TECHNICAL MEMORANDUM

TO: Kristin Starbird, Senior Project Manager
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FROM: Kleinfelder, Inc.

DATE: September 16, 2016

SUBJECT: Geology, Soils and Seismicity Technical Memorandum
Inglewood Oil Field Specific Plan
Culver City, California
Kleinfelder Project Number: 20162650.001A

1.0 INTRODUCTION

On behalf of BonTerra Psomas (Psomas), in support of its work for the City of Culver City, California (City or Culver City), Kleinfelder, Inc. (Kleinfelder), has prepared this *Geology, Soils and Seismicity Technical Memorandum* for the Culver City Inglewood Oil Field (IOF) Specific Plan (Project). In 2008, the County of Los Angeles certified an Environmental Impact Report (EIR) that resulted in the creation of the Baldwin Hills Community Standards District (CSD), which regulates the unincorporated County portion of the IOF. On June 23, 2014, pursuant to Culver City Municipal Code, Chapter 17.570, the City Council of the City of Culver City adopted a resolution declaring its intention to initiate a Specific Plan for the approximate 77.8 acres of the Inglewood Oil Field under City jurisdiction (Project Site). The primary purpose of this technical memorandum is to address potential concerns related to seismic and other geologic hazards in the vicinity of the project area due to oil field operations especially activities related to hydraulic fracturing and/or deep well water injection.

Throughout this Technical Memorandum, the City's portion of the IOF (77.8 acres) is referred to as the "Project Site" or the "City IOF." The entire surface boundary limits of the Inglewood Oil Field, including lands within both the City and County, is referred to as "Inglewood Oil Field" or "IOF." The off-Site portion of the Inglewood Oil Field that is within the jurisdiction of the County of Los Angeles is referred to as the "County IOF."

In this memorandum, seismic and geologic hazards due to activities associated with the oil field operations within the City IOF will be addressed. Some of these activities may include hydraulic fracturing and associated deep water well injection. The mechanism of hydraulic fracturing and deep water well injections, their relationships with earthquakes, any evidence of increased seismicity to these activities, and applicable mitigation measures will be presented.

The Specific Plan provides procedures, development and implementation standards, and conditions for future oil and gas exploration, development, and production activities within the City IOF. The Specific Plan contains several administrative items; requirements for permits, plans, and authorized well operations; guidance and requirements for supporting facilities, equipment and standards; guidance for environmental considerations to help reduce health and safety impacts on the surrounding community; and reporting requirements and safety initiatives. Upon adoption of the Specific Plan, there would be an amendment to Culver City Zoning Code Section 17.610.010.D to specify that the Specific Plan regulations will apply to oil and gas production uses in the City IOF and add a new section to Article 4 to reference the Specific Plan. Chapter 9.07 (Noise) would be amended clarify the regulations set forth in the Specific Plan as being applicable to the City IOF, and CCM Chapter 11.12, Oil, Gas and Hydrocarbons would be repealed. The onsite geology, seismicity and geologic hazards are incorporated into the description of potential Project impacts, and mitigation recommendations are provided within this Technical Memorandum.

The CSD was established in 2008 with the approval of the Los Angeles County Board of Supervisors to provide regulations and standards for drilling and oil production in the unincorporated (non-City) portion of the Inglewood Oil Field. While the City IOF is not subject to the requirements identified in the CSD, there are practices specified in the CSD that if implemented for activities in the City IOF would provide for oil field operation consistency and result in benefits for the adjacent County IOF. Section 4.4 of the CSD provides guidance on addressing and mitigating potential geology issues during the future development of the County IOF. Adherence, by the County IOF, with the CSD mitigation guidelines will help ensure that similar geological impacts that could affect the Project Site will be mitigated in accordance with Federal, State and Los Angeles County laws and regulations. Generally, this will include conducting geotechnical and geological investigations as required by law already, IOF monitoring for ground subsidence and/or uplift, and the installation of a seismometer to monitor IOF seismicity.

The CSD maintains that the County IOF employs secondary oil recovery operations, such as, water flooding, and it may begin steam injection in the future. The CSD does not discuss well stimulation techniques (i.e., hydraulic fracturing) or wastewater disposal in the subsurface. Currently all water produced is treated and reused in the waterflooding process for secondary oil recovery, in accordance with CSD Condition E.2(i). A subsequent hydraulic fracturing study was conducted by the previous operator, Plains

Exploration & Production Company (PXP), in 2011-2012 (Cardno ENTRIX, 2012), to study the feasibility and potential impacts of the type of fracturing operation that may occur in the IOF. The study concluded hydraulic fracturing would be conducted in the IOF in the future. It is not known if the flowback (wastewater) associated with future hydraulic fracturing, in excess of the amount needed for waterflooding, will be disposed into deep disposal wells (discussed in detail in Sections 3.0, 5.6 and 6.4). However, this Technical Memorandum assesses the potential impacts associated with deep disposal of wastewater.

The purpose of this Technical Memorandum is to identify existing topography, geology, soils, and seismicity within the Project Site, and to analyze potential impacts to those conditions associated with the continued development and operation of the IOF in accordance with the proposed Specific Plan. Additionally this Technical Memorandum will identify mitigation measures that would avoid or reduce the significance of any identified impacts. This will include discussions on hydraulic fracturing and waste water disposal in Class II injection wells. Currently there are no hydraulic fracturing (also referred to as well stimulation) activities occurring on the Project Site. However, if hydraulic fracturing is conducted in the future, the operator, at a minimum, will be required to adhere to the California Senate Bill 4 (SB 4) well stimulation regulations (discussed in Section 3.0). Also, any future disposals of waste water into the underground (currently this practice does not occur in the IOF) will require a Class II Injection Well permit. The primary information sources include Project-specific investigations, available resources from the USGS and the California Geological Survey (CGS), as well as other sources listed in the Reference Section. Thresholds of significance for the impact analysis are derived from Appendix G of the 2015 *CEQA Guidelines*.

2.0 MAXIMUM BUILDOUT SCENARIO

This technical memorandum includes impact analyses that are based on a “Maximum Buildout Scenario”, rather than the procedures of a specific leaseholder or operator, as this may change over time. The Maximum Buildout Scenario sets forth a combination of activities (e.g., construction, maintenance, and operation) that conservatively represents the potential impacts of oil field development in the context of the requirements and restrictions set forth in the Specific Plan. Development of the City IOF would occur over time at an unknown rate of implementation, and construction, maintenance, and operational activities will likely be occurring at the same time. Development of the City IOF in accordance with the Specific Plan would occur in no fewer than 11 years (2027), but not past 2031) based on future market conditions and other factors. Therefore, Maximum Buildout Scenario assumes the full build-out of the Project Site pursuant to the Specific Plan requirements for the purposes of assessing environmental impacts.

Table 1-1 provides the assumed schedule of the well drilling activities in the context of existing wells in the City IOF that are assumed to be operational in future years.

TABLE 1-1
ANNUAL MAXIMUM NEW WELLS

Year	Annual Maximum Number of New Wells	Existing/Future Conditions (Active Production and Injection)	Cumulative Total of On-Site Wells (Active Production and Injection)
Year 1: 2017	2	37	39
Year 2: 2018	2	39	41
Year 3: 2019	3	41	44
Year 4: 2020	3	44	47
Year 5: 2021	3	47	50
Year 6: 2022	3	50	53
Year 7: 2023	3	53	56
Year 8: 2024	3	56	59
Year 9: 2025	3	59	62
Year 10: 2026	3	62	65
Year 11: 2027	2	65	67

The Maximum Buildout Scenario for the Project Site includes:

- One well pad would be under construction on the Project Site
- 65 active production and injection wells (waterflooding for enhanced recovery and subsidence control) on the Project site. To date, permits for Class II injection wells for wastewater disposal into the deeper IOF strata have not been issued for the IOF. It is unknown if a future IOF operator, will ultimately decide to utilize this method of wastewater disposal, but for the purposes of this technical memorandum, it is assumed that deep injection wells may be required to accommodate produced water from hydraulic fracturing events[1].
- 2 new wells being drilled (not at the same time)
  - Portable temporary tanks (e.g., Baker tanks) will be used to collect drilling fluids.
  - No pits will be constructed or used to store drilling fluids.

[1] There is not a correlation between the number of wastewater injection wells needed and the number of fracking events. The hydraulic properties of the target injection strata would be needed to determine the number of wastewater injection wells needed for deep injection wells, which is unknown at this time. Therefore, a number of deep injections wells cannot be estimated.

   - It is assumed that 100 barrels (4,200 gallons) of potable water will be used per day for the drilling process.
   - Associated facilities (e.g., drilling rig, pumps, etc.) are assumed to be located on a graded well pad adjacent to the drill site.
   - A setback of at least 400 feet from Developed Areas and at least 75 feet from any public roadway will be required within the IOF for drilling or redrilling.
- No more than two rigs for reworking shall be present within the City IOF at any one time. Limits on simultaneous activity include one drill rig occurring at the same time as two rigs for reworking.
- One well stimulation event would occur on the Project Site at one time, although the number of events per year is not limited by the Specific Plan.

The City IOF is in the context of the larger Inglewood Oil Field. There are currently 790 production wells, 109 injection wells, and 31 wells identified as "new" (either production or injection wells) by DOGGR for a total of 930 active wells in the Inglewood Oil Field as a whole. There are currently 37 active wells within the City IOF. This means there is a total of 893 active wells in the County IOF in 2015. The Settlement Agreement allows for a maximum of 500 wells to be drilled by 2028 in the County IOF. Conservatively assuming no currently active wells are plugged, abandoned, or allowed to be idle, the maximum number of active wells within the County IOF in 2028 would be 1,393 active production and injection wells.

The cumulative impacts of the Maximum Buildout Scenario assumes the full buildout of the City IOF, set in the context of allowable future buildout of oil and gas productions activities in the adjacent County IOF pursuant to the Settlement Agreement.

3.0 REGULATORY SETTING

Several Federal, State, and local regulations and rules apply to implementation of the IOF Specific Plan and this Technical Memorandum. These include the following:

3.1 Federal

U.S. Code Title 42

The Earthquake Hazards Reduction Act was enacted in 1997 to "reduce the risks to life and property from future earthquakes in the United States through the establishment and maintenance of an effective earthquake hazards and reduction program." To accomplish this, the act established the National Earthquake Hazards Reduction Program (NEHRP). This program was significantly amended in November 1990 by the National Earthquake

Hazards Reduction Program Act (NEHRPA), which refined the description of agency responsibilities, program goals, and objectives.

NEHRP's mission includes improved understanding, characterization, and prediction of hazards and vulnerabilities; improvement of building codes and land use practices; risk reduction through post-earthquake investigations and education; development and improvement of design and construction techniques; improvement of mitigation capacity; and accelerated application of research results. The NEHRPA designates the Federal Emergency Management Agency (FEMA) as the lead agency of the program and assigns it several planning, coordinating, and reporting responsibilities.

3.2 State

California Building Code

California Code of Regulations (CCR), Title 24, Part 2, the California Building Code (CBC), provides minimum standards for building design in the State. Until January 1, 2008, the CBC was based on the then current Uniform Building Code and contained Additions, Amendments and Repeals specific to building conditions and structural requirements in California. The 2016 CBC, effective January 1, 2017, is based on the current (2015) International Building Code (IBC) and ASCE 7-10. Each jurisdiction in California may adopt its own building code based on the 2016 CBC. Local codes are permitted to be more stringent than the 2016 CBC, but, at a minimum, are required to meet all State standards and enforce the regulations of the 2016 CBC beginning January 1, 2017. The City of Culver City is in the process of adopting the 2016 CBC. Chapters 16 and 16A of the CBC deals with structural design requirements governing seismically resistant construction (Section 1604), including (but not limited to) factors and coefficients used to establish seismic site class and seismic occupancy category for the soil/rock at the building location and the proposed building design (Sections 1613.5 through 1613.7). Chapters 18 and 18A include (but are not limited to) the requirements for foundation and soil investigations; evaluation of seismic and geologic hazards such as liquefaction, lateral spreading, slope stability; excavation, grading, and fill; allowable load-bearing values of soils; and the design of footings, foundations, and slope clearances, retaining walls, and pier, pile, driven, and cast-in-place foundation support systems. Chapter 33 includes (but is not limited to) requirements for safeguards at work sites to ensure stable excavations and cut or fill slopes. Appendix J of the CBC includes (but is not limited to) grading requirements for the design of excavations and fills and for erosion control. Construction activities are subject to occupational safety standards for excavation, shoring, and trenching as specified in Cal-OSHA regulations (CCR, Title 8).

The Culver City's Department of Building Safety is responsible for enforcing all building codes adopted by the State and City, in accordance with City of Culver City's Municipal Code Title 15, Chapters 15.02 and 15.03.

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act was passed in 1972 to mitigate the hazard of surface faulting to structures for human occupancy. In accordance with this Act, the California State Geologist established regulatory zones, called earthquake fault zones (EFZ) [formerly named Special Studies Zones], around the surface traces of active faults and has published maps showing these zones (Bryant and Hart, 2007). Within these zones, buildings for human occupancy cannot be constructed across the surface trace of active faults. Each EFZ extends approximately 200 to 500 feet on either side of the mapped fault trace because many active faults are complex and consist of more than one branch that may experience ground surface rupture. This Act applies to the proposed Project because an EFZ is mapped on the Project Site (CDMG, 1986).

Seismic Hazards Mapping Act

The Seismic Hazards Mapping Act was developed to protect the public from the effects of strong ground shaking, liquefaction, earthquake-induced landslides, or other ground failure, and from other hazards caused by earthquakes. This act requires the State Geologist to delineate various seismic hazard zones and requires cities, counties, and other local permitting agencies to regulate certain development projects within these zones. Before a development permit is granted for a site within a seismic hazard zone, a geotechnical investigation of the site has to be conducted and appropriate mitigation measures incorporated into the Project design. In addition, CGS's Special Publication 117, Guidelines for Evaluating and Mitigating Seismic Hazards in California, provides guidance for the evaluation and mitigation of earthquake-related hazards for projects in designated zones of required investigations (CDMG, 1997). The State Geologist has prepared a map for the area in which the Project is located and the site has been delineated as an earthquake-induced landslide area (CDMG, 1999).

Well Stimulation Regulations, Senate Bill 4 (SB 4)

California Senate Bill 4 (Pavley; Chapter 313, Statutes of 2013) complements existing rules regulating the oil industry, and requires some of the strongest well construction standards in the nation by enacting further safeguards to public health and safety and the environment regarding the practices known as well stimulation, including hydraulic fracturing. Final SB 4 regulations became effective July 1, 2015.

SB 4 requires a permit from the Division of Oil, Gas, and Geothermal Resources (DOGGR) to conduct well stimulation. The permit application must include detailed information about the fluids to be used, a groundwater monitoring plan, a water management plan, and on-site seismic (earthquake) monitoring during and after the procedure. SB 4 also addresses important operational requirements such as pressure testing, well evaluation, geologic evaluation, well monitoring, and the storage and handling of fluids. Copies of an approved permit must be sent to neighboring property owners and tenants, and water well testing must be provided upon request. SB 4 requires the DOGGR to prepare regulations to ensure that well stimulation is done safely and to require detailed public disclosure about the well stimulation. The DOGGR must develop an internet website to facilitate public disclosure of well stimulation information, and the website must allow the public to easily search and aggregate the information.

As required by SB 4 the DOGGR prepared an environmental impact report in July 2015, titled *Final Environmental Impact Report, Analysis of Oil and Gas Well Stimulation Treatments in California*, consistent with the California Environmental Quality Act, addressing the practice of well stimulation in California. Additionally, under SB 4 the Natural Resources Agency completed an independent scientific study in July 2015 on well stimulation treatments, titled *An Independent Scientific Assessment of Well Stimulation in California, An Examination of Hydraulic Fracturing and Acid Stimulations in the Oil and Gas Industry*, by the California Council on Science and Technology (CCST), and the State Water Resources Control Board amended the Groundwater Quality Monitoring code to address necessary groundwater modeling criteria and needed groundwater monitoring programs.

Currently there are no well stimulation activities on the Project Site, or in the County IOF. However, the past operator, PXP, conducted both conventional and high-volume hydraulic fracturing tests. Both of these techniques were performed in vertical or slant borings. PXP planned to perform conventional and high-volume hydraulic fracturing in wells penetrating six of the deep (greater than 6,000 feet) hydrocarbon reservoirs (i.e., Rubel, Bradna, Moynier, City of Inglewood, Nodular and Sentous reservoirs). However, the former operator, Freeport McMoran (FM O&G), has not stated whether well stimulation techniques would be employed at the Project Site. If a future oil field operator decides to employee well stimulation techniques at the Project Site, at a minimum, they will be required to adhere to the SB 4 well stimulation regulations.

Underground Injection Control (UIC) Program for Class II Injection Wells

In California, wells that inject fluids associated with oil and natural gas production operations and do not enhance the permeability of subsurface rock formations are classified as Class II injection wells. These wells are regulated by the DOGGR under its Underground Injection Control (UIC) Program. Injection operations regulated under the UIC Program include waterflood, steamflood, cyclic steam, gas storage, wastewater disposal, and other enhanced oil recovery projects. DOGGR's UIC program is monitored and audited by the U.S. Environmental Protection Agency (EPA) because in 1982 DOGGR entered into a primacy agreement with the U.S. EPA for regulation of Class II injection wells under the federal Safe Drinking Water Act (SDWA). The requirements of DOGGR's UIC Program are found in the Public Resources Code (PRC), the SDWA, and in the state and federal regulations. The UIC Program includes permitting, inspection, enforcement, mechanical integrity testing, plugging and abandonment oversight, data management, and public outreach. Improvements to the program were made following an audit by the U.S. EPA in 2011 (Horsley Witten Group, 2011).

Under the UIC Program, a Class II well permit requires the operator to provide detailed data that, in DOGGR's judgment, are pertinent and necessary for the evaluation of a proposed injection project. The operator will be required to submit an application that includes a detailed engineering study, stating the primary purpose of the project; the reservoir and fluid characteristics of each injection zone; and the planned well drilling and plugging and abandonment program to complete the project, including a flood-pattern map showing all injection, production, plugged and abandoned wells, and unit boundaries. Additionally, a geologic study and injection plan must also be submitted. The geologic study must include a structural and isopach map, a cross section, and a representative electric log that identifies all geologic units, formations, freshwater aquifers, and oil or gas zones. The injection plan must include a map showing all injection facilities; maximum anticipated injection pressure and volumes; monitoring system or method used to ensure that injection fluid is confined to the intended zone or zones of injection; method of injection; corrosion protective measures; the source, analysis, and treatment of the injection fluid; and the location and depth of water-source wells to be used in conjunction with the project.

For water disposal wells with proposed injection into a non-hydrocarbon zone, the well's construction integrity should be consistent with that of wells completed into oil and gas zones. In order to ensure that injected fluids are confined to the intended zone, there must be 100 feet of cement across and above the top of the intended injection zone.

The previous IOF operator, PXP, had a UIC permit for 168 water flood Class II injection wells for enhanced oil recovery (water flooding). Also, PXP (Cardno ENTRIX, 2012) described possibly implementing steam injection for enhancing oil recovery. However, the former operator, FM O&G, stated they do not intend to use steam along with the current water flooding for enhanced oil recovery within the City IOF. To date, permits for Class II injection wells for wastewater disposal into the deeper IOF strata have not been issued. And it is unknown if a future IOF operator will ultimately decide to utilize this method of wastewater disposal. If so, they will, at a minimum, be required to adhere to the DOGGR regulations for UIC Class II injection wells.

3.3 Local

City of Culver City General Plan

State law since 1975 has required city general plans to include a safety element that addresses the issue of protection of its people from unreasonable risks associated with natural disasters, e.g., fires, floods, and earthquakes. The Seismic Safety Element of the General Plan contains policies that emphasize seismic safety issues because seismic events present the most widespread threat of devastation to life and property.

City of Culver City Seismic Safety Element

The Safety Element provides a contextual framework for understanding the relationship between hazard mitigation, response to a natural disaster, and initial recovery from a natural disaster. The policies of the Safety Element reflect the comprehensive scope of the City's Emergency Operations Center, which is tasked with integrating the City's emergency operations into a single operation. Culver City's Safety Element addresses many of the issues as required by State regulations, however, it was published in 1974 and is need of an update to reflect current information regarding the Newport-Inglewood fault, operations of the Inglewood Oil Field, as well as an analysis of current development and land use in the area.

City of Culver City Natural Hazard Mitigation Plan (NHMP)

The City of Culver City, along with the Culver City Unified School District approved its Natural Hazard Mitigation Plan (NHMP) in 2004. The plan identifies potential natural and human-caused hazards, and potential scenarios and estimated losses, addresses existing and proposed mitigation policies, programs and projects, and response programs. With regard to the Project Site, the NHMP identified earthquake, landslides, and wildfires as high-risk hazards, but high winds and dam failures are considered low-risk hazards.

Baldwin Hills Community Standard District

The Baldwin Hills Community Standard District (CSD) established new development standards and operating procedures for the oil and gas production operations at the County IOF. The ordinance, Number 2008-0057, amended Title 22 of the Planning and Zoning Code of the County of Los Angeles with the intent to implement regulations, safeguards, and controls for oil and gas production of the Inglewood Oil and Gas Field. Although the CSD does not apply to the City IOF, the safeguards and controls implemented during the production of oil and gas will be beneficial to all of the IOF, both the County IOF and City IOF.

The Los Angeles County General Plan was updated and adopted by the Board of Supervisors on October 6, 2015 and became effective on November 5, 2015. The General Plan included new Safety Element Goals and Policies, including Policy S.1.1: Discourage development in Seismic Hazard and Alquist-Priolo Earthquake Fault Zones and Policy S.1.3: Require developments to mitigate geotechnical hazards such as soil instability and landsliding, in Hillside Management Areas through siting and development standards.

Proposed Inglewood Oil Field Specific Plan

If approved, all activities on the City IOF would be required to be implemented in compliance with the Section 24 of the Specific Plan. The requirements of Section 24 include:

A. All proposed grading shall be subject to prior review and approval by the Public Works Director/City Engineer**.**

B. A site-specific geotechnical investigation shall be completed for permanent structures and for grading in excess of 1,000 cubic yards. The investigation shall be completed by a licensed California Engineering Geologist and licensed California Geotechnical Engineer and submitted to the Public Works Director/City Engineer for review and approval.

C. Following approval of the Comprehensive Drilling Plan the IOF Operator shall submit an Accumulated Ground Movement Plan to be reviewed and approved by the Public Works Director/City Engineer. The Plan will discuss subsidence and uplift within the City IOF and shall identify all measurement locations that will be used. The Plan shall include the measurement of vertical and horizontal ground movement and utilize Global Positioning System technology, as well as any other survey methods deemed appropriate by the Public Works Director/City Engineer. The Operator shall demonstrate, to the satisfaction of the Public Works Director/City Engineer, that an Accumulated Ground Movement Plan is being implemented and has been approved for other parts of the Inglewood Oil Field and can conclusively show that the Accumulated Ground Movement Plan applies to the Oil Field within the jurisdiction of the City.

D. Within 60 days of approval of the Accumulated Ground Movement Plan the Operator shall implement the Accumulated Ground Movement Survey as described in the approved Plan. The survey shall be prepared by a licensed expert approved or selected by the Public Works Director/City Engineer, for determining annual ground movement, including subsidence or uplift. Measurements shall be made using repeat pass Differentially Interferometric Synthetic Aperture Radar technology to establish baseline conditions. Within 30 days of completing the ground movement survey, the results of the annual monitoring survey shall be forwarded, by the Operator, to DOGGR for review and appropriate action and to the Public Works Director/City Engineer for review and comment. Annual survey reports shall be submitted for a minimum of five years after cessation of Oil Operations and the fifth report shall provide conclusions and recommendations regarding the need for continued surveying and reports. If an annual study is not approved, the Operator shall promptly take such actions as are necessary to obtain approval from the Public Works Director/City Engineer.

E. In the event that the annual ground movement monitoring surveys indicate that ongoing ground movement, equal to or greater than 0.6 inches (or a lesser value determined by the Public Works Director/ City Engineer) at any given location in the City IOF, the Operator shall review and analyze all claims or complaints of subsidence damage that have been submitted to the Operator or to the City in the 12 months since the last ground movement survey. The Operator shall prepare a report that assesses whether any of the alleged subsidence damage was caused by Oil Operations and submit said report to DOGGR and the Public Works Director/City Engineer. No further drilling operation shall commence until the cause of the movement is determined. If the cause of the movement is related to the oil field operations then no drilling/redrilling shall be approved until a remedy is implemented to the satisfaction of DOGGR and the Public Works Director/City Engineer.

F. A Fault Investigation Report is required before any tanks or other permanent structures can be constructed across an active fault or within the Alquist-Priolo Earthquake Fault Zone. The Fault Investigation Report shall be prepared by a California Certified Engineering Geologist, to be reviewed and approved by the Public Works Director/City Engineer.

G. Following the approval of the Comprehensive Drilling Plan the Operator must demonstrate the ability to track and record seismic activity relating to oil production activities. The Operator shall deploy and maintain a seismometer. The seismic data shall be used to determine site-specific ground motions as a result of any seismic event in the region. Measurements from the seismometer shall be recorded and transmitted in real-time to the California Integrated Seismic Network. The Operator shall cease operations and inspect all pipelines, tanks, and other infrastructure following any seismic event of magnitude M2.7 or larger. The Operator shall also promptly notify the Public Works Director/City Engineer and not resume operations and use of associated pipelines until all infrastructure is structurally sound as determined by DOGGR and the Public Works Director/City Engineer.

H. Following approval of the Comprehensive Drilling Plan the Operator shall develop and submit an Erosion Control Plan. All grading and drilling activities shall be in complete conformity with the approved Erosion Control Plan. The Erosion Control Plan should include discussions on the construction, and stabilization of graded slopes, benches (slope breaks), pads, and construction areas, and erosion mitigation measures such as, riprap, vegetation, silt fences, berms, basins, and drainage diversions.

I. Slopes shall be restored to their original grade, to the satisfaction of the Public Works Director/City Engineer, once the use that required the grading of the slope is no longer needed. However, if restoration of a slope would negatively affect existing drainage patterns or slope stability, then the slope shall be restored to a grade that avoids these negative effects, as determined by the Public Works Director/City Engineer.

4.0 ENVIRONMENTAL SETTING

4.1 Topography and Physiography

Culver City is on the western side of the Los Angeles Basin approximately 1.5 miles from the Pacific Ocean. Much of the terrain of Culver City is mostly level or slight rolling hills which vary in elevation from 40 feet above mean sea level (msl) on the west to approximately 100 feet in the central part. The Baldwin Hills are in the northeastern portion of the City and rise up to about 400 feet above msl on the Project Site representing 300 feet of relief between the Project Site to Ballona Creek. The Project Site comprises a 77.8-acre portion of the northwestern part of the Baldwin Hills.

The Baldwin Hills are part of a series of low hills that extend from the Santa Monica Mountains southeastward to Newport Beach. The hills are the result of a recent geological deformation along the Newport-Inglewood Zone, which is a geologic structural feature, composed of faults and folds and associated oil fields. The Baldwin Hills are the highest of the hills along this fault zone, reaching a height of 511 feet above msl. They rise gently from the south and east and relatively steep from the north and west. Before the development of the Inglewood Oil Field, the slopes descending the hills contained numerous scarps on the west, north, and east sides. Numerous canyons and gullies have incised into the scarps and extended to the top of the hills forming intervening flat-topped ridges. The central portion of hills is transected by a north-south trending graben (tectonic depression). The eastern side of the graben is bounded by a west-facing scarp, ranging in height from 75 to 150 feet and is the surface expression of the Newport-Inglewood fault (Barrows, 1974). The most rugged and steep portions of the oil field have been highly modified over the years by construction of well and tank pads, access roads, treatment plants, oil, water and waste sumps.

4.2 Regional Geologic Setting

The Baldwin Hills and Project Site are located in the Peninsular Ranges Geomorphic Province and within the Los Angeles Basin. The Peninsular Ranges are characterized by northwest-trending blocks of mountain ridges and sediment-floored valleys (CGS, 2002). The dominant geologic structure features are northwest-trending fault zones that either fade out to the northwest or terminate at east-trending faults that form the southern margin of the Transverse Ranges. The Los Angeles Basin is bounded on two sides by major faults: the Palos Verdes fault to the south, and the San Gabriel-Foothill fault to the north. The basin is bounded to the east and southeast by the Santa Ana Mountains and San Joaquin Hills, and to the northwest by the Santa Monica Mountains. Erosion of the surrounding mountains has resulted in deposition of alluvial materials (unconsolidated sediments) in low-lying areas by the Los Angeles River and in the Culver City area, the Ballona Creek.

Deformation in the Baldwin Hills area may have begun as early as the middle Miocene (approximately 15-16 million years ago). Movement along the Newport-Inglewood Fault Zone gently arched and displaced the sedimentary formations comprising the hills (Castle and Yerkes, 1976). Some of the prominent fault scarps and youthful dissection of the slopes suggest the Baldwin Hills are still actively rising.

The Baldwin Hills and Project Site is underlain by a thick sequence of Tertiary and Quaternary age sedimentary layers and Holocene-age alluvium. The near-surface sedimentary formations exposed on the Project Site consist primarily of the early to middle-Pleistocene, marine San Pedro Formation and the late-Pleistocene, nonmarine to shallow marine Inglewood Formation. Colluvial deposits are present at the toe of the slopes and may be present in the drainage channels and gullies emanating from the hill's slopes. The weathering and erosion of the exposed rock layers and colluvium has resulted in a thin mantle of surficial soils and artificial fill in the Project area. A geology map of the Baldwin Hills and the Project Site is provided in Figure 1.

4.3 Soil and Geologic Units

The Project Site is underlain by unconsolidated surficial deposits of undocumented artificial fill, in situ developed soil and colluvium, and formational geologic units ranging in age from Pleistocene to Tertiary (approximately 10,000 to 15 million years old).

Collectively these geologic formations are over 10,000 feet thick beneath the Project Site and include, in increasing age, San Pedro, Inglewood, Pico, Repetto, Monterey (also referred to as Puente) and Topanga Formations. The formational units mapped at the surface within the Project Site are the San Pedro (which locally includes the Baldwin Hills Sandy Gravel and Culver Sand) and Inglewood Formations. These two formations as well as the surficial deposits will be discussed separately below. The Pico, Repetto, Monterey, and Topanga Formations are source rocks for the oil and gas exploration and have undergone formation name changes during the years by the oil industry specific to the oil field. Therefore, to avoid confusion this study will discuss all of these units together below. However, for a detailed description of the separate oil- and gas-bearing zones the reader is directed to the "Hydraulic Fracturing Study, PXP Inglewood Oil Field" dated October 12, 2012.

4.3.1 Artificial fill, non-engineered fill (af)

Artificial fill comprises any earth material that is placed for construction purposes or any earth and non-earth material that is dumped as waste. Fills can be classified into two types: engineered fill and non-engineered fill. An engineered fill is a fill composed of earth material that is designed and placed under engineering supervision with documentation explaining its placement. It is compacted to a certain density and tested to verify its quality. Non-engineered fill is uncompacted fill or fill compacted without engineering control and without verification (documentation) of its quality by testing.

Most of the larger artificial fills in the Baldwin Hills area were placed during residential development in the very late 1940s and the 1950s for construction of roads and accompanying building pads without much preparation due to the lacking of proper grading codes. Since the 1920s, fill has been used in the IOF for siting of roads and oil wells. On the Project Site the fill was most likely generated from on-site surficial sediments during the creation of numerous oil field service roads and relatively flat well-drilling pads. Most of the fill deposits will have a similar lithology as the underlying geologic unit and are considered non-engineered fill. The fill will typically be composed of various amounts of sand, silt, clay, gravel, and most likely some organic material.

4.3.2 Colluvium (Qco)

Colluvium accumulates at the toe of slopes and is derived as the weathering and erosion of the slopes' underlying bedrock. The weathered material slowly creeps down the slope to the bottom where it can accumulate thicknesses up to 10 feet. The colluvium can also collect in small canyons, ravines, and swales. Colluvium is present underlying the western part of the Project Site along College Boulevard. Here the upslope source for colluvium is the Culver Sand to the east and the Inglewood Formation to the immediate north. Therefore, the colluvium will consist of an unconsolidated mixture of sand, silt and clay. The on-site colluvium should be considered expansive.

4.3.3 San Pedro Formation (Qsp)

The San Pedro Formation is mapped at the surface throughout most of the Project Site. The San Pedro Formation is a middle- to late-Pleistocene marine deposit consisting of medium- to coarse-grained sand and gravel, with localized lenses of very fine sand and clay. Locally it may be capped with the Lakewood Formation on some geology maps which may include the Baldwin Hills Sandy Gravel member. The San Pedro Formation is relatively unconsolidated to poorly consolidated and is approximately 200 feet thick in the Baldwin Hills area (Cardno CENTRIX, 2012). On the Project Site the San Pedro Formation has been differentiated, based on local lithology, into the Baldwin Hills Sandy Gravel and Culver Sand (Hsu et al, 1982).

Baldwin Hills Sandy Gravel (Qb). Baldwin Hills sandy gravel (Qb) is the most widely exposed rock in the Baldwin Hills, occupying nearly two-thirds of the area, commonly capping ridges. On the Project Site it is only present beneath the T-Vickers Tank Farm and the ridge trending to the north of the tanks. In the western part of the hills and the Project Site, the Baldwin Hills sandy gravel rests on Culver sand (Qc), in both erosional and transitional contact. The thickness of the Baldwin Hills sandy gravel is variable, ranging from about 50 feet to perhaps 100 feet. The unit comprises more clayey silt on the Project Site than the more abundant sand and gravel units found throughout the Baldwin Hills. The clayey silt facies unit consists of yellowish green to light gray, clayey silt with interbeds of angular-grained, sandy gravel and massive to laminated sand. The clayey silt beds are generally dense and hard, and more resistant to erosion than the sandy deposits. The unit was deposited in a nonmarine fluvial environment, which explains why it contains numerous interbeds of various lithology. The Baldwin Hills sandy gravel unit is prone to erosion on the Project Site.

Culver Sand (Qc). Culver sand is exposed mainly in the northwestern and western parts of the Baldwin Hills, where it rests unconformably (erosional) on the Inglewood Formation. It was deposited in nearshore marine environments and is the most widely mapped unit in the Project Site, reaching a maximum thickness of about 100 feet. On the Project Site the Culver sand consists predominantly of crudely stratified to laminated, light brown, poorly consolidated and partly sorted, fine- to coarse-grained sand interbedded with lenses and thin beds of gravel (Hsu et al, 1982). Also the sand can contain thin beds of gray, dense, clayey siltstone which can be expansive. On the Project Site the sand layers tend to be better cemented and denser than the sandy gravel layers. Both sand and gravel are poorly cemented and, therefore, commonly subject to erosion.

4.3.4 Inglewood Formation (Qi)

The early Pleistocene age Inglewood Formation is exposed mainly in the lower portions of steep slopes in the northern part of the Baldwin Hills and in slopes surrounding the Culver City Park and in an on-site, small canyon immediately north of the T-Vickers Tank Farm. The sediments of the Inglewood Formation were deposited in a shallow marine environment. Rocks of this unit can reach 300 feet thick and are overlain unconformably by coarser-grained rocks of the Culver sand in the Project area.

The Inglewood Formation consists principally of thinly interbedded, light-brown to gray-brown, well-consolidated siltstone and very fine-grained sandstone which locally can be clay-rich and which commonly contain calcareous and limonitic concretions. The sandstone generally is slightly coarser near the top of the unit; otherwise the lithology is relatively uniform. The rocks of the Inglewood Formation are generally dense and moderately expansive when weathered. A relatively higher incidence of surficial failure have occurred in slopes underlain by this unit than slopes underlain by other units, due to the more clayey soil and slope wash that tends to develop on this unit. Most of the bedrock landslides in the Baldwin Hills are derived from these rocks, apparently because of their clay content and because they are thinly-bedded, more fractured than the overlying rocks, and commonly dip adversely (downward) out of slopes.

4.3.5 Pico, Repetto, Monterey and Topanga Formations

The Pico, Repetto, Monterey, and Topanga Formations represent approximately 9,000 feet of sedimentary rock spanning approximately 1.8 million to 15 million years of time before the present. The formations consist of thick layers of sandstone and shale which have folded upward, and displaced and fractured by faulting of the Newport-Inglewood Fault Zone. The faulting and fracturing allows for the hydrocarbons trapped in the Nodular Shale reservoir, belonging to the Monterey Formation approximately 8,000 feet deep to migrate upward into the overlying sandstone layers of the Pico and Repetto Formations (Wissler, 1943). The sandstone layers from these two formations produce a majority of the oil and gas in the Baldwin Hills area.

There are nine hydrocarbon producing zones beneath the Project Site. These zones, in increasing age, include the Upper Investment-Investment (Pico Formation), Vickers (Pico and Repetto Formations), Rindge (Repetto Formation), Rubel (Repetto Formation), Upper and Lower Moynier (Repetto Formation), Bradna (Monterey Formation), City of Inglewood (Monterey Formation), Nodular Shale (Monterey Formation), and the Sentous (Monterey and Topanga Formations).

Table 4-1 (Stratigraphy and Lithology of the Inglewood Oil Field) shows the stratigraphy and lithology of the producing formations in the Baldwin Hills including the Project Site.

Table 4-1
Stratigraphy and Lithology of the Inglewood Oil Field

Epoch	Formation		Reservoir	Lithology, etc.	Thickness (feet)
Pleistocene	San Pedro				0 – 200
Pleistocene	Inglewood				150 – 300
Pleistocene	Pico	Upper		Cap rock to oil field	150 - 300
Upper Pliocene	Pico	Middle	Investment	Shale, some oil	200 - 600
Upper Pliocene	Pico	Lower	Vickers	Sandstone producer	1500 – 1700
Lower Pliocene	Repetto	Upper	Rindge	Sandstone producer	900 – 1000
Lower Pliocene	Repetto	Middle	Upper Rubel	Sandstone producer	250 – 300
Lower Pliocene	Repetto	Middle	Lower Rubel	Sandstone producer	699 - 700
Lower Pliocene	Repetto	Lower	Upper Moynier		300 - 400
Lower Pliocene	Repetto	Lower	Lower Moynier		600 - 700
Upper Miocene	Monterey		Bradna		700 - 1800
Middle Miocene	Monterey		City of Inglewood		0 – 250
Middle Miocene	Monterey		Nodular Shale	Shale, source of oil	150 – 175
Middle Miocene	Monterey		Sentous	Sandstone producer	200 - 1000
Middle Miocene	Topanga		Topanga		1500

Table adapted from information provided by Cardno ENTRIX (2012).

In 2012, there were 469 active production wells on the Inglewood Oil Field and a majority of them have been drilled on a slant targeting one of the producing zones. The Vickers and Rindge zones, 2,000 to 4,000 feet deep, accounted for more than 74 percent of the total cumulative production at the oil field. Overall, the shallow and extensive Vickers and Rindge zones have produced more than half of all the oil produced over the life of the Inglewood Oil Field. The shallowest producing zone is the Investment Zone at approximately 1,000 feet and deepest is the Sentous at approximately 8,500 feet (Cardno ENTRIX, 2012).

5.0 SEISMIC/GEOLOGIC HAZARDS

The IOF site is located in a seismic area with high historic seismicity. There are numerous tectonic faults in and around the IOF site. In general, seismic activities can be broadly divided into two categories; (1) historic or tectonic and (2) induced. Tectonic seismic activity is related to natural movements of the faults and an earthquake happens when sudden slip on these faults initiates rupture and may release large amount of energy resulting in ground shaking and other associated hazards such as ground rupture, liquefaction, lateral spreading, sloped failures, etc. Induced seismicity is defined as an event directly related to some man made activity. Recently, many parts of the country have experienced induced seismicity due to oil extraction operations (USGS 2016). In the areas of low tectonic activities, it is relatively easy to identify induced seismicity from the historical tectonic seismicity. However, in the areas of high tectonic seismicity, differentiating induced seismicity from the tectonic seismicity is not that simple and may require long term monitoring for assessment. In the following sections, both tectonic and induced seismicity are discussed especially with regards to the IOF.

5.1 Regional and Local Faults

A fault is a fracture or line of weakness in the earth's crust, along which rocks on one side of the fault are offset relative to the same rocks on the other side of the fault. Generally, a fault exists as a zone (referred to as a fault zone) comprised of parallel to subparallel faults and fault splays. A fault splay is a minor fault which branches off a larger fault. Surface rupture occurs when movement on a fault, or fault zone, deep within the earth breaks through to the surface. Fault rupture almost always follows preexisting faults, which are zones of weakness. Rupture may occur suddenly during an earthquake or slowly in the form of fault creep. Sudden displacements are more damaging to structures because they are accompanied by shaking. An earthquake on the Newport-Inglewood Fault Zone could cause ground rupture to occur along any of the faults or fault splays within the fault zone.

Based on criteria established by the CGS, faults may be categorized as active, potentially active, or inactive. Active faults are those that show evidence of surface displacement within the last 11,000 years (Holocene age). Potentially active faults are those that show evidence of the last displacement within the last 1.6 million years (Quaternary age). Faults showing no evidence of displacement within the last 1.6 million years also may be considered inactive for most purposes, except for some critical structures. Table 5-1 (Major Named Faults Considered Active in Southern California) provides a summary of major named active faults in southern California based on USGS (2014).

As shown on Figures 2 and 3 there are two major faults (active and inactive) in the vicinity of the Project Site: the Newport-Inglewood Fault Zone and the Overland Avenue/Charnock faults. The Newport-Inglewood Fault Zone, which is seismically active and part of the San Andreas Fault System, extends at least 45 miles onshore, from the Cheviot Hills southeastward to the Newport Mesa, and beyond to the offshore area (Bryant, 1988) for a total of approximately 130 miles. This right-lateral fault zone is composed of numerous fault splays that collectively are capable of producing a magnitude 7.5 earthquake. Not all the faults or fault splays in the fault zone are active, however they do form structural oil/gas-producing traps by juxtaposing differing lithologies of sedimentary rock layers against each other in the subsurface (see Figure 3). The fault zone is up to approximately 1 mile wide and responsible for the Baldwin Hills uplift and the Inglewood Oil Field (Toppozada et al., 1988).

Table 5-1
Major Named Faults Considered Active in Southern California

Fault	***Maximum Magnitude***	***Slip Rate (mm/yr.)***	***Type of Fault***	***Largest Most Recent Seismic Event***
Cabrillo	6.0–6.8	0.1	Right normal	Holocene
Cucamonga	6.5 – 6.7	1.5	Thrust	Holocene
Elsinore (Glen Ivy Segment)	6.7 – 6.9	5.0	Right lateral strike-slip	1910
Hollywood	6.5 – 6.7	0.9	Left reverse	Holocene
Malibu Coast	6.7 - 7.0	0.3	Left reverse	Late Quaternary
Northridge Thrust	6.7 – 6.9	1.5	Thrust	1994
Newport-Inglewood Zone	7.0 - 7.5	1.0	Right lateral strike-slip	1933
Oak Ridge	7.0 –7.4	3.0–4.0	Thrust	Holocene
Palos Verdes	7.3 – 7.7	3.0	Right reverse	Holocene
Raymond	6.5 – 6.8	2.0	Left lateral	Holocene
San Andreas (Southern Segment)	7.0–8.0	16.0–34.0	Right lateral strike-slip	1857
San Cayetano	7.1 – 7.2	6.0	Thrust	1660
San Fernando	6.5 – 6.7	2.0	Thrust	1971
San Gabriel	7.2 – 7.3	1.0	Right-lateral strike-slip	Late Quaternary
San Jacinto (San Bernardino Segment)	6.9 – 7.1	6.0	Right lateral strike-slip	1968
Santa Monica	6.4 – 7.4	1.0	Left reverse	Late Quaternary
Santa Susana	6.7 – 6.9	6.0	Left reverse	Holocene
Sierra Madre	7.1 – 7.3	2.0	Reverse	Holocene
Verdugo	6.7 – 6.9	0.39	Reverse	Holocene
Elsinore (Whittier)	6.8 – 7.0	2.5	Right lateral strike-slip	1987

SOURCE: USGS/CGS, http://geohazards.usgs.gov/cfusion/hazfaults_2014_search/query_main.cfm

Approximately one to two miles northwest and west of the Project Site are two faults in Ballona Gap that are not associated with the Newport-Inglewood fault. They are the Overland Avenue and the Charnock faults (see Figure 2). Both faults have been located by well-log and water-level data and form the east and west sides of a dropped block or graben. Both have been shown on the water-level contour maps of the Los Angeles County Flood Control District since 1938, where water levels are generally 40 to 50 feet higher to the east of the faults.

The Overland Avenue fault, so named because of its inferred trace nearly coincides with Overland Avenue in Culver City, is about 6 miles long and trends to the northwest, from the southwestern part of the Baldwin Hills northwestward across Ballona Gap. The Charnock fault is immediately west of the Overland Avenue fault and forms the western edge of the graben. The area between the two faults has dropped as much as 140 feet during the Pliocene, however, the late Pleistocene and Holocene sediments have not been displaced, therefore the faults are only considered potentially active by the CGS (Jennings 1994).

Alquist-Priolo Earthquake Fault Zones

The purpose of the Alquist-Priolo Earthquake Fault Zones Act is to prevent the construction of buildings used for human occupancy across the surface trace of active faults. The law requires the State Geologist to establish regulatory zones (known as Earthquake Fault Zones [EFZs]) around the surface traces of active faults and to issue appropriate maps (Bryant and Hart, 2007). The zones vary in width, but average about one-quarter mile wide. For the purposes of the Act, an active fault is one that has ruptured in the last 11,000 years. Most of the fault splays of the Newport-Inglewood Fault Zone have been included as an Alquist-Priolo EFZ within the Baldwin Hills area (CDMG, 1986). A majority of the Alquist- Priolo EFZ is located to the east of the Project Site and La Cienega Boulevard (Figure 4). However, a short splay of the Newport-Inglewood EFZ is mapped at the northeastern edge of the Project Site near the Stoneview Nature Center (Figure 4). Construction within this zone requires that a special geologic study be conducted to locate and assess any active fault traces within the EFZ prior to development/construction of structures.

5.2 Seismicity

Earthquakes are caused by the violent and abrupt release of strain built up along faults. When a fault ruptures, energy spreads, sometimes unequally, in the form of seismic waves. Seismic waves are categorized into two groups, body waves and surface waves. Body waves travel through the crust and eventually reach the ground interface, creating surface waves. Body waves and surface waves cause the ground to vibrate up and down and side to side at different frequencies depending on the frequency content of the earthquake rupture mechanism, the distance from the earthquake source, and the path and material through which the seismic waves spreads.

The Project Site is located in a high seismic activity area. Many earthquakes in the past have happened in the region. Any building within the Project Site should follow the California Building Code (CBC) for the design purposes. Per 2013 CBC, a peak ground acceleration (PGA) of 0.7g should be used for any liquefaction and/or lateral spreading analysis within the Project Site. In order to evaluate the level of ground shaking that might be anticipated within Project Site, probabilistic PGA data available from the USGS were reviewed. A major seismic event on the Newport-Inglewood Fault Zone could cause strong ground shaking at the Project Site and PGA of 1g or higher could be anticipated, which has been observed in past earthquakes of similar magnitude.

Earthquake Magnitude

Earthquakes are classified based on the amount of energy released, using logarithmic scales known as the Richter scale and the Moment Magnitude scale. Each whole number of Richter magnitude represents a tenfold increase in the wave amplitude (earthquake size) generated by an earthquake, as well as a 3.16-fold increase in energy released. Thus, a magnitude 6.3 earthquake is ten times larger than a magnitude 5.3 earthquake and releases 31.6 times more energy. In contrast, a magnitude 7.3 event is 100 times larger than a magnitude 5.3, and releases 1,000 times more energy. One limitation of the Richter magnitude scale is that it has an upper limit at which large earthquakes appear to have about the same magnitude. As a result, the moment magnitude scale (M), which does not have an upper limit magnitude, was introduced in 1979, and is used to characterize earthquakes greater than magnitude 3.5. Earthquakes of M 6.0 to 6.9 are classified as “moderate,” M 7.0 to 7.9 as “major,” and M 8.0 and larger as “great.”

The entire southern California area is a seismically active region. With respect to the Project Site the Newport-Inglewood Fault Zone is considered capable of generating a major earthquake with a maximum moment magnitude of M 7.0 to 7.5.

Earthquake Intensity

The Modified Mercalli Intensity (MMI) Scale is a scale used for measuring the intensity of an earthquake. The scale quantifies the effects of an earthquake on the Earth's surface, humans, objects of nature, and man- made structures on a scale of I through XII, with I denoting a weak earthquake and XII one that causes almost complete destruction. Although this scale is useful in describing earthquake effects for the general public, it is not employed by engineers when designing seismic-resistant structures. Therefore, the MMI Scale is more applicable to understanding the effects from ground shaking in developed communities rather than agricultural areas. This is especially true in a city, such as Culver City, where there's such a diverse mix (both in age and construction type) of residential and commercial structures, and greater density of population to be subjected to ground shaking. Table 5-2 (Modified Mercalli Intensity Scale) provides abbreviated definitions of the scale ratings.

Table 5-2
Modified Mercalli Intensity (MMI) Scale

Scale Rating	*Description*
I	Not felt
II	Felt by persons at rest, on upper floors, or favorably placed.
III	Felt indoors; hanging objects swing; vibration like passing of light trucks; duration estimated; may not be recognized as an earthquake.
IV	Hanging objects swing; vibration like passing of heavy truck or sensation of a jolt like a heavy ball striking the walls; standing automobiles rock; windows, dishes, doors rattle; wooden walls and frame may creak.
V	Felt outdoors; direction estimated; sleepers wakened; liquids disturbed some spilled; small unstable objects displaced or upset; doors swing; shutters, pictures move; pendulum clocks stop, start, change rate.
VI	Felt by all; many frightened and run outdoors; persons walk unsteadily; windows, dishes, glassware broken; knickknacks, books, etc., off shelves; pictures off walls; furniture moved or overturned; weak plaster and masonry D cracked.
VII	Difficult to stand; noticed by drivers of automobiles; hanging objects quiver; furniture broken; weak chimneys broken at roof line; damage to masonry D, including cracks, fall of plaster, loose bricks, stones, tiles, and embraced parapets; small slides and caving in along sand or gravel banks; large bells ring.
VIII	Steering of automobiles affected; damage to masonry C, partial collapse; some damage to masonry B; none to masonry A; fall of stucco and some masonry walls; twisting, fall or chimneys, factory stacks, monuments, towers, elevated tanks; frame houses moved on foundations if not bolted down; loose panel walls thrown out; decayed piling broken off. Branches broken from trees; changes in flow or temperature of sprigs and wells; cracks in wet ground and on steep slopes.
IX	General panic; masonry D destroys; masonry C heavily damaged, sometimes with complete collapse; masonry B seriously damaged; general damage to foundations; frame structures, if not bolted, shifted off foundations; frames racked; serious damage to reservoirs; underground pipes broken; conspicuous cracks in ground and liquefaction.
X	Most masonry and frame structures destroyed with their foundations; some well-built wooden structures and bridges destroyed; serious damage to dams, dikes, embankments; large landslides; water thrown out of banks of canals, rivers, lakes, etc.; sand and mud shifted horizontally on beaches and flat land; rails bent slightly.
XI	Rails bent greatly; underground pipelines completely out of service.
XII	Damage nearly total; large rock masses displaced; lines of sight and level distorted; objects thrown in the air.

SOURCE: "Pre-Earthquake Planning for Post- Earthquake Rebuilding", Spangle, William E., 1987.
Definitions: Masonry A = Good workmanship and mortar, reinforced designed to resist lateral force.
Masonry B = Good workmanship and mortar, reinforced. Masonry C = Good workmanship and mortar, unreinforced.
Masonry D = Poor workmanship and mortar and weak materials, like adobe.

The following table provides correlations between MMI and earthquake magnitudes that are typically observed at locations near the epicenter of earthquakes of different magnitudes (USGS, 2016).

Magnitude	Typical Maximum Modified Mercalli Intensity
1.0 - 3.0	I
3.0 - 3.9	II - III
4.0 - 4.9	IV - V
5.0 - 5.9	VI - VII
6.0 - 6.9	VII - IX
7.0 and higher	VIII or higher

A major earthquake on the Newport-Inglewood fault could have an MMI ranging from VIII to XI within the Project Site. However, the City IOF is more likely to experience shaking intensity ranging from I to VI from either a natural or human induced quake (discussed in Sections 5.4 – 5.6). In fact, in April and May of 2015, three earthquakes ranging from IV to VI (MMI scale), with epicenters in the Baldwin Hills area were felt in Culver City. A more detailed discussion of these earthquakes is provided at the end of the following section (5.3).

5.3 Historical Seismicity

Seismic events present the most widespread threat of devastation to life and property. With an earthquake, there is no containment of potential damage. Since the late 1700s there have been approximately 60 damaging seismic events, or earthquakes, in the Los Angeles region. The following is a description of a few of the significant historical earthquakes of the Los Angeles Basin region.

Earthquakes were reported in the Los Angeles area by Spanish explorers as early as 1769. Members of the Portola expedition felt more than twenty-four earthquakes during one week in 1769 while traveling in the area between the Santa Ana and Los Angeles Rivers.

Between December 1812 and January 1813 Franciscan missionaries recorded earthquake events in southern California (Toppozada et al., 1981). Two prominent earthquakes that were recorded occurred on December 8, 1812 and December 21, 1812. The December 8, 1812 earthquake destroyed the bell tower at Mission San Juan Capistrano, causing the roof of the church to cave in, and killing 40 Indians who were in the church. At Mission San Gabriel, statues in the church were broken, the bell tower was cracked, and other Mission buildings were extensively damaged. And at the Mission San Fernando, the walls of the church were damaged, and 30 beams were required to support them. This earthquake is postulated to have had a magnitude of about 7.0. Jacoby and others (1987) found evidence from tree-rings for an 1812 earthquake on the San Andreas fault 30 miles northeast of San Gabriel, and hypothesized that it was the December 8 event. A second earthquake occurred on December 21, 1812 and most probably had its epicenter located in the Santa Barbara channel (Toppozada et al., 1981). Earthquake damage was reported at missions at San Buenaventura, Santa Barbara, Santa Ynez, and Purisima Concepcion in Ventura and Santa Barbara counties. Because these two separate events occurred in the same month and only about two weeks apart in time, there has been confusion and the mistaken impression that a single earthquake was destructive from Orange County to Santa Barbara County. But this was not the case.

On July 10, 1855 an earthquake occurred on one of the surface faults (Hollywood-Raymond, Whittier, or Newport-Inglewood) bordering the Los Angeles basin. It could also have been located on a concealed fault as was the case for the 1987 Whittier Narrows earthquake. During the July 10, 1855 quake, the bells of Mission San Gabriel were thrown down, and 26 buildings in Los Angeles were damaged. The earthquake was felt from San Bernardino to Santa Barbara.

A magnitude 4.9 earthquake occurred June 21, 1920 and was destructive only at Inglewood (Richter, 1970). Because of this it was assumed to have a shallow epicenter at or west of Inglewood. According to Taber (1920), "the damage to buildings was due to poor construction rather than to the intensity of the vibrations. Thin brick walls built as fronts to wooden buildings and not tied in properly, toppled outward into the street. Poorly built brick cornices and fire walls along the fronts of buildings were shaken off."

The Long Beach earthquake (magnitude 6.3) of March 10, 1933 had a hypocenter just off the coast of Newport Beach at a depth of about 6 miles. Aftershocks (magnitude up to 5.4) occurred along the Newport-Inglewood fault zone from Newport Beach to Long Beach, a distance of 15 miles. This indicates that the earthquake was generated by about 15 miles of subsurface faulting that began near Newport Beach and propagated northwestward along the Newport-Inglewood fault zone toward Long Beach. Fault rupture was not identified at the surface, and no tsunami was observed. This earthquake at MM intensity VII to IX caused damage from Laguna Beach to Marina del Rey and inland to Whittier.

In 1944 two earthquakes caused damage in Torrance and Gardena. On June 18, 1944 two earthquakes of M 4.5 and M 4.4, respectively, occurred in the Dominguez Hills and damaged oil wells in the Rosecrans oil field at depths of 3,000 feet to 6,000 feet (Barrows, 1974).

The San Fernando earthquake (February 9, 1971) had a magnitude of M 6.4 and was located in the San Fernando Valley. Also known as the Sylmar earthquake, it had an epicenter in the San Gabriel Mountains although it occurred on the Sierra Madre Fault System along the mountain front. Fault rupture and strong ground shaking (lasting for 12 seconds) in the valley was extensive causing widespread damage to hospitals, freeways, dams, schools, utility infrastructure and the collapse of buildings. This earthquake at Modified Mercalli Intensity of XI, far exceeding the building code requirements, caused enough damage to lead to adoption of more stringent building codes. The mountainous areas experienced over 1,000 earthquake-induced landslides, causing the destruction and closure of many mountain roads. As a result of this earthquake, legislation was passed in 1972 known as the Alquist-Priolo Earthquake Fault Zoning Act, with the goal of reducing damage and losses due to surface fault ruptures. The act restricts construction of buildings designed for human occupancy across active faults.

The Whittier Narrows earthquake occurred on October 1, 1987. The magnitude of 5.9 earthquake happened in the Puente Hills near the town of Rosemead, California. The focus of the earthquake occurred on a splay of the Puente Hills blind thrust fault system approximately 8.5 miles deep. Damage to freeways caused their temporary closing, however, most damage was minor compared to the 1971 San Fernando earthquake. In fact, the damage caused by the Whittier Narrows earthquake occurred mainly in buildings constructed prior to the adoption of these more stringent building codes.

The Northridge earthquake, the most recent of these seismic episodes, occurred January 17, 1994, with a magnitude of 6.7, producing strong ground motions over an extensive area. The earthquake occurred on a previously unrecognized blind thrust fault, and no surface rupture that can be unequivocally associated with the main shock has been identified. The earthquake's movement on the Northridge blind thrust fault initiated about 11 miles below the town of Reseda (epicenter) in the San Fernando Valley, and it is presumed that the subsurface rupture stopped about 3 miles below the surface. Two magnitude 6.0 aftershocks were recorded within the first day of the main shock. The main shock lasted 1 to 20 seconds and produce the highest ground acceleration ever recorded on instruments in the United States of 16.7 meters/second. The earthquake affected a densely built-up, primarily low-rise area, with Modified Mercalli Intensities ranging from VII to IX. The moderate-sized Northridge earthquake was the most costly seismic event in the United States since the 1906 San Francisco earthquake, resulting in the loss of life, physical injury, psychological trauma, and property damage estimated to be up to $40 billion.

The Northridge earthquake was one of the most measured earthquakes in history because of extensive seismic instrumentation in buildings and on the ground throughout the region. The quake provided valuable data for evaluating existing standards and techniques, and improving hazard mitigation. Two weeks after the Northridge quake, a seismic retrofit tilt-up (concrete walls poured and tilted up on the site) ordinance was adopted and made retroactive by the City of Los Angeles. Subsequently, Los Angeles adopted a series of ordinances that required retrofitting of certain existing structures (e.g., foundation anchoring of hillside dwellings) and for new construction, as well as an ordinance that required evaluation of structures by a structural engineer during the construction process.

More recently there have been several earthquakes recorded by the USGS near the project site occurring along the Newport-Inglewood Fault Zone. On October 28, 2001 a magnitude M4.0 earthquake was recorded in Compton approximately 8.5 miles (13.7 kilometers) southeast of the project site. There was no damage from this quake and there were no reports of it being felt by anyone even though it occurred during the day at 11:27am. The earthquake's focus was 13.1 miles (21.1 kilometers) deep which most likely is the reason for it not being felt by anyone. In 2009, at 8:39pm local time, a M4.7 earthquake struck Inglewood followed by a M4.0 approximately two days later. These earthquakes occurred on May 17 and 19, 2009 approximately 5.5 and 6 miles (8.9 and 9.7 kilometers) southeast of the project site. Their epicenters were located north of interstate I-105 and south of the former Hollywood Park Race Track. Both earthquakes were felt throughout the Los Angeles Basin and regionally from San Bernardino to San Diego (both quakes), with the M4.7 also being felt as far away as San Francisco, Las Vegas, NV, Phoenix, AZ, and Rosarito in Baja California, Mexico. The M4.7 (Modified Mercalli Intensity of VI) also caused minor damage with a few broken windows being reported. No damage from the M4.0 (Modified Mercalli Intensity of IV) was reported. Analysis by the USGS determined both earthquakes occurred on the Newport-Inglewood fault at depths of 8.6 miles (13.8 kilometers) and 7.9 miles (12.7 kilometers) for the M4.7 and M4.0 quakes, respectively.

In April and May of 2015, three earthquakes occurred in the Baldwin Hills area (north of West Slauson Avenue) that were felt by local residents. The three earthquakes were magnitude M3.3 (April 12), M3.8 (May 3) and M3.1 (May 23) and ranged in depth from 7.4 miles (11.9 kilometers) to 6.5 miles (10.5 kilometers). All three quakes occurred on faults splays of the Newport-Inglewood Fault Zone and were reportedly felt throughout the Los Angeles Basin including Culver City, and as far away as San Diego, Palm Desert, Ridgecrest and parts of Ventura County. In the Baldwin Hills area the Modified Mercalli Intensity of the three earthquakes was reported to be V (M3.1) and VI (M3.3 and M3.8). No damage from these earthquakes was reported.

In addition to the above mentioned seismic events, the site and its vicinity have experienced many seismic events with magnitudes less than 3. Usually, these lower magnitude events are not damaging but are relevant in terms of oil exploration activities. An event of magnitude M2.7 or higher follows the requirements of SB 4 and the proposed Specific Plan's section on Seismic Activity Tracking to have Oil field operations and pumping cease immediately. In addition, we are proposing in this document that if an earthquake of magnitude M2.0, up to M2.7 occurs within 5 kilometers of the City IOF, pumping proceeds with caution, at reduced flow rates, and the Operator conducts a study of the relationship between the seismicity and injection. However, measurement of the small magnitude events was not that reliable prior to 1980 due to limitations of the measuring instruments. Therefore, we have searched the available earthquake database from 1980 till August 24, 2016 for all events with $M \geq 1$. The earthquake database is principally comprised by the Advanced National Seismic System (ANSS). The ANSS catalog is a worldwide earthquake catalog, which is created by merging the master earthquake catalogs from contributing ANSS member networks and then removing duplicate events, or non-unique solutions from the same event. The ANSS network includes the Northern and Southern California Seismic Networks, Pacific Northwest Seismic Network, University of Nevada, Reno Seismic Network, University of Utah Seismographic Stations and United States National Earthquake Information Service. Results of our search are plotted on Figures 6 and 7 for 0 to 4 km and 4 to 10 km from the center of the project site, respectively.

Historical seismicity data are presented in Appendix A. For each event, coordinated universal time (UTC) and associated date, latitude, longitude, depth and magnitude, are presented. Table A1 lists all earthquakes ($M \geq 1$) within a 4-km radius from the center of the project site (Latitude: 34.013N, Longitude: 118.380W). Table A2 lists all the earthquakes ($M \geq 1$) within 4 to 10 km from the center of the project site.

Table A1 shows that a total of 293 events with magnitude 1 or higher were recorded since 1980 within 4 km of the site. Out of these events, 61 events were M2 or higher and only 8 were M2.7 or higher. This translates into about 1½ event (M2 to 2.7) per year and M2.7 or higher event every 4½ years since 1980.

Table A2 shows that if the radius is extended to 10 km, there were additional 804 events with M1 or higher since 1980. Out of these 804 events, 177 were M2 or higher and 41 were M2.7 or higher. This translates into about 4 events (M2 to 2.7) per year and little more than 1 event of M2.7 or higher every year since 1980.

Earthquake frequency bar charts are plotted on Figures A1 through A3 for earthquakes within 0-4 km and on Figures A4 through A6 on for earthquakes within 4-10 km. We understand that hydraulic fracturing within the County's portion of the IOF started in 2002 and "High Volume" hydraulic fracturing in 2011.

Figure A1 shows all M≥1 events within 4 km of the center of the project site for each year since 1980. Maximum number of events in a single year of 31 was recorded in 2003. Although these events were recorded in the year immediately after the commencement of hydraulic fracturing, the data don't show any significant pattern to draw any conclusions. Figure A2 shows all M≥2 events within 4 km of the center of the project site for each year since 1980. Maximum number of events (M≥2) in a single year is 6 recorded in 1999, 2002, and 2015. Figure A3 shows all M≥2.7 within 4 km of the center of the project site for each year since 1980. Maximum number of events (M≥2.7) in a single year is 3 recorded in 2015. This shows that the data are not sufficient enough to establish any correlation between seismicity and hydraulic fracturing.

Figure A4 shows all M≥1 events within 4 to 10 km of the center of the project site for each year since 1980. Maximum number of events in a single year of 75 was recorded in 2009. Figure A2 shows all M≥2 events within 4 to 10 km of the center of the project site for each year since 1980. Maximum number of events (M≥2) in a single year is 19 recorded in 2009. Figure A3 shows all M≥2.7 within 4 to 10 km of the center of the project site for each year since 1980. Maximum number of events (M≥2.7) in a single year is 6 recorded in 2013. This shows that the data are not sufficient enough to establish any correlation between seismicity and hydraulic fracturing.

A similar conclusion was reported by Segall (2016), in which, he conducted a Poisson Test on the seismicity data reported in Tables A1 and A2 to assess whether these events are random in time or not. Events following Poisson process are random in time. His analysis of the data shows that it cannot be proven that data are not random in time. Thus, a correlation between seismicity and hydraulic fracturing cannot be established. The Segall (2016) study is included in the EIR as an appendix.

5.4 Induced Seismicity

Induced seismicity is earthquake activity resulting from human activity that causes a rate of energy release, or seismicity, which would be expected beyond the normal level of historical seismic activity. For example, if there is already a certain level of seismic activity

before human activities begin, one would expect that this “historical” seismic activity would continue at the same rate in the future. Therefore, if human activity causes an increase in seismic activity, then this increase in seismic activity would be considered “induced.” In addition, if the seismic activity returns to background levels after the human activity stops, that would be another indication that the seismic activity was induced.
Naturally occurring earthquakes are generally the result of the buildup of stresses caused by the lateral or vertical movement of tectonic plates. As the plates move, the stress in the rocks accumulates until the energy is released in brittle failure. This gradual accumulation and release of stress and strain is referred to as the elastic rebound theory of earthquakes. Most earthquakes are the result of the sudden elastic rebound of previously stored energy. The magnitude of earthquakes is generally a product of earthquake moment and is proportional to the rupture area of a brittle fault, defined as the product of a fault’s length and width (depth for a vertical fault). Significant earthquakes generally occur at depths where the rocks have sufficient strength to accumulate stress as opposed to aseismic slip or creep that occurs at shallower depths. The depth at which rocks accumulate stress and generate significant earthquakes is referred to as the seismogenic depth. The seismogenic depth for the Newport-Inglewood Fault Zone in the Los Angeles Basin is estimated at 6 to 11 kilometers (3.7 to 6.1 miles) (Hauksson, 1987).

Although the vast majority of earthquakes that occur in the world each year have natural causes, some of these earthquakes are related to human activities and are called induced seismic events or induced earthquakes. Induced seismic activity has been documented since at least the 1930s and has been attributed to a range of human activities, including the impoundment of large reservoirs behind dams, controlled explosions related to mining or construction, and underground nuclear tests. In addition, energy technologies that involve injection or withdrawal of fluids from the subsurface can also create induced seismic events that can be measured and felt. Historically known induced seismicity has generally been small in both magnitude and intensity of ground shaking (National Research Council, 2013).

The most famous early instance was in Wilmington, California, where oil production triggered a series of damaging earthquakes, from 1947 to 1961, up to a maximum magnitude M4.7 (Kovach, 1974). The cause of these “slump earthquakes” was traced to subsidence due to rapid extraction of oil without replacement of fluids into the producing strata (Nicholson and Wesson, 1990 and 1992; Kovach, 1974). Once this was realized, the oil extraction was balanced with waterflooding to both mitigate the seismicity and enhance the oil recovery. Since then, the oil and gas industry has adopted these practices not only to mitigate seismicity, but also to mitigate damage to the producing oil wells that would be sheared off as subsidence occurred.

In the last decade, a number of examples of earthquake activity related to oil and gas production (i.e., well stimulation) as well as injection of fluids (e.g., wastewater disposal) have been observed. Almost all induced seismicity associated with oil production can be traced to either fluid injection or extraction, and in many cases is either due to well stimulation and/or waste disposal activities. It's generally accepted that well stimulation induced seismicity produces lower magnitude earthquakes. However, the disposal of wastewater has produced significant seismic events, occasionally yielding larger magnitude earthquakes than those associated with well stimulation. In some cases, such as in California, Texas, Colorado, Oklahoma, and Arkansas, wastewater volume exceeds the volume of water needed to balance pore pressure in the producing zone. Therefore, as further discussed below, the excess wastewater disposed in deep disposal wells can sometimes produce significant induced seismicity by increasing the fluid pressure within the disposal formation.

5.5 Induced Seismicity from Well Stimulation

Two main types of stress cause induced seismicity; shear and tensile. A tensile stress is responsible for volumetric strains, also known as hydrostatic stress, and is applied uniformly throughout the rock affecting pore pressure, while a shear stress is responsible for deformation of a material usually parallel to a fault or fracture. Almost all of the significant activity (recorded and felt) is associated with the type of failure called shear failure. These types of earthquakes can be any size depending on the geologic environment and available forces to cause the earthquake.

Well stimulation activities (e.g., hydraulic fracturing) aims to improve the production of wells by increasing the number of and extending the reach of fluid pathways (i.e., fractures) between the formation and the well. This is achieved by injecting fluid, typically water, at high pressure into low-permeability rocks, such that the fluid pressure fractures the rocks or stimulates slip across pre-existing faults or fractures. Increasing the fracture density and extent of the fracture network enhances fluid flow and allows for more distant fluids to be accessed by a well. In addition to fluid, a propping agent (silca sand or ceramic beads in the IOF) is injected to keep the newly formed fractures open. Well stimulation usually takes a few hours to a few days to complete and there is a period where the hydraulic fracturing fluid is allowed to flow back to the surface where it is collected for disposal, treatment, or reuse. Currently, the IOF operator treats all produced water on-site and then injects (i.e., waterflooding) it back into the oil producing formation to help control subsidence.

The fracturing of the rock during well stimulation activities generates microseism that may be numerous but are of very low magnitude. Observations made at numerous fracturing wells indicate that induced earthquakes are generally less than magnitude 2.0. (National Academy of Sciences, 2013). Hydraulic fracturing is distinct from many types of shear-induced seismicity, because it applies forces that create tensile fractures. Shear failure has been associated with it as the fluid leaks off into existing fractures, but due to the very-high-frequency nature of tensile failure only the associated shear failure is observed by microseismic monitoring. However, hydraulic fracturing is rarely a seismic hazard when used to enhance oil production permeability, partly because such operations include relatively low volume of fluid injected for a short duration (hours or days at the very most), compared to months and years for the other types of fluid injections, such as wastewater disposal (discussed in Section 5.6, Induced Seismicity from Wastewater Injection below).

Generally, well stimulation appears to pose a lower risk of inducing destructive earthquakes than the high-pressure or high-volume injection of oil and gas wastewater. Hydraulic fracturing is intended to cause earthquakes, albeit very small, with the intent to fracture the rock. The intentionally produced earthquakes, called microseisms, are generally small earthquakes of less than a magnitude 1 (M<1), and are typically not felt at the surface (Ellsworth, 2013; Rutqvist, 2013; and Ellsworth et al., 2015). However, several studies in the past six years have reported that well stimulation activities have mostly induced earthquakes up to magnitude M3 in Ohio, Oklahoma, and Canada, (Ellsworth, 2013; and Ellsworth, et al., 2015), however recent work by Atkinson et al. (2015 and 2016) have uncovered a M4.5 event (discussed below). These induced earthquakes were large enough to be felt but too small to be cause damage. However, these cases do illustrate that hydraulic fracturing activities can induce larger magnitude earthquakes if the induced fracture network intersects a fault. No induced earthquakes due to well stimulation are known to have been reported in California.

<u>Ohio:</u> A total of 86 earthquakes were recorded in eastern Ohio in two sequences between October, 2013 and March, 2014. A series of ten earthquakes greater than M0.0, including six in the range M1.7 - 2.2**,** were recorded in Harrison County by the Ohio regional seismic network between October 2 and 19, 2013. The first of these events occurred 26 hours after the initiation of hydraulic fracturing operations in one of three nearby wells (Friberg, et al., 2014). No felt seismicity was reported. The entire event sequence occurred at a depth of 9,842 - 11,811 feet, or about 1,640 - 3,280 feet below the bottom of the perforation interval (depth at 7,874 feet). The hypocenters delineated an approximately 1,600 feet long basement fault (Friberg, et al., 2014).

A sequence of 77 induce earthquakes, M1.0-3.0 were recorded close to a hydraulic fracturing operation in Poland, Ohio between March 4 and 12, 2014. The induced events coincided with six hydraulic fracture events located between 2,461 and 2,625 feet away from the zone of seismicity. No previous seismicity had been detected in the area before hydraulic fracturing began, and none occurred during almost 100 more distant fracture stages. The seismicity rate decayed rapidly after the well was shut down on March 10, 2014 with only 6 events during the following 12 hours and then only one over the next two months (Skoumal, et al., 2015). Earthquake hypocenter locations sharply define a 1,640 foot-long vertical plane that is assumed to be a pre-existing fault. The focal mechanism solution for the M3.0 induced event is consistent with the fault strike/dip and with the regional tectonic stress orientation.

Oklahoma: Several earthquakes were reported felt by residents living near a well being hydraulically fractured in south-central Oklahoma. The first of 86 earthquakes occurred within 24 hours of the initiation of hydraulic injection, which began on January 16, 2011. The largest earthquake recorded in the sequence had a magnitude 2.9 (Benz, et al., 2015). The foci of the earthquakes were located at the fluid injection depth of approximately 8,200 feet and ranged up to 6,560 feet away from the well. A study by Holland (2011 and 2013) found that the area was highly faulted, and after receiving the oil field pumping data concluded that the hydraulic fracturing triggered the earthquakes observed in this study.

Also, two sequences of earthquakes occurred in Oklahoma in June 1978 and May 1979. The largest event was magnitude 1.9, and two of the events were reported to have been felt (Nicholson and Wesson, 1990). In each case, nearby hydraulic fracturing operations correlated with the seismic events, but a lack of local seismic recording resulted in large location uncertainties and precluded a definite determination that the events were induced.

British Columbia and Alberta, Canada: The largest magnitude earthquakes (maximum M4.5) attributed to hydraulic fracturing occurred between April 2009 and August 2015 in the Western Canada Sedimentary Basin (WCSB) in British Columbia and Alberta (Wang, et al., 2016; Schultz, et al., 2015; Farahbod, et al., 2015; Ellsworth, 2013; Atkinson et al., 2015 and 2016; and Ellsworth, et. al., 2015). Twenty-two earthquakes in the series were larger than M3.0, and 69 larger than M1.5. Nearly all events occurred in the depth range 9,186 - 9,416 feet and within 650 feet of the perforation interval of several (at least six) wells. The well field is located within the Snowbird Tectonic Zone (Fox Creek, Alberta), which comprises numerous north-south trending subparallel faults in the region (Wang, et al., 2016). The investigation into the cause of these events concluded that the events were caused by hydraulic fracturing in proximity of pre-existing faults. Two of the well stimulation events were recorded by dense seismometer deployments at the surface. Precise hypocentral locations showed that the induced earthquakes occurred on previously unknown faults located outside of the stimulation interval that were well oriented for failure in the ambient stress field (Wang, et al., 2016; Schultz, et al., 2015; Farahbod, et al., 2015; and Ellsworth, 2013).

In June 2015 a M3.9 earthquake occurred in the Horn River basin in northern British Columbia and Alberta and is the first induced-earthquake to trigger the "stop light" for well stimulation operation in compliance with a newly enacted "traffic light" regulation in Canada (Wang, et al., 2016). Although the earthquake size (i.e., M3.9) falls slightly below the red light (cease all operations) threshold (M4.0) as defined by the provincial traffic light regulation, it was the initial magnitude determination of M4.4 that the red light designation was predicated. A month later, August 2015, a M4.5 (originally reported as M4.6) quake occurred in Fort St. John about 300 miles south of the Horn River basin's M3.9 event. This M4.5 quake is potentially the largest hydraulic fracturing-induced earthquake in the world (Atkinson et al., 2016). Section 7.0 below has a discussion on the "traffic light" system.

The WCSB is located approximately 500 miles east of the nearest tectonic plate boundary in an area of relatively low seismic activity. Most of the observed M≥3 earthquakes, since 1985 are considered to be associated with oil and gas production activities (Atkinson et al., 2016). In 2010 to 2015, the number of observed M≥3 earthquakes rose sharply in the WCSB as did the number of hydraulic fracturing events/wells, but not the number of disposal wells. Statistical analysis by Atkinson et al. (2016) determined that of the 107 earthquakes (M≥3) that occurred between 2010 and 2015, 65 were related to hydraulic-fracturing events and 33 were caused by deep-well disposal of wastewater and the remaining 7 were due to natural causes. However, it should be noted that within the WCSB the seismicity associated with wells that undergo hydraulic fracturing is still lower than seismicity associated with the number of deep-wells used for wastewater disposal (Atkinson et al., 2016). Atkinson et al. (2016) research could not establish a correlation between the maximum magnitude of a seismic event with the volume of injected fluid during hydraulic fracturing. However, their analysis did determine that the potential for hydraulic fracturing-induced earthquakes could linger weeks to months following well stimulation.

The consensus among most researchers is that the likelihood of a large and damaging earthquake induced by well stimulation appears to be remote (Ellsworth, 2013; Rutqvist, 2013; Zeng, et al., 2014; Rubinstein and Mahani, 2015; Maxwell, et al., 2015; National Research Council, 2013; and California Council on Science and Technology [CCST], 2015). However, research by Atkinson et al. (2016) documents that a minor- to light-size earthquake (i.e., M3 to M4.5) could happen. To date, the largest observed event attributed to hydraulic-fracture well stimulation is an M4.5 earthquake that occurred in the WCSB of British Columbia, in 2015 (Wang, et al., 2016; Atkinson et al., 2015 and 2016). The generally lower magnitudes of events associated with hydraulic fracturing relative to those induced by wastewater disposal are usually attributed to the short injection durations, smaller injection volumes, and flowback of injection fluids following stimulation, which result in smaller regions affected by elevated fluid pressures compared with the longer time periods and much higher volumes of wastewater injection. None of the reported events related to hydraulic fracturing have occurred in California.

5.6 Induced Seismicity from Wastewater Injection

Wastewater is a byproduct of many oil and gas extraction operations. At times these fluids can be cleaned and reused or applied for other purposes. Currently, the IOF operator treats all produced water and injects (i.e., waterflooding) it back into the oil producing formations to help control subsidence and enhance oil recovery (Cardno ENTRIX, 2012). Waterflooding typically aims to keep the fluid pressure in the oil producing formation near original level. However, if the wastewater is unsuitable for waterflooding or other uses it must be disposed of. Flowback of injection fluids generally has impurities which make it unusable. Typical wastewater disposal includes injection deep underground into high-permeability formations, usually deeper than the production reservoirs, for permanent sequestration and isolation from oil/gas reservoirs and drinking-water aquifers. Underground disposal of wastewater has a lengthy history because it is typically considered an economic and safe option (Ferguson, 2015). Unfortunately, in recent years the volume of wastewater needing disposal has increased, requiring more disposal wells and leading to higher injection pressures to force the wastewater into the surrounding rock formations. Injection rates of disposal wells range widely from one hundred barrels (35,000 gallons)/month to in excess of one million barrels (35 million gallons)/month (Rubinstein et al., 2015).

Deep well disposal of wastewater can induce earthquakes in four different ways: (1) the injected wastewater raises pore-fluid pressure within a fault, (2) the wastewater injection fills and compresses fluids within pore spaces causing deformation (poro-elastic effects), (3) the injection of the wastewater is colder than the rock formation it is being injected into causes thermoelastic deformation, and (4) the injected wastewater adds mass to the injection formation (Rubinstein and Mahani, 2015). Observations and numerical modeling indicate that increased fluid pressure within faults most strongly influences whether a wastewater disposal well will induce earthquakes (McGarr, 2014; Shapiro and Dinske, 2009; and McClure and Horne, 2011). Their modeling also found that the injected wastewater does not need travel the entire distance from the disposal well to a fault for the injection to affect the fault's behavior. The increased pore pressure in the rock can affect a fault's behavior over a great distance, up to 20 miles (Horton, 2012; Goebel et al., 2016; Keranen et al., 2013). As wastewater is injected into a formation, the pore pressure within that rock rises. If this pore pressure increase is transmitted to a fault, the increase in pore pressure counteracts the stresses locking the fault, resulting in a lower effective stress. As the effective stress locking the fault reduces, the fault's frictional resistance to slip is lowered and the fault is more prone to move. If a fault is suitably oriented with respect to the local stress field, it may slip causing an earthquake.

In the past decade the number of recorded earthquakes made a dramatic increase in the midwest and eastern parts of the United States. Where typically these parts of the country would experience approximately 24 M3.0, or greater, earthquakes per year, the number jumped to 326 per year since 2009 (USGS, 2016). The states experiencing the elevated levels of earthquake activity include Oklahoma, Arkansas, Texas, Colorado, New Mexico, Ohio, and West Virginia, which also happen to be experiencing a boom of hydraulic fracturing activities and wastewater disposal injections in deep wells. Earthquakes up to M5.6 have been scientifically linked to wastewater injection wells in at least six of the Midwestern states; Oklahoma, Texas, Colorado, New Mexico, Arkansas, and Ohio. In these areas of seismic quiescence, the abrupt appearance of earthquakes were easily attributed to nearby injection of wastewater into deep disposal wells. A recent investigation (Goebel et al., 2016) reports that a 2005 earthquake swarm in southern Kern County, California was caused by deep well disposal of wastewater. This is the first documented case of an induced earthquake occurring along an active fault, as well as the first reported in California.

<u>Oklahoma:</u> Oklahoma's earthquake activity has increased dramatically since 2009, with the increase linked to wastewater injection wells (Holland, 2011 and 2013; and Llenos and Michael, 2013). About 90 percent of Oklahoma's earthquakes are associated with wastewater injection activities. The state has experienced more than 200 earthquakes of M3.0 or greater since 2009 (approximately 40 per year), compared to 1-2 per year between 1975 and 2008 (USGS, 2016). The largest of these was a M5.8 earthquake near Pawnee, Oklahoma on September 3, 2016. The other larger event was a M5.7 earthquake near Prague, Oklahoma, outside of Oklahoma City (Ellsworth, 2013; Ellsworth et al., 2015; Benz et al., 2015; and Keranen et al., 2013). It destroyed 14 homes, damaged infrastructure and numerous buildings, and injured two people. These earthquakes have been linked to wastewater disposal wells (Holland, 2011 and 2013; McNamara et al., 2015). Additional earthquake swarms have been recorded in southern and northern Oklahoma, which have also been linked to wastewater injection wells (Ellsworth et al., 2015; and Keranen et al., 2013).

Arkansas: Earthquake activity in central Arkansas increased sharply in 2010 and 2011, when earthquake swarms were recorded and felt near the towns of Guy and Greenbrier. The induced earthquakes, which were near several wastewater injection wells, included a M4.7 earthquake in February 2011 (Horton, 2012). After the first wastewater disposal well became operational in April 2009, the rate of M≥2.5 earthquakes increased from one in 2007 to 157 in 2011. Analysis by researchers (Horton, 2012; and Llenos and Michaels, 2013) determined that a preexisting fault, later named the Guy-Greenbrier Fault Zone, was present in the basement rock units beneath the disposal rock formations. This inactive fault was unknown prior to wastewater disposal. As the wastewater disposal increased the pore pressure within the disposal units underlying the Guy-Greenbrier Fault Zone began to bleed off wastewater. The wastewater now entering into the fault zone decreased the effective stress allowing the fault zone to slip creating the Guy-Greenbrier earthquake swarm. Following the M4.7 earthquake, the disposal wells were shut down and the rate and size of earthquakes steadily dropped during the first three months following shutdown as the pore pressure buildup from months of injection returned to the pre-injection level. Only six earthquakes occurred on the Guy-Greenbrier Fault Zone in the six months following the permanent shutdown (Horton, 2012).

Texas: Several regions of Texas have experienced increased seismic activity near wastewater disposal wells in areas where no previous seismic activity had been recorded. In regions near Dallas-Ft. Worth, Cleburne, and Timpson, scientists have linked increased earthquake activity to wastewater injection wells (Frohlich et al., 2011; Justinic et al., 2013; Frohlich et al., 2014; and Walter et al., 2016). The Dallas-Fort Worth region has experienced a series of 180 small earthquakes between 2008 and 2009, which have been linked to wastewater disposal injection (Frohlich et al., 2011). Since 2009, the region has been hit by stronger earthquakes between M3.0 and M4.0.

Timpson, Texas, has experienced a series of damaging earthquakes, including the largest ever recorded in eastern Texas, a M4.8 in May 2012 (Frohlich et al., 2014). This earthquake caused significant structural damage to chimneys and brick veneer in the area. The earthquake sequence lasted between May 2012 and January 2013 and included a M4.0 foreshock and aftershocks of magnitude M4.1 and 4.3. The earthquakes' focal depths were shallow ranging between 1.6 to 4.6 kilometers deep and have been attributed to wastewater disposal activities nearby. An M2.8 earthquake was felt on June 9, 2009 in the Cleburne, Texas, an area close to two wastewater disposal wells (Justinic et al., 2013). The wells were located approximately 0.8 miles and 2 miles from the epicenter. Like the Dallas-Fort Worth earthquakes, the Cleburne area had no previous history of felt earthquakes. At least

50 smaller seismic events were recorded on a temporary micro-earthquake network installed shortly after the initial June 9 event.

Colorado/New Mexico: Seismicity near Trinidad, Colorado within the Raton Basin of Colorado and New Mexico that occurred between August 2011 and December 15, 2011, is believed to have been caused by injection of wastewater near the southern extension of a local fault zone (Rubinstein et al., 2014). The sequence included three earthquakes M≥4, the largest of which was M5.3. Between 2001 and 2013, sixteen M>3.8 earthquakes have been attributed to expanded wastewater disposal activity in the Raton Basin. During this time the median fluid injection rate increased from 119 million gallons/month to 2.6 billion gallons/month (Rubinstein et al., 2014). Prior to 2001, only one M>3.8 earthquake was recorded in the Raton Basin. The 2011 earthquake sequence occurred within 6.2 miles of five injection wells, four of which are high injection-rate, high-volume wells. At the end of August 2011, cumulative injection into these wells ranged from 475–700 million gallons/month.

California: An earthquake swarm in 2005 occurred at the southern end of the Central Valley, California, along the left-lateral strike-slip White Wolf fault. The White Wolf fault is an active fault that has produced one of the largest earthquakes in the past decade, the 1952, M7.3 Kern County earthquake. The White Wolf swarm occurred at the southern end of Kern County in the largest oil-producing (>75 percent of the state's oil production) and fluid-injecting (>80 percent of all injection wells) county in California (DOGGR, 2016).

Fluid injection rates at the southern end of the Central Valley increased rapidly from about 4.4 million gallons/month to more than 22 million gallons/month between 2001 and 2010. Effective well depths are reported between 4,000 – 5,000 feet. The wastewater disposal target zone was a highly permeable stratigraphic layer within the Monterey Formation (DOGGR, 2016). About 5 months prior to the swarm approximately 75 percent of the high-rate wastewater injection occurred in only one well, WD05. Well WD05 is located in an area of closely spaced, buried, northwest striking faults. Based on geological mapping, seismicity, and well-log data, the buried fault is referred to as "Tejon fault." Both seismicity and well-log data suggest that the Tejon fault is shallow, close to the well WD05 injection site (approximately 2 kilometers deep), and deepens toward the northwest before intersecting with the White Wolf fault at approximately 9 kilometers deep (Goebel et al., 2016).

The White Wolf swarm in 2005 deviates from standard main shock-aftershock patterns. It is comprised of a M4.5 event on September 22, followed by two M4.7 events and a M4.3 event the same day as well as some smaller magnitude "fore shocks" (Goebel et al., 2015 and 2016). Identification of the White Wolf swarm was based on a statistical assessment of injection and seismicity rate changes (Goebel et al., 2015). The statistical assessment showed that an abrupt increase in injection rates in 2005 was followed by a large increase in seismicity rates when compared to previous rate variations since 1980 (Goebel et al., 2015). This sequence deviates from commonly observed tectonic sequences in the area by showing significantly elevated seismicity rates above the background associated with a rapid increase in injection rates. Also, the seismicity sequence showed evidence for deep migration within the crystalline basement between injection wells and the nearby White Wolf fault suggesting that wastewater disposal likely contributed to triggering the earthquake swarm. Once the induced earthquakes of the White Wolf swarm were differentiated from earthquakes of natural causes, the seismic parameters of the swarm earthquakes were analyzed (i.e., focal depth, location) and the subsurface geologic structure was evaluated.

Analyses suggest that the rock pore pressure at the 1.5 kilometer deep injection well (WD05) was being bled off by the Tejon fault. This channeling effect may have been further intensified if the White Wolf fault acted as flow barrier, thereby trapping the pressure front resulting in more rapid pressure increase at the intersection between the two faults, White Wolf and Tejon (Goebel et al., 2016). This in turn reduces the effective stress along the White Wolf fault, triggering slip and the initiation of the earthquake swarm. Other cases of relatively deep induced seismicity far from wastewater injection sites have been reported in several other regions such as Oklahoma, Colorado, and Arkansas, where induced earthquakes occurred at 8 kilometer (approximately 5 miles) depth and from 7 to 35 kilometers (approximately 4.5 to 22 miles) distance from the wastewater injection well (Horton, 2012; Keranen et al., 2014).

Large-scale, continuous injection of wastewater into a single formation over time periods of months to years commonly generates overpressure fields of much larger extent than those resulting from well stimulation activities. Therefore, the likelihood of inducing larger seismic events increases as the volume of injected wastewater increases. The largest of these was a M5.8 earthquake near Pawnee, Oklahoma on September 3, 2016. The other larger event was a M5.7 earthquake near Prague, Oklahoma, outside of Oklahoma City, (Keranen et al., 2013), but the cause of this event is still the subject of active research, and the possibility that it was a natural tectonic earthquake cannot confidently be ruled out at present. However, the largest earthquake for which there is clear evidence for a causative link to wastewater injection is the 2011 M5.3 event in the Raton Basin of Colorado and New Mexico (Rubinstein et al., 2014). Although it may be low in absolute terms, the seismic risk of damage associated with wastewater disposal injection is relatively much greater than that associated with well stimulation activities. And the increase in seismicity associated with the increase in wastewater disposal may increase the likelihood of damage, as well as nuisance.

5.7 Additional Seismic Hazards

Besides surface rupture along a fault (discussed in Section 5.1, Regional and Local Faults above), the primary seismic hazard associated with earthquakes is ground shaking. Secondary hazards associated with seismic activity include liquefaction, differential settlement, and landsliding/slope stability. Tsunamis and seiches are generally associated with seismic activity. Underwater landslides can also cause these phenomena. Because of the Project Site elevation and the absence of onsite water bodies, effects associated with tsunamis and seiches is not considered in this hazard analysis.

Ground shaking

The principal seismic hazard occurring as a result of an earthquake produced by local faults is strong ground shaking. The intensity of ground shaking depends on several factors, including the magnitude of the earthquake, distance from the fault rupture, and the underlying soil conditions. In general, the larger the magnitude of an earthquake and the closer a site to the fault rupture, the greater will be the effects. However, soil conditions can also amplify the earthquake ground motions. Low bedrock motions can be significantly amplified by soft thick alluvium as seen in 1985 Mexico earthquake.

There are two primary methods to estimate expected ground motions at a site; probabilistic and deterministic. The building codes are based on USGS data which uses a combination of both methods to estimate ground motions at a site. In the probabilistic method, all of the known seismic sources in the region including background seismicity and their relative rate of seismicity are taken into consideration resulting in expected values of either peak or spectral acceleration associated with certain probability of exceedance or an earthquake return period. California Building Code and International Building Code are based on ground motions having 2 percent probability of exceedance in 50 years (return period of about 2,475 years). Figures 8 and 9 show that for a rock site, peak ground acceleration (PGA) value associated with 2 percent probability of exceedance in 50 years within 2 km and 5 km from the approximate center of the project site, respectively. This shows that there is 2 percent probability in next 50 years that the project site may experience PGA of 0.8g or higher. Both of these figures show that within 5 km of the project site, expected PGA is 0.8g for a seismic event associated with 2 percent probability of exceedance in 50 years except at small portion in the south-southwest where expected PGA is about 0.6g. These plots were developed using USGS data which are used in national seismic hazard maps and are for a competent rock site (Site Class boundary between B and C). USGS maps are based on 0.01 degree grid. Alternatively, a site-specific probabilistic seismic hazard analysis (PSHA) can be performed to do a better estimation as it uses more relevant site-specific information such as subsurface soil conditions at the site. However, a site-specific PSHA is beyond the scope of this project.

In the deterministic method, it is assumed that the closest seismic sources will experience the maximum earthquake expected for that fault during the life of the project. Using the earthquake magnitude, distance to the fault, fault mechanism, and site conditions as input parameters, and using ground motion prediction equations (GMPE), PGA and spectral accelerations can be estimated. There are five GMPEs currently being used in California for shallow crustal events such as associated with the faults in the project region. These GMPEs are based on statistical analysis of worldwide seismicity data and therefore, provide median values with standard deviations resulting in a range of expected values at a site. These GMPEs are only valid for M3 or higher events and are not applicable for lower magnitude events. The deterministic method is also referred as the scenario event and is typically used for emergency response and planning purposes. For example, for our project site and for a M3 event with 0 km distance, deterministically expected PGA would be less than 0.1g. This PGA value would increase to about 0.1 to 0.25g for M4 event and to about 0.3 to 0.6g for M5. Similarly, a M7.5 event on the Newport-Inglewood fault and at a distance of 0 km for a soil site could produce PGA of about 0.5 to 0.9g.

As previously discussed, strong ground shaking should be anticipated within the Project Site, where a peak ground acceleration ranging from 0.5g to 0.9g (50 to 80 percent of the acceleration due to gravity) could occur during the maximum earthquake (about M7.2) expected on the Newport-Inglewood fault. According to USGS, a maximum magnitude of 7.5 is associated with the Newport-Inglewood fault.

Modern, well-constructed buildings are designed to resist ground shaking through the use of shear walls and reinforcements. The current building codes include regulations and requirements designed to reduce risks to life and property from ground shaking to the maximum extent feasible. These building codes are enforced by Culver City's Department of Building Safety, in accordance with City of Culver City's Municipal Code Title 15, Chapters 15.02 and 15.03.

Liquefaction

Liquefaction involves the sudden loss of strength in saturated, cohesionless soils that are subjected to ground vibration and which results in temporary transformation of the soil into a fluid mass. If the liquefying layer is near the surface, the effects are much like that of quicksand for any structures located on top of it. If the layer is deeper in the subsurface, it may provide a sliding surface for the material above it. The effects of liquefaction include the loss of the soil's ability to support footings and foundations, which may cause buildings and foundations to buckle. These failures were observed in the 1971 San Fernando and the 1994 Northridge earthquakes.

Figure 5 illustrates areas within Culver City that are susceptible to liquefaction, as delineated by the California Geological Survey. As shown, liquefaction-prone areas are limited to the Ballona Creek area to the west and north of Jefferson Boulevard (CDMG, 1999). As Figure 5 shows, the Project Site is not located within a State of California delineated zone of possible liquefaction.

Earthquake Induced Landslides

A landslide is a mass down-slope movement of earth materials under the influence of gravity, and includes a variety of forms including: rockfalls, debris slides, mudflows, block slides, soil slides, slumps, and creeps. These mass movements are triggered or accelerated by earthquake-induced ground motion, increased water content, excessive surface loading, or alteration of existing slopes by man or nature. Earthquake-induced landslides, usually associated with steep canyons and hillsides, can originate on or move down slopes as gentle as one degree in areas underlain by saturated, sandy materials. As shown in Figure 5, areas identified as potential earthquake-induced landslide zones include almost all of the descending slopes to the west of La Cienega Boulevard, which would encompass all of the Project Site. All of these State of California delineated zones (CDMG, 1999) of potential earthquake-induced landslides are required to be investigated prior to any development/construction activities.

5.8 Geologic Hazards

Landslides

Slope failures, also commonly referred to as landslides, include many phenomena that involve the downslope displacement and movement of material, either triggered by static (i.e., gravity) or dynamic (i.e., earthquake) forces. Exposed rock slopes undergo rockfalls, rockslides, or rock avalanches, while soil slopes experience shallow soil slides, rapid debris flows, and deep-seated rotational slides. Landslides may occur on slopes of 15 percent or less; however, the probability is greater on steeper slopes that exhibit old landslide features such as scarps, slanted vegetation, and transverse ridges. Landslides typically occur within slide-prone geologic units that contain excessive amounts of water, are located on steep slopes, or where planes of weakness are parallel to the slope angle.

The Baldwin Hills have a well-documented history of chronic shallow landslide and erosion problems (Hsu et al., 1982; CDMG, 1999). On-site surficial sediments are generally characterized by unconsolidated to semi-consolidated sand, silt, and gravel. Well-defined bedding planes, which might be subject to deep-seated landslides, are generally absent. Potential slope failures are generally a result of surficial (i.e., less than 10 feet deep) slumping and unraveling of sediments as a result of oversteepened slopes and saturated conditions; however, deep-seated landslides/slumps are locally present. Debris flows have also occurred in many areas of oversteepened slopes, during or subsequent to successive heavy rainfall events. Vegetation has been removed throughout much of the active surface field, thus contributing to surficial slope instability.

Following the heavy rains of 1969, 1978 and 1980 the Baldwin Hills suffered widespread damage from slope failures. While most of the failures took place in the northeastern part of the hills, between La Cienega Boulevard and Stocker Street, in the City of Los Angeles, they also occurred in the western part of the hills in Culver City (Hsu et al., 1982), including the Project Site. The problems of the slope instability during these rainy years are particularly severe in the Baldwin Hills for two reasons. First, the hills were mostly developed in the very late 1940s and the 1950s, prior to enactment of stringent grading codes by local governments. Second, the terrain developed consisted mostly of steep natural slopes underlain by soft sedimentary rocks. The resulting tracts contain graded and natural slopes with angles as steep as 45 degrees, or even steeper, commonly without proper drainage devices and retaining walls. Modern grading codes require that cut and fill slopes be designed no steeper than 26 degrees, unless steeper angles can be shown to be stable. Additionally, fills were not placed as effectively as they would have been under today's more stringent compaction and supervision requirements.

No landslides were mapped on the Project Site by Hsu et al. (1982). A few small debris flows were observed falling into the canyon below Duquesne Avenue on the Project Site. These were too small to delineate aerially on maps. The Inglewood Formation (discussed in Section 4.3.4) is mapped in the canyon where the small debris flows are located on the Project Site (Hsu et al., 1982). The Inglewood Formation is susceptible to slope instability due to the surficial soils that develop on the formation are clay-rich. The remainder of the Project Site is underlain by Baldwin Hills Sandy Gravel and the Culver Sand, which are particularly susceptible to erosion.

Subsidence

Subsidence has been concern in the Baldwin Hills for decades and is one of the most serious environmental problems caused by oilfield operations within the Los Angeles Basin. Subsidence is caused by the reduction of pore pressure within the oil producing strata as the fluid is removed. The resulting compaction, which is propagated to the surface, typically causing a bowl-shaped subsidence at the surface, centered over the IOF (Chilingar and Endres, 2005). Subsidence is often accompanied by large-scale earthcracking, and in some cases includes horizontal and/or vertical movement. Although the precise failure mechanism is unclear, subsidence due to uncontrolled oil withdrawal may have contributed to failure of the former 20-acre Baldwin Hills Reservoir in 1963, killing five people and damaging or destroying 277 homes (Castle and Yerkes, 1976; Hudson and Scott, 1965).

As described in the Baldwin Hills CSD EIR (Los Angeles County, 2008), prior to 1971 the maximum cumulative subsidence of any of the areas along the Newport-Inglewood fault zone was centered over the Inglewood Oil Field, where 67,000 acre-feet of oil, water, and sand had been withdrawn from shallow production horizons (Hamilton and Meehan, 1971; and Barrows, 1974). The Culver City Seismic Safety Element (Leighton, 1974) reported that the northwest part of the hills was experiencing a subsidence rate of 0.24 to 0.36 inches per year from 1911 to 1963. However, that rate was slowing due to water injection (i.e., waterflooding) into the IOF (Leighton, 1974) and as of 1971, effectively eliminated subsidence associated with oil and gas production (County of Los Angeles, 2008).

The County IOF has an ongoing program of annual subsidence monitoring in accordance with requirements in the CSD. A baseline survey was established in 2010, and the survey stations utilized can be seen on the 2015 annual ground movement survey map (available at: http://www.inglewoodoilfield.com/plans/). The latest survey event in May, 2015 found that 28 of the 45 survey stations exceed the established threshold of allowable ground movement of 0.6 inches when compared to the 2010 baseline. Ground movement among the 28 stations ranged from 0.6 inches to 3.74 inches over the 5-year span. Within the City IOF, one of the stations (#109) located near the T-Vickers Tank Farm shows ground movement of 0.88 inches from 2010 to 2015, which includes 0.37 inches in the past year (2014 to 2015). However, according to the previous operator, PXP, (Cardno ENTRIX, 2012) none of these changes in ground surface are being attributed to oil and gas production activities. Determination of this will be possible after subsequent surveys have been performed for comparison to the baseline and subsequent surveys. To note, measurements of subsidence before and after the high-volume hydraulic fracturing study did not detect a measurable change (Cardno ENTRIX, 2012).

In response to the May 2015 survey results, DOGGR issued Order 1105, on November 15, 2015, to the IOF Operator requesting well information, pressure data, maps and reservoir rock information. The IOF Operator, on December 8, 2015, responded to the DOGGR Order, requesting an extension to providing the requested data, and to suggest that the CSD-mandated subsidence threshold of 0.6 inches should be replaced with a less stringent requirement similar to Long Beach's 1.5 inches. On December 21, 2015, DOGGR's letter acknowledged its review of the Operator's extension request, and expressed appreciation in exchanging information so that a science-based decision can be made. No other information to date is available, nor have any decisions been issued or publically published by DOGGR.

Soil Erosion

The Baldwin Hills has had a history of erosion problems (Hsu et al., 1982). On-site surficial sediments are generally characterized by unconsolidated to semi-consolidated sand, silt, and gravel. The topography of the Baldwin Hills, including the Project Site, has been modified by creation of numerous oil field service roads and relatively flat well-drilling pads. Steep cut slopes, with gradients up to approximately 0.75:1 (horizontal to vertical) to near-vertical, are present along many of the roads and on the perimeter of apparently old abandoned well pads. These slopes are subject to erosion, due to the generally unconsolidated nature of the exposed soils. Cut slopes adjacent to apparently newer well pads are less steep, with gradients up to approximately 1:1. Natural slopes are locally eroded with steep-sided gullies. Much of the Project Site has slopes in excess of 20 percent. Also, the Project Site is underlain by Baldwin Hills Sandy Gravel and the Culver Sand, both of which are particularly susceptible to erosion. Vegetation has been removed throughout much of the site, thus contributing to surficial slope instability.

Expansive Soils

The soil conditions in the Project area are directly related to the underlying geologic units. The soil profile is generated by in-place weathering of the native units and by slow downhill creep of surficial materials on the steeper slopes, resulting in local buildup of thick soil (colluvium) in the swales or at the toe of the slopes. The clayey soils within the Baldwin Hills are subject to significant volume change due to variation in soil moisture content. Changes in soil moisture could result from a number of factors, including rainfall, landscape irrigation, utility leakage, and/or perched groundwater. Clay-rich soils are known to develop on the Inglewood Formation and should be considered susceptible to expansion (Hsu et al., 1982). The Inglewood Formation has been mapped in the canyon below Duquesne Avenue on the Project Site. Also, colluvium is mapped underlying the western part of the Project Site along College Boulevard and should be considered expansive. The remainder of the Project Site is underlain by sandier units belonging to the Baldwin Hills Sandy Gravel and the Culver Sand, which are generally not considered to be expansive. However, soils may vary locally and should thus be evaluated on a site-specific basis. Such an evaluation may include laboratory testing.

6.0 PROJECT IMPACTS AND MITIGATION

6.1 Analytic Method

The Project is the adoption of the Inglewood Oil Field Specific Plan and implementing ordinances. Such actions would not have a direct effect related to geologic and soils conditions, but oil field operations that are likely to occur as a result of the proposed Project could be subject to geologic or soils hazards, and could exacerbate existing hazards. Baseline information for the analysis was compiled from a review of published geologic maps and reports, as well as information compiled and provided by the City of Culver City, the former operators, FM O&G and PXP, in conjunction with its overall planning and hazard mitigation processes to identify geologic conditions and geologic hazards to the Project Site.

Independent of the CEQA process, there is a comprehensive regulatory framework implemented at the state and City level to mitigate potential hazards associated with geologic and soils conditions. The design-controllable aspects of building foundation support, protection from seismic ground motion, and soil instability are governed by existing regulations. Compliance with these regulations is required, not optional. Compliance must be demonstrated before permits would be issued. The analysis presented herein assumes compliance with all applicable laws, regulations, and standards.

Appendix G of the California *CEQA Guidelines* sets forth guidance for the determination of significance of geology/soils and seismic impacts. This guidance provides specific criteria to be considered when making a significance determination.

6.2 Thresholds of Significance

Based on the *CEQA Guidelines,* Appendix G, a project may be deemed to have a significant effect on the environment with respect to geology and soils if it would:

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:
    - Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault (refer to Division of Mines and Geology Special Publication 42);
    - Strong seismic ground shaking;
    - Seismic-related ground failure, including liquefaction; or
    - Landslides
- Result in substantial soil erosion or the loss of topsoil;

- Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse;

- Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property; and/or

- Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water.

6.3 Effects Not Found to Be Significant

Septic or Alternative Waste Water Disposal Systems

The development of the proposed Project would not include the addition, removal, or use of septic tanks or alternative waste water disposal systems. Therefore, there would be no impact related to the issue of support for septic or alternative wastewater disposal systems and no mitigation is required. Therefore, there is ***no impact***, because the oil field will not utilize septic tanks.

Liquefaction

As shown in Figure 5, liquefaction-prone areas are present in Culver City primarily limited to the Ballona Creek area to the west and north of Jefferson Boulevard (CDMG, 1999). However, the Project Site is not located within a State of California delineated zone of possible liquefaction. Therefore, liquefaction is considered to have ***no impact*** on the Project Site.

6.4 Less-Than-Significant Impacts

Soil Erosion and Loss of Topsoil

The construction of graded drill pads would increase the potential for soil erosion. The poorly consolidated nature of the Culver sand and Baldwin Hills sandy gravel will readily erode during construction activities. However, compliance with proper grading techniques in accordance with the State Building Code, grading requirements of Culver City's Public Works Department (in accordance with City of Culver City's Municipal Code Title 15), and requirements of the proposed Specific Plan (e.g., Geotechnical Investigation, Erosion Control Plan, Slope Restoration) would ensure that the impacts would be ***less than significant***.

Expansive Soils

The soil conditions in the City IOF are directly related to the underlying geologic units. The soil profile is generated by in-place weathering of the native units and by slow downhill creep of surficial materials on the steeper slopes, resulting in local buildup of thick soil (colluvium) in the swales or at the toe of the slopes. The clayey soils within the City IOF are subject to significant volume change due to variation in soil moisture content. Changes in soil moisture could result from a number of factors, including rainfall, landscape irrigation, utility leakage, and/or perched groundwater. Clay-rich soils are known to develop on the Inglewood Formation and should be considered susceptible to expansion (Hsu et al., 1982). The Inglewood Formation has been mapped in the canyon below Duquesne Avenue on the Project Site. Also, potentially expansive colluvium is mapped underlying the western part of the Project Site along College Boulevard. However, compliance with proper grading techniques in accordance with the State Building Code, grading requirements of Culver City's Public Works Department, and requirements of the proposed Specific Plan (e.g. Geotechnical Investigation) would ensure that the impacts would be ***less than significant***.

Landslides and Earthquake-Induced Landslides

As shown in Figure 5, the western and northwestern portion of the City IOF is located in an earthquake-induced landslide hazards zone (CDMG, 1999). Previous investigations (Hsu et al, 1982; Castle and Yerkes, 1976) have documented the inherent slope instability that exists in the Baldwin Hills and at the Project Site. The Project Site is underlain by weak bedrock and unfavorable (out of slope) bedding angles that make the slopes extremely prone to failure during heavy rainfall and/or strong ground shaking. Earthquake-induced landslide hazard zones are areas where Holocene-age landslide movement has occurred, or local slope of terrain, and geological, geotechnical and ground moisture conditions indicate a potential for landslide exists. The California Seismic Hazard Mapping Act of 1990, updated October 2, 2007, requires the proper identification and investigation of these landslide-prone areas. Compliance with the requirements of the proposed Specific Plan (e.g., Geotechnical Investigation), with the State Building Code, grading requirements of Culver City's Public Works Department and adherence to the Seismic Hazards Mapping Act would mitigate the impacts from the potential earthquake-induced landslide areas on both the City IOF and County IOF to be considered ***less than significant***.

Subsidence

As discussed in Section 5.8, one of the more serious environmental problems caused by oilfield operations within the Los Angeles Basin has been subsidence, which exists in the IOF, both City and County portions. The subsidence occurs when the fluid (oil and water) withdrawal from the porous subsurface formations reduces the pore pressure in the formation. The void space once occupied by the oil and water becomes occupied by air, which leaves the formation susceptible to compaction under the weight of overlying geologic materials. Filling this void space with a fluid, such as, produced water (i.e., water flooding) will help prevent or lessen the effects of subsidence.

The CSD requires an annual ground movement survey at the County IOF, which currently includes several survey monuments within the City IOF boundaries. The proposed Specific Plan requires the Operator to submit, for approval, a Comprehensive Ground Movement Plan within 180 days of the approval of the City IOF Comprehensive Drilling Plan. The ground movement survey will commence within 60 days of Plan's approval by the Culver City's Public Works Department Director/City Engineer. The City IOF survey may include survey location points utilized by the County IOF survey, but at a minimum it should include locations 1,000 feet beyond the horizontal limit of the proposed borehole bottoms. The ground movement survey will occur annually up to five years after the oil field operations have ceased. The results of all surveys will be submitted Culver City's Public Works Department Director/City Engineer and DOGGR for review.

Surveying for both vertical and horizontal ground movement is accomplished using satellite-based Global Positioning System (GPS) technology. Accumulated subsidence or uplift is measured using repeat pass Differentially Interferometric Synthetic Aperture Radar (inSAR) technology. The data are then evaluated to determine whether the City IOF operations are related to any detected subsidence or uplift. In the event that ground movement monitoring indicates that on-going uplift or subsidence, 0.6 inch or greater, at any given location within the City IOF has occurred then the City's Public Works Department Director/City Engineer and DOGGR will be notified and the Operator will cease oil operations on the City IOF until the cause has been determined. If the IOF's operations are the cause, then a remedy must be submitted by the Operator, and approved, before City IOF oil operations can resume.

The CSD requires annual ground movement monitoring in the Baldwin Hills area, including the City IOF and County IOF, and the proposed Specific Plan's Accumulated Ground Movement Plan and Survey section requires monitoring in the City IOF. If either survey detects on-going uplift or subsidence of 0.6 inch or greater, at any location, then the Director of Los Angeles County Public Works, IOF Operator and the California DOGGR, shall inspect the IOF for damages and evaluate the Operator's fluid injection and withdrawal rates to determine where adjustments to these rates may be needed. The injection pressures associated with secondary recovery operations (i.e., water flooding) shall not exceed the formation's fracture pressures as specified by the DOGGR. Water flooding must continue in the oil producing formations in the City IOF and County IOF for subsidence mitigation to be successful. Therefore, compliance with the monitoring requirements of the proposed Specific Plan (e.g., Accumulated Ground Movement Plan and Survey), regulations by the DOGGR and Los Angeles County Department Public Works, and requirements of the CSD would ensure that potential subsidence impacts at the City IOF and County IOF would be considered ***less than significant***.

6.5 Significant and Unavoidable

Ground Rupture of a Known Earthquake Fault

The Inglewood Oil and Gas Field is located in the Baldwin Hills, which were formed as a result of uplift and deformation of sedimentary rock layers due to movement of the Newport-Inglewood Fault Zone. This fault zone, which overall is seismically active is comprised of many smaller faults and fault splays (see Figures 2 and 3). An active fault is one that has had movement within Holocene time (approximately the last 11,000 years). However, not all of the faults and fault splays within the fault zone are active; some are ancient and with estimated movement older than the Holocene. All of the faults within the fault zone have displaced and deformed the subsurface strata, which helped in developing the structural oil traps for the IOF. Some of the faults terminate in the subsurface while others extend to the ground surface. Some of the faults at the surface were determined by CGS to possibly be active. Therefore, under the Alquist-Priolo (A-P) Act (Bryant and Hart, 2007) CGS placed a zone around the faults known as Earthquake Fault Zones (EFZs). All faults within an EFZ are assumed to be active until a detailed investigation confirms it or not, and generally a construction setback from the active faults is established. Also, due to the lack of datable soils, an active fault may not be zoned as an EFZ. Also, construction, which predates the implementation of the A-P Act, may have placed buildings and roadways above active faults obscuring them from detection. At the northern end of the Project Site within the 400-foot buffer zone is the only EFZ within the Project Site (see Figure 4). This EFZ extends northward into the parking area of the Stoneview Nature Center. In accordance with the proposed Specific Plan (e.g., Fault Investigation Report), the operator will need to conduct a detailed fault study (to locate and assess any active fault traces) before any work can be completed within this EFZ or any active fault on the City IOF. The presence of active faulting may require a construction setback (usually 50 feet) from the fault.

Ground rupture caused by naturally occurring earthquakes is inevitable and avoidance of known active faults are about the only course of action. Criteria set forth in the proposed Specific Plan, Alquist-Priolo Act, adherence to the State Building Code, and requirements of Culver City's Public Works Department will provide the best mitigation within the City IOF.

However, possible ground rupture caused by induced earthquakes is avoidable. Two recently published research articles by Goebel et al. (2016) and Atkinson et al. (2016) are important in understanding the ground rupture potential from induced earthquakes.

Goebel et al. (2016) research on the 2005 White Wolf earthquake swarm of four earthquakes ranging from M4.3 to M4.7 is significant because: 1) it documents California's first induced earthquake due to wastewater disposal, and 2) it documents the first induced earthquake along a known active fault. Previously all induced seismicity had been documented in seismically quiet areas, where the abrupt increase in seismicity was easy to correlate to wastewater disposal or well stimulation activities. The method by Goebel et al. (2015) analyzes short-range spatiotemporal correlations between changes in fluid injection and seismicity rates as it searches through the entire of injection rate threshold database and determines the statistical significance of correlated changes in injection and seismicity rates. This method is similar to the research by McGarr (2014), Bommer et al. (2016), Weng et al. (2015) and Hajati et al. (2015).

Atkinson et al. (2016) research is significant because it documents the occurrence of earthquakes from M3 to M4.5 associated with hydraulic fracturing activities, where previous research suggested that M3 earthquake was the largest known to exist. Atkinson et al. (2016) analysis also determined that the potential for hydraulic fracturing-induced earthquakes could linger weeks to months following well stimulation activities. However, their research could not establish a correlation between the maximum magnitude of a seismic event with the volume of injected fluid during hydraulic fracturing. The earthquakes analyzed by Atkinson et al. (2016) occurred within an area of western Canada where inactive faults are present. Hydraulic fracturing activities induced sufficient pressure on these existing inactive faults to produce earthquakes along them.

Currently, well stimulation is not occurring in the IOF (City or County areas); however, according to the former operator FM O&G (2015b), well stimulation activities will commence in the future. The commencement of well stimulation activities in the City IOF will introduce increased pore pressure on the existing faults of the Newport-Inglewood Fault Zone. The very nature of hydraulic fracturing is to fracture the bedrock thus creating microseisms (earthquakes of M<1). However, research by Atkinson et al. (2016) has shown that larger earthquakes (up to M4.5 thus far) can be produced, and their potential could last weeks to months following the well stimulation activities. Also, well stimulation activities will produce flowback. If the volume of flowback from the well stimulation activities exceeds the volume needed for current waterflooding, then the excess wastewater will need to be disposed. The excess wastewater could be removed from the project site, or it could be disposed into wells drilled below the oil producing zones (maybe the Topanga Formation). This option could set up a situation similar to White Wolf swarm presented above and in Section 5.6. That is, wastewater disposal that increases pore pressure in the "Topanga Formation" and several faults within the Newport-Inglewood Fault Zone, which cut through the area, thus providing a channeling effect to reduce the effective stress on the active faults within the fault zone. This could trigger slip on the active faults generating an earthquake large enough to cause ground rupture and substantial ground shaking.

It's been established that felt induced earthquakes are more likely to be generated by disposal wells than well stimulation activities (National Research Council, 2013; Atkinson et al., 2016). And in California there are no requirements for earthquake monitoring during wastewater disposal like there is for well stimulation activities. SB 4 requires monitoring for, and reporting to DOGGR, any earthquakes of magnitude M2.7 or greater that occur onsite during the process of well stimulation and up to 10 days after its completion. However, the proposed Specific Plan (e.g., Seismic Activity Tracking section) requires the installation of a seismometer and monitoring of earthquake activity when oil operations are being conducted on the City IOF. Other possible mitigation measures related to well stimulation activities and the disposal of wastewater into wells within the City IOF could be:

1) Dispose wastewater (flowback) from well stimulation activities offsite.
2) Avoid siting disposal wells into or through active faults.
3) Develop an induced seismicity checklist and protocols for screening well stimulation and wastewater disposal activities similar to what's suggested by Zoback (2012) and National Research Council (2013) summarized below in Section 7.0 as a "traffic light" system.
4) If the "traffic light" system discussed in Section 7.0 isn't adopted, then deploy a network of seismometers to monitor seismic activity during well stimulation and wastewater disposal activities, and establish a seismic threshold which would trigger cessation of activities. Adherence to the proposed Specific Plan (e.g., Seismic Activity Tracking section) and adoption of SB 4's magnitude M2.7 earthquake threshold is recommended.

The faults within the City IOF are part of the Newport-Inglewood Fault Zone, which is also located within the County IOF. Unfortunately, any induced-earthquake (due to well stimulation and/or wastewater disposal activities) occurring within the County IOF will also affect the City IOF and vice versa. Therefore, any fully effective mitigation measure should be applicable to both the City IOF and County IOF. So, adherence to the above discussed actions will help lessen the effects from induced earthquake ground rupture but it is considered to be ***significant and unavoidable***.

Ground shaking

Seismic ground shaking is the direct result of movement along a fault. The Project Site is in a location adjacent to the active Newport-Inglewood Fault Zone and will most likely be subjected to ground shaking in the future. Ground shaking caused by naturally occurring earthquakes is inevitable and avoidance is not possible. Mitigating their effects by advanced preparation is generally the accepted method. However, possible ground shaking caused by more frequent induced earthquakes is avoidable. Recently published research by Goebel et al. (2016) and Atkinson et al. (2016), described in the preceding section, are important in understanding the ground shaking potential from induced earthquakes. The research by Goebel et al. (2016) on the 2005 White Wolf earthquake swarm of four earthquakes ranging from M4.3 to M4.7 is significant because; 1) it documents California's first induced earthquake due to wastewater disposal, and 2) it documents the first induced earthquake along a known active fault. Atkinson et al. (2016) research is significant because it documents the occurrence of well stimulation-induced earthquakes ranging in magnitude from M3 to M4.5, where previous research suggested that M3 earthquake was the largest known to exist. Atkinson et al. (2016) analysis also determined that the potential for hydraulic fracturing-induced earthquakes could linger weeks to months following well stimulation activities.

Currently, well stimulation is not occurring in the IOF (City or County areas); however, according to the former operator FMO&G (2015b), well stimulation activities will commence in the future. The commencement of well stimulation activities in the City IOF will introduce increased pore pressure on the existing faults of the Newport-Inglewood Fault Zone. The very nature of hydraulic fracturing is to fracture the bedrock thus creating microseisms (earthquakes of M<1). However, research by Atkinson et al. (2016) has shown that larger earthquakes (M4.5 thus far) can be produced, and their potential could last weeks to months following the well stimulation activities. Also, well stimulation activities will produce flowback. If the volume of flowback from the well stimulation activities exceeds the volume needed for current waterflooding, then the excess wastewater will need to be disposed. The excess wastewater could be removed from the project site, or it could be disposed into wells drilled below the oil producing zones (maybe the Topanga Formation). This option could set up a situation similar to White Wolf swarm presented above and in Section 5.6. That is, wastewater disposal that increases pore pressure in the subsurface and several faults within the Newport-Inglewood Fault Zone provide a channeling effect to reduce the effective stress on the active faults within the fault zone. This could trigger slip on the active faults generating an earthquake large enough to cause substantial ground shaking.

It's been established that felt induced earthquakes are more likely to be generated by disposal wells than well stimulation activities (National Research Council, 2013, Atkinson et al., 2016). And in California there are no requirements for earthquake monitoring during wastewater disposal like there is for well stimulation activities. SB 4 requires monitoring for, and reporting to DOGGR, any earthquakes of magnitude M2.7 or greater that occur onsite during the process of well stimulation and up to 10 days after its completion. However, the proposed Specific Plan (e.g., Seismic Activity Tracking section) requires the installation of a seismometer and monitoring of earthquake activity when oil operations are being conducted on the City IOF. Other possible mitigation measures related to well stimulation activities and the disposal of wastewater into wells within the City IOF could be:

1) Dispose wastewater from well stimulation activities offsite.
2) Avoid siting disposal wells into or through active faults.
3) Develop an induced seismicity checklist and protocols for screening well stimulation and wastewater disposal activities similar to what's suggested by Zoback (2012) and National Research Council (2013) summarized below in Section 7.0 as a "traffic light" system.
4) If the "traffic light" system discussed in Section 7.0 isn't adopted, then deploy a network of seismometers to monitor seismic activity during well stimulation and wastewater disposal activities, and establish a seismic threshold which would trigger cessation oil field operations. Adherence to the proposed Specific Plan (e.g., Seismic Activity Tracking section) and adoption of SB4's (for well stimulation) magnitude M2.7 earthquake threshold is recommended.

The faults within the City IOF are part of the Newport-Inglewood Fault Zone, which is also located within the County IOF. Unfortunately, any induced-earthquake (due to well stimulation and/or wastewater disposal activities) ground shaking occurring within the County IOF will also affect the City IOF and vice versa. Therefore, any fully effective mitigation measure should be applicable to both the City IOF and County IOF. So, adherence to the above discussed actions will help lessen the effects from induced earthquake ground shaking but they are considered to be ***significant and unavoidable***.

7.0 CONCLUSIONS

There were several main subject areas that were identified as impacts of the proposed Project. The impacts need to be addressed as they expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving. Table 7-1 presents a summary of Project Impacts for the various geologic and seismic hazards that may affect the Project, from activities within the City IOF and the Maximum Buildout Scenario within the County IOF. The table also lists the significant threshold levels that are discussed in Section 6.0.

Table 7-1
Summary of Project Impacts and Significance Level

Project Impact	*Significance Level*
Soils capable of supporting septic systems	No impact
Ground rupture from an earthquake fault	Significant and unavoidable
Seismic ground shaking	Significant and unavoidable
Liquefaction	No impact
Landslides	Less than significant
Earthquake-induced landslides	Less than significant
Subsidence	Less than significant
Soil erosion and loss of topsoil	Less than significant
Expansive soils	Less than significant

Mitigation for ground rupture and ground shaking caused by naturally occurring earthquakes is generally accepted to be avoidance and advanced preparation. Criteria set forth in the proposed Specific Plan, Alquist-Priolo Act, adherence to the State Building Code, and requirements of Culver City's Public Works Department will provide the best mitigation within the City IOF. However, mitigation for ground rupture and ground shaking due to induced-earthquakes (well stimulation and/or wastewater disposal activities) may not be avoidable and will need additional measures to lessen their severity to the City IOF and Culver City. Options for induced-earthquake mitigation are listed in Section 6.5, Ground Rupture and Ground Shaking. One of the mitigation options (Number 3) is to develop a "traffic light" system for screening well-stimulation and wastewater disposal activities within the City IOF, as described by Zoback (2012) and National Research Council (2013). The "traffic light" system is described more fully below and is recommended.

The "traffic light" system is a risk-based mitigation plan that allows for a response to an instance if induced seismicity is detected, and to assist in guiding decisions on injection operations as related to all forms of injection-induced seismicity. This allows for low levels of seismicity, but adding monitoring and mitigation requirements, including the requirement to modify or even cease operations if the level of seismic impacts becomes unacceptable. The "traffic light" system can be developed that allow operations to continue, require changes in the operations to reduce the seismic impact, or require a suspension of operations to allow time for further analysis before resuming. Each color of the traffic lights should correspond to measured level of seismicity, such as, RED could correspond to a M2.7, or greater, earthquake (near the threshold of a felt earthquake). This would be similar to the level of detected earthquake required in SB 4 and the proposed Specific Plan, Seismic Activity Tracking section. The “traffic light” system will include:

- **Green:** The GREEN light is defined by levels of ground motion that are either below the threshold of general detectability or, if at higher ground motion levels, at occurrence rates lower than the already-established background activity level in the area: ***Oil field operations (i.e., oil/gas extraction and waterflooding, well stimulation, and waste water injection) proceed as outlined in the approved Comprehensive Drilling Plan***.

- **Yellow:** The YELLOW light is defined by ground motion levels at which people would be aware of the seismic activity associated with the stimulation. Because the City IOF is located in an active fault zone and in a densely populated City with a diverse mix of residential and commercial structures, a conservative earthquake magnitude range for the YELLOW light is deemed prudent. Therefore, the occurrence of a magnitude M2.0, up to M2.7, earthquake within 5 kilometers of the City IOF will be considered a YELLOW light situation. Under the cautionary YELLOW light condition the following is required: ***Oil field operations proceeds with caution, at reduced flow rates, and the Operator conducts a study of the relationship between the seismicity and injection. If seismicity ceases or is found not to be related to injection, then operations can return to GREEN light condition.***

- **Red:** The RED light condition will exist if a magnitude M2.7, or greater, earthquake is detected within 5 kilometers of the City IOF. The magnitude M2.7 follows the requirements of SB 4 and the proposed Specific Plan’s section on Seismic Activity Tracking. Under a RED light condition the following is required: ***Oil field operations cease immediately. The Operator inspect all pipelines, tanks, and infrastructure, and conduct a study of the relationship between the seismicity and operations. The results of the study will be submitted to Culver City’s Public Works Director/City Engineer and DOGGR for approval before operations can resume.***

The “traffic light” control system allows for a response to an instance if induced seismicity is detected. Its design should be to ensure the health and safety of the citizens of Culver

City. The ultimate success of the "traffic light" control system is fundamentally tied to the strength of the collaborative relationships and dialogue among all of the stakeholders. The stakeholders should include the City of Culver City and its residents, operator of the IOF, officials from Los Angeles County and DOGGR.

8.0 LIMITATIONS

This work was prepared in a manner consistent with the level of care and skill ordinarily exercised by other members of Kleinfelder, Inc.'s, profession practicing in the same locality, under similar conditions and at the date the services are provided. Our conclusions, opinions, and recommendations are based on a limited number of observations and data. We have, however, satisfied ourselves that the quantity and nature of the existing observations and data are appropriate in our professional opinion to support our work per the standard of care to which we adhere. Kleinfelder, Inc., makes no other representation, guarantee, or warranty, expressed or implied, regarding the services, communication (oral or written), report opinion, or instrument of service provided.

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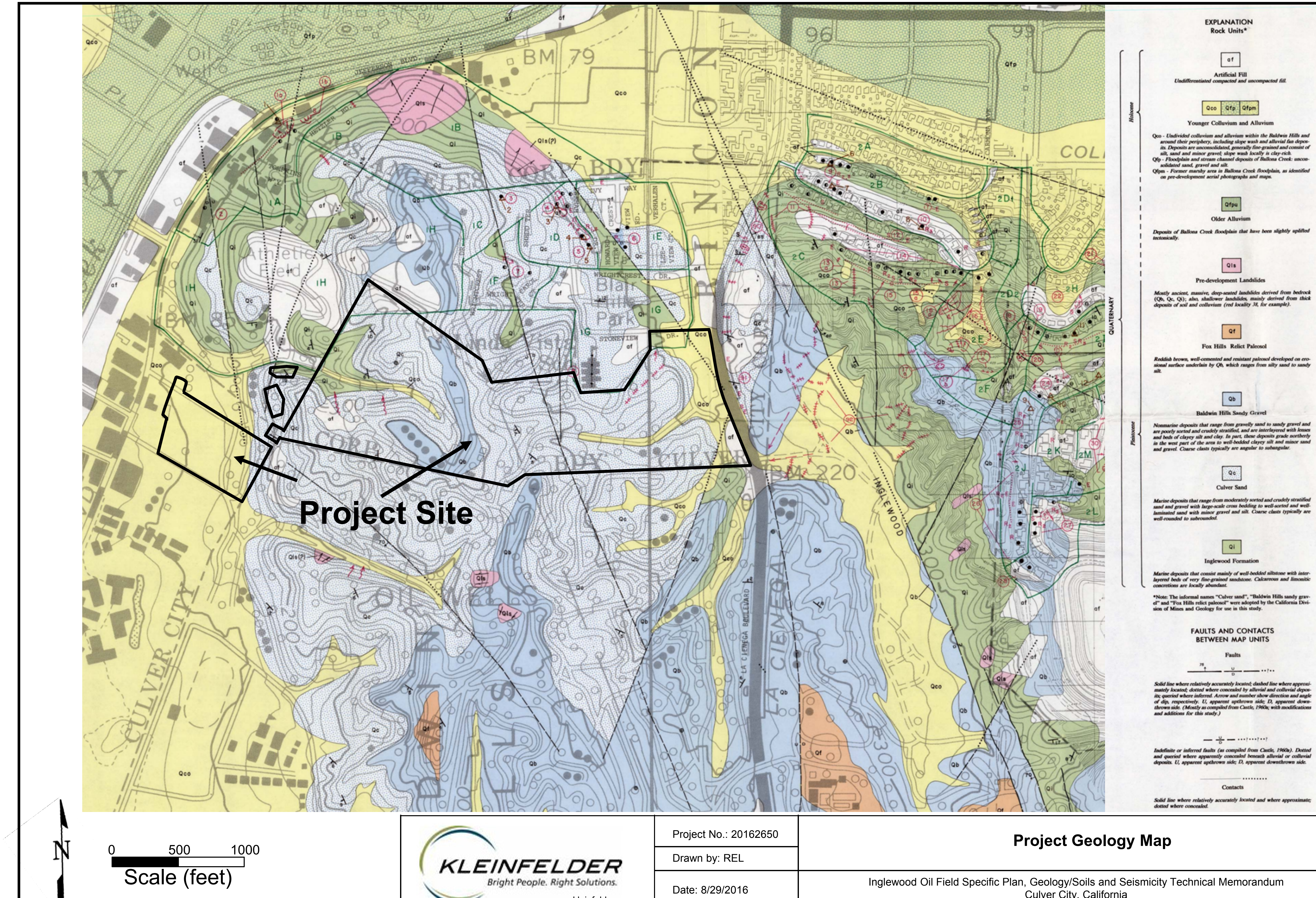
FIGURES

Appendix

FIGURES



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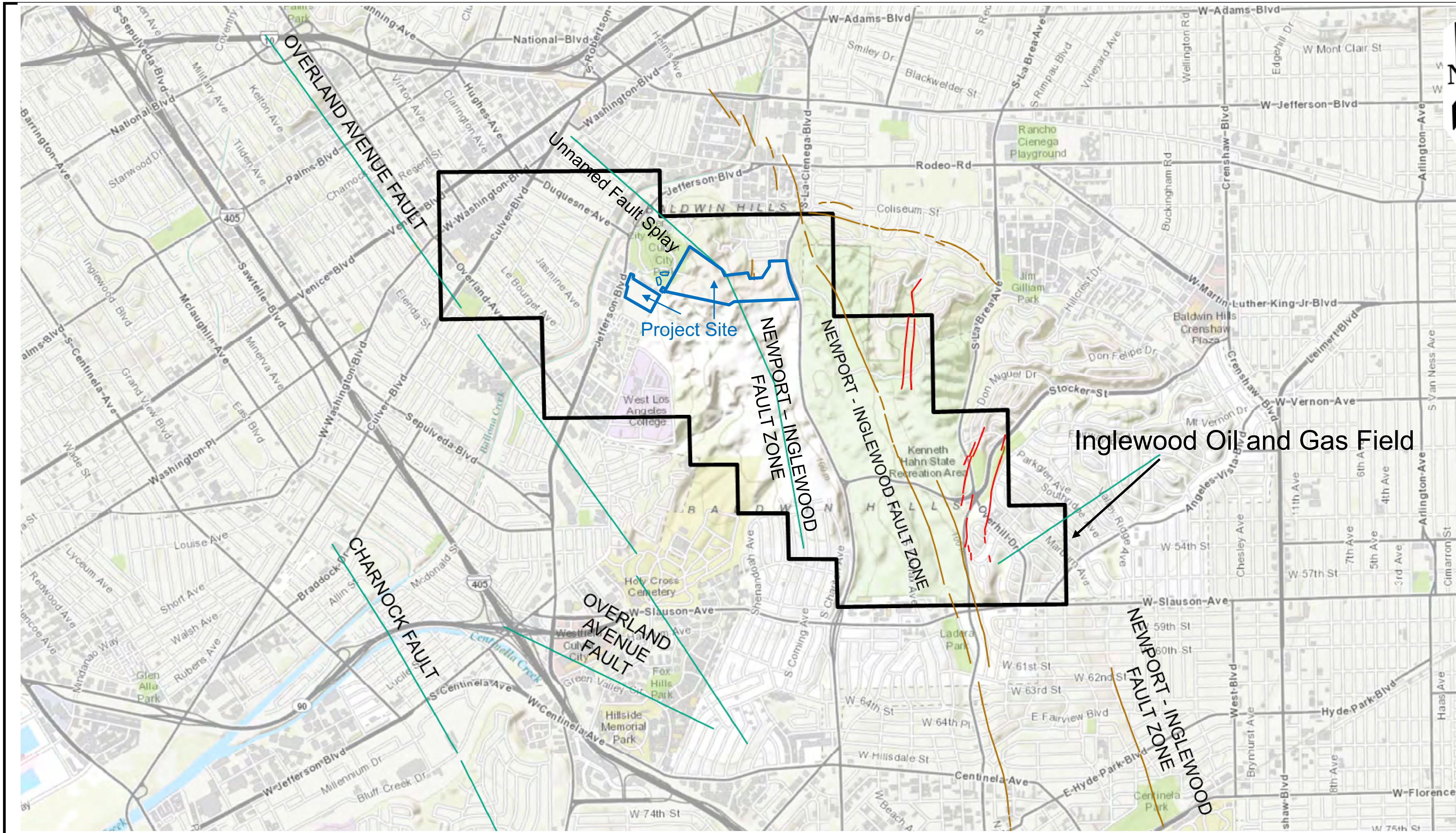
Project No.: 20162650	**Project Geology Map**	Figure 1
Drawn by: REL		
Date: 8/29/2016	Inglewood Oil Field Specific Plan, Geology/Soils and Seismicity Technical Memorandum Culver City, California	



Adapted from Draft EIR, Analysis of Oil and Gas Well Stimulation Treatments in California, January 2015

0 0.5 1
Scale (miles)

- FAULT - HISTORICALLY ACTIVE
- FAULT - HOLOCENE ACTIVE
- FAULT - LATE QUATERNARY

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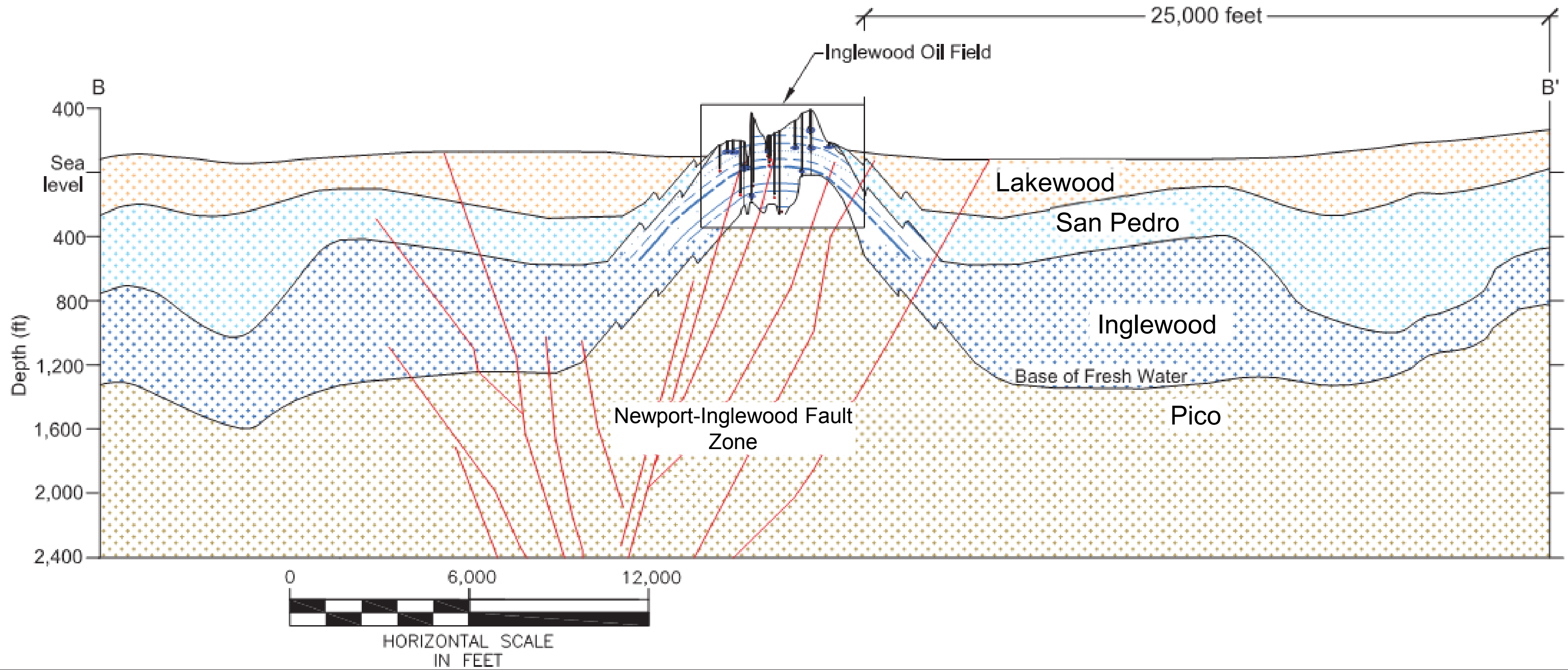
Project No.: 20162650	**Regional Fault Map**	Figure 2
Drawn by: REL		
Date: 8/29/2016	Inglewood Oil Field Specific Plan, Geology/Soils and Seismicity Technical Memorandum Culver City, California	

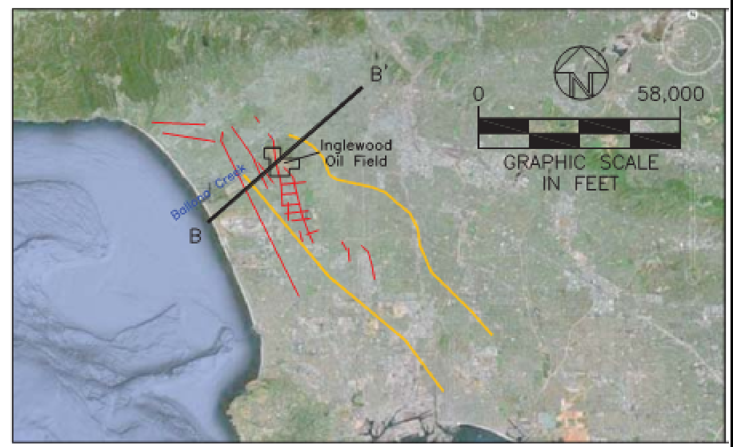


LEGEND

- Fault
- Fold Axis
- Geologic Formation
- Cross–Section

NOTES: 1. Vertical scale greatly exaggerated.
2. Both San Pedro and Inglewood formations are present at the oil field. Depiction is an estimate, as both formations crop out and have complex folds.
3. Cross–section depicted located as shown in inset map.

Source: USGS 2003



Source: U.S. Geological Survey (2003) Water Resources Investigation Report 03-0465

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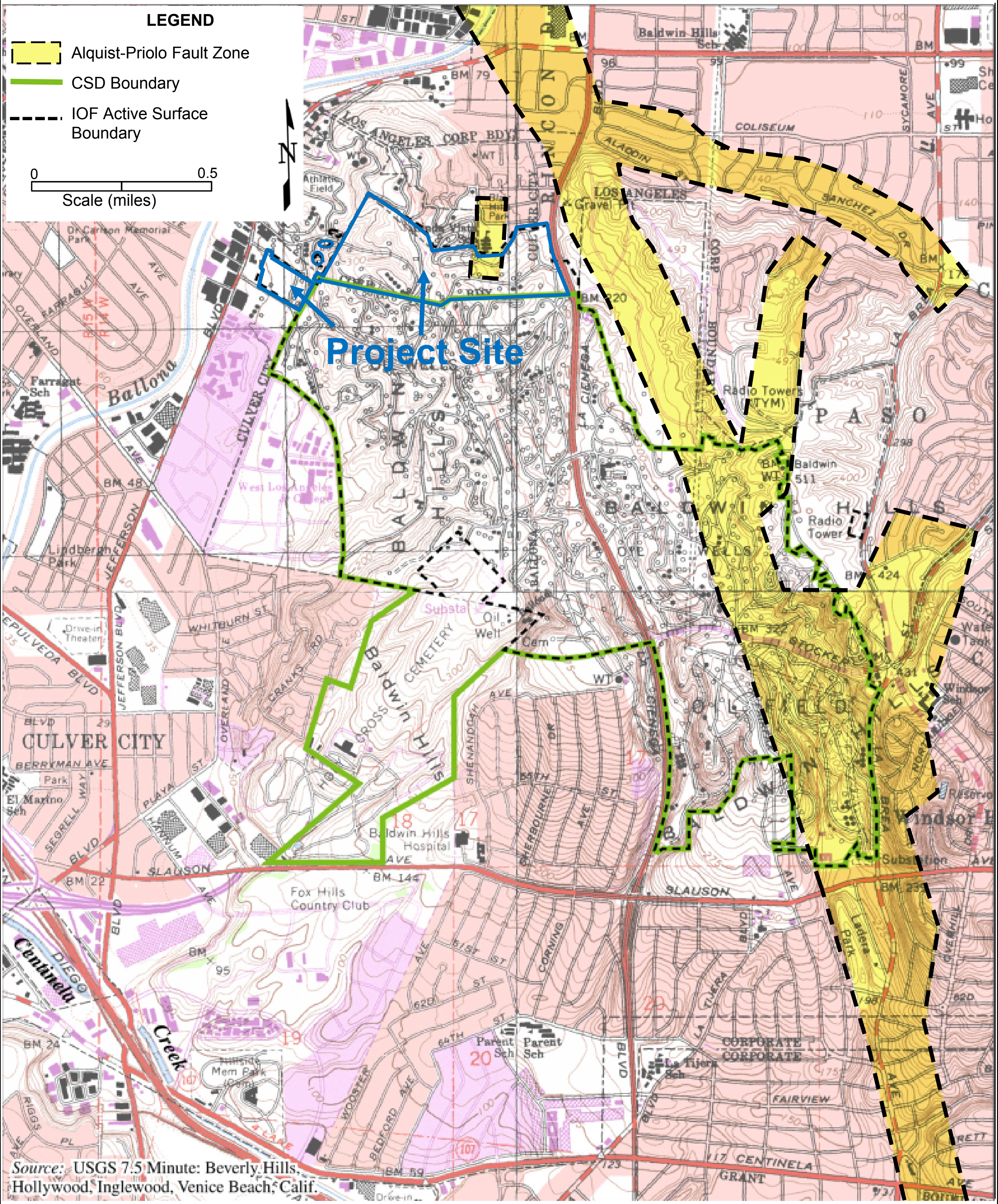
Drawn by: REL

Date: 8/29/2016

Regional Geologic and Fault Cross-Section

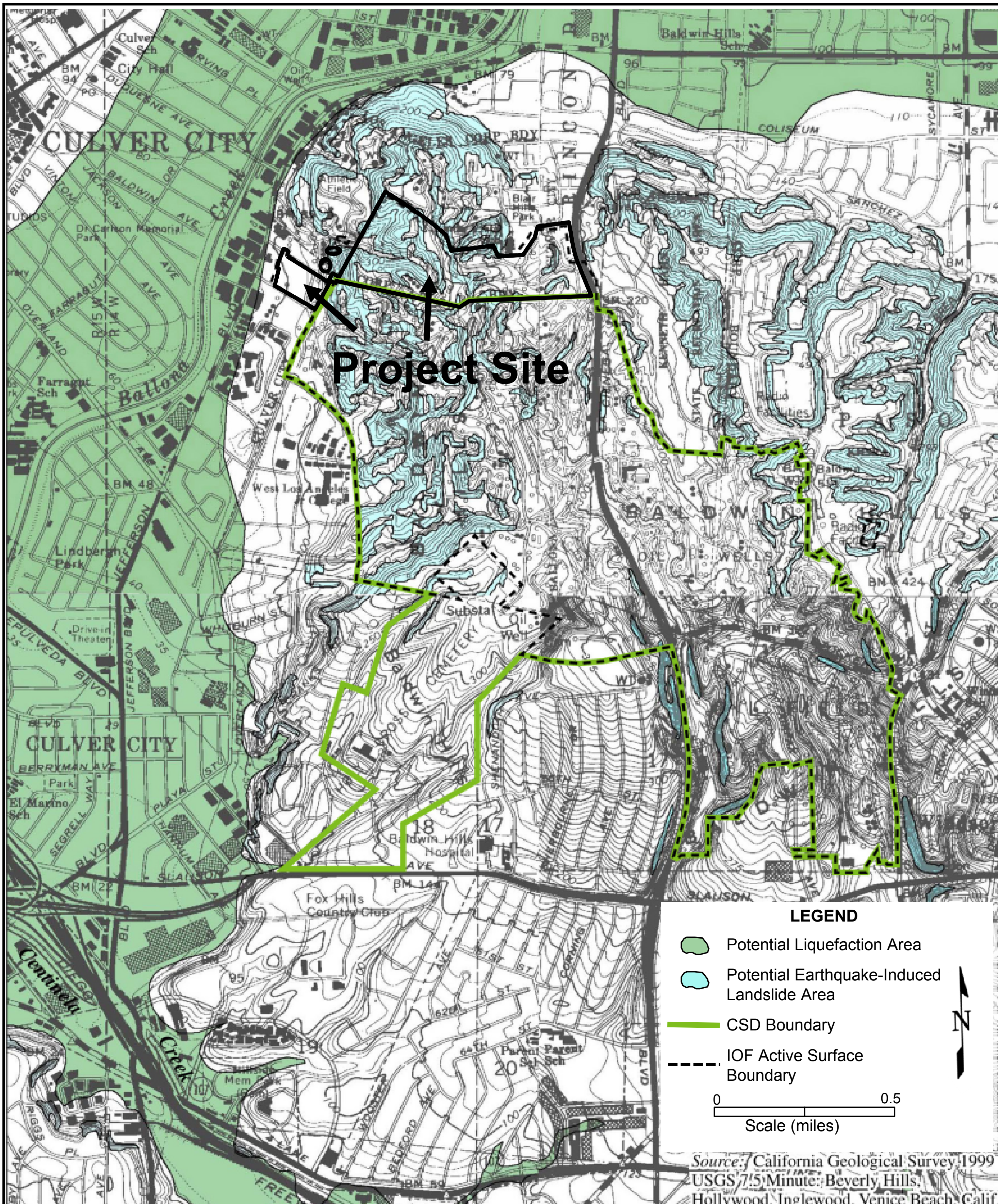
Inglewood Oil Field Specific Plan, Geology/Soils and Seismicity
Technical Memorandum
Culver City, California

Figure
3



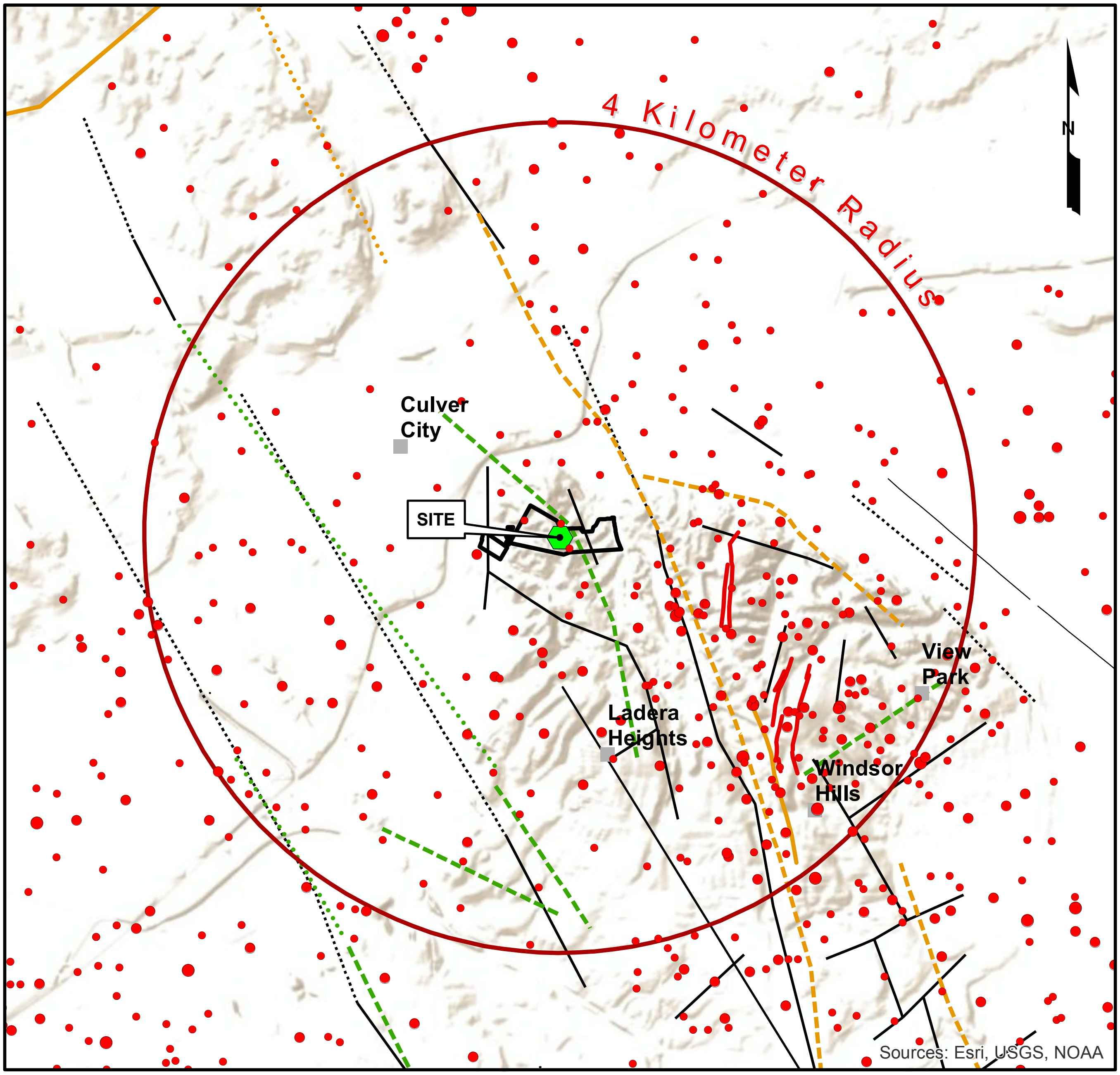
Adapted from Final EIR, Baldwin Hills Community Standards District, October 2009

KLEINFELDER Bright People. Right Solutions. www.kleinfelder.com	Project No.: 20162650	**Alquist-Priolo Earthquake Fault Zones**	Figure 4
	Drawn by: REL	Inglewood Oil Field Specific Plan, Geology/Soils and Seismicity Technical Memorandum Culver City, California	
	Date: 8/29/2016		



Adapted from Final EIR, Baldwin Hills Community Standards District, October 2009

KLEINFELDER Bright People. Right Solutions. www.kleinfelder.com	Project No.: 20162650	**Liquefaction and Earthquake-Induced Landslide Zones**	Figure 5
	Drawn by: REL	Inglewood Oil Field Specific Plan, Geology/Soils and Seismicity Technical Memorandum Culver City, California	
	Date: 8/29/2016		



Faulting Legend

Quaternary Faults (Bryant, 2005; USGS, 2009)

Historic displacement (< 200 years)
- Mapped Fault Location
- Dashed were Approximated
- Concealed

Holocene displacement (< 11,000 years)
- Mapped Fault Location
- Dashed were Approximated
- Concealed

Late Quaternary displacement (< 750,000 years)
- Mapped Fault Location
- Dashed were Approximated
- Concealed

Quaternary displacement (< 1,600,000 years)
- Mapped Fault Location
- Dashed were Approximated
- Concealed

Pre-Quaternary Geologic Structures (CGS, 2000)
- fault, approx. located
- fault, approx. located, queried
- fault, certain
- fault, concealed
- fault, concealed, queried
- fault, inferred, queried

ANSS Earthquakes

Magnitude
- 1.0 - 1.9
- 2.0 - 2.9
- 3.0 - 3.9
- 4.0 - 4.9
- 5.0 - 5.9
- 6.0 - 6.9

0 0.5 1 2 Kilometers

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PROJECT NO.	20162650
DRAWN:	09/14/16
DRAWN BY:	AL
CHECKED BY:	ZZ
FILE NAME:	Fig6_CulverCity_Epicenter.mxd

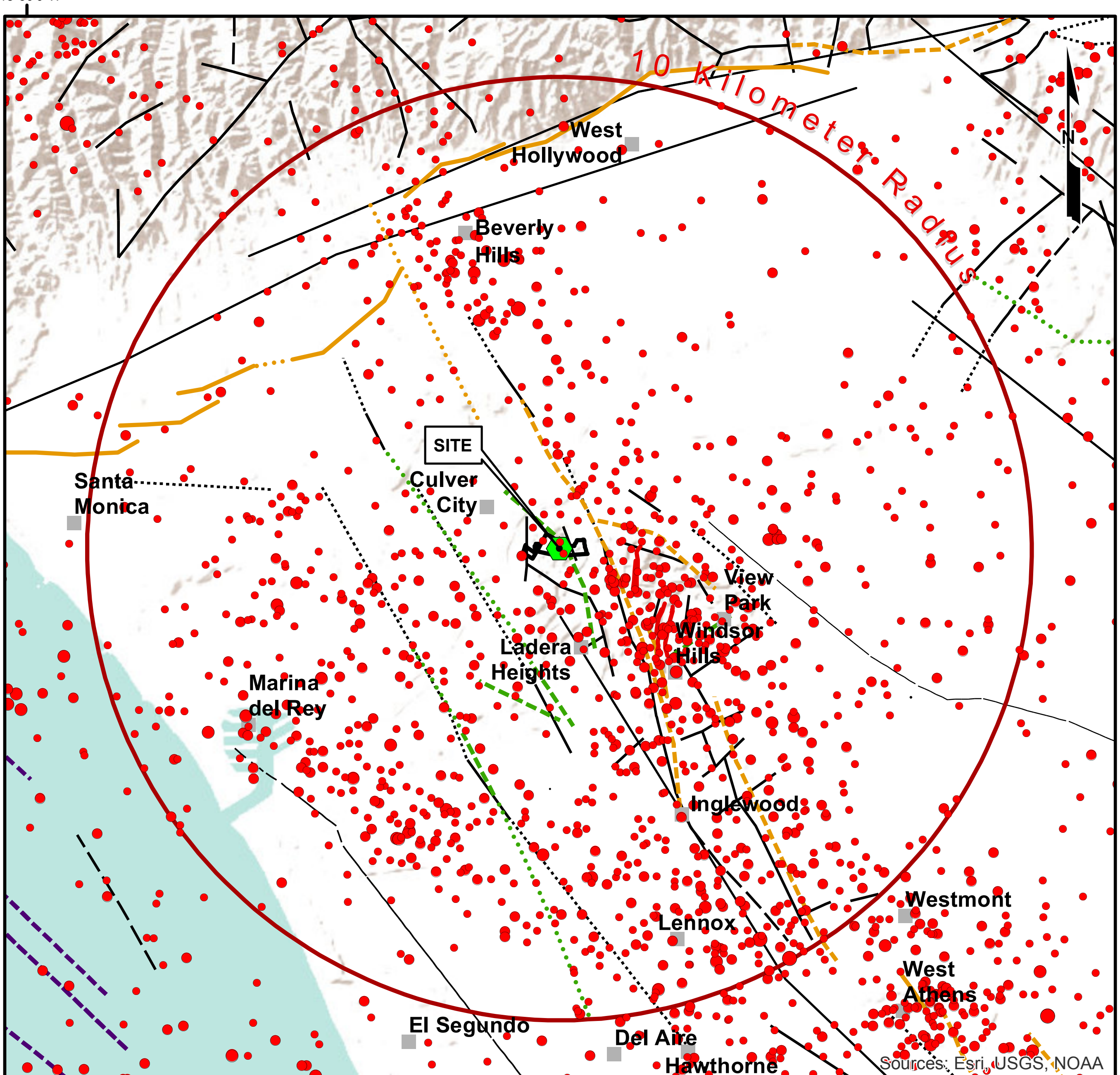
HISTORICAL SEISMICITY (M>=1) FROM 1980 TILL AUGUST 24, 2016 WITHIN A 4-KM RADIUS

INGLEWOOD OIL FIELD SPECIFIC PLAN
GEOLOGY/SOILS AND SEISMICITY
TECHNICAL MEMORANDUM
CULVER CITY, CALIFORNIA

FIGURE

6

118°30'0"W



118°30'0"W

Faulting Legend

Quaternary Faults (Bryant, 2005; USGS, 2009)

Historic displacement (< 200 years)
- Mapped Fault Location
- Dashed were Approximated
- Concealed

Holocene displacement (< 11,000 years)
- Mapped Fault Location
- Dashed were Approximated
- Concealed

Late Quaternary displacement (< 750,000 years)
- Mapped Fault Location
- Dashed were Approximated
- Concealed

Quaternary displacement (< 1,600,000 years)
- Mapped Fault Location
- Dashed were Approximated
- Concealed

Pre-Quaternary Geologic Structures (CGS, 2000)
- fault, approx. located
- fault, approx. located, queried
- fault, certain
- fault, concealed
- fault, concealed, queried
- fault, inferred, queried

ANSS Earthquakes

Magnitude
- 1.0 - 1.9
- 2.0 - 2.9
- 3.0 - 3.9
- 4.0 - 4.9
- 5.0 - 5.9
- 6.0 - 6.9

0 1 2 4 Kilometers

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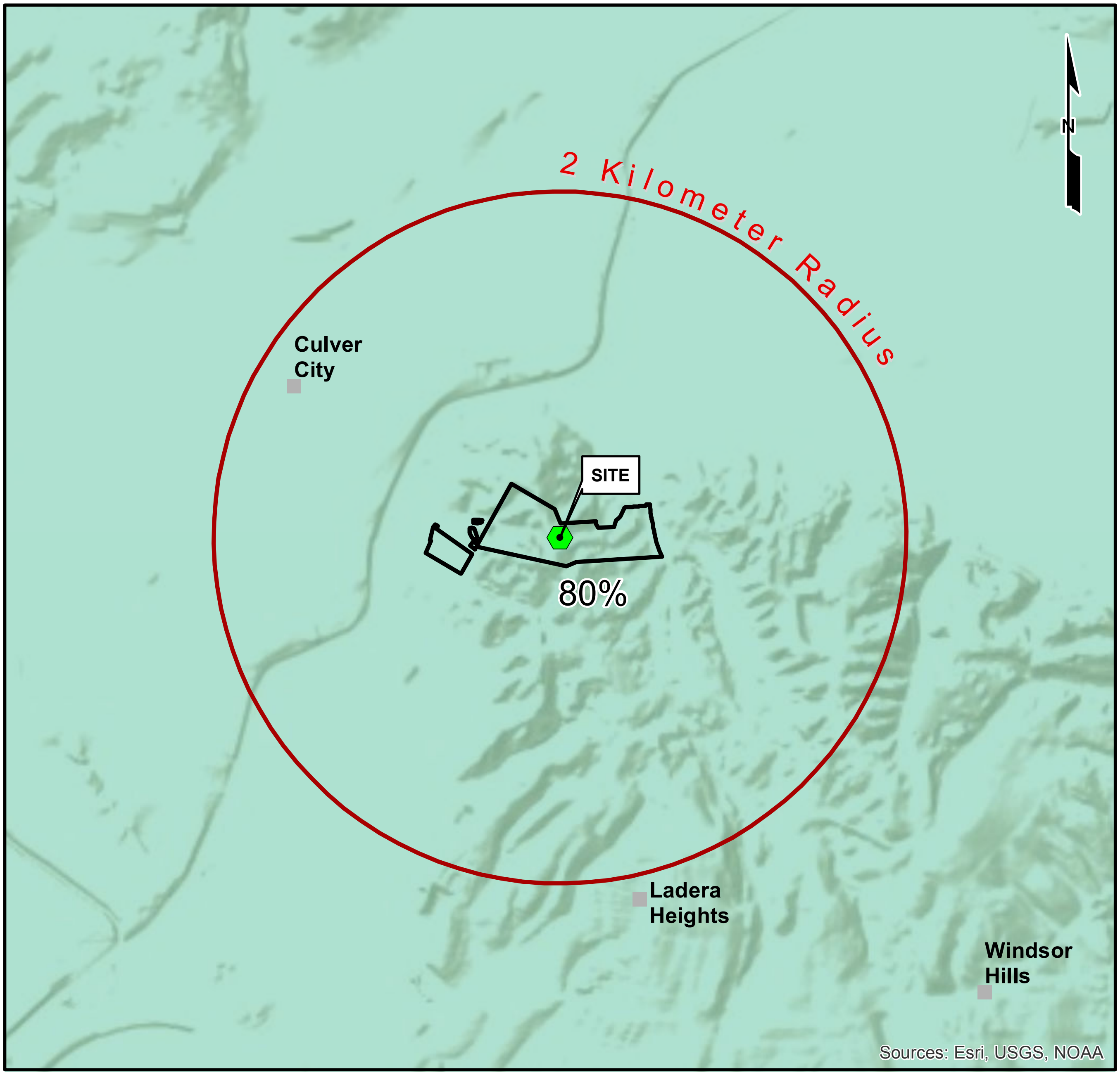
PROJECT NO.	20162650
DRAWN:	09/13/16
DRAWN BY:	AL
CHECKED BY:	ZZ
FILE NAME:	Fig7_CulverCity_Epicenter.mxd

HISTORICAL SEISMICITY (M>=1) FROM 1980 TILL AUGUST 24, 2016 WITHIN A 10-KM RADIUS

INGLEWOOD OIL FIELD SPECIFIC PLAN
GEOLOGY/SOILS AND SEISMICITY
TECHNICAL MEMORANDUM
CULVER CITY, CALIFORNIA

FIGURE
7



Legend

Project Boundary

2-km radius

PGA for 2% in 50 Years

80% gravity

0 0.5 1 2 Kilometers

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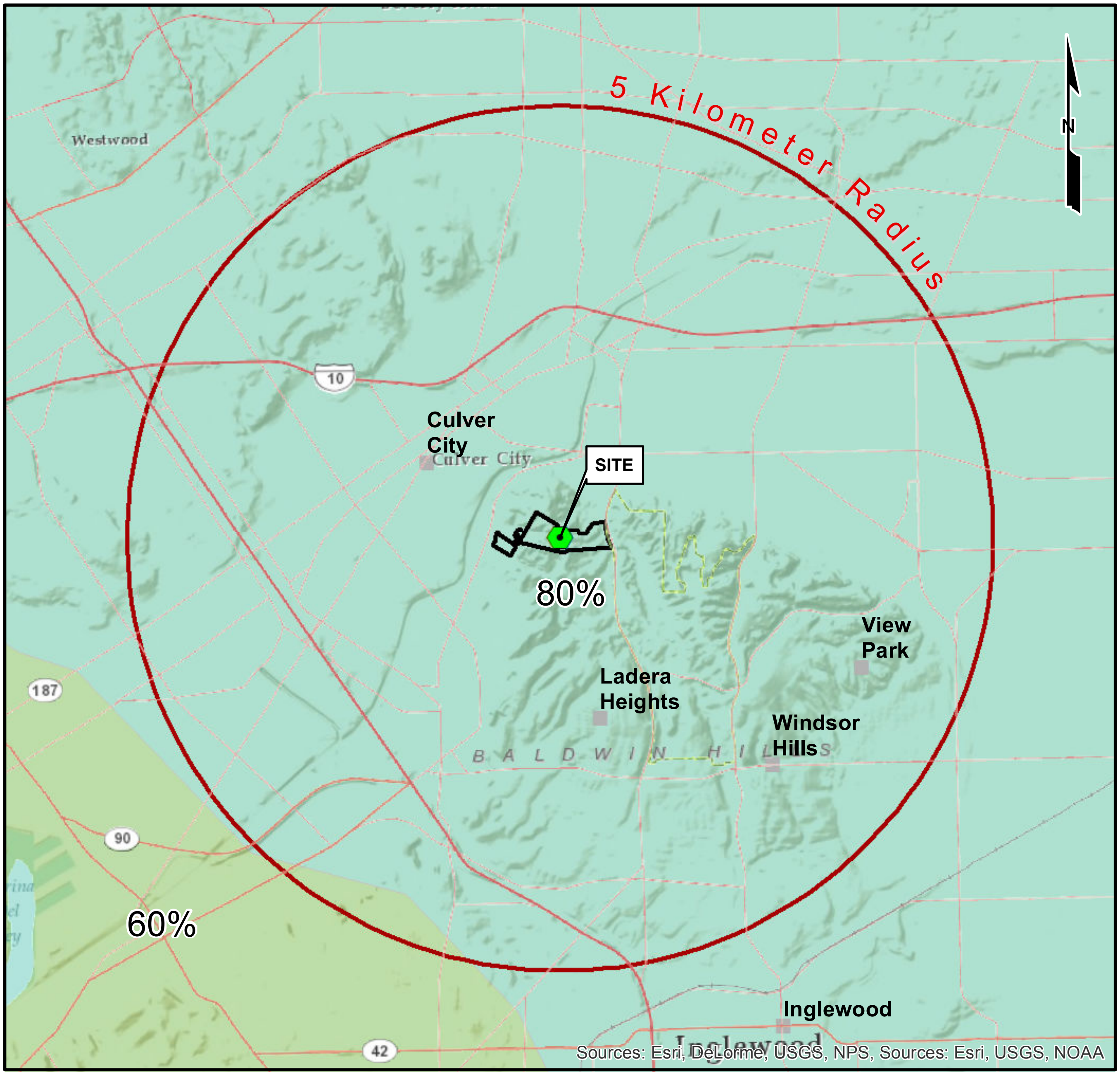
PROJECT NO.	20162650
DRAWN:	09/13/16
DRAWN BY:	AL
CHECKED BY:	ZZ
FILE NAME:	Fig8_CulverCity_PGA.mxd

GROUND MOTIONS MAP
(PGA for 2% in 50 years)

INGLEWOOD OIL FIELD SPECIFIC PLAN
GEOLOGY/SOILS AND SEISMICITY
TECHNICAL MEMORANDUM
CULVER CITY, CALIFORNIA

FIGURE

8



Legend

Project Boundary

5-km radius

PGA for 2% in 50 Years

60% gravity

80% gravity

0 1 2 4 Kilometers

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PROJECT NO.	20162650
DRAWN:	09/14/16
DRAWN BY:	AL
CHECKED BY:	ZZ
FILE NAME:	Fig9_CulverCity_PGA.mxd

GROUND MOTIONS MAP
(PGA for 2% in 50 years)

INGLEWOOD OIL FIELD SPECIFIC PLAN
GEOLOGY/SOILS AND SEISMICITY
TECHNICAL MEMORANDUM
CULVER CITY, CALIFORNIA

FIGURE

9

APPENDIX A

Table A1: Historical Seismicity (0-4 km)

1980 – August 24, 2016

No.	Date	Time (UTC)	Latitude	Longitude	Depth (km)	Mag
1	8/25/1980	17:48:48	34.006	-118.418	4.99	1.50
2	1/12/1981	9:29:49	33.983	-118.395	2.89	1.88
3	3/10/1981	8:20:13	33.991	-118.413	4.79	1.55
4	11/10/1981	19:41:07	34.037	-118.366	10.69	1.10
5	3/24/1982	16:47:59	34.018	-118.402	5.50	1.40
6	12/8/1984	15:33:37	34.024	-118.415	8.24	1.45
7	4/2/1985	23:46:45	34.036	-118.369	5.04	1.60
8	9/3/1985	2:58:54	34.048	-118.373	3.10	2.88
9	9/29/1985	4:43:02	33.986	-118.377	13.97	1.46
10	11/3/1985	7:48:25	33.985	-118.363	10.27	2.00
11	11/16/1985	14:13:15	34.031	-118.380	11.05	2.05
12	1/12/1986	6:14:58	34.005	-118.372	12.91	2.04
13	7/30/1986	1:14:01	33.996	-118.376	3.17	2.73
14	7/31/1986	19:16:46	33.997	-118.374	3.13	2.68
15	9/19/1986	11:35:02	33.987	-118.399	6.06	1.88
16	10/3/1987	18:55:52	34.025	-118.390	4.91	1.70
17	4/3/1988	12:40:20	34.006	-118.350	4.41	1.94
18	6/12/1988	7:58:46	33.996	-118.382	8.83	1.92
19	12/2/1989	4:06:13	33.993	-118.370	6.94	2.20
20	12/11/1989	0:08:41	33.990	-118.361	9.27	2.33
21	12/11/1989	2:36:54	34.007	-118.393	4.67	1.50
22	12/11/1989	4:26:37	33.991	-118.368	9.08	1.86
23	1/4/1990	13:27:56	34.028	-118.367	10.12	1.20
24	1/6/1990	11:30:50	34.045	-118.382	6.68	2.05
25	7/12/1990	19:59:18	34.038	-118.377	5.72	2.61
26	12/19/1990	17:00:56	33.999	-118.359	6.75	1.70
27	5/8/1991	0:16:46	34.004	-118.357	4.19	1.94
28	5/17/1991	10:38:24	33.987	-118.350	5.48	1.98
29	6/20/1991	23:22:40	34.009	-118.341	4.79	1.70
30	11/7/1991	11:18:57	34.020	-118.345	4.90	1.60
31	12/6/1991	1:29:53	33.985	-118.368	8.31	1.70
32	5/30/1992	20:41:32	34.026	-118.362	10.26	1.70
33	8/13/1992	14:43:14	34.007	-118.365	12.05	2.14
34	8/17/1992	17:57:31	34.007	-118.359	8.78	1.70
35	8/30/1992	8:15:12	34.006	-118.368	14.13	3.61
36	10/19/1992	10:13:28	34.001	-118.380	5.36	1.60
37	1/2/1993	0:30:12	34.000	-118.350	9.97	1.96
38	6/17/1993	21:34:43	34.001	-118.387	2.23	2.01

39	6/19/1993	9:21:48	33.989	-118.401	6.54	1.62
40	7/3/1993	1:02:21	34.017	-118.419	7.55	1.92
41	8/29/1993	16:28:19	34.002	-118.416	8.70	2.31
42	9/8/1993	12:16:05	34.003	-118.421	7.09	1.79
43	1/23/1994	5:14:53	33.983	-118.360	11.37	1.99
44	1/25/1994	20:53:28	34.000	-118.349	7.29	2.05
45	2/26/1994	16:40:49	34.046	-118.372	9.30	1.51
46	3/5/1994	8:48:37	34.040	-118.362	8.94	1.70
47	3/31/1994	6:44:26	34.032	-118.345	8.07	1.35
48	4/16/1994	7:23:20	33.995	-118.414	5.48	1.38
49	4/25/1994	1:55:42	34.018	-118.354	12.25	1.73
50	5/15/1994	21:22:24	34.021	-118.413	10.55	1.66
51	6/5/1994	18:11:31	34.004	-118.403	11.38	1.98
52	6/6/1994	15:16:32	33.981	-118.391	10.77	1.79
53	6/6/1994	17:34:25	33.996	-118.390	3.02	1.92
54	7/7/1994	17:06:42	34.008	-118.378	11.49	1.81
55	9/11/1994	14:59:36	34.002	-118.382	9.91	1.36
56	11/13/1994	23:42:23	34.047	-118.379	7.78	1.72
57	11/29/1994	10:03:21	34.013	-118.408	12.55	1.23
58	11/30/1994	8:16:26	34.032	-118.348	5.31	1.53
59	12/31/1994	3:59:49	34.019	-118.346	9.23	1.59
60	1/1/1995	19:51:09	34.005	-118.356	13.60	1.63
61	1/18/1995	22:50:04	34.004	-118.383	2.33	1.20
62	1/21/1995	23:36:06	34.049	-118.380	9.84	2.42
63	4/12/1995	9:09:29	33.990	-118.407	12.61	1.48
64	6/30/1995	11:26:55	34.024	-118.375	7.61	2.01
65	7/8/1995	8:00:15	33.991	-118.358	12.83	1.73
66	9/25/1995	9:11:43	34.000	-118.369	6.73	1.34
67	10/22/1995	4:56:35	34.020	-118.368	1.75	1.40
68	11/1/1995	20:20:11	34.000	-118.371	11.70	1.53
69	11/17/1995	9:22:46	34.012	-118.379	13.42	1.26
70	12/16/1995	2:01:38	34.002	-118.353	8.94	1.61
71	1/23/1996	15:53:25	34.001	-118.390	12.95	1.78
72	4/8/1996	14:06:50	34.014	-118.357	9.01	2.00
73	4/17/1996	17:27:29	33.993	-118.411	12.22	1.62
74	4/27/1996	13:04:59	33.999	-118.404	8.17	2.55
75	5/4/1996	13:28:20	34.026	-118.340	5.06	1.25
76	5/18/1996	4:32:47	34.044	-118.388	7.54	1.76
77	6/10/1996	10:17:36	33.994	-118.347	9.81	1.78
78	8/12/1996	20:39:43	33.996	-118.348	9.42	2.15
79	10/12/1996	2:54:01	34.022	-118.386	8.41	1.87
80	10/19/1996	10:20:57	34.007	-118.347	0.15	1.55
81	10/24/1996	12:43:49	34.014	-118.366	11.02	1.76
82	11/20/1996	15:25:40	34.030	-118.389	9.47	1.73
83	1/1/1997	12:48:27	34.007	-118.345	7.03	2.00
84	2/16/1997	7:53:33	34.020	-118.364	5.05	1.66

85	4/4/1997	9:35:09	33.987	-118.357	4.40	2.42
86	4/5/1997	14:33:25	33.986	-118.359	3.97	2.47
87	4/10/1997	18:17:05	33.998	-118.360	6.59	1.90
88	4/19/1997	11:09:49	34.019	-118.358	11.46	1.86
89	4/27/1997	15:15:36	34.025	-118.374	8.62	1.59
90	7/24/1997	12:09:44	33.996	-118.359	13.37	1.27
91	8/3/1997	6:32:38	34.017	-118.365	9.77	1.69
92	9/11/1997	1:13:28	34.022	-118.371	9.65	1.66
93	10/3/1997	4:23:23	34.040	-118.382	3.17	1.75
94	5/10/1998	18:02:11	33.988	-118.407	5.31	1.43
95	5/10/1998	18:02:34	33.990	-118.410	5.19	1.61
96	6/12/1998	20:30:20	33.995	-118.346	1.72	1.92
97	7/14/1998	6:32:11	34.025	-118.368	5.05	1.61
98	8/7/1998	19:10:11	34.003	-118.382	12.54	2.13
99	8/26/1998	22:44:26	34.006	-118.422	11.61	2.34
100	9/13/1998	2:40:03	34.023	-118.377	11.71	1.79
101	1/23/1999	0:41:58	33.995	-118.365	13.18	2.26
102	1/25/1999	22:28:06	34.031	-118.377	3.30	1.72
103	2/12/1999	4:59:20	34.022	-118.380	5.50	1.82
104	2/12/1999	5:18:01	34.005	-118.385	9.97	2.02
105	2/26/1999	4:49:24	34.018	-118.340	11.86	2.11
106	3/1/1999	3:41:44	34.045	-118.369	2.49	1.65
107	4/9/1999	13:45:38	34.024	-118.358	12.13	1.79
108	4/19/1999	3:58:10	33.995	-118.351	8.87	2.12
109	6/27/1999	16:38:14	33.991	-118.400	13.40	2.01
110	7/7/1999	9:15:43	34.037	-118.382	13.40	2.00
111	7/8/1999	12:09:14	34.014	-118.361	1.15	1.53
112	1/27/2000	11:49:53	33.985	-118.367	9.11	1.20
113	3/12/2000	7:08:27	34.011	-118.348	11.31	2.34
114	3/13/2000	4:47:35	34.003	-118.354	10.39	2.36
115	3/13/2000	7:28:10	34.018	-118.354	7.06	1.85
116	7/28/2000	6:07:52	34.018	-118.393	11.87	1.62
117	9/6/2000	20:32:46	33.993	-118.399	23.07	1.71
118	12/7/2000	16:17:19	34.044	-118.377	11.25	1.64
119	8/6/2001	9:07:28	34.026	-118.400	13.90	1.55
120	9/1/2001	14:28:46	34.010	-118.365	13.33	1.69
121	10/6/2001	8:39:01	34.012	-118.407	15.14	1.34
122	11/6/2001	20:48:35	34.006	-118.379	16.17	1.79
123	12/22/2001	20:23:36	34.017	-118.364	9.28	1.75
124	1/5/2002	9:44:37	34.001	-118.409	8.68	2.27
125	1/25/2002	13:38:23	34.013	-118.416	12.93	1.28
126	2/21/2002	4:00:31	33.998	-118.355	12.86	2.66
127	3/5/2002	5:45:14	33.991	-118.352	9.46	1.42
128	3/7/2002	1:20:43	34.009	-118.357	11.46	1.55
129	3/9/2002	16:56:57	33.993	-118.358	10.37	1.53
130	4/8/2002	10:53:29	34.006	-118.404	10.12	2.02

131	4/8/2002	12:18:06	34.007	-118.395	11.02	1.66
132	4/22/2002	9:51:32	33.991	-118.393	15.34	1.45
133	6/16/2002	11:12:49	34.020	-118.383	18.72	1.44
134	6/19/2002	0:26:26	33.998	-118.351	13.29	2.96
135	8/13/2002	10:28:58	34.000	-118.399	12.36	2.43
136	8/21/2002	15:24:44	34.037	-118.363	8.88	1.85
137	9/16/2002	7:46:25	34.019	-118.401	10.28	1.82
138	9/25/2002	18:59:49	33.995	-118.401	12.37	1.72
139	9/30/2002	0:51:48	34.012	-118.358	14.36	1.82
140	11/20/2002	11:00:40	34.016	-118.361	15.36	1.56
141	12/20/2002	0:54:43	34.009	-118.359	9.65	1.55
142	12/23/2002	5:10:53	34.006	-118.368	15.30	2.21
143	1/1/2003	6:23:07	33.997	-118.366	17.06	1.26
144	1/4/2003	5:33:49	33.995	-118.366	16.28	1.60
145	1/5/2003	20:36:15	34.035	-118.372	13.96	1.65
146	1/11/2003	2:58:12	34.006	-118.366	14.10	2.61
147	1/11/2003	7:54:33	34.008	-118.368	14.62	2.75
148	1/13/2003	11:10:51	34.007	-118.369	14.67	2.38
149	1/13/2003	22:57:06	33.985	-118.357	10.18	1.47
150	1/17/2003	10:53:20	34.004	-118.360	15.26	1.61
151	1/18/2003	20:37:08	34.033	-118.364	14.19	1.32
152	1/21/2003	0:20:28	34.005	-118.368	15.42	2.23
153	1/24/2003	1:09:42	34.014	-118.380	9.29	1.86
154	1/28/2003	6:27:27	33.996	-118.353	10.42	1.39
155	1/28/2003	22:38:03	33.997	-118.355	13.29	1.46
156	1/30/2003	5:52:32	34.023	-118.359	12.32	2.36
157	2/1/2003	2:43:51	34.031	-118.362	11.02	1.07
158	2/4/2003	17:20:14	34.023	-118.359	10.13	1.99
159	2/11/2003	9:15:23	34.017	-118.349	12.54	1.72
160	2/12/2003	9:42:26	34.001	-118.360	14.09	1.61
161	4/1/2003	11:27:24	33.997	-118.354	14.26	1.47
162	4/7/2003	7:33:47	34.005	-118.363	14.49	1.61
163	4/7/2003	7:34:47	33.999	-118.406	16.81	1.72
164	4/10/2003	17:22:51	34.018	-118.357	12.64	1.20
165	4/12/2003	12:34:13	33.993	-118.347	9.19	1.31
166	5/7/2003	3:15:26	34.029	-118.372	9.17	1.54
167	5/15/2003	9:09:38	34.030	-118.361	12.85	1.47
168	5/18/2003	14:41:29	33.999	-118.345	10.46	1.82
169	6/4/2003	6:36:56	34.001	-118.387	14.27	1.59
170	6/4/2003	22:53:16	33.994	-118.360	12.88	1.54
171	6/8/2003	8:09:00	33.988	-118.364	12.89	1.84
172	6/15/2003	15:38:21	33.999	-118.349	13.56	1.45
173	10/15/2003	8:47:15	34.002	-118.400	12.82	1.61
174	2/8/2004	11:26:43	33.993	-118.415	13.52	1.68
175	2/23/2004	13:00:26	34.002	-118.359	13.18	1.20
176	2/24/2004	4:31:55	33.995	-118.348	11.86	1.47

177	2/28/2004	7:26:46	34.006	-118.365	14.12	1.84
178	2/29/2004	5:26:43	33.993	-118.365	15.14	1.88
179	3/29/2004	16:07:43	33.999	-118.364	14.96	2.01
180	3/31/2004	3:26:47	34.004	-118.364	13.14	1.28
181	5/16/2004	19:18:29	33.987	-118.390	9.14	2.46
182	6/19/2004	20:06:58	33.978	-118.373	11.86	1.69
183	6/22/2004	9:26:20	33.992	-118.353	12.86	1.47
184	7/15/2004	16:48:43	34.013	-118.364	10.46	1.53
185	8/21/2004	19:30:41	34.022	-118.347	11.38	1.78
186	3/7/2005	21:59:13	33.996	-118.344	10.51	1.84
187	3/29/2005	16:59:54	33.999	-118.360	14.38	1.31
188	2/2/2006	15:30:55	34.024	-118.409	9.55	1.52
189	2/11/2006	8:25:26	33.999	-118.350	11.79	1.53
190	3/2/2006	17:30:35	34.009	-118.378	13.35	1.50
191	3/21/2006	4:16:56	34.033	-118.383	13.50	1.57
192	5/5/2006	21:15:48	33.992	-118.362	13.21	2.09
193	6/18/2006	3:52:04	34.001	-118.395	13.58	1.24
194	7/25/2006	13:00:54	34.030	-118.365	9.74	2.13
195	9/22/2006	2:02:52	33.993	-118.416	12.80	1.95
196	1/8/2007	11:31:15	34.020	-118.380	7.64	1.73
197	2/15/2007	11:29:24	33.993	-118.351	13.56	1.64
198	5/11/2007	4:21:58	34.012	-118.398	10.54	1.68
199	7/9/2007	21:40:07	34.024	-118.367	12.76	1.80
200	9/15/2007	5:44:04	34.030	-118.378	14.21	1.56
201	9/25/2007	22:14:05	34.009	-118.372	7.02	1.30
202	11/21/2007	11:31:25	33.985	-118.363	13.31	1.92
203	11/25/2007	4:37:33	34.011	-118.402	12.45	1.79
204	12/17/2007	22:36:06	34.004	-118.362	11.87	1.91
205	8/15/2008	11:31:06	34.001	-118.362	10.27	1.13
206	10/31/2008	23:29:00	34.008	-118.347	10.97	1.65
207	11/20/2008	1:22:39	34.033	-118.380	11.14	1.54
208	12/1/2008	20:40:09	34.012	-118.341	11.92	1.80
209	3/9/2009	8:38:19	34.026	-118.353	10.58	1.56
210	3/20/2009	16:27:27	34.043	-118.358	9.81	1.80
211	7/3/2009	16:04:24	33.985	-118.360	13.36	1.22
212	7/10/2009	8:55:41	34.009	-118.356	13.00	2.00
213	3/7/2010	4:33:38	33.996	-118.357	12.36	2.19
214	3/7/2010	15:42:21	33.998	-118.347	12.13	1.34
215	11/20/2010	5:09:29	33.998	-118.385	12.62	1.73
216	11/20/2010	5:10:16	33.998	-118.387	13.01	1.95
217	1/4/2011	17:41:29	33.991	-118.350	12.11	1.66
218	3/26/2011	23:17:03	34.002	-118.368	8.73	1.57
219	4/17/2011	6:21:42	34.014	-118.366	11.81	1.76
220	5/7/2011	5:39:04	34.000	-118.371	12.98	1.38
221	5/11/2011	15:13:18	33.992	-118.378	10.84	2.30
222	7/24/2011	14:28:56	34.001	-118.378	12.43	2.18

223	9/2/2011	15:40:25	33.983	-118.383	12.29	1.56
224	9/14/2011	16:20:27	33.978	-118.371	11.99	1.85
225	9/27/2011	11:05:01	33.978	-118.384	14.02	1.34
226	12/14/2011	9:20:52	33.991	-118.384	12.01	1.26
227	12/23/2011	7:53:35	33.993	-118.387	12.76	1.51
228	1/8/2012	19:09:21	34.012	-118.369	14.59	1.70
229	2/2/2012	13:08:40	34.016	-118.403	11.32	1.39
230	6/7/2012	5:32:54	33.999	-118.413	11.09	1.50
231	6/24/2012	18:35:02	34.001	-118.341	11.38	1.37
232	7/11/2012	19:13:07	34.007	-118.412	10.49	2.41
233	10/2/2012	12:49:21	34.013	-118.413	12.53	1.42
234	10/14/2012	3:15:25	34.009	-118.369	12.85	1.53
235	3/15/2013	11:16:54	34.011	-118.370	13.72	1.43
236	5/18/2013	17:51:35	34.026	-118.372	13.25	1.12
237	6/20/2013	14:24:23	34.031	-118.358	11.06	1.48
238	7/14/2013	8:29:21	34.017	-118.386	10.27	1.85
239	8/28/2013	2:29:54	34.017	-118.363	10.23	2.07
240	3/9/2014	21:58:55	33.991	-118.355	1.67	1.45
241	4/11/2014	0:13:54	34.007	-118.368	10.43	1.67
242	5/24/2014	22:42:53	33.999	-118.370	13.16	1.40
243	6/3/2014	3:08:47	34.004	-118.355	11.88	1.40
244	6/29/2014	6:39:39	33.989	-118.385	11.87	1.20
245	10/5/2014	18:04:42	34.012	-118.412	11.85	1.48
246	10/7/2014	7:20:52	34.005	-118.354	11.13	1.95
247	10/17/2014	19:38:49	34.042	-118.391	11.66	1.49
248	11/14/2014	10:47:09	34.018	-118.376	12.65	1.29
249	11/29/2014	3:25:18	34.008	-118.372	14.85	1.16
250	12/8/2014	9:37:48	34.006	-118.357	11.35	1.29
251	4/12/2015	23:35:47	33.998	-118.357	11.42	2.65
252	4/13/2015	4:17:41	33.998	-118.360	11.90	3.32
253	4/13/2015	5:37:26	34.006	-118.351	11.06	1.44
254	4/15/2015	0:10:11	34.007	-118.360	11.00	1.76
255	5/3/2015	11:07:18	33.994	-118.361	11.11	3.80
256	5/3/2015	18:09:30	34.007	-118.365	8.09	1.41
257	5/3/2015	19:51:57	33.992	-118.354	9.55	2.07
258	5/4/2015	5:10:16	33.991	-118.363	9.91	1.00
259	5/7/2015	17:19:35	33.989	-118.359	5.36	1.60
260	5/9/2015	11:30:36	34.010	-118.339	4.43	1.09
261	5/11/2015	14:14:05	33.999	-118.350	8.54	1.32
262	5/23/2015	17:06:51	33.989	-118.354	10.48	3.09
263	5/24/2015	16:53:50	34.000	-118.371	9.39	1.55
264	5/25/2015	19:57:32	34.007	-118.351	6.76	1.43
265	6/11/2015	3:28:11	33.995	-118.353	7.15	1.44
266	6/28/2015	12:08:39	34.008	-118.362	7.83	1.17
267	7/8/2015	14:07:30	33.994	-118.375	7.22	1.65
268	7/20/2015	11:50:06	33.992	-118.358	9.34	1.41

269	7/26/2015	2:50:33	33.991	-118.358	9.17	1.99
270	7/26/2015	9:23:01	33.998	-118.356	8.88	1.50
271	8/3/2015	9:53:26	33.993	-118.361	8.93	1.70
272	8/25/2015	3:42:32	33.994	-118.356	8.37	1.79
273	11/23/2015	17:36:43	34.002	-118.340	9.12	2.06
274	1/12/2016	23:17:47	33.985	-118.391	9.23	1.32
275	1/18/2016	4:22:44	34.006	-118.339	7.25	1.69
276	1/25/2016	14:31:05	34.012	-118.389	8.97	2.19
277	2/16/2016	9:15:07	34.015	-118.384	8.63	1.33
278	2/27/2016	10:09:40	34.023	-118.376	6.29	1.26
279	2/27/2016	17:53:49	34.012	-118.418	8.80	1.19
280	2/28/2016	23:27:47	34.008	-118.416	10.28	1.72
281	4/12/2016	18:19:17	33.998	-118.364	4.25	1.40
282	4/16/2016	2:19:35	33.994	-118.344	7.70	1.60
283	4/17/2016	17:32:01	34.017	-118.364	11.62	1.58
284	4/29/2016	3:19:25	34.022	-118.349	4.55	1.65
285	4/29/2016	8:59:06	34.009	-118.347	7.04	1.23
286	7/29/2016	5:24:55	34.003	-118.346	8.97	1.34
287	7/31/2016	9:38:10	34.005	-118.353	8.18	1.14
288	8/4/2016	11:27:12	33.997	-118.351	9.55	1.11
289	8/4/2016	15:43:31	34.016	-118.347	6.96	1.39
290	8/12/2016	12:04:49	33.998	-118.351	9.21	2.12
291	8/13/2016	5:09:41	34.013	-118.353	5.91	1.29
292	8/16/2016	10:02:36	33.999	-118.343	8.42	1.28
293	8/23/2016	12:04:11	34.008	-118.357	7.28	1.23

Table A2: Historical Seismicity (4 – 10 km)
1980 – August 24, 2016

No.	Date	Time (UTC)	Latitude	Longitude	Depth (km)	Mag
1	1/8/1980	5:43:23	34.022	-118.480	5.27	2.31
2	1/27/1980	21:24:19	33.957	-118.329	6.00	1.60
3	3/11/1980	12:25:04	34.016	-118.295	14.57	1.75
4	3/12/1980	4:39:09	34.049	-118.313	10.47	2.55
5	4/4/1980	3:23:47	33.982	-118.289	3.79	1.80
6	5/2/1980	1:43:03	33.976	-118.427	8.70	1.80
7	9/9/1980	1:32:27	34.006	-118.323	7.67	2.00
8	11/1/1980	2:12:31	34.029	-118.464	12.00	1.44
9	1/28/1981	4:00:16	34.023	-118.331	6.10	2.74
10	1/30/1981	8:37:44	33.989	-118.321	2.09	1.87
11	2/17/1981	2:44:35	33.971	-118.324	5.09	1.91
12	3/7/1981	21:51:49	33.956	-118.382	2.80	1.63
13	5/23/1981	20:39:00	34.049	-118.288	8.68	1.54
14	6/28/1981	3:59:02	33.949	-118.355	1.36	1.90
15	6/28/1981	4:00:19	33.966	-118.357	5.26	1.70
16	10/3/1981	7:23:30	33.965	-118.316	0.29	1.80
17	10/3/1981	7:23:46	33.956	-118.298	12.85	1.80
18	10/3/1981	7:26:18	33.947	-118.317	12.90	1.84
19	10/3/1981	7:31:29	33.950	-118.350	14.23	1.70
20	10/10/1981	8:57:43	33.955	-118.320	9.56	1.86
21	10/10/1981	9:00:10	33.962	-118.320	3.93	1.30
22	10/10/1981	9:05:10	33.952	-118.315	0.71	1.59
23	10/10/1981	9:09:21	33.951	-118.308	5.00	1.60
24	10/10/1981	9:50:21	33.962	-118.315	5.04	1.60
25	10/24/1981	23:43:19	33.965	-118.466	11.45	1.63
26	10/29/1981	4:39:10	34.044	-118.446	12.70	1.60
27	1/7/1982	17:34:58	33.951	-118.328	5.67	2.09
28	1/7/1982	17:36:41	33.958	-118.329	5.67	2.40
29	3/1/1982	7:53:29	34.024	-118.322	5.17	1.73
30	4/4/1982	19:57:08	34.053	-118.382	11.63	2.29
31	4/22/1982	3:45:27	34.052	-118.283	5.07	1.70
32	7/22/1982	0:04:25	33.932	-118.345	1.80	2.31
33	8/27/1982	11:59:25	34.044	-118.457	5.37	2.18
34	9/17/1982	10:59:47	33.962	-118.293	5.21	2.25
35	12/4/1982	3:08:18	33.952	-118.323	1.72	2.58
36	12/6/1982	0:41:01	33.966	-118.388	2.43	2.35
37	3/1/1983	7:09:23	33.958	-118.327	5.32	2.62
38	3/27/1983	17:43:51	33.943	-118.376	10.22	2.12

39	3/30/1983	6:05:40	33.977	-118.332	5.06	1.71
40	5/3/1983	23:26:56	33.950	-118.312	5.22	1.30
41	5/4/1983	0:07:19	33.955	-118.340	13.32	2.19
42	5/4/1983	0:29:53	33.962	-118.325	2.68	1.30
43	10/9/1983	5:10:09	33.937	-118.364	9.09	2.43
44	12/26/1983	2:53:03	33.955	-118.345	4.77	1.60
45	1/31/1984	12:32:06	34.001	-118.337	12.14	2.06
46	3/28/1984	9:41:20	33.979	-118.478	12.55	1.75
47	7/24/1984	2:12:02	33.940	-118.394	5.33	1.95
48	12/23/1984	1:27:59	34.043	-118.460	5.14	1.71
49	1/7/1985	2:19:40	33.987	-118.309	5.03	1.97
50	2/8/1985	2:26:46	34.079	-118.332	4.40	2.19
51	2/25/1985	9:09:29	34.092	-118.330	9.43	1.46
52	3/2/1985	4:53:49	33.984	-118.443	7.40	2.42
53	4/4/1985	11:57:49	34.010	-118.435	14.20	1.50
54	6/27/1985	18:11:24	33.998	-118.464	4.47	1.57
55	7/2/1985	7:28:33	33.982	-118.347	20.91	1.48
56	7/13/1985	4:16:30	34.065	-118.330	3.10	2.48
57	9/26/1985	10:57:38	33.976	-118.358	11.29	2.31
58	10/3/1985	6:08:38	33.976	-118.356	10.63	1.63
59	11/16/1985	12:56:04	34.052	-118.383	11.81	1.40
60	3/19/1986	19:38:48	34.093	-118.425	8.49	2.42
61	4/1/1986	3:44:38	33.961	-118.345	3.79	1.92
62	4/1/1986	4:18:09	33.961	-118.332	4.36	2.21
63	4/1/1986	4:20:59	33.972	-118.337	4.12	2.12
64	4/25/1986	2:43:40	33.936	-118.331	2.44	1.91
65	5/10/1986	11:42:45	33.972	-118.440	7.98	2.38
66	5/21/1986	18:35:54	33.976	-118.357	6.06	1.88
67	6/1/1986	13:34:32	33.982	-118.349	3.41	1.88
68	7/20/1986	12:02:38	33.980	-118.349	7.87	1.99
69	9/2/1986	14:33:43	34.033	-118.290	7.14	1.76
70	9/27/1986	16:46:06	33.947	-118.312	2.90	2.05
71	9/29/1986	14:57:16	33.983	-118.407	5.18	1.91
72	9/30/1986	5:53:16	33.952	-118.331	1.94	1.77
73	10/11/1986	15:36:48	33.965	-118.338	3.77	1.96
74	10/13/1986	11:18:54	33.959	-118.416	7.94	2.33
75	10/13/1986	14:56:05	33.937	-118.338	9.20	2.11
76	10/15/1986	7:15:13	34.005	-118.310	8.13	1.84
77	11/3/1986	13:12:21	34.066	-118.379	7.93	1.88
78	11/6/1986	1:18:43	33.975	-118.332	15.23	1.50
79	11/8/1986	10:54:34	34.012	-118.445	7.63	2.39
80	11/18/1986	18:28:20	34.028	-118.432	14.26	1.60
81	1/2/1987	13:04:00	33.965	-118.375	3.02	1.90
82	1/17/1987	1:30:49	33.953	-118.355	7.25	1.70
83	1/23/1987	22:43:57	33.957	-118.413	5.61	2.62
84	2/26/1987	0:23:02	33.958	-118.345	12.10	2.00

85	2/26/1987	0:31:12	33.947	-118.349	15.04	2.37
86	2/26/1987	0:41:16	33.948	-118.349	14.95	2.08
87	2/26/1987	1:23:31	33.944	-118.344	14.57	2.47
88	2/26/1987	2:45:40	33.937	-118.346	13.76	1.89
89	2/26/1987	2:49:58	33.935	-118.346	14.34	1.87
90	2/26/1987	4:18:29	33.928	-118.358	14.51	2.00
91	2/26/1987	4:46:13	33.949	-118.352	15.85	2.07
92	3/17/1987	16:54:41	33.957	-118.338	1.60	1.30
93	3/21/1987	12:15:31	33.996	-118.314	4.30	1.80
94	3/28/1987	19:29:00	33.980	-118.327	5.64	3.20
95	4/4/1987	1:32:22	34.039	-118.296	7.44	1.90
96	4/17/1987	18:02:01	34.023	-118.438	11.36	1.70
97	6/9/1987	13:09:59	33.990	-118.332	4.75	1.97
98	6/26/1987	12:53:45	33.987	-118.294	6.59	2.32
99	7/2/1987	21:17:26	33.943	-118.332	14.72	2.14
100	7/17/1987	5:45:24	34.001	-118.445	10.74	1.51
101	12/4/1987	11:17:57	33.974	-118.469	5.92	2.03
102	12/30/1987	23:00:11	33.997	-118.336	4.26	2.08
103	1/7/1988	13:46:44	34.052	-118.289	11.32	1.73
104	1/21/1988	2:17:28	34.088	-118.407	7.33	1.00
105	1/27/1988	1:25:45	33.952	-118.338	4.54	2.18
106	2/12/1988	19:41:31	34.056	-118.377	4.77	1.40
107	4/23/1988	7:16:45	33.978	-118.327	4.53	2.25
108	5/22/1988	4:05:35	33.955	-118.373	6.05	2.01
109	6/11/1988	4:56:41	33.979	-118.448	5.62	2.34
110	6/13/1988	15:42:22	33.972	-118.451	12.73	2.50
111	8/14/1988	12:58:34	33.971	-118.350	3.60	1.60
112	9/14/1988	22:00:40	33.945	-118.340	5.07	2.15
113	10/17/1988	5:25:02	34.072	-118.403	5.01	1.70
114	10/22/1988	15:15:42	33.950	-118.445	7.31	2.87
115	10/31/1988	17:59:33	33.975	-118.323	3.52	2.83
116	12/27/1988	11:36:41	33.944	-118.339	5.22	2.55
117	12/31/1988	16:13:50	34.037	-118.281	4.80	1.60
118	12/31/1988	18:22:35	34.068	-118.426	4.34	2.15
119	2/3/1989	5:57:51	34.053	-118.351	2.28	2.14
120	2/14/1989	6:06:29	33.945	-118.326	2.95	1.70
121	3/11/1989	11:43:42	33.944	-118.348	6.57	2.96
122	7/16/1989	21:35:01	33.975	-118.399	13.00	2.21
123	10/10/1989	18:24:03	33.986	-118.292	2.81	1.70
124	10/13/1989	1:03:50	33.972	-118.435	7.28	2.42
125	10/22/1989	14:40:53	33.945	-118.365	7.40	2.08
126	2/25/1990	7:40:06	34.002	-118.426	8.38	1.99
127	2/27/1990	2:02:50	33.966	-118.333	5.61	2.29
128	3/21/1990	20:54:59	34.064	-118.362	1.76	1.70
129	5/15/1990	15:52:11	33.953	-118.343	5.10	1.60
130	5/19/1990	18:45:48	34.047	-118.423	2.56	2.11

131	11/17/1990	11:19:06	33.952	-118.317	4.30	1.40
132	11/19/1990	10:04:42	33.928	-118.360	3.74	1.70
133	12/31/1990	15:05:36	33.981	-118.346	4.28	2.14
134	1/20/1991	14:13:03	34.041	-118.304	11.09	1.99
135	2/7/1991	0:15:34	33.980	-118.340	5.11	2.79
136	2/12/1991	23:35:19	33.988	-118.338	4.57	2.14
137	2/13/1991	10:47:39	33.983	-118.340	4.12	1.70
138	3/16/1991	23:58:45	34.007	-118.424	6.33	2.03
139	4/2/1991	4:46:25	34.014	-118.330	6.54	2.82
140	4/2/1991	15:06:57	34.015	-118.330	6.46	2.56
141	4/2/1991	15:25:24	34.014	-118.329	5.26	2.11
142	4/2/1991	15:52:40	34.016	-118.331	6.26	2.07
143	4/17/1991	5:43:05	33.954	-118.367	3.61	2.89
144	5/10/1991	13:46:55	33.935	-118.416	7.85	2.11
145	5/26/1991	12:50:58	34.014	-118.332	6.78	2.96
146	5/26/1991	13:01:56	34.014	-118.330	6.25	2.35
147	5/26/1991	14:37:42	34.013	-118.321	5.96	1.97
148	6/9/1991	14:46:02	33.998	-118.302	12.72	1.87
149	6/19/1991	15:00:58	33.989	-118.334	14.63	1.97
150	8/11/1991	9:40:15	33.943	-118.325	16.77	1.91
151	8/21/1991	8:26:18	34.020	-118.328	9.25	2.08
152	11/9/1991	9:56:17	33.959	-118.326	10.44	1.81
153	11/9/1991	10:03:18	33.961	-118.292	0.14	1.30
154	12/7/1991	1:19:49	34.074	-118.383	4.79	1.60
155	1/23/1992	4:42:44	33.971	-118.396	3.02	2.00
156	8/15/1992	18:55:55	33.986	-118.470	8.10	1.70
157	8/19/1992	2:28:59	33.989	-118.303	2.77	1.30
158	8/26/1992	14:13:08	33.933	-118.358	5.80	2.12
159	10/14/1992	9:54:33	33.944	-118.331	13.48	1.50
160	10/22/1992	7:11:55	34.060	-118.404	4.32	1.85
161	10/27/1992	4:01:23	33.950	-118.397	13.63	1.50
162	11/12/1992	4:20:58	34.020	-118.444	6.61	1.86
163	12/9/1992	18:30:51	34.021	-118.442	7.48	2.16
164	1/27/1993	5:49:11	33.927	-118.360	21.94	1.70
165	2/17/1993	20:37:42	33.936	-118.418	13.35	1.46
166	3/4/1993	6:20:36	33.979	-118.418	4.17	1.38
167	3/9/1993	20:06:46	33.994	-118.420	4.25	1.55
168	3/20/1993	5:20:05	33.949	-118.345	13.18	1.44
169	4/4/1993	19:23:49	33.935	-118.344	6.16	1.68
170	4/22/1993	13:08:17	34.066	-118.405	9.92	1.84
171	5/15/1993	20:50:22	34.097	-118.341	4.23	1.50
172	6/3/1993	6:07:53	33.957	-118.334	5.76	1.68
173	8/4/1993	8:13:01	34.029	-118.332	10.02	2.24
174	9/29/1993	10:46:24	33.989	-118.417	5.90	2.07
175	12/3/1993	12:31:59	33.963	-118.321	8.84	2.06
176	1/18/1994	18:46:59	33.958	-118.418	14.01	2.99

177	1/28/1994	6:45:26	33.956	-118.387	14.19	1.93
178	1/29/1994	10:31:01	34.035	-118.289	5.09	1.80
179	2/4/1994	8:39:52	33.943	-118.381	12.90	2.04
180	2/8/1994	21:55:09	34.064	-118.437	9.52	1.31
181	2/16/1994	4:35:47	33.975	-118.437	12.55	1.53
182	2/23/1994	21:30:00	34.067	-118.409	6.54	1.50
183	3/2/1994	9:32:34	33.954	-118.420	16.08	1.20
184	3/6/1994	5:12:38	33.959	-118.409	14.38	1.54
185	3/7/1994	12:29:02	33.954	-118.407	15.99	1.57
186	3/7/1994	23:16:57	33.939	-118.394	13.72	1.92
187	3/8/1994	23:33:38	33.967	-118.413	12.67	1.80
188	3/11/1994	20:45:20	34.086	-118.391	3.11	1.70
189	3/22/1994	12:23:50	34.098	-118.403	2.86	1.26
190	3/24/1994	17:11:07	34.078	-118.414	5.48	1.44
191	4/10/1994	15:24:33	34.073	-118.360	11.66	1.10
192	4/18/1994	8:37:34	33.936	-118.344	11.41	1.39
193	4/18/1994	9:40:01	34.056	-118.384	14.67	1.96
194	4/25/1994	1:07:49	34.003	-118.466	5.47	1.24
195	4/26/1994	5:35:33	33.991	-118.329	10.23	1.67
196	4/26/1994	10:06:11	33.989	-118.340	11.08	2.36
197	5/16/1994	5:14:57	33.991	-118.343	8.92	1.16
198	5/19/1994	13:40:34	34.099	-118.377	5.38	1.24
199	5/24/1994	12:12:38	33.961	-118.418	14.96	1.78
200	5/30/1994	0:27:53	33.986	-118.306	8.17	1.48
201	6/20/1994	15:29:07	34.073	-118.432	12.64	1.22
202	7/8/1994	21:00:15	33.972	-118.330	10.77	1.54
203	7/21/1994	22:57:51	33.973	-118.439	11.89	2.68
204	7/21/1994	23:16:30	33.966	-118.438	12.66	1.54
205	7/22/1994	0:49:45	33.983	-118.440	1.07	1.33
206	8/30/1994	9:12:15	33.992	-118.435	10.24	1.12
207	9/4/1994	1:55:30	33.967	-118.431	10.27	1.31
208	9/4/1994	6:36:48	33.968	-118.422	7.78	1.74
209	9/19/1994	3:14:26	33.933	-118.352	17.49	1.48
210	9/22/1994	16:54:55	33.982	-118.339	11.58	1.59
211	9/23/1994	20:30:27	33.982	-118.356	11.13	1.92
212	10/3/1994	8:22:51	33.968	-118.416	0.93	1.23
213	10/22/1994	10:25:33	33.999	-118.441	11.60	1.32
214	11/3/1994	14:34:05	34.097	-118.407	8.79	1.85
215	11/5/1994	13:27:16	34.072	-118.355	6.45	1.21
216	11/9/1994	4:02:54	33.939	-118.329	10.59	1.83
217	11/13/1994	19:12:12	34.056	-118.365	5.68	1.45
218	11/17/1994	7:24:38	34.050	-118.452	9.46	1.60
219	11/22/1994	15:07:07	34.060	-118.383	4.79	1.54
220	12/1/1994	5:19:30	34.051	-118.348	7.63	1.37
221	12/6/1994	2:00:41	34.089	-118.374	5.07	1.56
222	12/11/1994	10:48:26	33.989	-118.435	13.97	3.46

223	12/17/1994	11:27:50	33.976	-118.431	12.79	1.59
224	1/13/1995	11:49:45	33.986	-118.453	14.54	2.10
225	1/20/1995	6:40:59	34.058	-118.391	8.38	1.73
226	1/21/1995	21:09:31	33.972	-118.425	12.96	1.62
227	1/23/1995	22:24:20	33.961	-118.400	13.68	1.60
228	1/24/1995	0:41:24	33.975	-118.435	13.17	2.10
229	1/27/1995	11:59:02	33.956	-118.404	14.00	1.86
230	1/30/1995	5:47:26	33.957	-118.434	5.03	1.31
231	2/20/1995	1:34:42	34.020	-118.472	13.29	1.57
232	2/23/1995	21:02:11	33.974	-118.454	11.05	1.79
233	3/15/1995	17:34:08	33.998	-118.322	10.56	2.16
234	3/22/1995	0:03:32	33.971	-118.438	13.00	1.98
235	4/29/1995	11:40:30	34.061	-118.423	22.46	1.33
236	5/2/1995	18:51:57	34.057	-118.420	4.40	1.23
237	5/3/1995	19:32:20	33.950	-118.374	12.32	2.93
238	5/3/1995	21:19:56	33.949	-118.374	11.65	1.51
239	5/3/1995	23:23:19	33.952	-118.374	11.89	1.79
240	5/3/1995	23:54:41	33.951	-118.368	10.85	1.67
241	5/4/1995	0:00:10	33.950	-118.375	12.62	2.75
242	5/5/1995	4:22:06	33.950	-118.362	11.04	1.94
243	6/21/1995	5:53:31	33.978	-118.441	11.28	2.00
244	6/21/1995	12:41:12	33.983	-118.436	13.24	1.53
245	6/26/1995	3:05:06	33.981	-118.441	13.19	1.20
246	6/27/1995	3:39:13	33.975	-118.438	12.85	1.70
247	6/27/1995	7:01:55	33.977	-118.438	13.25	1.53
248	7/1/1995	19:49:53	33.979	-118.355	11.74	1.70
249	7/1/1995	23:04:49	33.961	-118.320	10.87	2.01
250	7/19/1995	10:44:01	33.948	-118.321	19.27	2.04
251	7/27/1995	11:26:03	33.970	-118.430	14.36	1.73
252	8/13/1995	1:56:35	33.941	-118.389	14.03	1.59
253	9/16/1995	23:17:37	33.981	-118.327	13.18	1.44
254	10/30/1995	11:37:31	33.984	-118.317	5.77	1.25
255	11/3/1995	10:56:59	33.996	-118.469	12.32	1.41
256	12/4/1995	0:56:42	33.967	-118.316	5.04	1.26
257	12/5/1995	9:56:03	34.026	-118.441	14.33	2.57
258	12/6/1995	6:19:31	34.037	-118.414	14.32	1.53
259	12/14/1995	12:40:14	33.963	-118.406	2.67	1.45
260	12/16/1995	13:12:03	33.957	-118.406	14.81	1.41
261	12/18/1995	11:28:15	33.961	-118.405	13.77	1.67
262	12/24/1995	4:54:43	34.028	-118.279	4.68	1.08
263	3/12/1996	7:05:19	33.980	-118.305	12.14	1.20
264	3/14/1996	9:30:03	33.956	-118.362	12.14	1.43
265	5/3/1996	9:49:30	33.979	-118.429	10.27	1.22
266	5/21/1996	10:10:43	33.958	-118.405	13.02	2.13
267	5/23/1996	4:43:21	33.961	-118.327	11.23	1.82
268	6/2/1996	6:46:28	34.073	-118.420	5.42	1.18

269	7/5/1996	20:54:29	33.954	-118.348	10.92	2.17
270	7/10/1996	20:51:13	33.963	-118.470	13.77	2.04
271	7/14/1996	14:27:52	33.981	-118.402	11.29	1.59
272	8/12/1996	13:06:13	33.993	-118.340	9.25	1.61
273	8/12/1996	20:25:48	33.979	-118.332	10.52	2.91
274	9/7/1996	12:30:50	33.976	-118.341	11.94	1.92
275	9/7/1996	12:39:31	33.983	-118.342	11.68	1.60
276	9/27/1996	21:35:00	34.089	-118.364	5.24	1.95
277	10/11/1996	19:19:35	33.979	-118.345	4.37	1.63
278	11/11/1996	13:20:57	34.008	-118.311	13.05	1.49
279	11/12/1996	16:27:35	33.948	-118.355	9.34	1.72
280	12/9/1996	19:49:36	33.973	-118.341	0.91	1.78
281	12/29/1996	2:57:44	34.012	-118.459	10.52	1.84
282	3/29/1997	17:17:58	34.010	-118.295	11.51	1.76
283	4/4/1997	9:26:25	33.983	-118.354	4.20	3.30
284	5/17/1997	1:16:26	34.073	-118.438	5.25	1.24
285	5/18/1997	19:45:38	33.992	-118.275	6.36	1.06
286	5/29/1997	20:30:31	34.070	-118.383	2.40	1.73
287	6/10/1997	13:51:18	34.009	-118.295	10.75	2.35
288	6/29/1997	18:08:55	34.035	-118.303	7.25	1.51
289	7/11/1997	2:22:09	33.955	-118.357	9.33	1.73
290	8/12/1997	12:17:33	34.005	-118.450	10.64	1.43
291	8/14/1997	19:37:36	33.961	-118.397	11.41	1.43
292	9/19/1997	19:23:40	34.010	-118.279	9.35	1.61
293	10/29/1997	13:50:56	33.950	-118.333	11.69	1.66
294	10/29/1997	13:54:08	33.950	-118.327	12.20	1.86
295	11/1/1997	10:22:42	33.980	-118.345	10.35	1.33
296	11/22/1997	0:38:40	33.950	-118.359	8.25	1.57
297	11/24/1997	12:41:02	33.950	-118.307	20.89	2.09
298	1/12/1998	6:55:12	33.970	-118.408	12.49	1.95
299	3/19/1998	22:16:48	34.011	-118.443	11.60	1.87
300	4/1/1998	16:43:17	33.933	-118.336	5.23	1.38
301	4/7/1998	4:02:08	33.940	-118.334	5.13	1.39
302	4/25/1998	6:23:21	34.033	-118.340	6.63	1.98
303	5/5/1998	18:14:09	34.054	-118.394	8.90	1.92
304	6/4/1998	0:36:21	34.020	-118.440	1.73	1.87
305	6/12/1998	17:35:04	33.977	-118.325	10.87	2.04
306	6/25/1998	15:43:54	34.050	-118.360	4.83	1.50
307	7/12/1998	18:18:00	34.068	-118.306	3.05	1.87
308	8/1/1998	20:57:42	33.968	-118.390	5.03	2.34
309	8/26/1998	21:51:10	34.008	-118.423	10.72	2.84
310	10/10/1998	11:22:22	34.016	-118.331	11.58	2.04
311	10/15/1998	12:52:05	34.016	-118.280	5.01	1.65
312	11/26/1998	10:28:31	33.970	-118.451	13.06	1.97
313	12/13/1998	23:09:51	33.955	-118.318	10.91	2.55
314	12/13/1998	23:28:53	33.974	-118.315	9.77	1.96

315	12/15/1998	6:15:16	33.961	-118.363	5.30	1.77
316	12/15/1998	6:31:30	33.986	-118.433	14.48	1.40
317	1/23/1999	5:26:53	33.976	-118.369	1.34	1.30
318	2/23/1999	15:30:53	33.954	-118.341	5.21	1.78
319	3/1/1999	5:51:33	34.034	-118.318	8.34	2.55
320	3/8/1999	3:09:09	34.058	-118.396	11.15	2.22
321	3/28/1999	15:59:35	33.960	-118.377	11.85	1.87
322	4/3/1999	6:52:52	34.018	-118.303	5.71	1.40
323	4/12/1999	23:08:03	34.008	-118.284	11.50	2.40
324	4/15/1999	4:54:30	34.082	-118.332	3.44	1.47
325	5/17/1999	2:41:48	33.950	-118.326	4.70	1.40
326	5/30/1999	13:47:59	33.983	-118.333	11.56	1.20
327	6/3/1999	19:39:51	34.079	-118.346	8.96	1.77
328	6/17/1999	1:25:58	33.992	-118.288	5.48	2.17
329	6/17/1999	1:28:12	33.997	-118.282	6.72	2.18
330	6/17/1999	3:20:24	33.996	-118.282	5.17	1.76
331	6/28/1999	19:27:21	33.998	-118.282	2.76	1.47
332	6/29/1999	18:18:32	34.022	-118.316	4.92	1.30
333	7/7/1999	20:43:49	33.999	-118.338	4.70	1.83
334	7/9/1999	7:08:55	33.964	-118.338	10.88	1.55
335	11/4/1999	18:22:53	34.027	-118.452	6.99	1.49
336	11/6/1999	8:24:41	33.936	-118.348	21.45	1.54
337	11/15/1999	3:33:13	34.078	-118.442	16.42	1.30
338	11/15/1999	4:26:52	34.064	-118.418	7.01	1.63
339	11/20/1999	13:39:19	33.925	-118.378	13.45	1.89
340	12/8/1999	19:18:33	34.094	-118.424	3.66	1.40
341	12/31/1999	6:44:11	34.002	-118.426	10.24	1.97
342	1/1/2000	8:55:04	33.993	-118.428	13.22	1.79
343	1/17/2000	13:35:16	34.035	-118.299	11.01	1.43
344	1/23/2000	12:48:38	33.949	-118.380	13.70	1.67
345	1/27/2000	8:14:23	33.955	-118.301	13.44	1.78
346	4/25/2000	11:11:10	33.980	-118.452	14.43	1.67
347	5/4/2000	13:43:18	33.938	-118.378	12.14	1.83
348	6/22/2000	15:25:02	34.089	-118.410	2.77	1.50
349	9/1/2000	10:37:21	34.034	-118.329	11.32	1.50
350	9/16/2000	13:24:41	33.976	-118.420	12.74	3.08
351	9/18/2000	6:52:21	34.040	-118.307	12.92	1.40
352	9/18/2000	12:29:58	33.979	-118.429	13.90	1.00
353	12/6/2000	14:13:23	34.080	-118.369	7.68	1.27
354	12/17/2000	14:11:24	34.027	-118.308	11.98	1.77
355	12/21/2000	7:30:28	33.959	-118.375	13.52	1.64
356	3/8/2001	23:51:43	33.962	-118.325	5.30	1.62
357	8/18/2001	14:17:53	34.029	-118.428	13.64	1.36
358	9/7/2001	2:23:55	34.079	-118.406	10.08	1.84
359	9/9/2001	23:59:18	34.059	-118.389	7.80	4.24
360	9/10/2001	0:01:01	34.073	-118.398	9.52	2.88

361	9/10/2001	0:06:23	34.078	-118.397	8.91	1.99
362	9/10/2001	0:25:28	34.057	-118.392	9.30	1.80
363	9/10/2001	0:29:42	34.069	-118.401	10.43	1.50
364	9/10/2001	1:06:00	34.080	-118.411	12.14	1.28
365	9/10/2001	3:04:28	34.077	-118.417	11.34	1.57
366	9/10/2001	5:09:12	34.055	-118.393	9.71	1.76
367	9/10/2001	5:37:36	34.074	-118.418	10.88	1.40
368	9/10/2001	6:55:03	34.065	-118.399	10.61	1.49
369	9/10/2001	7:19:25	34.073	-118.397	9.20	1.49
370	9/10/2001	7:45:12	34.074	-118.415	9.76	1.48
371	9/10/2001	9:10:08	34.085	-118.405	9.79	1.54
372	9/10/2001	16:04:46	34.060	-118.410	10.82	1.88
373	9/10/2001	19:04:38	34.059	-118.395	9.94	1.73
374	9/11/2001	1:56:02	34.064	-118.394	9.12	1.20
375	9/11/2001	4:23:41	34.064	-118.412	11.24	1.47
376	9/11/2001	4:25:56	34.084	-118.412	9.23	1.41
377	9/11/2001	7:41:07	34.087	-118.418	9.39	1.54
378	9/11/2001	8:32:35	34.065	-118.407	10.05	1.63
379	9/11/2001	9:10:30	34.068	-118.403	8.78	2.18
380	9/11/2001	17:02:16	34.060	-118.390	10.35	1.87
381	9/12/2001	10:04:20	34.046	-118.409	14.93	1.32
382	9/12/2001	14:58:12	34.063	-118.384	10.88	1.96
383	9/12/2001	18:55:41	34.077	-118.414	10.37	1.81
384	9/13/2001	9:40:04	34.086	-118.415	10.15	1.32
385	9/13/2001	19:29:42	34.069	-118.388	9.41	1.98
386	9/14/2001	3:56:58	34.076	-118.396	10.14	1.50
387	9/14/2001	7:44:10	34.075	-118.410	10.90	1.25
388	9/14/2001	8:25:31	34.069	-118.411	10.76	1.50
389	9/14/2001	12:08:49	34.064	-118.405	8.95	1.77
390	9/14/2001	16:01:10	34.092	-118.404	11.32	1.68
391	9/16/2001	1:23:02	34.074	-118.412	11.21	1.57
392	9/17/2001	13:08:50	34.070	-118.403	11.06	1.81
393	9/19/2001	9:19:23	34.064	-118.411	11.94	1.58
394	9/20/2001	7:47:59	34.091	-118.405	10.20	1.46
395	9/20/2001	15:09:01	34.082	-118.417	11.40	1.00
396	9/23/2001	0:11:21	34.069	-118.390	8.05	1.61
397	9/23/2001	9:44:13	34.067	-118.404	8.83	1.45
398	9/25/2001	9:41:42	34.065	-118.405	9.19	1.59
399	9/26/2001	9:31:40	34.061	-118.396	8.03	1.64
400	9/30/2001	6:49:57	33.964	-118.415	16.37	1.68
401	10/7/2001	8:53:41	34.070	-118.396	9.68	2.44
402	10/12/2001	7:33:39	33.944	-118.319	12.10	1.61
403	10/20/2001	6:59:41	34.077	-118.412	9.84	1.67
404	10/22/2001	0:28:57	34.057	-118.398	10.68	2.97
405	10/22/2001	0:36:34	34.062	-118.404	8.85	1.54
406	10/22/2001	1:11:50	34.072	-118.408	9.04	1.67

407	10/22/2001	1:58:41	34.060	-118.398	8.31	1.54
408	10/22/2001	2:06:41	34.072	-118.407	9.87	1.62
409	10/22/2001	20:06:32	34.066	-118.403	9.74	2.32
410	10/23/2001	22:25:13	34.069	-118.404	9.65	2.51
411	10/28/2001	16:52:19	34.043	-118.314	20.80	1.63
412	10/28/2001	18:13:13	33.961	-118.360	22.85	1.83
413	10/28/2001	18:14:00	33.951	-118.344	22.23	1.96
414	11/15/2001	23:19:32	34.070	-118.408	8.35	1.30
415	12/6/2001	13:55:18	34.068	-118.388	4.55	1.70
416	12/15/2001	21:41:13	34.049	-118.421	14.45	1.51
417	1/1/2002	4:44:36	33.954	-118.350	16.83	1.62
418	1/1/2002	5:21:56	33.950	-118.339	18.51	1.96
419	1/1/2002	6:56:13	33.961	-118.353	19.57	1.95
420	1/6/2002	4:49:27	34.053	-118.426	14.11	1.80
421	1/23/2002	4:48:35	34.073	-118.411	9.66	1.82
422	1/26/2002	16:52:15	33.966	-118.410	13.00	1.76
423	2/7/2002	18:10:54	34.077	-118.400	8.07	1.75
424	2/10/2002	16:52:39	34.072	-118.402	7.24	1.62
425	2/12/2002	0:29:43	34.096	-118.385	4.78	1.85
426	2/12/2002	20:56:40	34.057	-118.395	8.24	1.83
427	3/3/2002	19:46:31	34.059	-118.400	7.26	1.52
428	3/3/2002	20:06:43	34.066	-118.405	9.12	1.49
429	3/3/2002	21:22:41	34.080	-118.405	6.80	1.68
430	3/4/2002	15:13:44	34.070	-118.388	9.17	1.87
431	3/18/2002	21:29:38	33.978	-118.367	13.68	1.70
432	3/27/2002	21:45:30	34.021	-118.440	13.45	1.69
433	3/28/2002	15:20:53	34.032	-118.436	13.38	1.71
434	3/31/2002	16:44:52	34.024	-118.435	14.37	1.61
435	4/8/2002	16:39:53	33.950	-118.368	15.10	1.83
436	5/2/2002	7:23:48	34.072	-118.421	8.60	1.58
437	5/10/2002	6:50:16	34.010	-118.426	15.93	1.73
438	6/2/2002	5:58:06	33.941	-118.383	15.19	1.63
439	7/2/2002	2:06:34	33.952	-118.366	14.31	1.67
440	7/5/2002	12:59:27	33.986	-118.349	11.59	1.60
441	9/20/2002	4:19:29	34.023	-118.301	11.74	1.76
442	10/14/2002	1:35:00	34.010	-118.443	12.98	1.90
443	10/15/2002	2:29:28	33.943	-118.316	14.19	1.81
444	10/15/2002	9:31:15	33.996	-118.335	13.21	1.40
445	11/12/2002	2:28:27	33.965	-118.409	15.49	2.21
446	12/7/2002	14:35:22	34.086	-118.440	4.91	1.56
447	12/15/2002	23:33:57	34.008	-118.432	9.51	1.83
448	12/30/2002	21:49:16	33.971	-118.353	6.11	1.62
449	1/26/2003	21:46:52	34.044	-118.418	1.81	1.38
450	3/2/2003	15:10:21	34.069	-118.433	8.05	1.49
451	3/6/2003	7:16:53	33.929	-118.365	16.42	1.85
452	3/24/2003	15:30:00	33.970	-118.405	12.76	1.71

453	6/7/2003	19:11:22	34.068	-118.399	7.44	1.80
454	6/10/2003	21:42:57	34.021	-118.316	11.46	1.51
455	6/17/2003	3:32:35	33.954	-118.424	14.78	1.89
456	6/21/2003	11:43:51	34.070	-118.384	6.15	1.40
457	9/28/2003	21:47:06	34.013	-118.435	12.77	1.44
458	10/25/2003	18:00:12	34.036	-118.479	12.46	2.10
459	12/22/2003	14:00:25	34.057	-118.340	11.22	1.49
460	3/6/2004	11:09:23	33.970	-118.352	13.44	1.16
461	3/23/2004	1:51:30	33.954	-118.415	12.57	2.79
462	3/23/2004	4:35:23	33.959	-118.415	13.05	1.89
463	4/4/2004	21:51:44	33.958	-118.417	13.60	1.70
464	4/22/2004	6:51:51	33.968	-118.421	14.01	1.83
465	6/19/2004	18:03:56	33.974	-118.365	11.83	2.52
466	7/5/2004	9:10:28	33.975	-118.359	12.46	1.66
467	7/19/2004	10:44:47	34.042	-118.407	8.84	1.87
468	7/27/2004	23:20:13	33.985	-118.311	5.05	1.44
469	8/11/2004	20:35:19	33.980	-118.427	13.88	1.72
470	10/30/2004	16:07:20	34.094	-118.377	1.51	2.67
471	11/8/2004	23:21:38	33.965	-118.369	14.85	1.20
472	12/14/2004	0:05:58	33.994	-118.326	12.94	1.97
473	12/18/2004	1:35:44	33.964	-118.350	14.02	2.14
474	1/15/2005	2:57:21	34.069	-118.322	8.70	1.41
475	6/6/2005	21:25:23	33.978	-118.449	15.68	1.77
476	6/23/2005	10:32:11	33.980	-118.425	15.61	2.81
477	7/9/2005	19:57:18	33.957	-118.357	15.44	1.59
478	8/20/2005	22:19:18	33.961	-118.390	14.55	1.68
479	9/2/2005	3:58:23	34.006	-118.334	13.93	1.67
480	9/11/2005	9:01:47	33.965	-118.377	14.37	1.36
481	10/7/2005	5:09:58	34.007	-118.438	12.75	1.59
482	10/22/2005	20:18:48	34.003	-118.445	12.51	3.11
483	10/23/2005	3:42:16	34.007	-118.440	12.76	3.11
484	11/7/2005	15:13:33	34.021	-118.441	10.94	1.72
485	11/10/2005	17:55:59	33.981	-118.404	13.92	1.56
486	11/13/2005	16:50:21	33.975	-118.368	13.32	2.24
487	11/14/2005	6:32:06	33.970	-118.404	16.56	1.60
488	11/14/2005	7:41:00	33.978	-118.363	12.46	1.69
489	11/19/2005	8:28:46	33.959	-118.380	14.35	1.39
490	11/19/2005	13:49:53	34.008	-118.446	11.70	1.57
491	11/29/2005	11:17:43	34.020	-118.452	9.20	1.56
492	12/5/2005	17:35:35	33.998	-118.297	13.49	1.95
493	2/5/2006	14:43:05	34.002	-118.444	11.30	2.30
494	2/11/2006	22:53:35	33.967	-118.373	13.51	1.73
495	4/12/2006	12:18:33	33.982	-118.312	10.83	1.30
496	4/18/2006	4:27:42	34.062	-118.376	10.10	1.87
497	4/30/2006	13:44:02	33.935	-118.336	15.69	1.41
498	8/24/2006	23:26:16	33.952	-118.403	14.55	2.53

499	10/9/2006	10:09:29	34.087	-118.389	3.94	1.03
500	10/23/2006	8:37:05	34.068	-118.300	10.81	1.38
501	11/28/2006	9:18:12	34.008	-118.448	12.88	1.32
502	12/25/2006	16:35:18	33.964	-118.330	11.22	1.48
503	1/28/2007	20:36:21	34.080	-118.435	9.08	1.14
504	2/4/2007	4:06:58	33.938	-118.321	13.26	1.78
505	3/4/2007	1:37:48	34.004	-118.434	15.86	1.35
506	7/17/2007	15:12:04	34.009	-118.325	14.10	1.32
507	9/1/2007	21:20:57	33.974	-118.427	13.59	1.60
508	9/28/2007	16:25:20	34.000	-118.453	12.82	2.73
509	9/28/2007	20:44:03	34.028	-118.466	11.54	1.72
510	10/8/2007	14:20:26	34.000	-118.448	11.62	1.74
511	10/10/2007	11:26:17	34.000	-118.452	13.04	1.52
512	11/6/2007	14:40:57	34.011	-118.461	13.13	1.87
513	12/5/2007	8:22:19	34.001	-118.451	13.80	1.66
514	12/10/2007	7:04:16	33.937	-118.370	5.97	1.44
515	12/24/2007	5:11:44	34.002	-118.457	13.69	1.67
516	1/12/2008	5:47:19	33.978	-118.452	13.83	1.91
517	2/6/2008	10:12:08	34.081	-118.383	8.93	1.86
518	2/16/2008	11:08:40	33.937	-118.406	13.95	1.42
519	2/23/2008	13:27:50	34.037	-118.470	11.78	1.75
520	3/13/2008	5:07:19	34.034	-118.309	5.63	1.01
521	3/27/2008	12:13:17	33.981	-118.401	11.75	2.43
522	6/10/2008	10:12:23	34.044	-118.301	13.03	1.59
523	6/21/2008	3:24:56	34.017	-118.444	11.87	1.48
524	6/25/2008	23:13:41	34.016	-118.455	11.65	1.90
525	6/25/2008	23:16:15	34.023	-118.446	11.68	1.69
526	6/26/2008	3:26:49	34.020	-118.456	12.70	1.70
527	6/28/2008	10:54:31	34.020	-118.451	12.07	1.44
528	9/23/2008	9:49:16	34.047	-118.404	15.47	1.89
529	10/1/2008	2:57:09	33.955	-118.385	13.35	2.97
530	10/22/2008	22:03:34	33.989	-118.431	11.79	2.51
531	12/10/2008	19:03:01	33.971	-118.346	13.61	1.52
532	12/11/2008	12:16:08	33.980	-118.353	12.78	1.57
533	12/11/2008	13:15:39	33.979	-118.342	11.43	2.38
534	1/15/2009	15:25:37	34.022	-118.422	11.21	1.00
535	1/24/2009	3:42:44	33.979	-118.461	11.14	3.30
536	1/24/2009	4:50:46	33.980	-118.473	12.46	1.74
537	2/21/2009	9:02:51	33.971	-118.368	8.15	1.50
538	3/16/2009	18:13:43	34.025	-118.337	10.21	1.66
539	3/20/2009	6:27:51	34.021	-118.333	12.47	1.48
540	3/25/2009	6:24:39	34.041	-118.350	7.82	1.39
541	3/27/2009	10:57:09	33.962	-118.342	23.05	1.11
542	4/19/2009	4:08:44	33.983	-118.470	12.05	2.19
543	4/19/2009	5:02:38	33.983	-118.472	11.55	1.18
544	4/29/2009	9:59:31	33.984	-118.477	13.51	1.10

545	5/12/2009	9:01:24	33.993	-118.456	9.90	2.53
546	5/12/2009	22:55:45	33.996	-118.484	11.51	1.29
547	5/18/2009	3:39:36	33.938	-118.336	13.82	4.70
548	5/18/2009	3:45:11	33.934	-118.346	14.86	3.06
549	5/18/2009	4:20:08	33.940	-118.329	6.22	1.09
550	5/18/2009	4:48:25	33.933	-118.352	14.77	1.58
551	5/18/2009	7:48:30	33.933	-118.373	16.55	1.48
552	5/18/2009	8:20:24	33.934	-118.342	14.34	2.31
553	5/18/2009	8:30:56	33.940	-118.365	12.37	1.62
554	5/18/2009	9:19:21	33.939	-118.361	16.45	2.48
555	5/18/2009	10:22:25	33.936	-118.340	13.49	1.36
556	5/18/2009	10:30:42	33.936	-118.367	15.45	1.50
557	5/18/2009	14:18:07	33.940	-118.348	14.60	1.21
558	5/18/2009	18:04:50	33.943	-118.326	14.76	1.36
559	5/19/2009	22:49:12	33.934	-118.329	12.71	4.04
560	5/20/2009	15:07:08	33.941	-118.362	16.75	1.21
561	5/20/2009	22:54:48	34.009	-118.319	13.35	2.22
562	5/21/2009	2:43:59	33.936	-118.345	11.91	2.65
563	5/21/2009	7:30:27	33.997	-118.291	13.26	1.44
564	5/22/2009	5:50:03	33.939	-118.339	16.43	1.28
565	5/22/2009	15:33:57	33.943	-118.354	14.81	1.81
566	5/26/2009	5:18:29	33.943	-118.386	18.57	1.53
567	6/1/2009	6:00:26	33.939	-118.342	14.62	1.32
568	6/1/2009	16:56:06	33.955	-118.338	5.79	1.17
569	6/2/2009	6:29:49	33.930	-118.354	15.02	2.09
570	6/2/2009	22:32:52	33.942	-118.359	13.36	2.31
571	6/5/2009	10:04:05	33.943	-118.360	12.75	1.62
572	6/5/2009	19:50:48	34.074	-118.378	8.10	1.57
573	6/7/2009	9:02:59	33.981	-118.423	15.43	2.25
574	6/8/2009	15:20:27	33.950	-118.366	14.60	1.41
575	6/8/2009	20:22:09	33.938	-118.356	16.19	2.28
576	6/12/2009	17:25:43	33.948	-118.345	13.72	1.46
577	6/13/2009	8:40:15	33.936	-118.374	18.00	1.38
578	6/15/2009	18:58:44	33.939	-118.374	15.64	2.28
579	7/5/2009	2:46:58	33.933	-118.379	18.63	1.65
580	7/5/2009	19:39:01	33.959	-118.362	15.48	1.63
581	7/11/2009	19:20:35	33.946	-118.348	15.00	1.61
582	7/14/2009	4:14:22	33.928	-118.359	15.86	3.08
583	7/14/2009	13:50:08	33.937	-118.328	13.84	1.30
584	7/20/2009	11:23:57	33.925	-118.378	17.31	1.49
585	7/25/2009	4:25:50	33.931	-118.369	13.40	1.70
586	7/30/2009	3:54:52	33.936	-118.376	15.12	1.70
587	7/30/2009	23:04:52	33.943	-118.392	15.67	2.68
588	7/31/2009	4:45:19	33.952	-118.410	15.79	2.05
589	8/2/2009	14:08:13	33.974	-118.468	10.38	1.64
590	8/16/2009	14:01:16	33.944	-118.383	14.94	1.51

591	8/20/2009	22:10:33	33.938	-118.389	16.79	1.71
592	9/2/2009	18:29:21	34.000	-118.322	10.50	1.66
593	9/3/2009	19:34:37	33.942	-118.352	15.43	1.67
594	9/7/2009	15:24:52	33.942	-118.368	15.92	1.67
595	9/11/2009	7:20:28	33.927	-118.360	15.84	1.76
596	9/12/2009	9:33:16	33.956	-118.361	11.61	1.77
597	9/12/2009	21:29:32	34.053	-118.368	14.25	1.51
598	9/18/2009	5:47:26	33.972	-118.476	13.74	1.35
599	9/29/2009	16:50:52	34.020	-118.450	12.58	1.65
600	10/17/2009	19:11:32	33.949	-118.387	15.67	1.64
601	10/17/2009	21:21:14	33.940	-118.387	16.02	1.55
602	10/28/2009	15:28:56	33.949	-118.371	14.47	2.06
603	10/29/2009	17:16:08	34.023	-118.323	13.75	1.37
604	11/30/2009	11:01:21	33.932	-118.334	12.92	2.31
605	12/18/2009	7:06:10	33.967	-118.441	15.50	1.96
606	12/21/2009	6:41:27	33.953	-118.363	14.98	1.42
607	12/26/2009	19:44:04	33.943	-118.350	12.67	1.78
608	12/27/2009	12:39:47	33.989	-118.457	9.04	1.63
609	1/13/2010	0:56:13	33.937	-118.346	11.73	2.03
610	1/17/2010	9:42:32	33.950	-118.400	15.29	2.01
611	2/9/2010	15:11:25	33.948	-118.379	11.91	1.64
612	3/5/2010	8:31:39	33.993	-118.342	12.85	2.09
613	3/5/2010	21:53:31	33.944	-118.329	13.10	1.43
614	3/15/2010	4:53:10	34.062	-118.373	6.78	1.49
615	3/19/2010	3:57:10	34.098	-118.413	7.25	1.56
616	3/23/2010	10:51:09	34.063	-118.446	6.95	1.48
617	4/19/2010	18:04:56	33.979	-118.320	7.54	1.89
618	4/21/2010	17:34:09	33.986	-118.329	4.64	1.88
619	4/22/2010	13:52:19	33.984	-118.306	4.68	1.58
620	4/27/2010	6:46:23	33.944	-118.359	9.75	1.48
621	5/6/2010	21:13:51	33.960	-118.402	13.83	1.82
622	5/15/2010	11:33:17	33.993	-118.343	12.17	2.92
623	6/3/2010	21:48:09	33.932	-118.378	14.62	1.46
624	6/14/2010	3:42:56	33.951	-118.355	14.47	1.41
625	6/25/2010	5:03:01	33.974	-118.373	13.36	1.63
626	7/1/2010	16:25:56	33.986	-118.332	12.80	1.65
627	7/17/2010	4:19:42	34.006	-118.426	12.74	1.87
628	9/1/2010	17:00:04	33.972	-118.357	10.51	1.98
629	9/7/2010	10:54:00	33.963	-118.389	15.10	1.86
630	9/9/2010	11:37:56	33.983	-118.467	10.25	1.61
631	11/4/2010	12:39:02	33.936	-118.327	20.05	1.62
632	11/19/2010	6:46:54	34.032	-118.311	12.19	1.41
633	11/20/2010	8:16:54	33.971	-118.313	10.09	1.57
634	12/12/2010	23:13:06	34.033	-118.328	13.14	1.52
635	12/18/2010	13:05:41	34.014	-118.323	9.84	1.12
636	1/3/2011	14:47:06	33.998	-118.338	8.40	1.56

637	2/9/2011	20:37:39	34.057	-118.448	11.45	1.99
638	2/13/2011	16:12:41	33.975	-118.369	13.55	1.17
639	3/22/2011	22:54:24	33.958	-118.359	8.51	1.88
640	3/30/2011	8:50:23	34.020	-118.305	11.71	1.33
641	4/2/2011	20:45:54	33.977	-118.370	9.32	1.57
642	4/10/2011	11:29:44	33.963	-118.407	15.10	1.30
643	4/24/2011	23:41:41	33.975	-118.361	11.27	2.16
644	4/29/2011	2:17:20	34.019	-118.449	9.63	1.49
645	5/14/2011	5:51:12	33.995	-118.286	15.26	1.57
646	5/30/2011	9:44:13	33.970	-118.363	11.59	1.59
647	5/30/2011	14:35:09	33.958	-118.364	13.37	1.85
648	5/31/2011	6:58:08	33.935	-118.372	17.27	1.62
649	6/12/2011	7:33:03	34.090	-118.356	10.44	1.78
650	6/20/2011	7:49:44	34.002	-118.335	11.43	1.11
651	6/20/2011	9:26:56	34.026	-118.322	12.29	1.71
652	7/15/2011	18:07:52	33.945	-118.345	14.47	2.16
653	7/17/2011	12:50:37	33.970	-118.329	14.59	1.51
654	7/28/2011	10:43:58	33.985	-118.428	13.77	1.27
655	7/31/2011	13:01:09	33.961	-118.341	12.65	1.45
656	9/8/2011	0:07:12	34.049	-118.288	10.83	1.56
657	9/14/2011	20:10:00	33.949	-118.392	16.35	1.41
658	9/21/2011	5:00:00	33.986	-118.482	12.66	1.63
659	9/30/2011	19:41:27	33.946	-118.450	14.09	1.90
660	11/11/2011	1:58:01	33.996	-118.468	13.00	2.40
661	11/29/2011	12:27:02	34.075	-118.374	4.19	1.93
662	12/14/2011	9:49:59	34.081	-118.404	8.26	1.46
663	12/21/2011	17:06:23	33.978	-118.413	11.15	2.43
664	12/27/2011	23:06:02	33.956	-118.314	16.73	1.74
665	3/14/2012	0:21:44	33.946	-118.405	10.37	1.55
666	4/19/2012	7:22:57	34.005	-118.423	13.02	1.10
667	5/12/2012	8:05:52	34.010	-118.437	8.38	1.83
668	6/5/2012	2:39:28	33.926	-118.375	12.37	1.20
669	6/30/2012	2:30:12	33.988	-118.415	9.66	1.11
670	7/25/2012	10:18:42	33.964	-118.407	10.70	3.74
671	7/25/2012	12:27:29	33.963	-118.405	10.40	2.33
672	7/25/2012	12:46:24	33.963	-118.396	9.94	1.41
673	8/20/2012	14:02:40	33.966	-118.398	9.66	2.05
674	8/24/2012	13:40:56	33.951	-118.404	11.35	1.08
675	9/3/2012	10:26:56	34.068	-118.392	2.24	3.20
676	9/7/2012	7:03:10	34.066	-118.398	1.40	3.40
677	9/21/2012	17:51:05	33.964	-118.290	4.87	1.38
678	9/24/2012	9:59:53	33.964	-118.354	4.20	1.59
679	10/15/2012	22:38:34	33.971	-118.419	8.31	1.83
680	10/25/2012	20:21:57	33.944	-118.355	18.06	1.93
681	11/5/2012	4:06:41	33.955	-118.350	8.42	2.30
682	11/5/2012	16:28:07	33.924	-118.377	8.36	2.05

683	11/20/2012	10:50:18	33.962	-118.420	9.02	1.27
684	11/23/2012	19:54:46	34.003	-118.428	10.56	1.81
685	11/23/2012	21:18:15	33.999	-118.426	10.86	2.38
686	11/24/2012	9:44:01	34.004	-118.430	10.91	2.41
687	11/25/2012	0:06:50	33.998	-118.427	12.04	1.57
688	12/5/2012	1:29:02	33.969	-118.333	4.12	1.66
689	12/15/2012	3:01:54	33.963	-118.412	8.90	1.35
690	12/19/2012	9:07:38	33.964	-118.401	10.44	1.79
691	12/22/2012	0:19:06	33.964	-118.325	5.39	1.74
692	4/5/2013	16:14:16	33.968	-118.428	10.68	1.81
693	4/27/2013	2:52:18	33.958	-118.419	11.83	3.14
694	4/29/2013	3:06:20	33.958	-118.410	10.12	2.72
695	5/9/2013	21:08:04	33.960	-118.416	11.94	2.91
696	5/11/2013	18:19:24	33.941	-118.328	11.38	1.82
697	5/17/2013	3:28:24	33.956	-118.411	11.08	1.51
698	5/24/2013	21:36:50	34.043	-118.353	8.65	1.41
699	6/1/2013	7:36:32	33.952	-118.402	9.63	1.04
700	6/4/2013	15:04:28	33.978	-118.353	5.31	1.50
701	6/23/2013	11:25:32	33.951	-118.430	13.45	1.70
702	7/1/2013	4:32:02	33.961	-118.415	11.54	2.72
703	7/1/2013	6:11:55	33.965	-118.423	10.68	1.92
704	7/1/2013	6:16:11	33.958	-118.412	10.95	1.41
705	7/2/2013	15:25:02	33.968	-118.433	10.61	1.87
706	7/11/2013	7:47:18	33.953	-118.417	10.22	1.49
707	7/18/2013	1:52:06	33.964	-118.374	6.84	1.28
708	7/21/2013	16:44:38	33.960	-118.424	11.35	1.93
709	7/23/2013	16:19:26	33.972	-118.330	6.15	1.54
710	8/9/2013	23:17:15	33.959	-118.426	9.84	2.70
711	8/10/2013	6:11:46	33.936	-118.352	9.09	1.45
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714	8/31/2013	1:14:39	33.990	-118.342	8.24	1.37
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716	9/13/2013	20:42:47	33.959	-118.377	9.06	2.07
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718	9/17/2013	16:31:56	33.958	-118.413	11.29	1.52
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720	10/13/2013	12:51:20	33.946	-118.395	9.86	1.08
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722	11/1/2013	13:58:07	33.949	-118.335	7.06	1.63
723	11/6/2013	10:04:20	33.943	-118.340	18.35	1.17
724	11/6/2013	10:05:50	33.939	-118.321	17.74	1.54
725	11/6/2013	10:06:03	33.935	-118.326	19.80	1.39
726	11/6/2013	10:06:18	33.941	-118.331	18.45	1.52
727	11/6/2013	10:10:34	33.941	-118.325	17.81	1.57
728	11/14/2013	4:56:45	33.964	-118.428	10.26	1.63

729	11/18/2013	0:56:21	34.026	-118.277	4.78	1.20
730	11/22/2013	9:46:00	33.953	-118.414	8.59	1.51
731	11/22/2013	9:46:44	33.948	-118.409	11.35	1.39
732	12/7/2013	10:21:31	34.055	-118.340	10.03	1.14
733	12/8/2013	5:36:32	33.944	-118.403	11.04	1.48
734	12/12/2013	5:28:29	34.020	-118.296	9.07	1.39
735	12/18/2013	7:45:22	33.960	-118.383	9.65	1.79
736	12/19/2013	15:53:39	33.982	-118.446	9.21	2.75
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746	3/8/2014	4:16:31	33.970	-118.428	9.70	3.13
747	3/9/2014	15:05:06	33.946	-118.430	12.88	1.13
748	3/10/2014	0:46:58	33.971	-118.432	9.05	1.55
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750	5/8/2014	4:58:09	33.937	-118.362	12.59	1.65
751	5/19/2014	9:13:43	33.970	-118.324	6.37	1.47
752	5/21/2014	11:43:58	34.041	-118.411	13.46	1.47
753	5/22/2014	3:13:16	34.005	-118.430	13.11	1.56
754	7/14/2014	14:34:15	33.953	-118.311	7.56	1.60
755	8/2/2014	1:13:17	33.969	-118.422	10.47	1.27
756	10/2/2014	4:04:26	33.976	-118.446	12.90	1.72
757	10/27/2014	14:43:14	33.980	-118.414	11.12	1.59
758	11/3/2014	3:00:00	34.024	-118.439	11.83	1.05
759	11/26/2014	13:31:19	33.962	-118.389	7.70	1.56
760	1/3/2015	9:30:56	33.933	-118.352	11.03	1.34
761	1/18/2015	13:15:05	34.074	-118.351	20.31	1.20
762	2/8/2015	1:24:54	33.974	-118.347	8.29	1.41
763	2/17/2015	1:25:11	34.058	-118.458	8.94	1.29
764	2/20/2015	13:18:06	33.949	-118.314	2.63	1.41
765	2/27/2015	11:19:02	33.956	-118.423	14.64	1.24
766	3/10/2015	21:16:09	33.946	-118.420	12.82	1.51
767	3/22/2015	18:26:41	33.963	-118.437	11.70	1.51
768	5/10/2015	15:31:17	33.966	-118.357	10.55	1.17
769	5/17/2015	1:23:24	33.981	-118.336	9.41	1.93
770	5/22/2015	10:32:53	33.972	-118.418	9.80	1.49
771	5/23/2015	7:03:58	33.971	-118.329	11.15	1.48
772	5/23/2015	16:34:04	33.995	-118.340	8.93	1.51
773	5/27/2015	12:52:49	33.967	-118.420	10.49	1.51
774	6/10/2015	20:28:24	33.975	-118.373	11.75	1.52

775	6/22/2015	21:49:05	33.967	-118.349	3.50	2.47
776	7/21/2015	5:49:54	33.952	-118.330	8.50	1.39
777	7/25/2015	14:03:57	33.969	-118.344	9.88	1.47
778	8/22/2015	1:53:30	33.977	-118.442	14.69	1.10
779	9/5/2015	4:55:33	33.991	-118.426	10.19	2.69
780	9/11/2015	3:44:47	34.095	-118.407	10.62	1.05
781	10/3/2015	7:20:08	33.993	-118.445	8.93	1.22
782	10/6/2015	8:36:26	33.988	-118.440	10.01	1.81
783	10/6/2015	8:37:32	33.992	-118.452	9.15	1.09
784	10/6/2015	8:38:24	33.990	-118.444	9.96	1.14
785	10/10/2015	5:40:23	34.024	-118.444	9.68	1.31
786	11/6/2015	3:58:48	33.938	-118.335	7.24	1.83
787	12/8/2015	23:00:49	33.998	-118.332	14.28	1.35
788	12/22/2015	10:00:24	33.977	-118.429	9.53	1.88
789	1/22/2016	12:31:44	34.003	-118.471	13.39	1.17
790	1/24/2016	21:23:07	34.009	-118.459	12.28	1.46
791	2/18/2016	23:40:51	34.099	-118.394	5.47	1.04
792	3/3/2016	8:05:13	33.952	-118.394	11.68	2.44
793	3/7/2016	23:02:04	33.971	-118.422	14.00	1.29
794	4/12/2016	13:05:50	33.991	-118.344	9.97	1.43
795	5/4/2016	22:21:12	34.029	-118.478	11.99	1.30
796	5/16/2016	22:09:40	33.990	-118.461	11.82	1.37
797	5/25/2016	23:42:17	34.033	-118.298	11.06	1.44
798	6/20/2016	10:49:43	34.079	-118.413	11.19	1.18
799	6/21/2016	0:14:55	34.070	-118.422	10.04	1.13
800	7/20/2016	18:51:42	33.994	-118.429	9.54	1.47
801	7/20/2016	18:59:06	33.992	-118.433	10.12	1.61
802	7/21/2016	4:02:56	33.961	-118.468	16.57	1.40
803	7/21/2016	11:51:29	34.034	-118.422	11.18	1.86
804	8/4/2016	11:25:09	34.005	-118.336	8.91	1.50

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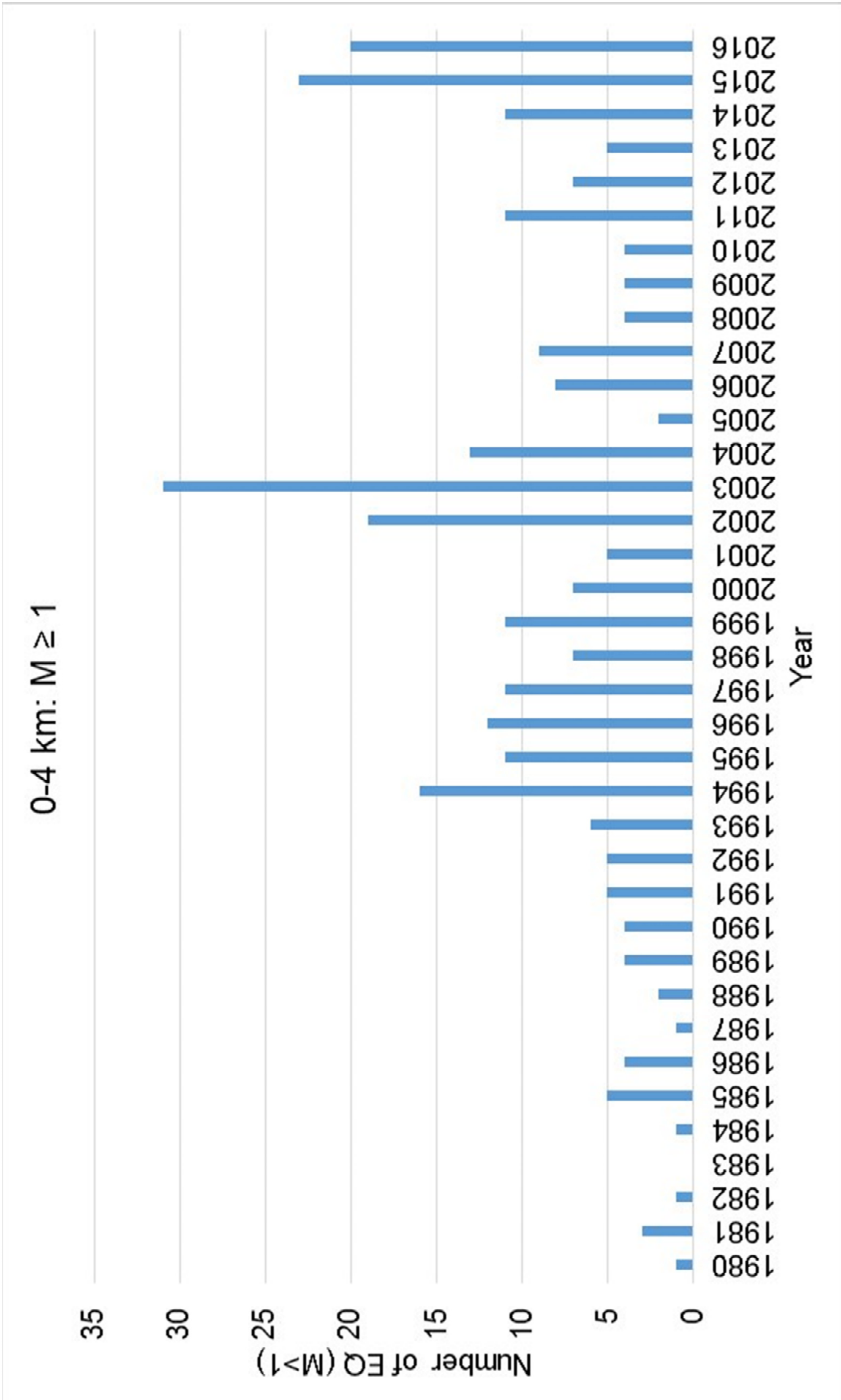

Figure A1: Earthquake (M≥1) Frequency Bar Chart (0 – 4 km)

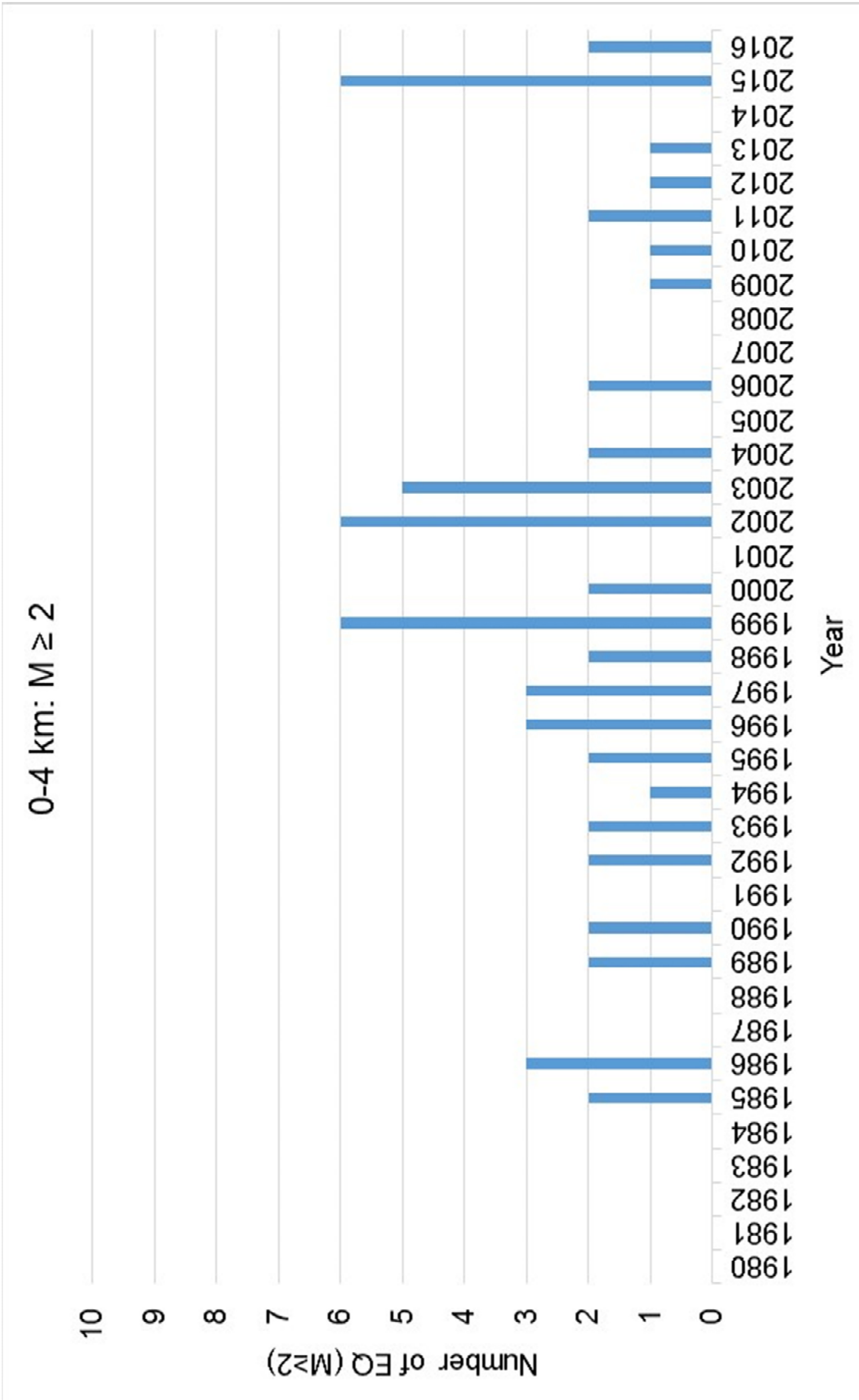

Figure A2: Earthquake (M≥2) Frequency Bar Chart (0 – 4 km)

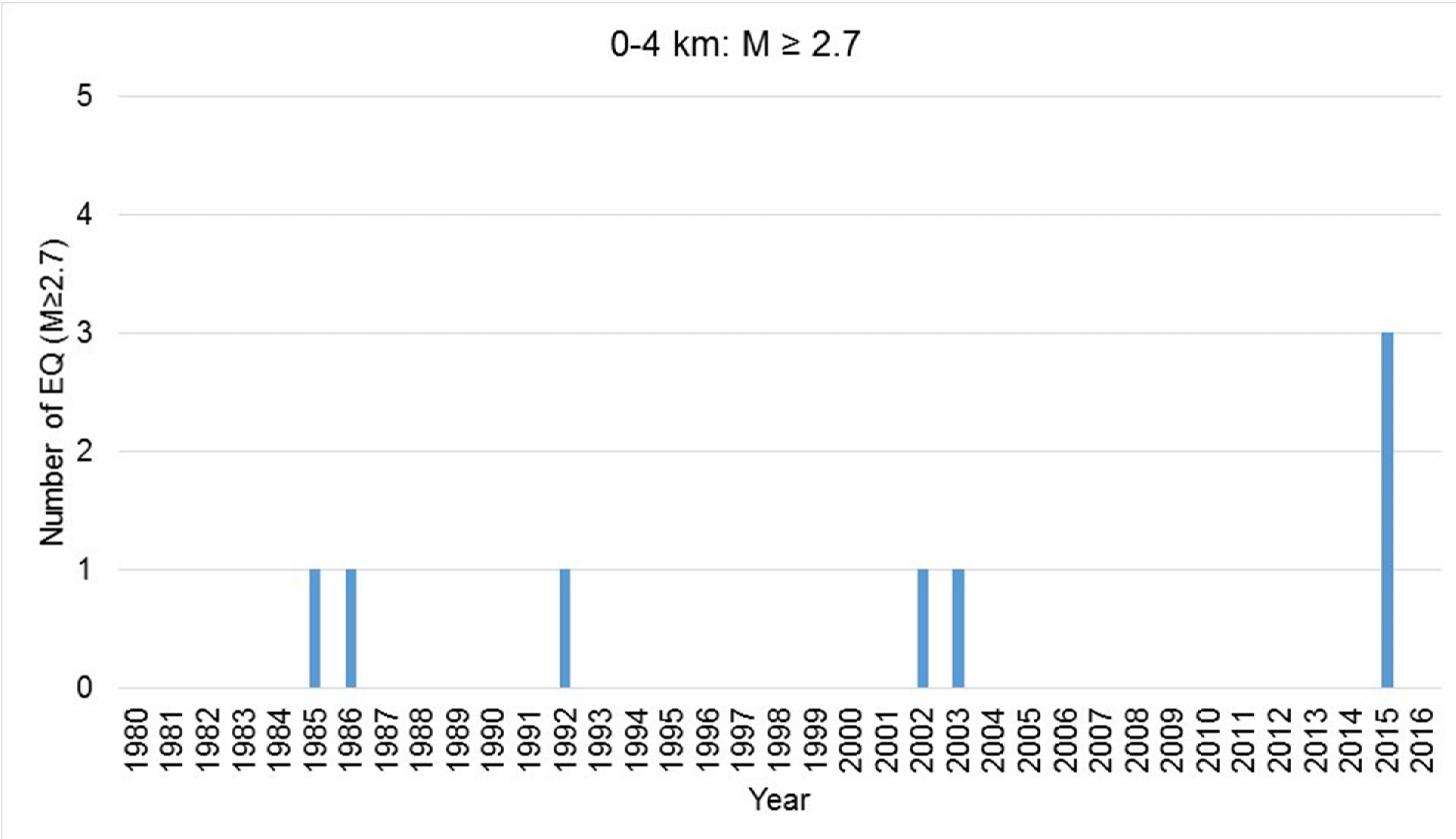

Figure A3: Earthquake (M≥2.7) Frequency Bar Chart (0 – 4 km)

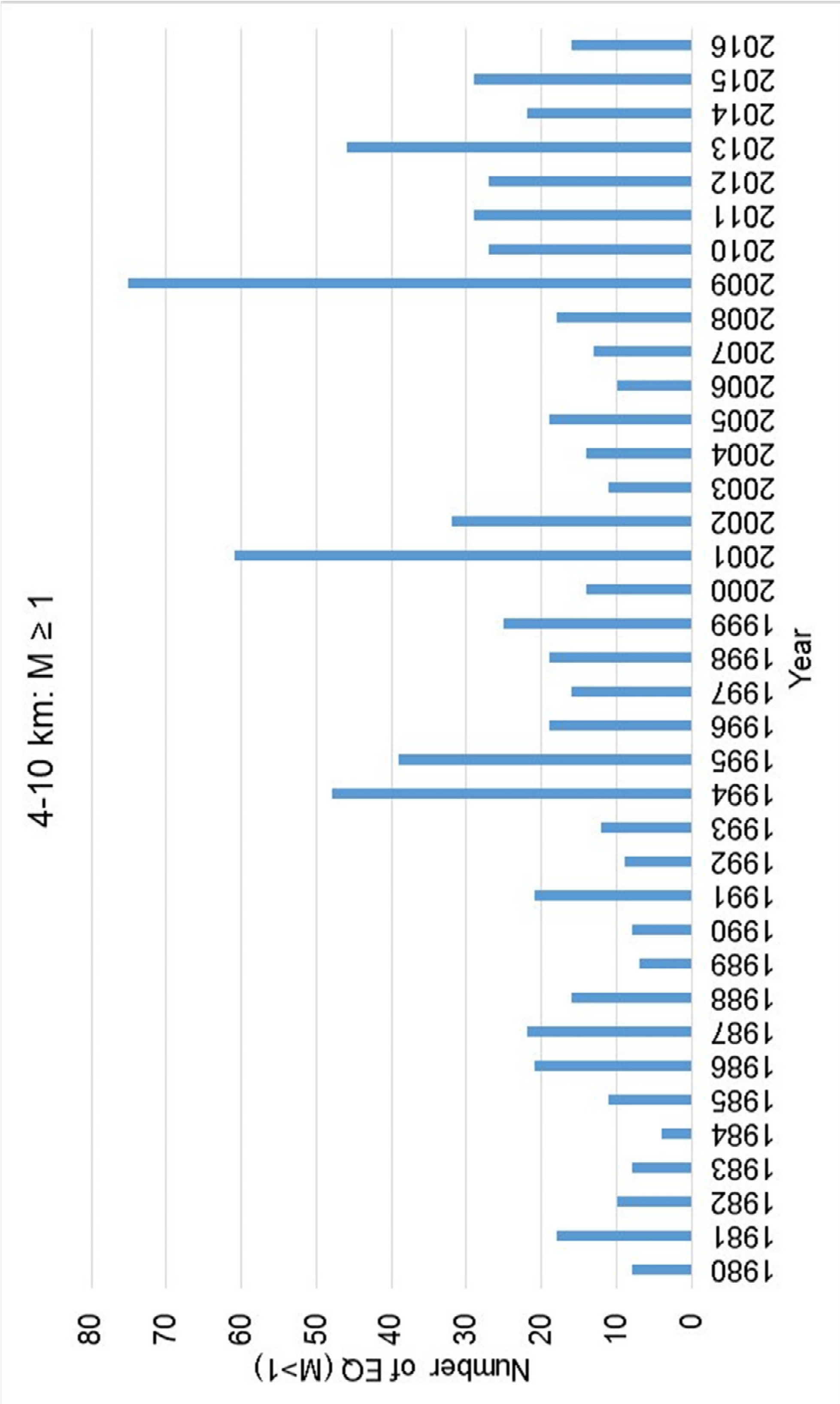

Figure A4: Earthquake (M≥1) Frequency Bar Chart (4 – 10 km)

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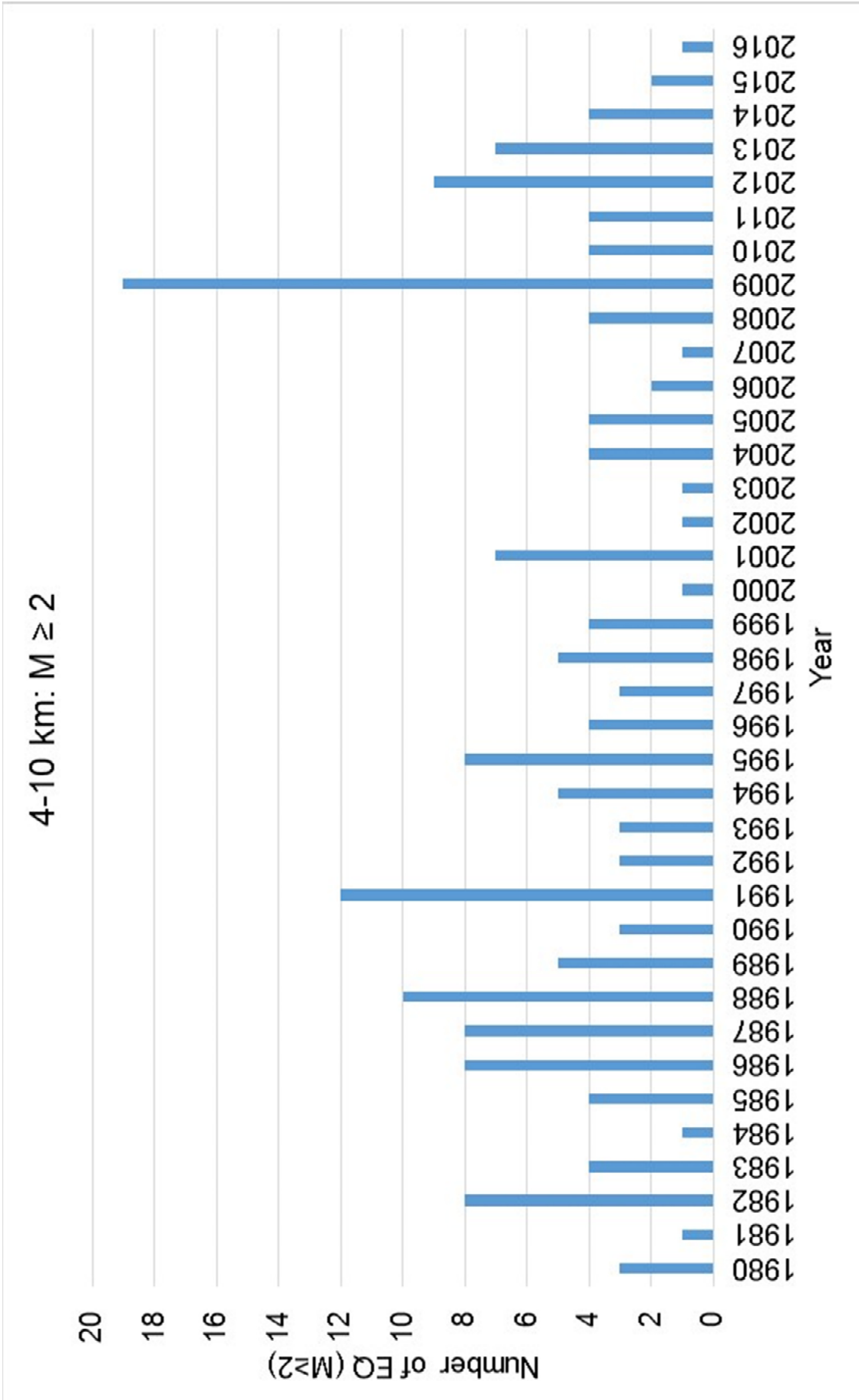

Figure A5: Earthquake (M≥2) Frequency Bar Chart (4 – 10 km)

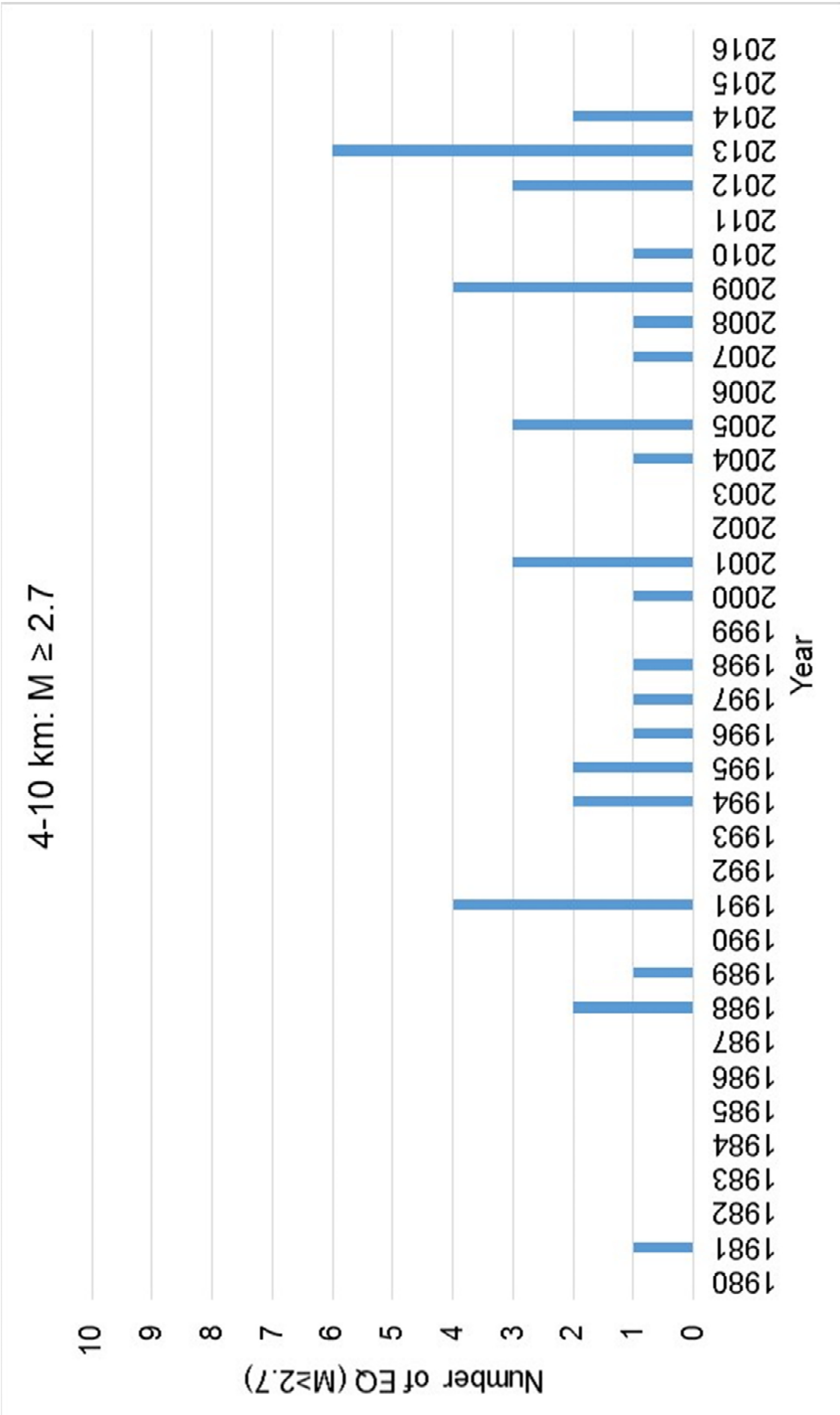

Figure A6: Earthquake (M≥2.7) Frequency Bar Chart (4 – 10 km)