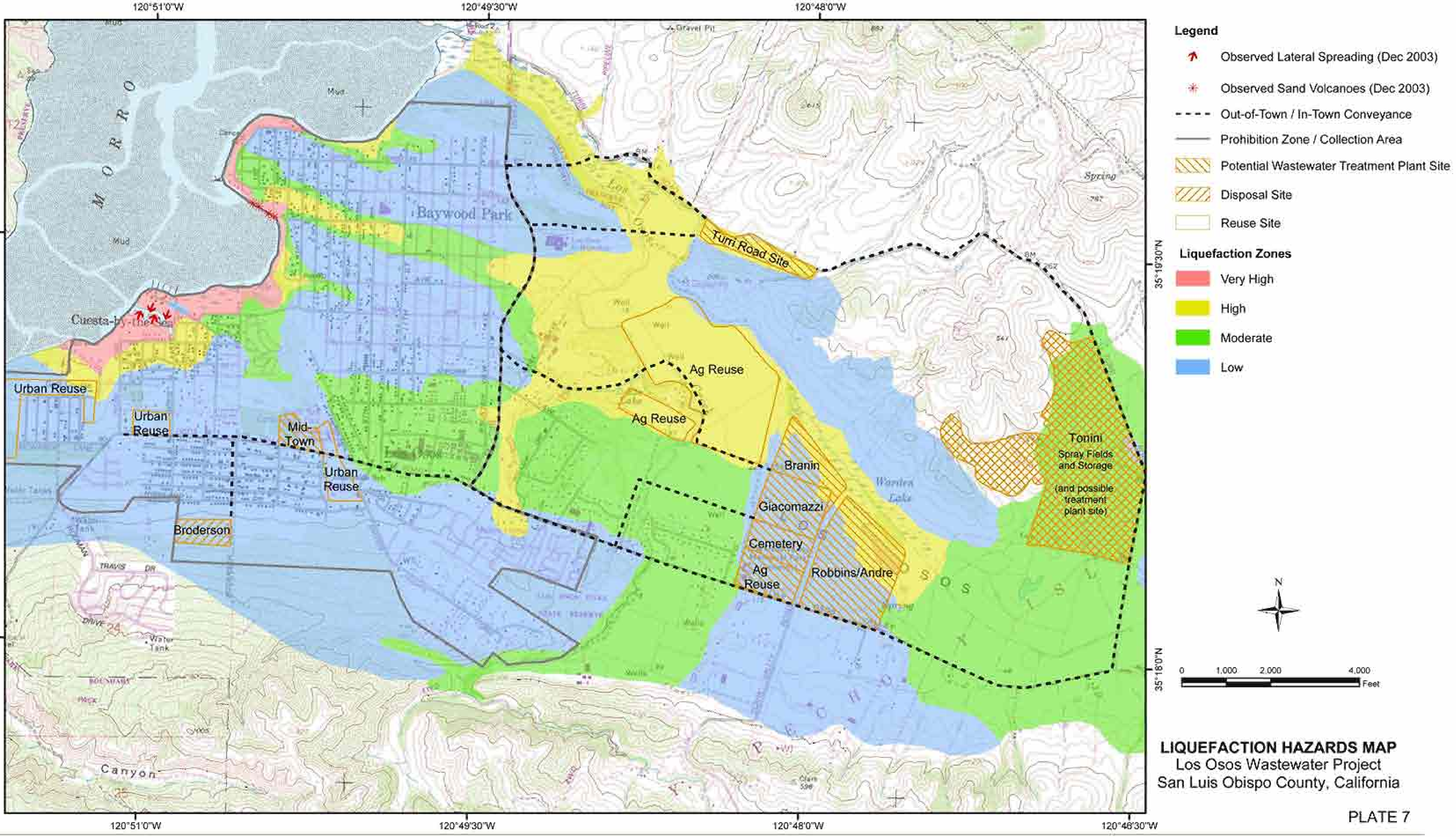
Source:
1) Earthquake Data:
Earthquake epicenters from ANSS Composite Catalog Search, 1933 to 2008, <www.ncedc.org/anss/> (downloaded March 2008)

2) Faults:
a) Bryant, 2005
b) Jennings, 1994

HISTORICAL SEISMICITY MAP
Los Osos Wastewater Project
San Luis Obispo County, California

PLATE 6

N:\Projects\3629_MBrandmanAssoc\3629-001_LosOsosWW_EIR\Outputs\Working\mxd\Plate6-Earthquakes.mxd, 05/22/08, kshell



LIQUEFACTION HAZARDS MAP
Los Osos Wastewater Project
San Luis Obispo County, California

PLATE 7

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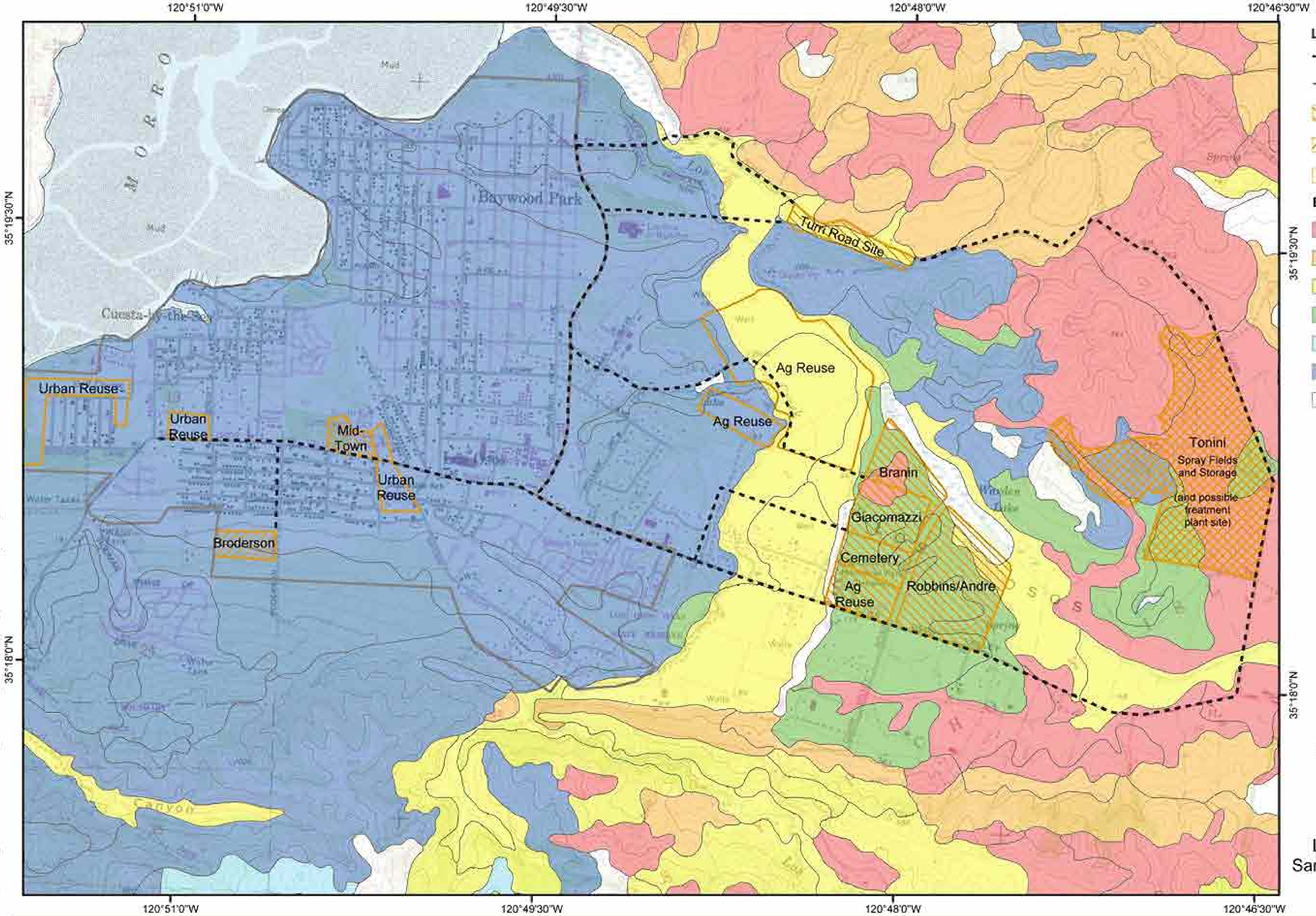

Legend

- - - - Out-of-Town / In-Town Conveyance

—— Prohibition Zone / Collection Area

▨ Potential Wastewater Treatment Plant Site

▨ Disposal Site

☐ Reuse Site

Expansion Potential of Soil

🟥 High

🟧 Moderate to High

🟨 Moderate

🟩 Low to High

🟦 Low to Moderate

🟦 Low

☐ Data Not Available

0 1,000 2,000 4,000 Feet

SOIL EXPANSION POTENTIAL MAP

Los Osos Wastewater Project
San Luis Obispo County, California

PLATE 8

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