GEOLOGIC HAZARDS AND GEOTECHNICAL ASSESSMENT REPORT
FREEPORT-MCMORAN OIL & GAS
ARROYO GRANDE OIL FIELD – PHASE V
SAN LUIS OBISPO COUNTY, CALIFORNIA

December 11, 2013

Prepared for

Ms. Michelle Gibbs
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Prepared by

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December 11, 2013

FILE NO.: SL-17061-SC

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PROJECT: FREEPORT-MCMORAN OIL & GAS
ARROYO GRANDE OIL FIELD – PHASE V
1821 PRICE CANYON ROAD
SAN LUIS OBISPO COUNTY, CALIFORNIA

SUBJECT: Geologic Hazards and Geotechnical Assessment Report

CONTRACT REF.: Estimated Budget for a Geologic Hazards and Geotechnical Assessment, Plains Exploration and Production Co, Arroyo Grande Oil Field – Phase V, 1821 Price Canyon Road, San Luis Obispo, CA, by Earth Systems Pacific, Doc. No.: 1301-126.PRP, dated January 25, 2013

Dear Ms. Gibbs:

In accordance with the above-referenced estimate and the Authorization for Expenditure No. 74685, this geologic hazards and geotechnical assessment report has been prepared for use in planning of Phase V development at the Arroyo Grande Oil Field in San Luis Obispo, California. This report is based upon a review of published maps and literature, site reconnaissance, analyses, and evaluation of the information obtained. As requested, electronic copies are being forwarded as indicated below.

We appreciate the opportunity to have provided geotechnical engineering and geologic services for this project and look forward to working with you as this project progresses. If there are any questions concerning this report, please do not hesitate to contact the undersigned.

Sincerely,

Earth Systems Pacific

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1.0 INTRODUCTION

Planned Development

Freeport-McMoRan Oil & Gas (FMOG) is in the process of submitting a plan for expanding production at the existing Arroyo Grande oil field at 1821 Price Canyon Road in San Luis Obispo County, California. The oil field has been in production from the early 1900's and continues to produce oil through the use of steam flooding and injection to allow for extraction from over 100 active wells. About 40 steam injection wells are used throughout the site (San Luis Obispo County 2012b). The expansion project, herein referred to as Phase V, entails several aspects which include the following:

- Modifications to 33 existing well pads that will include cuts and fills up to 45 feet
- Addition of 8 new well pads
- Construction of one new access roadway
- Grading of approximately 67 acres during project development
- Installation of new above ground piping to serve well pads
- Construction of access roads for upgraded/new well pads
- Installation of piping under Union Pacific Rail Road (UPRR) tracks, Ormonde Road, and Price Canyon Road
- Replacing the northern Pismo Creek pipe bridge
- Constructing three steam generators

The Phase V development will occur over a period of several years with development of a few well pads each year. Temporary drill rigs will be erected to drill wells over a period of a few days. Once the wells are drilled, they are developed and a pumping unit is erected to extract product. We understand that Linear Rod Pumps (LRP) will be used for most of the new wells as they do not require concrete foundations or large amounts of space like the more conventional beam style pump jacks. Relatively flat areas on the well pads will be created for the temporary drill rigs, truck mounted work-over rigs that service wells, and service vehicles.

Modifications to some of the existing well pads will involve removing stockpiles of soil and brush with little to no cuts or fills planned. Other existing pads will be expanded by cutting into existing hillsides and filling along existing fill slopes. The proposed new well pads will involve significant cuts and fills in vegetated areas. Access roadways will also be improved and/or constructed. Based upon the preliminary grading plans for Phase V (Cannon 2013), cuts up to 45 feet and fills up to 35 feet are anticipated for some of the pads. For the purposes of this

report, cut and fill depths are in reference to vertical thicknesses. Preliminarily, cuts are planned at 1 to 2:1 (horizontal to vertical) slope gradients and fills are planned at 1.5 to 2:1. We understand that the variation is mostly dependent upon the geometric constraints of the pads, the material type, and the goal of reducing the overall disturbed area. It is also our understanding that FMOG would like to have slopes at steeper angles if practicable to further reduce the disturbed area and the amount of grading necessary.

A pipe crossing is planned under UPRR tracks near the steam generator plant on the east portion of the facility. We understand that the crossing will most likely consist of a 3-foot diameter steel casing installed via jack and bore methods at a depth of 4.5 feet below the tracks or 3 feet below lowest adjacent grade, whichever is deeper. Two other pipe crossings are planned as well; one under Price Canyon Road near the northern gate (Gate 2) and another on Ormonde Road in the eastern portion of the project development area. It is assumed that the crossings will also use jack and bore methods and be a minimum of 4 feet below the roadways.

Another planned improvement is the replacement of the northern pipe bridge that crosses Pismo Creek. We understand that a new bridge will be constructed at a higher elevation than the current bridge due to flooding and geometric constraints. Lastly, three new steam generators will be constructed in the Phase V development; one near the existing steam generators in Facility Canyon and two on Signal 150 in the north east portion of the site.

Purpose and Scope of Work

The purpose of this report is to evaluate and define the potential geotechnical conditions and geologic hazards that could affect the proposed development of Phase V. Our scope included the following tasks:

- Review of available geologic and geotechnical studies pertaining to the site
- Site reconnaissance by a State of California Licensed Geotechnical Engineer and a Certified Engineering Geologist
- Documentation of existing site conditions where development is planned
- Compilation and summarization of data from the site reconnaissance
- Development of preliminary cross-sections at select well pad locations
- Preparation of this report that summarizes observations, conclusions, and preliminary recommendations

The well pads slated for improvement and development were observed and evaluated; however, additional analyses such as slope stability, liquefaction, and addressing other specific design features were beyond the scope of this report. Conclusions and qualitative recommendations pertaining to further studies are provided. This report is intended to comply with common geotechnical engineering and engineering geology practice in this area under similar conditions at this time. It is not intended serve as a design level geotechnical and geologic engineering report per applicable sections of the California Building Code (CBC or the Guidelines for Engineering Geology Reports (San Luis Obispo County 2005).

Preliminary conclusions regarding slope angles are provided. These are based upon observations of existing conditions. Preliminary conclusions discussed herein are for guidance during planning stages and are not intended for final design. There are geologic and geotechnical matters yet to be resolved. Consequently, the geotechnical engineer and the engineering geologist should be retained to perform site specific geotechnical and engineering geologic investigations for the proposed improvements. It is our intent that this report be used exclusively by the client to form the geotechnical and geologic basis of development planning of the project. Application beyond this intent is strictly at the user's risk. If future property owners wish to use this report, such use will be allowed to the extent the report is applicable, only if each user agrees to be bound by the same contractual conditions as the original client, or by contractual conditions that may be applicable at the time of the report's use.

This report does not address issues in the domain of contractors such as, but not limited to, site safety, loss of volume due to stripping of the site, shrinkage of soils during compaction, excavatability, dewatering, shoring, temporary slope angles, construction means and methods, etc. Analyses of the soil for lead or mold potential, man-made asbestos, corrosivity, radioisotopes, hydrocarbons, or chemical properties are beyond the scope of this report. Ancillary features such as fences, flag and light poles, signage, drainage basins, and nonstructural fills are not within our scope and are also not addressed.

In the event that there are any changes in the nature, design, or location of improvements, or if any assumptions used in the preparation of this report prove to be incorrect, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and the conclusions presented in this report are verified or modified in writing by the geotechnical engineer and engineering geologist. The criteria presented in this report are considered preliminary until such time as any peer review or review by any jurisdiction has been completed; further geotechnical and geologic studies have been performed; and conditions are observed by the geotechnical engineer/engineering geologist in the field during construction.

Site Setting

The Arroyo Grande Oil Field encompasses several parcels of land on the east and west sides of Price Canyon Road between Pismo Beach and San Luis Obispo, California (See Vicinity Map in Appendix A). Based upon a review of San Luis Obispo County's Geologic Study Area (GSA) Database (2012a), the site is not located within a GSA. However, according to the Initial Study Summary by the County (San Luis Obispo County, 2012b), the site is in an area of low to high landslide risk, and low to moderate liquefaction potential.

Price Canyon Road, Pismo Creek and UPRR tracks bisect the site in a north-south direction. The site slopes upwards along several terraced benches to the east and west. The benches were constructed as a part of oil field production activities and are interconnected by a series of one-lane gravel and dirt roadways. Man-made fill slopes throughout the site vary from 1.25:1 to 2:1 gradients. Man-made cut slopes also vary from 2:1 to near vertical. Natural topography is characterized by a series of ridgelines terminating in the valley along Price Canyon Road. Three main ridgelines ascend to the west from Price Canyon Road; the valley between the two northern ridges is known as "Facility Canyon" where the new water reclamation and oil plant were recently constructed. On the east side of Price Canyon Road, beyond Pismo Creek and the rail road tracks, a main ridgeline ascends to the east. The slopes along the sides of the ridgelines vary from 20:1 to 1.2:1 gradients. The ridgelines ascend to the north and south and are developed with the aforementioned terraced well pads and roadways. Elevations also vary from a low point along Pismo Creek of approximately 100 feet above mean sea level (msl) to a high point of 495 feet msl. A Proposed Development Map is included in Appendix A.

Ranchland and heavily vegetated hillsides surround the project site in all directions. Vegetation consisting of brush, poison oak, seasonal grasses, and mature trees characterize the hillsides beyond areas developed for oil production. The proposed improvement areas for new and expanded well pads are also heavily vegetated as depicted in Figure 1.

Figure 1: Typical Vegetation (Maino 19J)

Drainage across the site is generally by sheet flow to a series of drainage, swales, and culvert crossings that all eventually discharge to Pismo Creek. Two water storage ponds are present in the northwestern portion of the site. Other improvements include above ground

piping used to connect well heads, steam generators, process equipment; two pipe bridges across Pismo Creek; the water reclamation, oil, and gas plants in Facility Canyon; construction lay down yards; and office buildings. We understand that there are potentially layers of buried underground piping throughout the facility as it was common practice to bury piping when the field was first developed. The majority of the pipes that currently serve the site are above ground. Any new piping will be above ground or within buried vaults accessible for service.

Construction of significant improvement projects in Facility Canyon has recently been substantially completed. These improvements included several tank pads, equipment pads, piping, and roadways. A series of terraced pads were constructed during the various phases of work. In reviewing geotechnical reports by Fugro (2011a, 2011b), portions of the upper canyon pads were improved using vibro-compaction to reduce the potential for dynamic settlement of structures during a seismic event. Other areas were overexcavated to depths in excess of 10 feet and geotextile reinforced fills were then constructed; often using chemically treated soils to increase strength and reduce excessive soil moisture. Throughout Facility Canyon, subsurface water and unstable soils were prevalent. According to Cannon, subdrains were also placed throughout the facility to aid in stability. Overall, Facility Canyon is known to be underlain by loose, compressible alluvial soils prone to static and dynamic settlement. It should be noted; however, that with the exception of two pads (Signal 117 and Rock 12 J), most of the new well pads are not located in the areas of Facility Canyon where such conditions are likely to exist.

2.0 INVESTIGATION METHODOLOGY

Site Reconnaissance

Site reconnaissance was performed by a State of California Licensed Geotechnical Engineer and a Certified Engineering Geologist on April 18, April 19, May 17, and December 6, 2013 to observe the geologic surface conditions on and adjacent to the site, the conditions of existing cut and fill slopes, geomorphic features, existing roadways, well pads, and other improvements. Photographs were taken of the features, many of which are presented herein. Existing cut slopes were observed for geologic conditions and mapped where appropriate.

Literature Review

Several sources of geologic and geotechnical literature, maps, and reports were reviewed to gain and understanding of the geologic formations and structure, and geotechnical characteristics underlying the proposed improvement areas. Other information was reviewed to gain an understanding of constraints identified by the County of San Luis Obispo. The following documents were reviewed:

- Geologic map of the Arroyo Grande Quadrangle by Hall (1973)
- Geotechnical Reports by Fugro (1997, 2011a, 2011b, 2012a, 2012b, 2012c) and Earth Systems Pacific (2013)
- San Luis Obispo County Planning Documents pertaining to the site (2012b, 2012c)
- Geologic literature associated with the area (Hall 1973 and Antonellini, et. al. 1999)

Geologic and Geotechnical Hazards

The site was assessed with respect to geologic and geotechnical hazards. These included the following:

- Seismicity and earthquake hazards
- Liquefaction, dynamic settlement, and lateral spreading
- Erosion of soil and rock materials
- Landslides and stability of existing and planned cuts and fills
- Rock fall potential
- Seepage and springs
- Naturally-occurring asbestos in bedrock materials
- Tsunami and seiche potential
- Grading of well pads and other improvements
- Slope angles of cuts and fills
- Differential settlement due to grading of well pads
- Expansive soils
- Roadway and pad stability during seasonal weather patterns
- Storm water infiltration of runoff from graded pads
- Other proposed improvements

The potential hazards are discussed and qualitative conclusions are presented where applicable. Geologic and geotechnical recommendations are also presented at the end of this report in an effort to aid with future planning and implementation of Phase V. The recommendations primarily focus on future studies that will be needed and considerations for the overall development of the well pads and improvements. Each well pad, the North Pipe Bridge, and UPRR undercrossing was photo documented and specific observations were made of each site. Exhibits of well pads and other improvements are presented along with a summary of the well pads and improvements in Appendix B.

3.0 GEOLOGY

Geologic Site Setting

The site is within the Coast Ranges geologic and geomorphic province. This province consists of north-northwest trending sedimentary, volcanic, and igneous rocks. It starts at the Transverse Ranges south and extends into northern California. Rocks of the Coast Ranges province are predominately of Jurassic and Cretaceous age; however, some pre-Jurassic rocks, along with Paleocene-age to recent sediments are also present.

Within southern San Luis Obispo County, the Coast Ranges province is dominated by the San Luis Range. The San Luis Range is an elongated, northwest trending mountain range that is generally composed of Miocene and Pliocene marine sedimentary bedrock formations. These formations are contained in the Pismo Syncline, a broad, open, northwest-trending fold. The axis of the syncline is located approximately 1/2 mile southwest of the site. The syncline is exposed along the entire length of the San Luis Range and is bounded to the south by the San Miguelito fault and to the north by the Los Osos fault zone. These faults juxtapose Mesozoic basement rocks (Franciscan mélange and serpentinite) against Miocene and Pliocene marine sedimentary rock units (Pismo, Monterey and Obispo formations).

The west-northwest trending Los Osos fault lies along the northeastern margin of the San Luis Range. The majority of the rocks exposed in the northeastern flank of the San Luis Range are of the Franciscan assemblage, which includes greywacke sandstone, shale, metavolcanic rock and serpentinite. The central axis and southwest flank of the range consists predominantly of marine sedimentary bedrock units, which include the Pismo, Monterey, and Obispo formations.

The geologic structure in the vicinity of the site consists of northwest-southeast trending faults and folds (anticlines and synclines). A Geologic Map showing many of the features is presented in Appendix A. Observed geologic conditions are presented on the Proposed Development Map, also in Appendix A. Hall maps the site as being underlain by surficial alluvial sediments that are deposited along the east side of the deeply incised channel of Pismo Creek. He also shows sedimentary bedrock of the Pismo Formation as being exposed along the hillsides east and west of Pismo Creek. The sediments form a terrace, likely disconnected from the floodplain of Pismo Creek, between the creek and the base of the hills to the east of the site.

The Pismo Formation is extensively exposed along the canyon ridges and in cuts along Price Canyon Road. Where the Pismo Formation is exposed at the site, it comprises the Edna Member. Hall describes the Edna Member as having three predominant units in the site

vicinity; Tmpe (bituminous sandstone), Tmpe2&3 (quartz sandstone), and Tmpec (pebbly conglomeritic sandstone). The bituminous sandstone includes folds with active tar seeps and is exposed in existing cuts throughout the project area. Antonellini et. al., mapped the Price Canyon Road area in detail, and attribute the bituminous (tar) as being trapped within the sandstone by deformation bands and faulting within the formation. The quartz sandstone is non-bituminous and is present in cuts along the north, south and west boundaries of the site. The conglomerate (pebble) sandstone is inter-bedded amongst the bituminous and quartz sandstone units.

Subsurface Geologic Profile

The subsurface geologic profile was evaluated based upon existing subsurface data from various reports by Fugro and Earth Systems Pacific, existing cut and fill slopes, and our experience in this area. A significant amount of subsurface information was gathered during the geotechnical investigations for improvements recently constructed in Facility Canyon in the western portion of the site. Other subsurface investigations have been completed for specific improvements in the east portion of the site. Refer to the Proposed Development Map in Appendix A for the general locations where subsurface information has been gathered for geologic and geotechnical studies.

Based upon the available subsurface data, the valleys are filled with alluvial soils and fills that consists of discontinuous lenses of silty sand, clayey sand, silt and clay. According to geotechnical investigations, these materials are prone to liquefaction, dynamic settlement, and consolidation. Bedrock of the Pismo Formation and specifically various submembers of the Edna Member were encountered at varied depths throughout these valleys. Depths to underlying rock greatly vary from 12 to over 70 feet (Fugro 1997, 2011a, 2011b, 2012a, 2012b, and 2012c and ESP 2013).

Existing cuts along well pads were generally at slopes of 1.25:1 to near vertical. At the tops of the cuts, a thin layer of topsoil consisting of sandy materials ranging in thickness from 0.5 to 3 feet was observed. Below the topsoil, bedrock of the Pismo Formation was present. In general, the Edna Member was the predominant material of the Pismo Formation observed throughout the cut slopes. Geologic units of the Edna Member consisted of light to dark gray bituminous sandstone, light buff quartz sandstone, and buff to gray pebble conglomerate sandstone. Structurally, these geologic units were thickly bedded to massive, moderately fractured and sheared. Occasional tar seeps were observed within the bituminous sandstone. In some of the exposed cuts, jointing within the bedrock was well defined with one to two different joint plane orientations.

Fill slopes on existing well pads were estimated to range from 1.25:1 to 2:1 gradients. The fills appeared to be constructed of crushed bedrock materials that consisted of a soil and rock matrix. The surfaces of some of the slopes were covered with loose soil material and were perforated with rodent burrows. Some slopes were vegetated with seasonal grasses and brush. Fill slopes void of vegetation tended to be scarred by erosional rills and gullies (See Figure 2).

While most of the existing pads were characterized by cuts in bedrock and fills composed of parent rock materials, some areas of the site are characterized by alluvium. Based upon observations of surface materials, these areas include Pulas 8, Maino 19N, Cutshack Demo, Rock 12 J, UPRR undercrossing, and Signal 117.

Figure 2: Erosion on Fill Slope (Pulas 3)

Other pads may also be characterized by alluvium rather than bedrock; however, subsurface investigations will be necessary to further characterize those pads. Cross-sections of proposed grading at Signal 129 (A-A'); B-Lo Signal 171 (B-B') and Maino 19 J Extension and Maino 16 NW Upper (C-C') were developed to depict specific examples of proposed grading (see Appendix A).

Based upon subsurface information and our observations, per Table 1613.5.2 in the 2010 CBC, the alluvial soils would be considered an S_D (stiff soil) profile and the bedrock at the site would be considered an S_C (soft rock) profile. These profiles are used in seismic response analyses which are presented in the Earthquake Ground Motions part of this report. Revision of the profiles may be warranted pending further evaluation and subsurface investigation.

Faulting

The Los Osos, Hosgri-San Simeon, and San Andreas faults are the most significant regional *active* faults within a 65-mile radius of the site; any of these could affect the Phase V project areas during its anticipated lifespan (see the Historical Earthquake/Fault Map in Appendix B). The closest mapped fault to the site, regardless of activity, is the mid-Pleistocene-age Indian Knob fault, which crosses the northeast corner of the site and is not considered active (Hall, 1973). The closest *active* fault to the site is the Irish Hills segment of the Los Osos Fault, located approximately 7.5 mile northwest. Summarized below are 11 faults that were considered to be the most capable of causing strong ground motion at the site. Other faults, such as the Indian Knob and Edna faults are not listed because they are not considered active or capable of causing significant ground motion during the life of the project.

Summary of Causative Faults (Caltrans, 2007)

Fault	Approximate Distance From the Site (miles)	Maximum Moment Magnitude (Mw)	Fault or Fault Segment Length (miles)	Slip Rate (mm/yr)
Los Osos – Irish Hills Segment	7.5	7.0	9	0.5 ± 0.4
San Luis Range (S. Margin)	3.3	7.2	40	0.2 ±0.1
Rinconada	10	7.5	117	1.0 ± 1.0
Hosgri – San Simeon	14	7.5	107	2.5 ± 1.0
Casmalia (Orcutt Frontal Fault)	18	6.5	18	0.25 ± 0.2
Lions Head	22	6.6	25	0.02 ± 0.02
San Juan	29	7.1	42	1.0 ± 1.0
Los Alamos (W. Baseline)	34	6.9	17	0.7 + 0.7
San Andreas (Cholame)	39	7.3	38	34 ± 5
San Andreas (1857 Rupture)	39	7.8	214	34 + 5
San Andreas (Parkfield Segment)	43	6.6	23	34 ± 5

Groundwater

Based upon available subsurface information from Fugro, subsurface water was encountered in Facility Canyon at varied depths of 5.5 to 17.5 feet during subsurface investigations in 2007. Subsurface investigations by Fugro and Earth Systems Pacific on the east portion of the site for the Southern Pipe Bridge and the Hyla Steam Plant (Fugro 1997, 2012b and ESP 2013) indicate that depth to groundwater varied from 33 to 43 feet below the ground surface. Pismo Creek in this area has a flow line that is approximately 40 feet lower than the exploration locations.

4.0 GEOLOGIC HAZARDS AND GEOTECHNICAL ASSESSMENT

GEOLOGIC HAZARDS

Earthquake History

The historic seismicity in the region of the site was researched with a computer software program called EQSEARCH (Blake 2010). EQSEARCH is a program that performs automated searches of a custom catalog of historical Central California earthquakes. As the program searches the catalog, it determines the epicentral distance from the selected site to each of the earthquakes within the specified search area. The epicentral distances should be considered estimates, particularly for earthquake data prior to 1932, when modern instruments were first used to record earthquake data. The parameters used for the search consisted of earthquake Richter magnitudes ranging from 5.0 to 9.0 that occurred within a 65-mile radius from the site from 1800 to 2010. The specific method of analysis was developed by Boore and others (1997). A very dense soil/soft rock profile (S_C), applicable to well pad areas underlain by shallow bedrock, and a stiff soil profile (S_D) for well pad areas underlain by alluvium. Chapter 20 of ASCE 7-10 (ASCE 2010) was used to define the subsurface profile type.

Results of the search indicated that within the search parameters, 42 earthquakes have occurred (see the EQSEARCH results in Appendix B). The highest peak horizontal ground acceleration (PGA) estimated to have occurred at the site from those historical earthquakes is 0.24g for stiff soil (S_D) profiles and 0.19g for soft rock (S_C) profiles. These both were developed from the same earthquake. This earthquake, which occurred on the Hosgri fault and is known as the "Lompoc Earthquake," had a 7.5 magnitude, occurred in 1927, and was located approximately 20 miles southwest of the site (see the Historical Earthquake/Fault Map in Appendix B).

The largest magnitude earthquake that the search revealed had a 7.9 magnitude. This earthquake was located approximately 46 miles southeast and was known as the "1857 Earthquake" on the San Andreas fault. It produced an estimated PGA of 0.16g for S_D profiles and 0.12g for S_C profiles. The closest earthquake to the site was 5 miles north and had a magnitude of 5.7. It produced an estimated PGA of 0.24g for S_D profiles and 0.18g for S_C profiles.

Earthquake Ground Motions

The site is in a region of generally high seismicity and has the potential to experience strong ground shaking from earthquakes on regional or local causative faults. To characterize the seismicity at the site and to provide seismic design parameters, a Seismic Hazard Analysis was performed, using the United States Geological Survey Earthquake Hazards Program website (USGS, 2013). Maximum Considered Earthquake (MCE) ground motions were used in the analyses. The latitude (35.1857 north) and longitude (120.6194 west) of the central area of the site were determined from Google Earth (Europa Technologies 2013) and used in the analyses. The Seismic Design Response Acceleration Parameters are included in the following tables for very dense soil/soft rock (S_C) and stiff soil (S_D) subsurface profiles, respectively. Parameters were calculated in accordance with Chapter 16 of the 2013 CBC (CBSC 2013) and ASCE 7-10 (ASCE 2010).

SEISMIC DESIGN RESPONSE ACCELERATION PARAMETERS

Very Dense Soil/Soft Rock - Site Class C (S_C)

Mapped Acceleration Values for Site Class B		2013 CBC Site Coefficients and General Procedure Adjusted MCE Spectral Response Acceleration Parameters For Site Class C Site Coordinates: 35.1857; -120.6194					
Seismic Parameter	Value (g)	Site Coefficients	Value	Seismic Parameter	Value (g)	Seismic Parameter	Value (g)
S_S	1.30	F_a	1.00	S_{MS}	1.30	S_{DS}	0.861
S_1	0.487	F_v	1.31	S_{M1}	0.639	S_{D1}	0.426

Stiff Soil - Site Class D (S_D)

Mapped Acceleration Values for Site Class B		2013 CBC Site Coefficients and General Procedure Adjusted MCE Spectral Response Acceleration Parameters For Site Class D Site Coordinates: 35.1857; -120.6194					
Seismic Parameter	Value (g)	Site Coefficients	Value	Seismic Parameter	Value (g)	Seismic Parameter	Value (g)
S_S	1.30	F_a	1.00	S_{MS}	1.30	S_{DS}	0.861
S_1	0.487	F_v	1.51	S_{M1}	0.737	S_{D1}	0.491

Peak horizontal ground accelerations (PGA) based upon mapped MCE values for PGA were also calculated for the sites using the USGS website. The calculated PGA value was 0.552g regardless of the site classification.

Surface Ground Rupture

Surface rupture is the displacement and cracking of the ground surface that occur along a fault trace. Unlike seismically-induced ground shaking, which can affect a wide geographic area, surface rupture is confined to the area very near the fault. The project site is not located in an Alquist-Priolo Earthquake Fault Zone, and there are no mapped active faults immediately adjacent to or crossing the site. The closest mapped active fault to the site is the Irish Hills segment of the Los Osos Fault, located approximately 7.5 mile northwest. As surface ground rupture requires the immediate presence of a fault, the potential for surface fault rupture to occur at the site is considered to be very low to nil.

Liquefaction, Dynamic Settlement, and Lateral Spreading

The term liquefaction refers to a phenomenon that tends to occur in saturated soils of low density and that have grain sizes within a certain range, usually fine- to medium-grained poorly graded sands, silty sands, and silts. A sufficiently strong earthquake is also required to cause liquefaction. During liquefaction, the energy from the earthquake causes the water pressure within the pores of the soil to increase. The increase in water pressure decreases the friction between the soil grains, allowing the soil grains to move relative to one another. During this state, the soil will behave as a viscous liquid, temporarily losing its ability to support foundations and other improvements. The high pressure water will flow through the soil along the path of least resistance. As the pressure is released, the soils typically settle in a process called "dynamic settlement." Dynamic settlement can cause damage to structures and other surface and subsurface improvements.

Input parameters for liquefaction analysis include soil susceptibility, earthquake magnitude and PGA. Studies on soil susceptibility have found that silts and clays with low plasticity indices (PI) of less than 12 and high water content (W_c) to liquid limit (LL) ratios greater than 0.85 are susceptible to liquefaction during a seismic event (Bray & Sancio, 2006).

Much of the alluvial areas in Facility Canyon and along Pismo Creek have been evaluated for liquefaction potential. This evaluation was summarized in several reports by Fugro and found to be a significant geotechnical issue with respect to the improvements associated with the projects in that area. Well pads and improvements in the Facility Canyon area and where alluvium is present should have the specific potential for liquefaction evaluated. These include the UPRR undercrossing, Pulas 8, Maino 19N, Cutshack Demo, Rock 12 J and Signal 117. Well pads and improvements in areas characterized by shallow bedrock would not be prone to damage from liquefaction.

Associated with liquefaction would be the possibility of lateral spreading. Lateral spreading is the propensity of a soil mass to move laterally due to liquefaction of an underlying soil layer. It generally occurs on sloping ground or where there is a nearby descending slope (typically referred to as a "free face") overlying the liquefied zone (Zhang et. al, 2004). During a liquefaction event, the soils tend to "spread" laterally toward the slope. At this site, the majority of the well pads will not be situated adjacent to creeks or in areas that may have a combination of shallow groundwater and sloping topography. From a cursory standpoint, Signal 117, Cutshack Demo, and Rock 12 J are pads that could be prone to lateral spreading.

Specific areas of the proposed development could be subject to liquefaction, dynamic settlement, and lateral spreading. At a minimum, Pulas 8, Maino 19N, Cutshack Demo, Rock 12 J and Signal 117 should be further evaluated with respect to liquefaction as development progresses.

Erosion

The potential for erosion to occur varies within the different geologic units exposed in the cut slopes. Some evidence of erosion, such as rilling or gullying, was observed on the faces of cuts, especially slopes cut into quartz sandstone, pebbly conglomerate, and alluvium. In general, the bituminous sandstone is fine to medium grained and slightly to moderately cemented. It therefore, has a relatively low erosion potential. The quartz sandstone and pebble conglomerate geologic units have a moderately high potential for erosion as these units are medium to coarse grained and poorly cemented. When precipitation penetrates the outer layers of the two bedrock types, a swift weathering process occurs and results in minor episodic erosion. This is evidenced by soil berms that appeared to be deposited by erosion along the toes of cut slopes in the quartz sandstone and pebbly conglomerate materials. Furthermore, erosion of cementitious materials within joints and fractures on slope faces can lead to localized block or wedge failures. An example of this condition can be seen in Figure 3.

Figure 3: Localized Block Failures (Signal 129)

Site soils have high to very high potential for erosion due to their medium to coarse grained characteristics and relatively low silt and clay content. Erosion of fill slopes is generally by sheet flow; however, due to the medium to coarse grained characteristics of the site soils, rill erosion and shallow gullies can occur if concentrated surface water is allowed to flow over the slopes. The design of pads should control drainage and not allow concentrated flows over fill slopes. To reduce the potential for significant erosion, lined swales, V-ditches, erosion protection blankets and tackifiers, vegetation, and mid-slope benches should be incorporated into the design.

Landslides and Slope Stability

Cut Slopes

As previously discussed, geologic units of the Edna Member exposed along cuts were composed of bituminous sandstone, quartz sandstone and pebble conglomerate. No evidence of gross instability was observed during our reconnaissance. However, surficial instability and minor or localized block, topple, and wedge failures were observed in some of the cut slopes.

The majority of the bedrock units observed in the cut slopes are thickly bedded to massive. Where bedding is thin and dips out of slope, there is a moderate to high potential for small block failures to occur along the bedding and joint planes. These failures appear to be confined to localized or isolated areas within the bedrock. This is due to discontinuities in the beds and joints (e.g. shear zones and folds), which changes bedding orientation and reduces instability. Small block failures were also observed in some of the cut slopes. They are typically due to adverse bedding. One such failure is shown in Figure 4. These failures occur as a result of bedding dipping out of slope.

Figure 4: Bedding Plane Failure (Roadway)

Topple failures are small block-like failures that typically occur along the tops of cut slopes, but can sometimes occur within a slope face. As the bedrock weathers along fracture or joint planes, the fractures or joints widen due to erosion. As fractures or joints widen over time, blocks become detached from the slope face and topple down the slope. Expansion and contraction of the bedrock units also contribute to the detachment of the block from the face of the slope. Small blocks of bedrock lying along the bottom of a slope are evidence of topple, block and wedge failures as seen in Figure 4.

Based upon the history of the site, FMOG is accustomed to maintaining pads and roadways when periodic block and wedge failures occur. As slopes are cut during Phase V development, there will be a potential for adverse bedding. The potential will largely depend upon the bedding orientation, final slope gradient, and the geologic conditions. With monitoring during grading by a Certified Engineering Geologist, the potential for significant block and wedge failures could be reduced, provided that the grading contractor has the allowance to flatten portions of cut slopes as needed. Additional discussions pertaining to cut slope angles are presented later in this report.

Natural Slopes

During our reconnaissance, the natural slopes generally appeared to be grossly stable. However, a questionable area was noted by proposed well pads Maino 19 J Extension and Maino 16 NW Upper. This area was preliminarily mapped as colluvium or potential landslide debris (see Proposed Development Map in Appendix A). The slope geometry in this area appears to be irregular and hummocky, suggesting that this natural slope is unstable and episodes of sloughing and failure have occurred. The cut slope along the road below Maino 19 J comprises a mixture of dense soil and broken rock fragments suggesting that this material is landslide debris and/or colluvium. Given the topographic features, the area is likely a deep section of colluvium within an ancient drainage feature. However, the potential that this is a historic landslide cannot be ruled out without some amount of subsurface investigation. Further investigation of this area is recommended to adequately assess whether or not a landslide is present and the extent of the irregular feature.

Fill Slopes

Fill slopes are generally at angles of 1.25:1 to 2:1 and appeared during our reconnaissance to be grossly stable. Fill soils generally appear to consist of medium to coarse sand with gravel and cobbles, which are generally considered to be stronger than fine grained soils (such as silt or clay. Stronger soils, if properly placed and compacted, can often be constructed at slopes steeper than 2:1; however, further investigation and analyses of the stability of specific slopes should be undertaken to determine the appropriate angles for fill slope construction. Slope stability analyses are especially important where loads from drill rigs and other equipment will be in close proximity to the tops of existing and future fill slopes. A further discussion of fill slope angles is presented later in this report.

Rock Fall

Rock falls are somewhat related to topple failures as they occur when rocks become detached from a slope or are undermined by erosion. The majority of rock falls occur during or immediately after inclement weather where surface runoff erodes soil within fractures in the formation and reduces stability of the rock. Rock falls can also occur due to ground shaking during an earthquake. Figure 5 is an example of a potential rock fall near Maino 16J. The potential for rock fall is higher where cut slopes are steeper than 1:1, such as the slope in Figure 5. During construction slopes should be cut at designed angles and observed during excavation by a Certified Engineering Geologist. These measures would greatly reduce the potential for rock fall.

Figure 5: Rock Fall Potential (Maino 16 J)

Seepage and Springs

The majority of the evidence of springs observed on site was in the vicinity of drainage swales and along Facility Canyon. These were evidenced by the presence of cattails, lush broad leafed grass, green vegetation, and moist soil conditions. Evidence of springs was also observed on Rock 12 J, along the proposed road to Signal 20 Abandoned, upslope and adjacent to Signal 48, and along the south and west, upslope areas of Signal 121. Based upon topography, any grading around the Facility Canyon area will likely be subject to seepage and spring potential. In addition, seepage could occur at bedrock/alluvium contacts. Geotechnical reports for Facility Canyon, Fugro (2011a, 2011b) discusses the potential for seepage and springs throughout this area.

Figure 6: Evidence of Seepage along Road 1D to Signal 20

The water storage pond in the northwest area of the site could also be causing some seepage along the proposed access road 1D to Signal 20. Several areas of lush, green vegetation were noted and some swamp-like conditions were present downslope of the pond. This condition is depicted in Figure 6.

Figure 7: Tar Seepage on Signal 149

The bituminous sandstone (Tmpe) of the Edna Member is also known to have tar seeps within the formation. Antonelli et. al. (1999) discuss the extent of such seeps. There are several locations along Price Canyon Road where tar seeps are present in cuts that have been made in the formation. Seeps were seen in several other areas as were blocky sections of the rock that were saturated with tar material. Any cuts in the bituminous sandstone will likely encounter similar conditions where tar seeps might be present. An example of a tar seep on Signal 149 can be seen in Figure 7.

Naturally-Occurring Asbestos

Asbestos can occur naturally in certain rock formations, such as those that include serpentinite or ultramafic rock. The site is underlain by bituminous sandstone, quartz sandstone and pebble conglomerate of the Edna member of the Pismo Formation, which are not asbestos-bearing geologic units. Therefore, the potential for naturally-occurring asbestos to be present at the project is considered to very low.

Tsunami and Seiche Potential

Hazardous tsunamis along the California coastline can be caused by vertical displacement of submarine faults, or by submarine landslides. Tsunamis along the central California coast are relatively rare, and only a few such events are well documented. One of these occurred on November 4, 1927, when a major earthquake occurred off the coast of Point Arguello. The earthquake, known as the "Lompoc Earthquake," produced a tsunami that reached a height of 6 feet above mean high tide level along the coast of San Luis Obispo County.

The project site lies 2.5 miles from the Pacific Ocean at elevations over 100 feet above mean sea level; therefore, the potential for the site to be affected by a tsunami event is considered to be nil. The site is *not* located in the County of San Luis Obispo Tsunami Inundation Zone (July 2009).

A seiche is a single water wave that can be generated in a reservoir, lake or pond as the result of long-period surface waves normally caused by strong local earthquakes or larger earthquakes at farther distances. The site is not situated near any significant bodies of water or lake and the two storage ponds are relatively small. Therefore, the potential for a seiche to affect the site is nil.

GEOTECHNICAL ASSESSMENT

Grading

Grading for the various well pads will involve a myriad of operations ranging from cleaning up stockpiles and removal of brush, to significant cuts up to 45 feet and fills of 35 feet. We understand that grading will likely occur over several phases with a few pads graded at a time to provide access for drill rigs. The majority of grading will be performed on ground that is estimated to range from nearly flat to about 1.5:1. The surfaces of some of the existing fill slopes are composed of loose soil, significant vegetation, and in some cases organic waste, such as the wood chippings found on Signal 124. Existing cut slopes were historically cut at steep slope angles that range from about 1.25:1 to near vertical.

Preliminarily, most of the cut slopes for the well pads have been designed for 1:1 slopes (Cannon 2013). A more detailed discussion regarding cut and fill slope angles is presented in the next section. It is estimated that the majority of cuts will occur in the underlying Edna Member of the Pismo Formation. Anticipated bedrock materials consist of quartz sandstone, bituminous sandstone, and pebbly conglomerate sandstone. A more detailed estimation of where these materials will be encountered is presented on the Proposed Development Map in Appendix A. Based upon discussions with FMOG personnel and our experience in this area, bedrock materials are anticipated to be readily excavatable with dozers equipped with rippers (such as a Caterpillar D6 or D8) and excavators (such as a Caterpillar 325) equipped with rock teeth on their buckets. The most difficult material to excavate will likely be the bituminous sandstone and pebbly conglomerate. Scars from previous grading that occurred a number of years ago are still present in some locations indicating relatively hard indurated conditions (see Figure 8).

Figure 8: Scars from Previous Grading in Bituminous Sandstone (Signal P1-I1)

Where fill will be placed on sloping ground, hillside grading procedures will be necessary to construct stable well pads. This is especially the case where fills will be constructed on slopes that are 5:1 or steeper. Keyways and benches should be provided where fills will be constructed on such slopes; benches by themselves may be considered suitable for slopes flatter than 5:1. Refer to the Typical Bench and Keyway Detail in Appendix D for preliminary guidance regarding grading on sloping ground. There would also be a need to provide drainage of fills constructed on slopes; a Typical Back Drain Detail is also provided in Appendix D for reference. Where new fills are placed along existing fills, substantial benching into existing fill material will also be necessary to connect the two fills together.

Fill operations will consist of placing cut bedrock material as compacted fill. Moisture conditioning of fill material will be necessary to aid in compaction. It is anticipated that the cut bedrock materials will break down under large padded drum compactors. For these types of materials, a steel-wheeled padded drum compactor such as a Caterpillar 815 or 825 would be

beneficial because the wheels would break down bedrock materials and the blade on the front of the compactor can be used to spread and mix fill material as it is placed and compacted. Smaller pad drum compactors such as the CP series from Caterpillar will not likely be suitable as they are not heavy enough to suitably break down the excavated rock material.

When cut bedrock materials are placed as fill, it will be necessary to mix and break down the oversize fragments so that nesting of rocks and boulders does not occur. Depending upon the methods of excavation, bedrock that has been removed be produced from cuts could range in size from 6 inches up to 3 feet in dimension. Such materials will need to be broken down and placed in a sufficient soil matrix to ensure that voids caused by nesting of the rocks will not occur and that the fill can be properly compacted. Based upon information from FMOG and Cannon, we understand that during placement of fill that has come from cut bedrock, there is generally 20 percent shrinkage. Meaning that the bedrock is less dense in its current intact condition and when removed, processed and compacted. It would be prudent when planning cut and fill quantities, for a suitable amount of shrinkage to be incorporated.

Seepage of water was not observed in any of the cut slopes during our reconnaissance. However, we understand that springs are present in isolated areas of the site and are especially prevalent in and around Facility Canyon as previously discussed. Depending on weather patterns and the time of year, springs and subsurface water may be encountered during grading of well pads.

Proposed cuts and fills will vary in depth, topography and size for each well pad. As a result, evaluation and development of specific recommendations for grading of the well pads will be necessary prior to development. Based upon the preliminary grading plans, some of the pads will not require significant investigation; however, other pads will necessitate design-level geotechnical and geologic investigations and development of specific recommendations. Additional information pertaining to specific well pads is provided on the Well pad and Improvement Exhibits in Appendix C. A cursory identification of the pads that will need additional investigation and recommendations is also provided on the Well Pad and Improvement Summary in Appendix C.

Cut and Fill Slope Angles

The Phase V project will involve a total of about 67 disturbed acres. It is our understanding that keeping the disturbed area as small as practicable is a project goal. Cut and fill slope angles will greatly affect the total disturbed area of this project. The steeper the slopes for cuts and fills the less area that will be disturbed. Overall, initial plans indicate that cuts will be made at 1:1

and fills at 1.5:1 slope angles. If these slope angles can be further steepened, however, the disturbed area will be reduced, saving excavation costs, reducing the amount of vegetation and habitat take, and other benefits. While this may be a project goal, the cut and fill slope angles need to be designed and the pads constructed so that they are grossly stable.

Most of the existing slopes that were cut in bedrock vary from 2:1 to near vertical. The slopes that were cut at steep angles in bituminous sandstone of the Edna Member have generally remained stable with little erosion or weathering of the cut surface as depicted in Figure 8 on Page 19.

Cuts that were made in the quartz sandstone of the Edna Member are more prone to erosion and block failure can be seen in Figure 9. The quartz sandstone is generally more susceptible to weathering and saturation from precipitation. These characteristics lead to an increased potential for erosion and intermittent block failures.

Figure 9: Erosion and Block Failure of Cut in Quartz Sandstone (Signal 124)

In general, cuts that were made at 1:1 are in fair condition with little or no issues regarding stability or failures. Steeper cut slopes appear to be more prone to block and topple failures, and surficial instability due to weathering. With further evaluation and investigation, some cuts in bedrock may be steepened from planned 1:1 angles to possibly 1/2:1; however, specific evaluation by a Certified Engineering Geologist of these slopes will be necessary prior to and as the cuts are made. For preliminary planning purposes, cuts in bedrock should be designed for 1:1 and cuts in soil above the rock should be designed for 2:1 with the understanding that flatter slopes may be warranted depending upon the conditions encountered at the time of construction.

Based upon observations in the field, FMOG has a maintenance program to address periodic localized block failures of cut slopes. We understand that detritus from failures is either cleaned up or just moved to the toe of the cut slope to allow traffic to cross the pad and roadway. Given FMOG's ability to deal with failures on an operational basis, in some cases it may be better to construct slightly steeper slopes and allow moderate periodic failures than to flatten slopes in an attempt to completely avoid failures. Caltrans typically designs slopes with

the anticipation of periodic maintenance. As the pads and roads will not be open for public use, this could be a suitable option. Regardless, a Certified Engineering Geologist should observe cuts slopes as they are constructed so that any adverse bedding can be mitigated to reduce the potential for localized block failures.

With the exception of recent fills placed for the projects in Facility Canyon, most observed fills at the site are steeper than 2:1. Some of the fills, such as the roadway fill leading up to Signal 171, are at an approximate angle of 1.25:1 and appear to be grossly stable. It is likely that this fill was placed as properly compacted and moisture conditioned material in a controlled manner. Conversely, other fills (such as those placed for Signal 306/Signal 303) appear to be in a loose condition and significant erosion has occurred (see Figure 2 – Pulas 3 on Page 9). The site soils and anticipated material that will be generated from cuts in bedrock is judged to have sufficient strength to potentially allow the construction of fill slopes up to 1.5:1. This is under the assumption that fills are placed in a controlled fashioned that includes adequate keyways and benches cut into bedrock or other firm material, sufficient overbuilding of slopes to allow cutting back into compacted material, and inspection and testing by the Geotechnical Engineer during construction.

Differential Settlement

Differential settlement can occur when pads are constructed of materials with differences in compression characteristics, such as fill and bedrock. Based upon the preliminary grading plans (Cannon 2013), several well pads will be constructed such that portions of the pads will be in cut and other of fill. The fill is expected to settle relative to cuts in the underlying bedrock. We understand that the pads will only be used for oil wells and virtually no equipment will be constructed on permanent foundations. The temporary drill rigs and work over rigs are equipped with leveling jacks to accommodate localized settlement of subsurface soils and the crews are familiar with localized settlement under these pads.

Figure 10: Linear Rod Pumps

Furthermore, we understand that new wells will be equipped with LRP units to extract oil. LRP's (pictured in Figure 10) are attached directly to the well head and do not require large footings as the more familiar beam style pumps. Differential settlement of well pads is expected to

occur, but based on the proposed use of the pads, such an occurrence is not likely to be of significant concern. However, FMOG should be aware that the potential exists, especially where deep fills are planned.

Expansive Soils

Expansive soils tend to swell with seasonal increases in soil moisture and shrink during the dry season as soil moisture decreases. The volume changes that the soils undergo in this cyclical pattern can stress and damage slabs and foundations if precautionary measures are not incorporated into the design and construction. While isolated areas of soils with increased expansion potential could be exposed during grading, the potential for expansive soils to affect the site and planned development is considered to be very low.

Roadway and Pad Stability

The site is a 24-hours per day, 7 days per week operation regardless of weather. For that reason, vehicle access to well pads and roadways is necessary for servicing of equipment and wells. In general, the roadways and pads will likely be stable during most of the year; however, during and following inclement weather, instability could occur where road and pad surfaces become saturated. We understand that a significant amount of soil generated during the projects in Facility Canyon was chemically treated with cementitious products to dry and increase the strength of the soil. Depending upon the location of the pad, similar operations may be warranted. Geotextiles, gravel, and aggregate base could also be used to stabilize otherwise unstable areas. In general, roadway and pad stability due to saturated soil conditions is not expected to be a significant issue at this site.

Storm Water Infiltration

The increase in surface area from development of the well pads will lead to additional storm water during precipitation events. As previously discussed, erosion is a significant concern at the site if concentrated flows are allowed to traverse fill slopes and materials prone to erosion. The plan to address additional runoff is currently being developed and will likely depend upon agency requirements. For the most part, in developing storm water infiltration techniques, designers should not allow water to flow over or down slopes, water should not be allowed to pond or infiltrate at the tops of fill slopes, and the subsurface soil and rock will likely allow some infiltration with the quartz sandstone and soil presenting greater infiltration rate characteristics than the bituminous sandstone and pebbly conglomerate.

Other Improvements

UPRR and Roadway Undercrossings

As previously discussed, pipe crossings are planned under UPRR tracks, Ormonde Road, and Price Canyon Road. An exhibit of the proposed crossing area for the UPRR location is presented in Appendix C with the Well pad and Improvements Exhibits. The area of the planned UPRR and Ormonde Road crossings is generally at the same elevation as, or slightly lower than the route. The Price Canyon Road crossing will cut through the prism fill for the roadway, which is situated approximately 10 feet above the anticipated pipe invert elevation. We understand that jack and bore methods are being considered for installing the new carrier pipes that will house production piping. Further geotechnical investigation of the crossing areas should be performed to characterize the site and to provide subsurface information.

Northern Pipe Bridge

The existing northern pipe bridge over Pismo Creek will be replaced at a slightly higher elevation. Vegetation has grown over the existing bridge and it was difficult to access during our site visit. Cannon indicates that the creek banks are covered with loose sand soils and the existing foundations are slated to be reused provided they are deemed adequate for the proposed loads (Cannon 2013). Based upon our site visit, bedrock was exposed west of the northwestern abutment location and the conditions of the other side of the creek bank are unknown as they were not readily accessible. We understand that the same type of bridge will be constructed at a slightly higher elevation. An exhibit of the proposed pipe bridge crossing is presented in Appendix C with the Well pad and Improvement Exhibits. Further investigation of the existing foundations should be performed once vegetation is cleared from the existing foundations.

Steam Generators

A new steam generator (Edna AG-7) will be constructed adjacent to other generators in the Facility Canyon Area. It is anticipated that the new generator will be erected on a large slab-on-grade foundation. We understand that remedial grading for this area was conducted during construction of the improvements in Facility Canyon. No additional investigation for this generator is warranted from a geotechnical standpoint.

Two steam generators are planned on Signal 150 (Pad No. 38) as a part of the Phase V development. It is anticipated that these generators will be erected on large slab-on-grade foundations. As little subsurface information is available for this area, further geotechnical investigation is warranted for these generators.

5.0 RECOMMENDATIONS

The site is generally considered suitable, from a geologic and geotechnical engineering standpoint, for the proposed Phase V project. No conditions were observed that would constitute a sufficiently severe geotechnical/geologic constraint that constructing the proposed project would be precluded. This report is intended as a planning and guidance document to aid in development of future investigations and design of the well pads and other improvements. From a cursory standpoint, the primary geologic and geotechnical concerns anticipated at this site are the potentials for differential settlement on well pads, gross stability of slopes, the potential for surficial instability of cut and fill slopes, seepage, the potential for landslides, and the erodible nature of site soils. The following general items are recommended as Phase V development and planning progresses:

- Cut slopes in soil should be designed for 2:1 slope angles.
- Cut slopes in bedrock may be *preliminarily* designed for 1:1 slope angles.
- Fill slopes may be *preliminarily* designed for 1.5:1 slope angles.
- Concentrated drainage should not be allowed to flow over cut or fill slopes.
- Fills on sloping ground should be keyed into underlying firm material (bedrock) and subsequent benching will be necessary as fill is placed and compacted.
- Cut slopes should be observed and evaluated by a Certified Engineering Geologist at the time of construction. Flatter slopes or removal of adverse bedding may be further recommended at the time of construction, depending upon observed conditions.
- Site specific geotechnical and geologic investigations should be performed for pads where cuts and fills are planned. The investigations should include subsurface exploration, laboratory analyses, evaluation of liquefaction, differential settlement, slope stability, and other geologic and geotechnical concerns as deemed necessary. Specific recommendations for grading of the well pads and other improvements should be developed for the individual pads. A table summarizing recommended additional geotechnical and geologic services for the well pads and improvements is presented in Appendix C.

6.0 CLOSURE

Our intent was to perform this assessment in a manner consistent with the level of care and skill ordinarily exercised by members of the profession currently practicing in the locality of this project and under similar conditions. No representation, warranty, or guarantee is either expressed or implied. This report is intended for the exclusive use by the client as discussed in the "Purpose and Scope of Work" section of this report. Application beyond the stated intent is strictly at the user's risk.

This report is valid for conditions as they exist at this time for the type of project described herein. The conclusions and recommendations contained in this report could be rendered invalid, either in whole or in part, due to changes in building codes, regulations, standards of geologic, geotechnical or construction practice, changes in physical conditions, or the broadening of knowledge.

If changes with respect to development type or location become necessary, if items not addressed in this report are incorporated into plans, or if any of the assumptions used in the preparation of this report are not correct, this firm shall be notified for modifications to this report. Any items not specifically addressed in this report should be planned and designed in accordance with the CBC and the requirements of the governing jurisdiction.

The preliminary recommendations of this report are intended to guide the project as it progresses and are based upon the geologic and geotechnical conditions observed at site and may be augmented by additional requirements of the engineer, or by additional recommendations provided by this firm based on site specific studies and conditions exposed at the time of construction. Well pads and proposed improvements should be addressed with specific recommendations as the project progresses.

This document, the data, conclusions, and recommendations contained herein are the property of Earth Systems Pacific. This report shall be used in its entirety, with no individual sections reproduced or used out of context. Copies may be made only by Earth Systems Pacific, the client, and the client's authorized agents for use exclusively on the subject project. Any other use is subject to federal copyright laws and the written approval of Earth Systems Pacific.

Thank you for this opportunity to have been of service. If you have any questions, please feel free to contact this office at your convenience.

End of Text.

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APPENDIX A

Vicinity Map
Geologic Map
Proposed Development Map
Cross-Sections A-A', B-B', and C-C'

VICINITY MAP

FMOG - Arroyo Grande Oil Field - Phase V
1821 Price Canyon Road
San Luis Obispo County, California

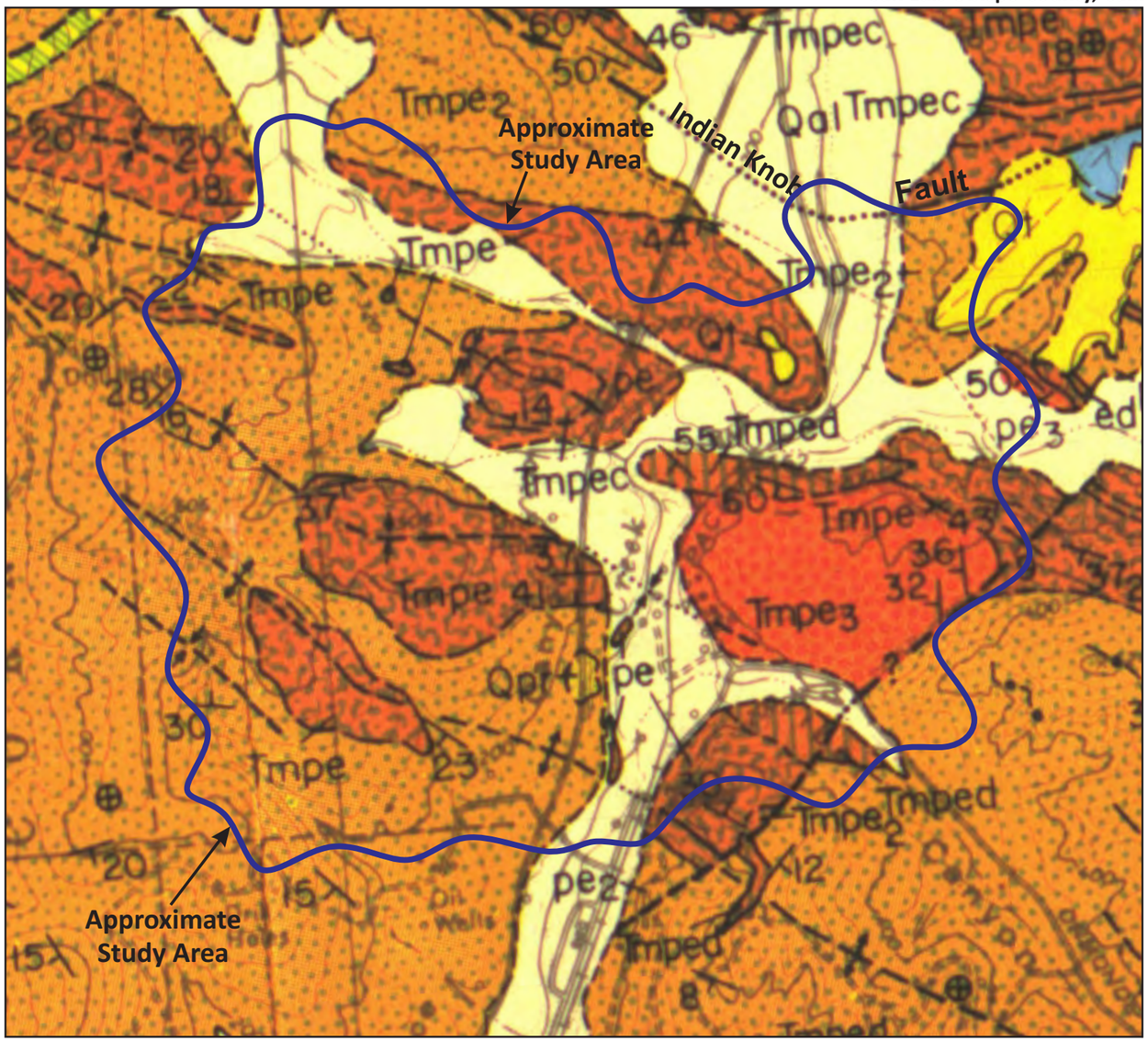
Extract from: USGS 7.5 minute Quadrangles,
San Luis Obispo and Pismo Beach, California

EARTH SYSTEMS PACIFIC
(805) 544-3276 - (805) 544-1786
4378 Old Santa Fe Road, San Luis Obispo, CA 93401
www.earthsys.com - email: esp@earthsys.com

December 2013
SL- 17061-SC

GEOLOGIC MAP

FMOG - Arroyo Grande Oil Field - Phase V
1821 Price Canyon Road
San Luis Obispo County, California



Extract from: Geologic Map of the Arroyo Grande Quadrangle, San Luis Obispo County, California, by Clarence A. Hall, 1973

Geologic Units

Qal

Alluvial deposits
-unconsolidated gravels, sand, silt and clay

Qt

Terrace deposits

Tmpe	$Tmpe_2$	$Tmpe_3$	Tmped	Tmpec

Pismo Formation
Edna member
Tmpe: bituminous quartz sandstone
$Tmpe_2$: non-bituminous arkosic or quartz sandstone
$Tmpe_3$: coarse grained quartz sandstone
Tmped: dolomitic hard sandstone
Tmpec: conglomerate (pebble)

EXPLANATION

Geologic Symbols

Contact
Dashed where approximately located or inferred

High-angle fault
Dashed where approximately located or inferred; dotted where concealed

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

Anticline
Showing axis at surface. Dashed where approximately located; dotted where concealed

Syncline
Showing axis at surface. Dashed where approximately located; dotted where concealed

⊕ 30 90
Horizontal Inclined Vertical
Strike and dip of beds

N

Approx. Scale: 1" = 1000'

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December 2013

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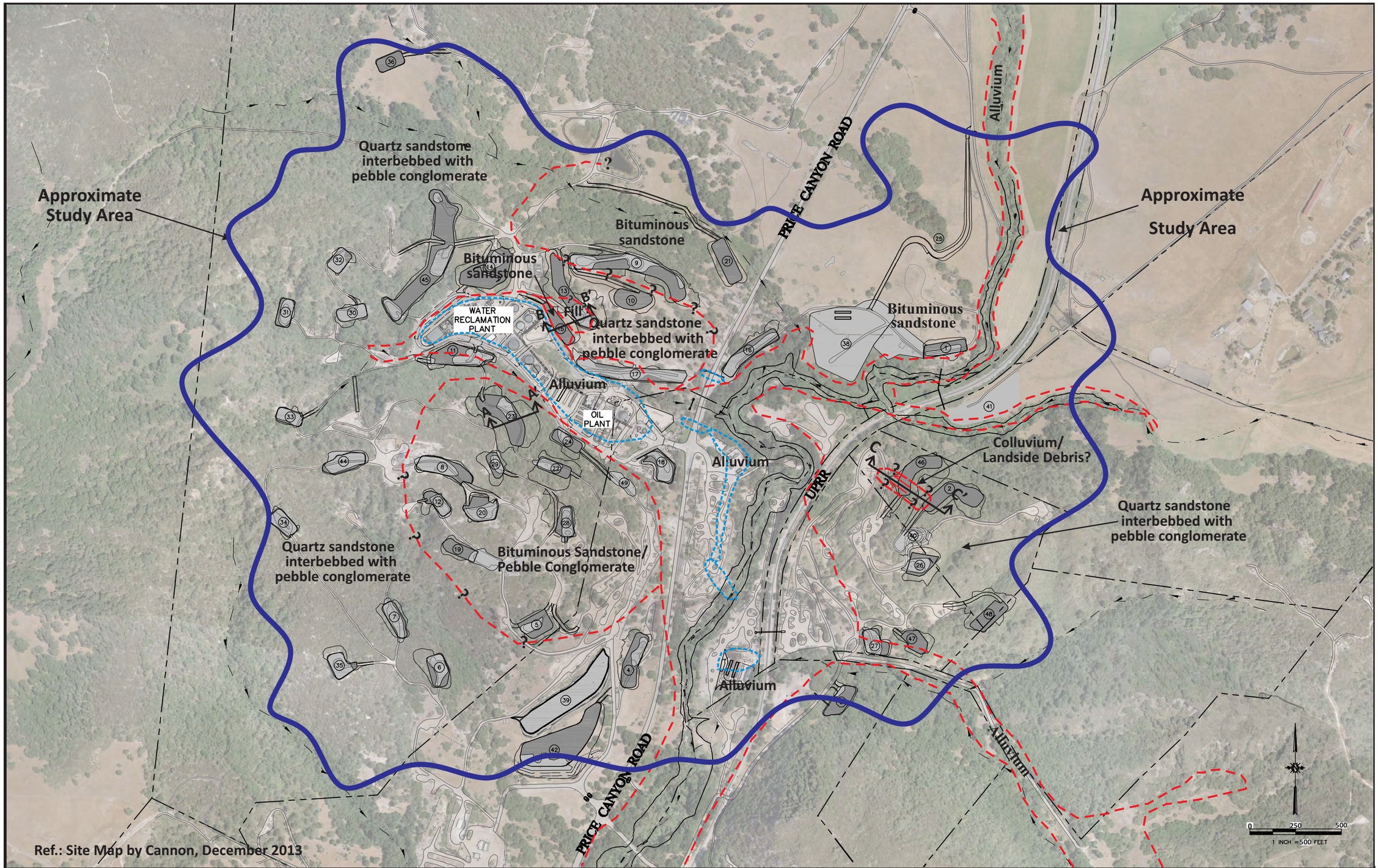
SL-17061-SC



LEGEND

?----------? Geologic contact, dashed where approximate, queried where uncertain

---------- Subsurface Investigation Areas (Fugro)

Approximate Cross Section Location

Earth Systems Pacific
4378 Santa Fe Road, San Luis Obispo, CA 93401
www.earthsys.com - email: esp@earthsys.com
(805) 544-3276

Proposed Development Map

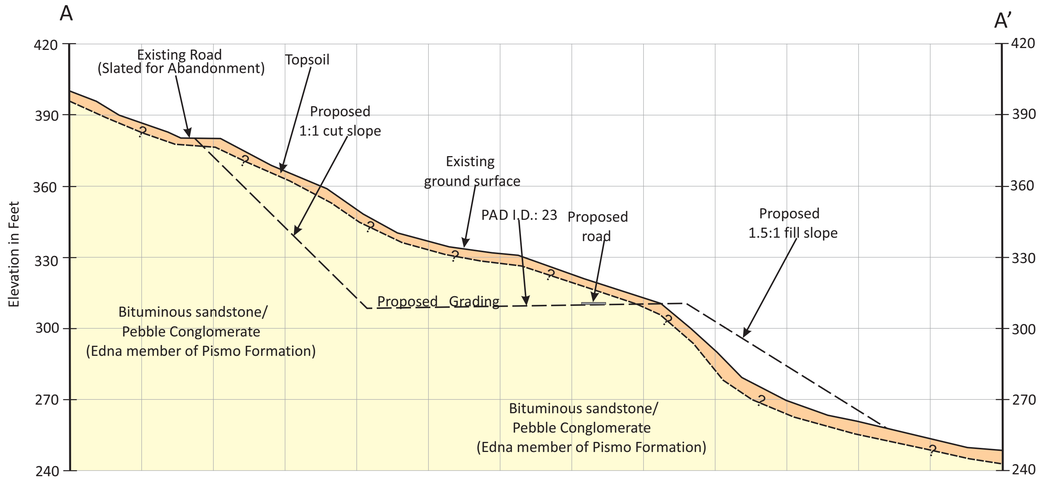
FMOG - Arroyo Grande Oil Field - Phase V
1821 Price Canyon Road
San Luis Obispo County, California

Date
December 2013

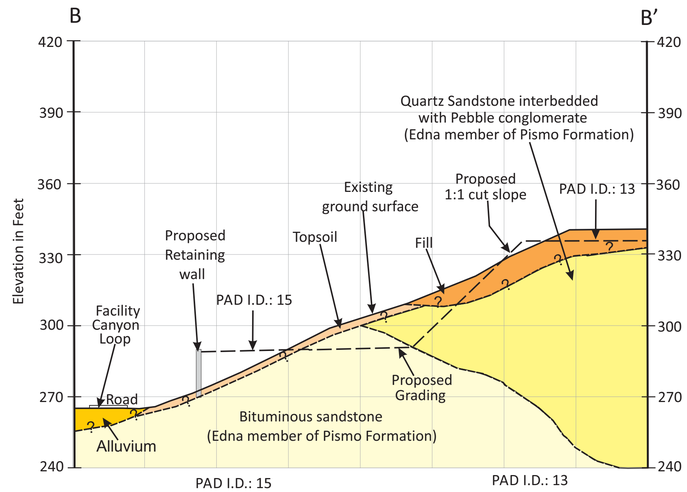
Project No.
SL-117061-SC

CROSS SECTIONS A-A', B-B' & C-C'

FMOG - Arroyo Grande Oil Field - Phase V
1821 Price Canyon Road
San Luis Obispo County, California



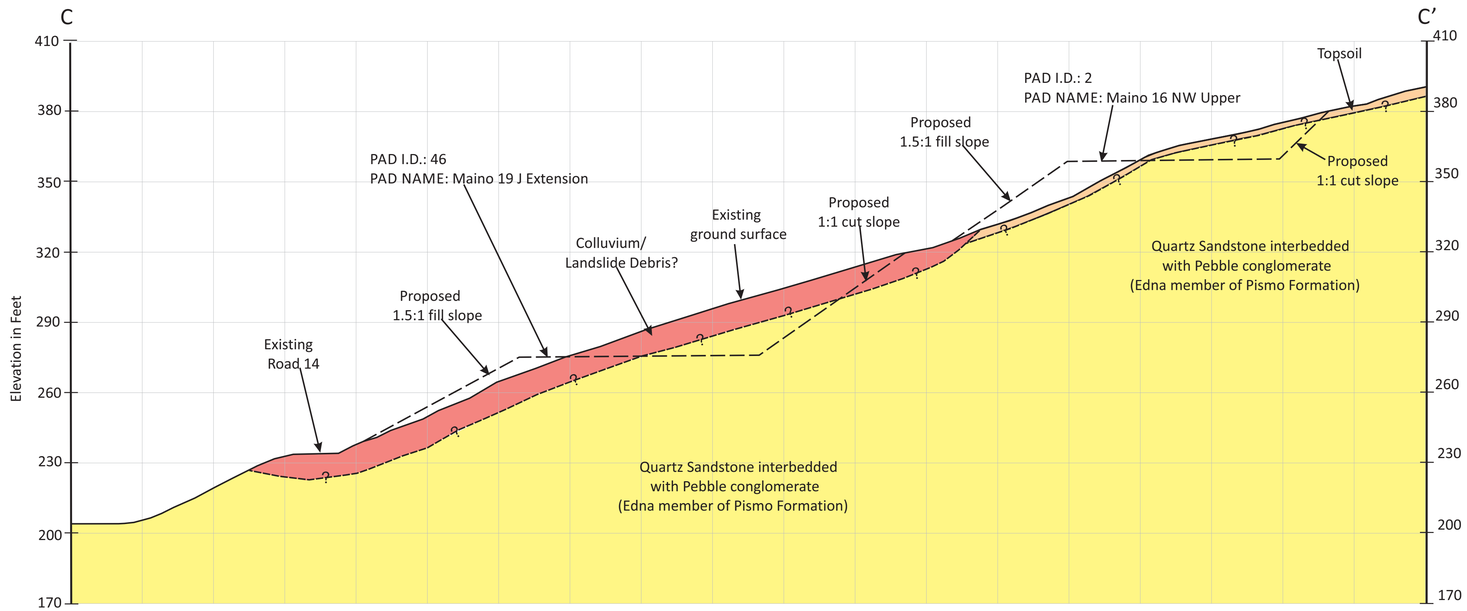
PAD I.D.: 23
PAD NAME: Signal 129
Approximate Scale: 1" = 30'



PAD I.D.: 15
PAD NAME: B-LO Signal 171

PAD I.D.: 13
PAD NAME: Signal 171,
Gas Plant Upper

Approximate Scale: 1" = 30'



PAD I.D.: 46
PAD NAME: Maino 19 J Extension

PAD I.D.: 2
PAD NAME: Maino 16 NW Upper

Approximate Scale: 1" = 30'

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December 2013

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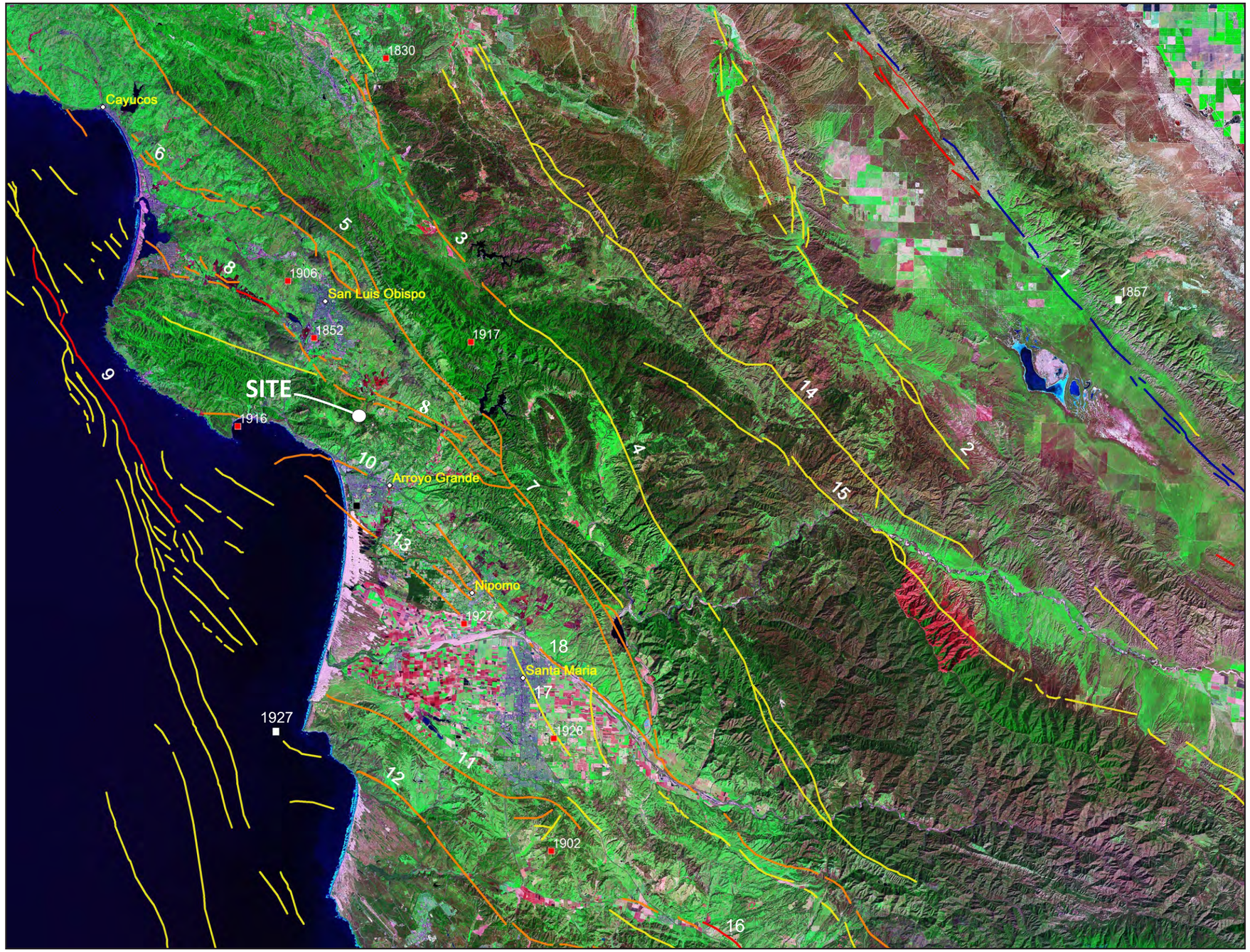
SL - 17061-SC

APPENDIX B

Historical Earthquake/Fault Map
EQSEARCH Data Results

HISTORICAL EARTHQUAKE/ FAULT MAP

FMOG - Arroyo Grande Oil Field - Phase V
1821 Price Canyon Road
San Luis Obispo County, California



LEGEND

- Historic rupture (<200 years)
- Holocene fault (<10,000 years)
- Late Quaternary (<700,000 years)
- Quaternary fault (<1.6 million)

HISTORICAL EARTHQUAKE MAGNITUDE

5.0 to 5.9 | 6.0 to 6.9 | 7.0 to 7.9

FAULTS

1 San Andreas
2 San Juan
3 Rinconada
4 East Huasna
5 Oceanic
6 Cambria
7 West Huasna
8 Los Osos
9 Hosgri-San Simeon
10 San Luis Range (South Margin)
11 Casmalia (Orcutt Frontal)
12 Lions Head
13 Oceano
14 La Panza
15 South Cuyama
16 Los Alamos (West Baseline)
17 Santa Maria
18 Santa Maria River

Note: Not all faults are shown on map

REFERENCES

Blake, T.F., EQSEARCH, 2000, updated 2010
Jennings, C.W,& Bryant, W.A., 2010

N

(Approximate Scale: 1" = 6 miles)

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December 2013

SL - 17061-SC

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*     Version 3.00      *
*                       *
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ESTIMATION OF
PEAK ACCELERATION FROM
CALIFORNIA EARTHQUAKE CATALOGS

JOB NUMBER: SL-12480-SD

DATE: 05-23-2013

JOB NAME: PXP Phase V Development

EARTHQUAKE-CATALOG-FILE NAME: ALLQUAKE.DAT

SITE COORDINATES:
SITE LATITUDE: 35.1857
SITE LONGITUDE: 120.6194

SEARCH DATES:
START DATE: 1800
END DATE: 2010

SEARCH RADIUS:
65.0 mi
104.6 km

ATTENUATION RELATION: 2) Boore et al. (1997) Horiz. - NEHRP C (520)
UNCERTAINTY (M=Median, S=Sigma): M Number of Sigmas: 0.0
ASSUMED SOURCE TYPE: DS [SS=Strike-slip, DS=Reverse-slip, BT=Blind-thrust]
SCOND: 0 Depth Source: A
Basement Depth: 5.00 km Campbell SSR: Campbell SHR:
COMPUTE PEAK HORIZONTAL ACCELERATION

MINIMUM DEPTH VALUE (km): 0.0

EARTHQUAKE SEARCH RESULTS

Page 1

FILE CODE	LAT. NORTH	LONG. WEST	DATE	TIME (UTC) H M Sec	DEPTH (km)	QUAKE MAG.	SITE ACC. g	SITE MM INT.	APPROX. DISTANCE mi [km]
T-A	35.2500	120.6700	00/00/1830	0 0 0.0	0.0	5.70	0.181	VIII	5.3(8.5)
T-A	35.2500	120.6700	12/17/1852	0 0 0.0	0.0	5.70	0.181	VIII	5.3(8.5)
MGI	35.1700	120.7500	12/01/1916	2253 0.0	0.0	5.70	0.147	VIII	7.4(12.0)
MGI	35.2500	120.5000	07/10/1917	043 0.0	0.0	5.30	0.113	VII	8.1(13.0)
MGI	35.2500	120.5000	07/09/1917	2222 0.0	0.0	5.00	0.097	VII	8.1(13.0)
MGI	35.2500	120.5000	07/09/1917	2238 0.0	0.0	5.30	0.113	VII	8.1(13.0)
MGI	35.2500	120.5000	07/10/1917	045 0.0	0.0	5.30	0.113	VII	8.1(13.0)
MGI	35.3000	120.7000	12/07/1906	640 0.0	0.0	5.90	0.143	VIII	9.1(14.6)
MGI	35.0000	120.5000	11/19/1927	332 0.0	0.0	5.00	0.064	VI	14.5(23.3)
DMG	34.9000	120.7000	11/04/1927	135053.0	0.0	7.50	0.186	VIII	20.2(32.6)
MGI	35.5000	120.6000	01/01/1830	0 0 0.0	0.0	5.00	0.047	VI	21.7(35.0)
MGI	34.9000	120.4000	03/29/1928	625 0.0	0.0	5.30	0.052	VI	23.3(37.5)
MGI	34.8000	120.4000	12/12/1902	0 0 0.0	0.0	5.70	0.054	VI	29.4(47.3)
DMG	34.7000	120.3000	01/12/1915	431 0.0	0.0	5.50	0.040	V	38.1(61.3)
DMG	34.7000	120.3000	07/31/1902	920 0.0	0.0	5.50	0.040	V	38.1(61.3)
MGI	35.6000	121.1000	02/01/1853	21 0 0.0	0.0	5.00	0.030	V	39.4(63.4)
DMG	35.7500	120.3300	08/18/1922	512 0.0	0.0	5.00	0.028	V	42.2(67.9)
MGI	34.6000	120.4000	08/01/1902	330 0.0	0.0	6.30	0.056	VI	42.3(68.1)
MGI	34.6000	120.4000	07/28/1902	657 0.0	0.0	6.30	0.056	VI	42.3(68.1)
DMG	35.7500	120.2500	03/10/1922	112120.0	0.0	6.50	0.060	VI	44.1(71.0)
GSG	35.7060	121.1020	12/22/2003	191556.0	7.0	6.40	0.056	VI	45.0(72.5)
DMG	35.8000	120.3300	12/28/1939	121538.0	0.0	5.00	0.027	V	45.4(73.1)
DMG	35.8000	120.3300	06/08/1934	447 0.0	0.0	6.00	0.045	VI	45.4(73.1)
DMG	35.8000	120.3300	06/05/1934	2148 0.0	0.0	5.00	0.027	V	45.4(73.1)
DMG	35.8000	120.3300	06/08/1934	430 0.0	0.0	5.00	0.027	V	45.4(73.1)
GSB	35.8190	120.3640	09/28/2004	171524.2	8.0	6.00	0.045	VI	46.0(74.1)
DMG	35.3000	119.8000	01/09/1857	16 0 0.0	0.0	7.90	0.121	VII	46.9(75.4)
DMG	35.7300	121.2000	11/22/1952	74637.0	0.0	6.00	0.042	VI	49.8(80.1)
GSB	35.9170	120.4650	12/20/1994	102747.2	8.0	5.00	0.024	V	51.2(82.4)
DMG	35.9300	120.4800	12/24/1934	1626 0.0	0.0	5.00	0.024	V	52.0(83.6)
DMG	35.9500	120.5300	06/29/1966	195325.9	0.0	5.00	0.024	IV	53.0(85.3)
DMG	35.9500	120.5000	06/28/1966	42613.4	0.0	5.50	0.031	V	53.2(85.6)
GSB	35.9530	120.5020	09/29/2004	171004.0	11.0	5.10	0.025	V	53.4(85.9)
DMG	35.9500	120.4700	11/16/1956	323 9.0	0.0	5.00	0.024	IV	53.4(86.0)
DMG	35.9700	120.5000	06/28/1966	4 856.2	0.0	5.10	0.025	V	54.6(87.8)
DMG	36.0000	120.5000	03/03/1901	745 0.0	0.0	5.50	0.029	V	56.6(91.1)
DMG	36.0000	120.5000	02/02/1881	011 0.0	0.0	5.60	0.031	V	56.6(91.1)
DMG	36.0000	120.9200	11/02/1955	1940 6.0	0.0	5.20	0.024	V	58.7(94.5)
GSB	35.8280	121.3230	09/17/1991	211029.3	8.0	5.10	0.023	IV	59.4(95.6)
DMG	36.0000	121.0000	02/26/1932	1658 0.0	0.0	5.00	0.022	IV	60.1(96.8)
BRK	35.8400	121.3300	08/29/1983	101031.0	0.0	5.20	0.024	V	60.3(97.0)
DMG	34.6090	121.4350	11/05/1969	1754 7.9	10.0	5.60	0.029	V	61.0(98.1)

****

-END OF SEARCH- 42 EARTHQUAKES FOUND WITHIN THE SPECIFIED SEARCH AREA.

TIME PERIOD OF SEARCH: 1800 TO 2010

LENGTH OF SEARCH TIME: 211 years

THE EARTHQUAKE CLOSEST TO THE SITE IS ABOUT 5.3 MILES (8.5 km) AWAY.

LARGEST EARTHQUAKE MAGNITUDE FOUND IN THE SEARCH RADIUS: 7.9

LARGEST EARTHQUAKE SITE ACCELERATION FROM THIS SEARCH: 0.186 g

COEFFICIENTS FOR GUTENBERG & RICHTER RECURRENCE RELATION:
a-value= 0.761
b-value= 0.332
beta-value= 0.765

TABLE OF MAGNITUDES AND EXCEEDANCES:

Earthquake Magnitude	Number of Times Exceeded	Cumulative No. / Year
4.0	42	0.20000
4.5	42	0.20000
5.0	42	0.20000
5.5	20	0.09524
6.0	9	0.04286
6.5	3	0.01429
7.0	2	0.00952
7.5	2	0.00952

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*    E Q S E A R C H    *
*                       *
*     Version 3.00      *
*                       *
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ESTIMATION OF
PEAK ACCELERATION FROM
CALIFORNIA EARTHQUAKE CATALOGS

JOB NUMBER: SL-12480-SD

DATE: 05-23-2013

JOB NAME: PXP Phase V Development

EARTHQUAKE-CATALOG-FILE NAME: ALLQUAKE.DAT

SITE COORDINATES:
SITE LATITUDE: 35.1857
SITE LONGITUDE: 120.6194

SEARCH DATES:
START DATE: 1800
END DATE: 2010

SEARCH RADIUS:
65.0 mi
104.6 km

ATTENUATION RELATION: 3) Boore et al. (1997) Horiz. - NEHRP D (250)
UNCERTAINTY (M=Median, S=Sigma): M Number of Sigmas: 0.0
ASSUMED SOURCE TYPE: DS [SS=Strike-slip, DS=Reverse-slip, BT=Blind-thrust]
SCOND: 0 Depth Source: A
Basement Depth: 5.00 km Campbell SSR: Campbell SHR:
COMPUTE PEAK HORIZONTAL ACCELERATION

MINIMUM DEPTH VALUE (km): 0.0

EARTHQUAKE SEARCH RESULTS

Page 1

FILE CODE	LAT. NORTH	LONG. WEST	DATE	TIME (UTC) H M Sec	DEPTH (km)	QUAKE MAG.	SITE ACC. g	SITE MM INT.	APPROX. DISTANCE mi [km]
T-A	35.2500	120.6700	00/00/1830	0 0 0.0	0.0	5.70	0.237	IX	5.3(8.5)
T-A	35.2500	120.6700	12/17/1852	0 0 0.0	0.0	5.70	0.237	IX	5.3(8.5)
MGI	35.1700	120.7500	12/01/1916	2253 0.0	0.0	5.70	0.193	VIII	7.4(12.0)
MGI	35.2500	120.5000	07/10/1917	043 0.0	0.0	5.30	0.148	VIII	8.1(13.0)
MGI	35.2500	120.5000	07/09/1917	2222 0.0	0.0	5.00	0.127	VIII	8.1(13.0)
MGI	35.2500	120.5000	07/09/1917	2238 0.0	0.0	5.30	0.148	VIII	8.1(13.0)
MGI	35.2500	120.5000	07/10/1917	045 0.0	0.0	5.30	0.148	VIII	8.1(13.0)
MGI	35.3000	120.7000	12/07/1906	640 0.0	0.0	5.90	0.188	VIII	9.1(14.6)
MGI	35.0000	120.5000	11/19/1927	332 0.0	0.0	5.00	0.084	VII	14.5(23.3)
DMG	34.9000	120.7000	11/04/1927	135053.0	0.0	7.50	0.244	IX	20.2(32.6)
MGI	35.5000	120.6000	01/01/1830	0 0 0.0	0.0	5.00	0.062	VI	21.7(35.0)
MGI	34.9000	120.4000	03/29/1928	625 0.0	0.0	5.30	0.069	VI	23.3(37.5)
MGI	34.8000	120.4000	12/12/1902	0 0 0.0	0.0	5.70	0.071	VI	29.4(47.3)
DMG	34.7000	120.3000	01/12/1915	431 0.0	0.0	5.50	0.052	VI	38.1(61.3)
DMG	34.7000	120.3000	07/31/1902	920 0.0	0.0	5.50	0.052	VI	38.1(61.3)
MGI	35.6000	121.1000	02/01/1853	21 0 0.0	0.0	5.00	0.039	V	39.4(63.4)
DMG	35.7500	120.3300	08/18/1922	512 0.0	0.0	5.00	0.037	V	42.2(67.9)
MGI	34.6000	120.4000	08/01/1902	330 0.0	0.0	6.30	0.074	VII	42.3(68.1)
MGI	34.6000	120.4000	07/28/1902	657 0.0	0.0	6.30	0.074	VII	42.3(68.1)
DMG	35.7500	120.2500	03/10/1922	112120.0	0.0	6.50	0.079	VII	44.1(71.0)
GSG	35.7060	121.1020	12/22/2003	191556.0	7.0	6.40	0.074	VII	45.0(72.5)
DMG	35.8000	120.3300	12/28/1939	121538.0	0.0	5.00	0.035	V	45.4(73.1)
DMG	35.8000	120.3300	06/08/1934	447 0.0	0.0	6.00	0.060	VI	45.4(73.1)
DMG	35.8000	120.3300	06/05/1934	2148 0.0	0.0	5.00	0.035	V	45.4(73.1)
DMG	35.8000	120.3300	06/08/1934	430 0.0	0.0	5.00	0.035	V	45.4(73.1)
GSB	35.8190	120.3640	09/28/2004	171524.2	8.0	6.00	0.059	VI	46.0(74.1)
DMG	35.3000	119.8000	01/09/1857	16 0 0.0	0.0	7.90	0.158	VIII	46.9(75.4)
DMG	35.7300	121.2000	11/22/1952	74637.0	0.0	6.00	0.056	VI	49.8(80.1)
GSB	35.9170	120.4650	12/20/1994	102747.2	8.0	5.00	0.032	V	51.2(82.4)
DMG	35.9300	120.4800	12/24/1934	1626 0.0	0.0	5.00	0.032	V	52.0(83.6)
DMG	35.9500	120.5300	06/29/1966	195325.9	0.0	5.00	0.031	V	53.0(85.3)
DMG	35.9500	120.5000	06/28/1966	42613.4	0.0	5.50	0.041	V	53.2(85.6)
GSB	35.9530	120.5020	09/29/2004	171004.0	11.0	5.10	0.033	V	53.4(85.9)
DMG	35.9500	120.4700	11/16/1956	323 9.0	0.0	5.00	0.031	V	53.4(86.0)
DMG	35.9700	120.5000	06/28/1966	4 856.2	0.0	5.10	0.032	V	54.6(87.8)
DMG	36.0000	120.5000	03/03/1901	745 0.0	0.0	5.50	0.039	V	56.6(91.1)
DMG	36.0000	120.5000	02/02/1881	011 0.0	0.0	5.60	0.041	V	56.6(91.1)
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DMG	36.0000	121.0000	02/26/1932	1658 0.0	0.0	5.00	0.028	V	60.1(96.8)
BRK	35.8400	121.3300	08/29/1983	101031.0	0.0	5.20	0.031	V	60.3(97.0)
DMG	34.6090	121.4350	11/05/1969	1754 7.9	10.0	5.60	0.038	V	61.0(98.1)

****

-END OF SEARCH- 42 EARTHQUAKES FOUND WITHIN THE SPECIFIED SEARCH AREA.

TIME PERIOD OF SEARCH: 1800 TO 2010

LENGTH OF SEARCH TIME: 211 years

THE EARTHQUAKE CLOSEST TO THE SITE IS ABOUT 5.3 MILES (8.5 km) AWAY.

LARGEST EARTHQUAKE MAGNITUDE FOUND IN THE SEARCH RADIUS: 7.9

LARGEST EARTHQUAKE SITE ACCELERATION FROM THIS SEARCH: 0.244 g

COEFFICIENTS FOR GUTENBERG & RICHTER RECURRENCE RELATION:
a-value= 0.761
b-value= 0.332
beta-value= 0.765

TABLE OF MAGNITUDES AND EXCEEDANCES:

Earthquake Magnitude	Number of Times Exceeded	Cumulative No. / Year
4.0	42	0.20000
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5.0	42	0.20000
5.5	20	0.09524
6.0	9	0.04286
6.5	3	0.01429
7.0	2	0.00952
7.5	2	0.00952

APPENDIX C

Well Pad and Improvement Summary
Well Pad and Improvement Exhibits

Well Pad and Improvement Summary

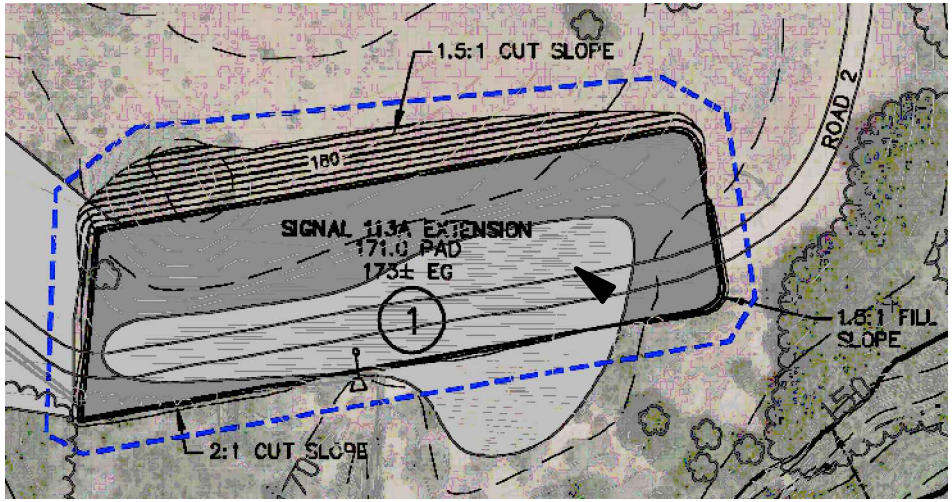
FMOG - Arroyo Grande Oil Field - Phase V
1821 Price Canyon Road
San Luis Obispo County, California

Pad I.D.	Pad Name	New or Existing Pad	Existing Pad Grade Elev. (ft)	Prop. Pad Grade Elev. (ft)	Estimated Maximum Cut (ft)	Estimated Maximum Fill (ft)	Additional Geologic / Geotechnical Services	
							Perform Subsurface Investigation and Analyses	Provide Geotechnical Recommendations
1	Signal 113 A Extension	Existing	173	171	19	4	NO	YES
2	Maino 16 NW Upper	New	---	354	30	19	YES	YES
3	Dollie 108 G	Existing	---	172	6	6	NO	YES
4	Rock 12 N	Existing	195	195	13	8	NO	YES
5	Signal 9N-1	Existing	329	329	7	17	YES	YES
6	Signal 306/ Signal 303	Existing	287	288	14	11	NO	YES
7	Signal 161	Existing	348	348	4	8	NO	YES
8	Pulas 2	Existing	472	470	8	8	NO	YES
9	Signal 195-301 Connector	Existing	---	354	30	23	YES	YES
10	Signal 8 Abandoned	New	---	418	20	12	YES	YES
11	Signal 117	Existing	282	288	11	8	YES	YES
12	Pulas 3	Existing	423	422	12	12	YES	YES
13	Signal 171, Gas Plant Upper	Existing	339	335	26	25	YES	YES
14	Signal 125	Existing	310	312	16	16	YES	YES
15	B-Lo Signal 171	New	---	291	32	15	YES	YES
16	Signal 149	Existing	---	171	14	3	NO	YES
17	Signal 113-115 Connector	Existing	---	228	28	18	YES	YES
18	Rock 12 J	Existing	186	188	7	4	YES	YES
19	Signal 66 C Extension / Pulas 4	Existing	379	379	14	11	YES	YES
20	Signal 162	Existing	444	447	12	6	NO	YES
21	Signal 20 Abandoned	New	---	232	11	15	YES	YES
22	Signal P1 I1	Existing	310	310	23	20	YES	YES
23	Signal 129	Existing	316	314	46	28	YES	YES
24	Cutshack Demo	New	230	233	23	10	YES	YES
25	Signal Extension Road	New	---	---	0	10	YES	YES
26	Maino 20 K	Existing	318	320	25	27	YES	YES
27	Maino 19 N	Existing	195	197	9	2	NO	YES
28	Signal 9 J 2	Existing	365	366	15	2	YES	YES
29	Signal 131/B-Lo Pulas 2	Existing	398	402	24	4	YES	YES
30	Signal 123	Existing	397	395	7	3	NO	YES
31	Pulas 8	Existing	410	411	5	1	NO	YES
32	Signal 124	Existing	449	446	6	16	YES	YES
33	Pulas 6	Existing	409	408	4	0	NO	YES
34	Signal 135	Existing	496	495	5	5	NO	YES
35	Signal 180	Existing	362	361	8	4	NO	YES
36	Signal 48	New	348	348	3	2	YES	YES
38	Signal 150 (Steam Generators)	Existing	---	---	---	---	NO	YES
39	Rock 401	Existing	223	223	---	---	NO	NO
40	Maino 16 NW	New	---	339	---	---	NO	NO
41	Maino Morehouse 303	Existing	161	161	1	2	NO	YES
42	Gate 1	New	---	201	0	33	NO	YES
44	Signal 141	Existing	465	465	0	5	NO	YES
45	Signal 121 AWT Connection	Existing	---	344	24	8	YES	YES
46	Maino 19 J Extension	New	---	271	37	9	YES	YES
47	Maino 6 Abandoned	New	---	237	14	9	YES	YES
48	B-Lo Morehouse 3	New	---	331	22	13	YES	YES
49	Rock 98 Expansion	Existing	229	229	---	---	NO	NO
NA	North Pipe Bridge Replacement	New	---	---	---	---	YES	YES
NA	UPRR Undercrossing	New	---	---	---	---	YES	YES

Note: Pads 37 and 43 removed per FMOG

FMOG - ARROYO GRANDE OIL FIELD - PHASE V

1821 Price Canyon Road
San Luis Obispo County, California



Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 5/17/2013, looking northwest

PAD I.D.: 1

PAD NAME: Signal 113 A Extension

PROPOSED IMPROVEMENTS: Cut up to 19 feet along the north side. Fill up to 4 feet along the southeast side.

Photo Location and Direction

FIELD OBSERVATIONS:

- Existing cut at 1:1 to ½:1 in bituminous sandstone
- Some fracturing and shearing in exposed slope along the north side of the pad

RECOMMENDATIONS:

- Prepare geotechnical recommendations for pad construction based upon observed conditions; subsurface investigation not warranted

N

NOT TO SCALE

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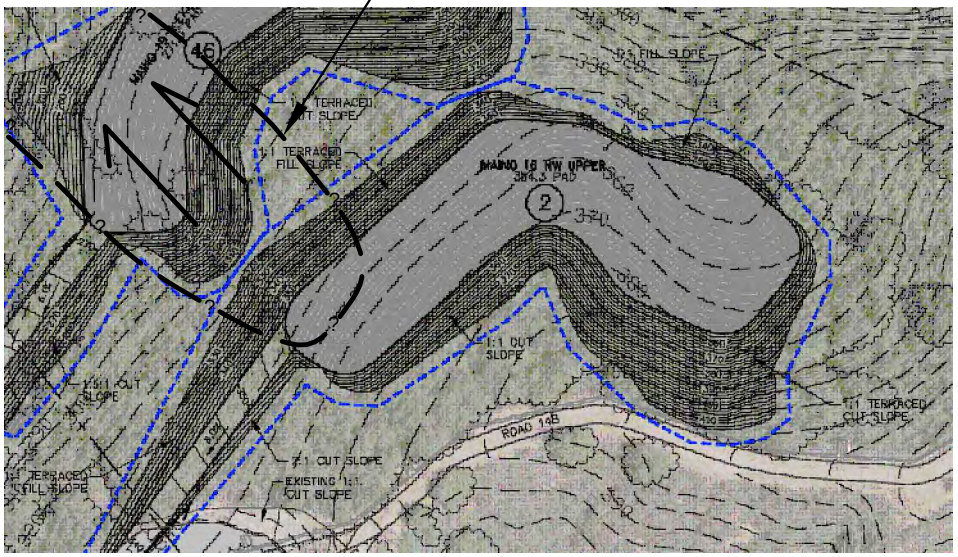
Colluvium / Landslide Debris?



Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking northeast

PAD I.D.: 2

PAD NAME: Maino 16 NW Upper

PROPOSED IMPROVEMENTS: Cut along the south side up to 30 feet. Fill along the west side up to 19 feet.

Photo Location and Direction

FIELD OBSERVATIONS:

- Adjacent Maino 16 NW Lower pad appears to have been cut at a slope of approximately 1:1. Following cut, slope appears to have eroded and was subsequently rebuilt and is now surfaced with erosion control blanket
- Existing topography is sloped at approximately 20 to 30 percent to the northwest
- Existing slopes heavily wooded
- Possible colluvium/landslide debris

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for pad construction

N

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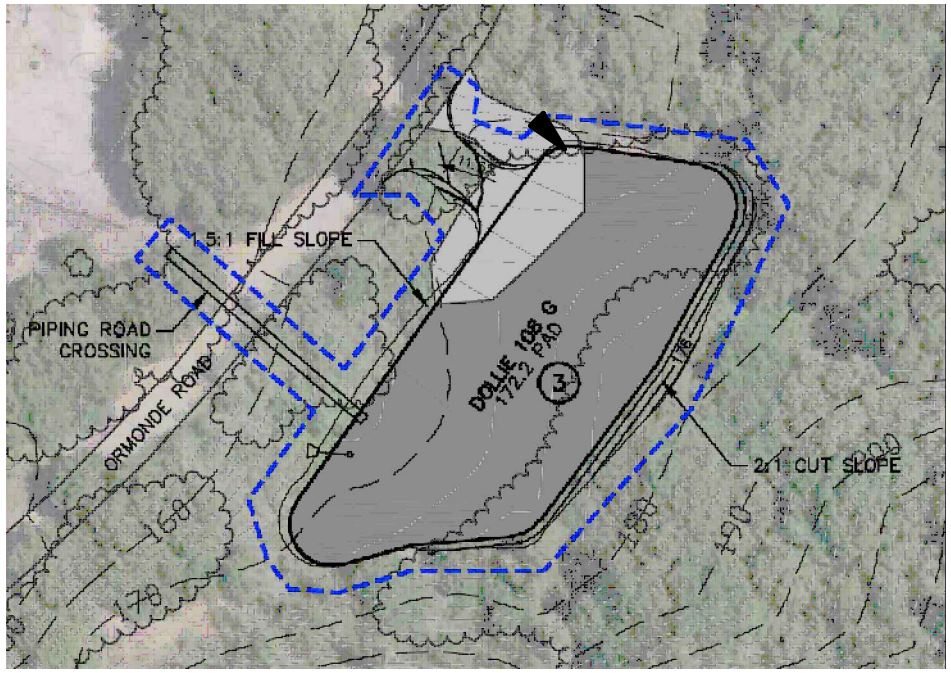

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 5/17/2013, looking southeast

PAD I.D.: 3

PAD NAME: Dollie 108 G

PROPOSED IMPROVEMENTS: Pad clearing and grubbing. Cut along the east side up to 6 feet. Fill along the west side up to 6 feet.

FIELD OBSERVATIONS:

- Heavily vegetated area
- Relatively flat

RECOMMENDATIONS:

- Prepare geotechnical recommendations for pad construction based upon observed conditions; subsurface investigation not warranted

Photo Location and Direction

N

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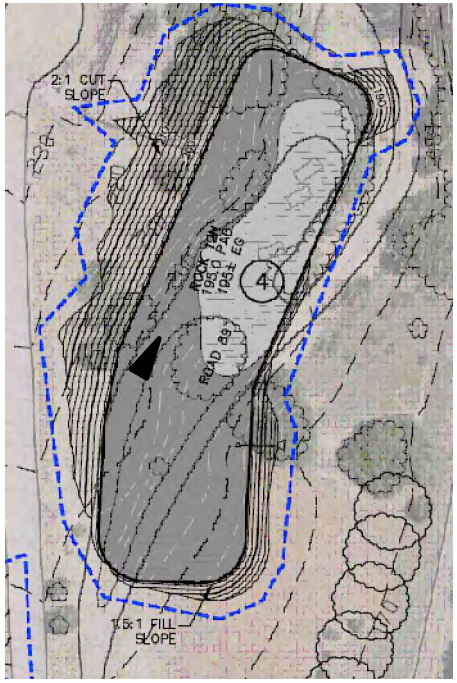

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking north

PAD I.D.: 4

PAD NAME: Rock 12 N

PROPOSED IMPROVEMENTS: Extend existing pad north and south with cuts along the west side up to 13 feet and fill along the south side up to 8 feet.

Photo Location and Direction

FIELD OBSERVATIONS:

- Exposed 6 to 8 feet tall cut on west side with silty sand overlying quartz sandstone
- Cut sloped at approximately ½:1
- Culvert runs northwest to southeast along the middle of the pad from surface drainage above

RECOMMENDATIONS:

- Prepare geotechnical recommendations for pad construction based upon observed conditions; subsurface investigation not warranted

N

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Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking east

PAD I.D.: 5

PAD NAME: Signal 9N-1

PROPOSED IMPROVEMENTS: Cut along north side of pad up to 7 feet. Fill along the southeast side up to 17 feet. East access road will be improved/reestablished

Photo Location and Direction

FIELD OBSERVATIONS:

- Existing cut on north side in soil over quartz sandstone with interbedded lenses of pebbly conglomerate
- Fill up to 15 feet tall on southeast side
- Heavy brush vegetation and loose soil on existing fill slope

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for pad construction

N

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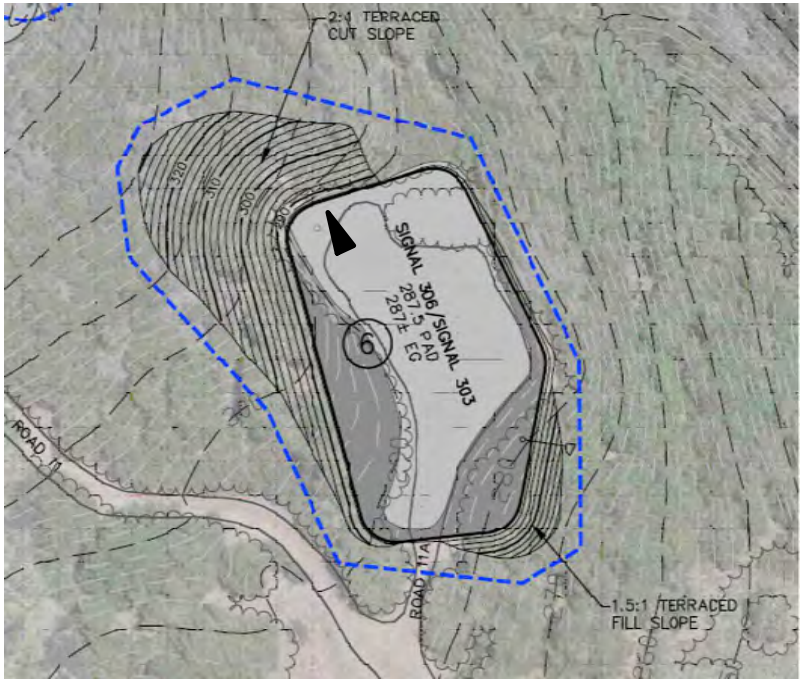

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking north & northwest

PAD I.D.: 6

PAD NAME: Signal 306 / Signal 303

PROPOSED IMPROVEMENTS: Cut up to 14 feet along the west side. Fill up to 11 feet along the southeast corner.

Photo Location and Direction

FIELD OBSERVATIONS:

- Existing cut slope at approximately ½:1 along the north face into moderately weathered and thickly bedded quartz sandstone
- Loose soil, rock, and debris fill along the east side; sloped at approximately 1.75:1 to 2:1
- Sheet flow drainage to the east where erosion has occured

RECOMMENDATIONS:

- Prepare geotechnical recommendations for pad construction based upon observed conditions; subsurface investigation not warranted

N

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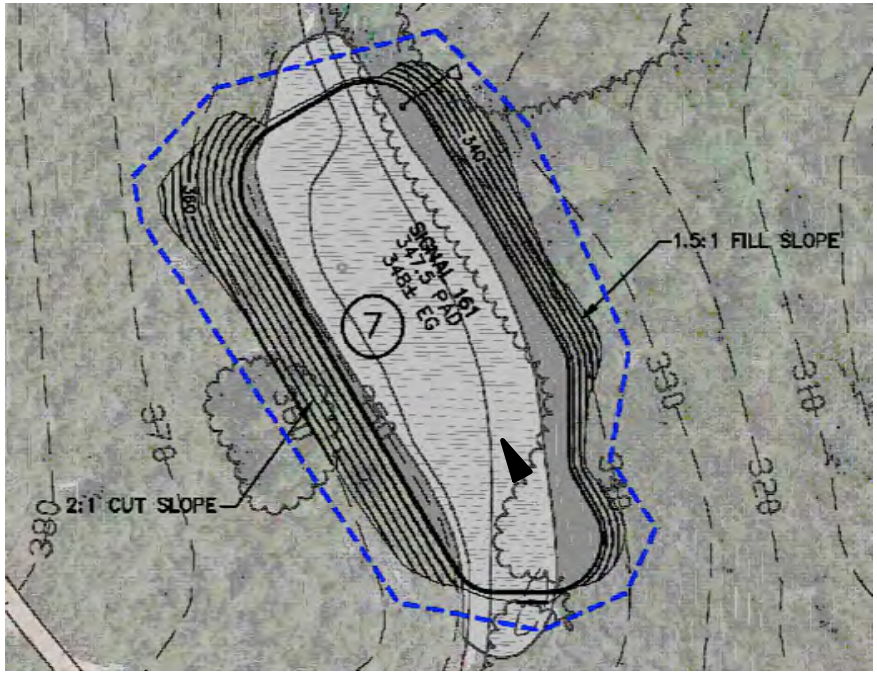

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 5/17/2013, looking northwest

PAD I.D.: 7

PAD NAME: Signal 161

PROPOSED IMPROVEMENTS: Fill along the east side of the pad up to 8 feet. Cut along the west side up to 4 feet.

FIELD OBSERVATIONS:

- East fill slope is at approximately 2:1 and 10 feet tall
- East and west slopes are heavily vegetated

RECOMMENDATIONS:

- Prepare geotechnical recommendations for pad construction based upon observed conditions; subsurface investigation not warranted

Photo Location and Direction

N

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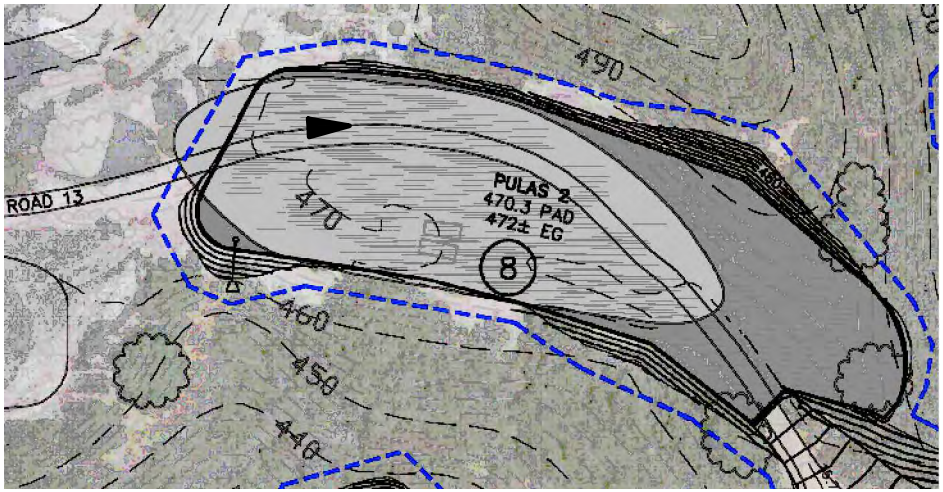

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 12/9/2013, looking east

PAD I.D.: 8

PAD NAME: Pulas 2

PROPOSED IMPROVEMENTS: Cut along north side up to 8 feet. Fill along south side up to 8 feet.

FIELD OBSERVATIONS:

- Existing cuts into quartz sandstone
- Proposed improvement area heavily vegetated

RECOMMENDATIONS:

- Prepare geotechnical recommendations for pad construction based upon observed conditions; subsurface investigation not warranted

Photo Location and Direction

N

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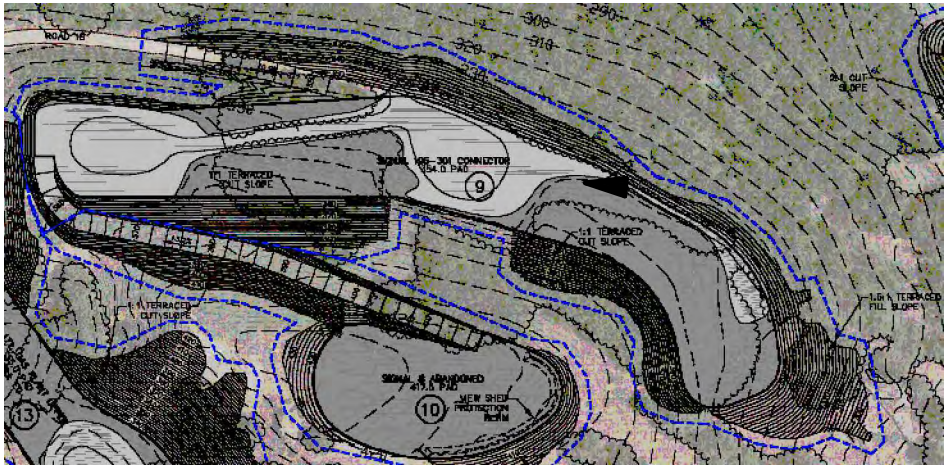

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking west

PAD I.D.: 9

PAD NAME: Signal 195-301 Connector

PROPOSED IMPROVEMENTS: Fill along the north side of the existing pad up to 11 feet. Extend existing pad east with cuts and fill up to 23 feet and to the west with cuts up to 30 feet.

Photo Location and Direction

FIELD OBSERVATIONS:

- Existing cut slopes approximately 45 feet tall into bituminous sandstone
- Existing cut at approximately ½:1 to 1:1 with some areas near vertical
- Block failures along toe of cut slopes
- Improvement areas vegetated with trees and seasonal grasses

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for pad construction

N

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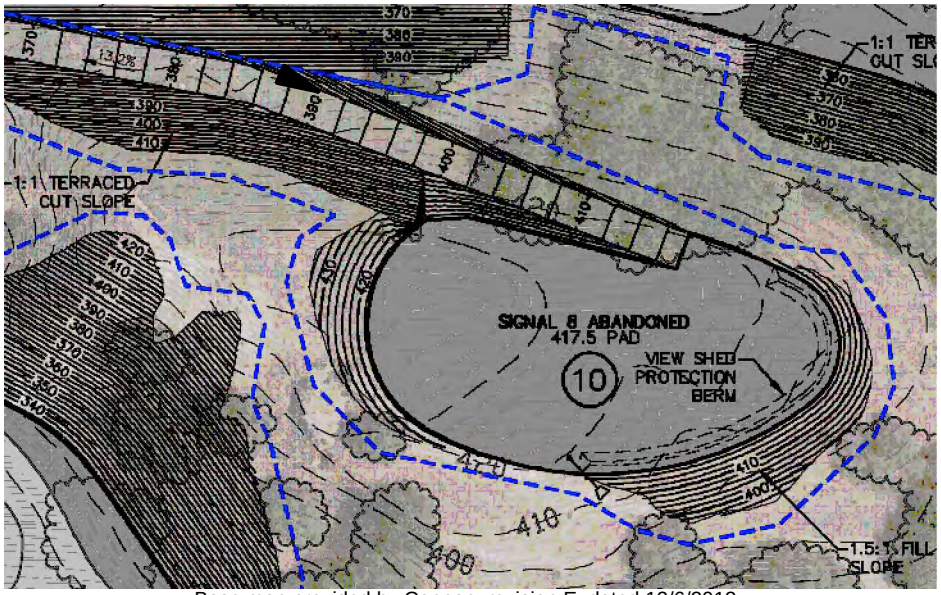

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking up towards the pad from the west

PAD I.D.: 10

PAD NAME: Signal 8 Abandoned

PROPOSED IMPROVEMENTS: Build road from Signal 195 to top of the existing hill. Cuts at the top of the hill up to 20 feet. Fill for road to pad up to 12 feet.

Photo Location and Direction

FIELD OBSERVATIONS:

- Existing cut at the top of the hill into quartz sandstone with soil cap
- Topography to the pad is steep
- Erosion along south side of proposed roadway
- Fills for roadway to be constructed over steep terrain

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for pad construction

N

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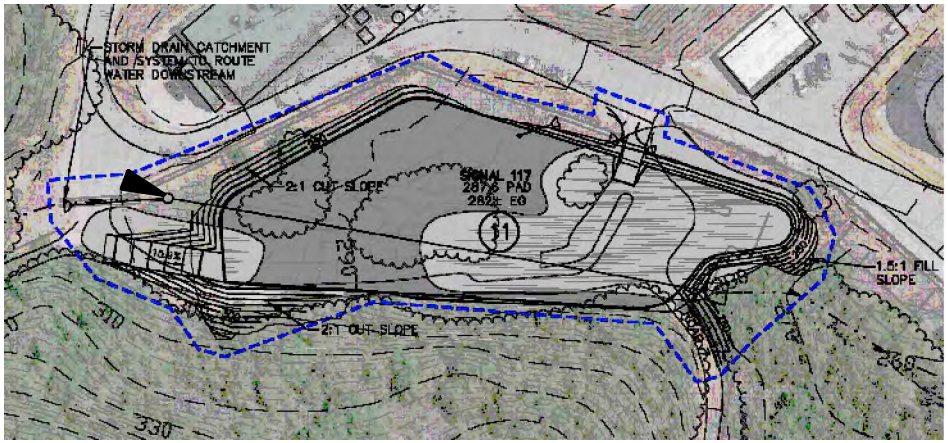

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking east

PAD I.D.: 11

PAD NAME: Signal 117

PROPOSED IMPROVEMENTS: Cuts along the west side up to 11 feet. Fill along the east side up to 8 feet.

Photo Location and Direction

FIELD OBSERVATIONS:

- Existing drainage area
- Drainage will be extended culvert to the east
- Potential unstable soils due to shallow groundwater

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for pad construction

N

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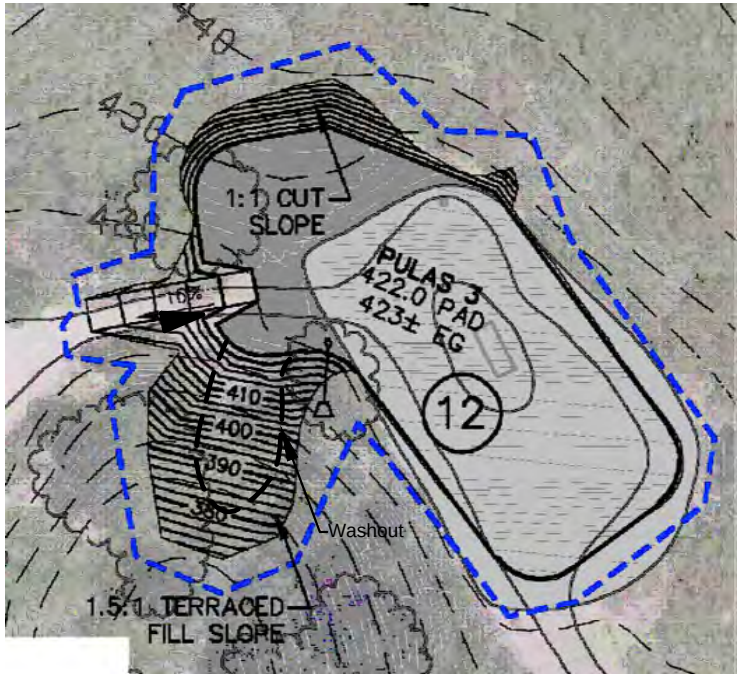

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking east

PAD I.D.: 12

PAD NAME: Pulas 3

PROPOSED IMPROVEMENTS: Cut along the north side up to 12 feet. Fill along southwest corner up to 12 feet.

Photo Location and Direction

FIELD OBSERVATIONS:

- Existing cuts at approximately 1:1 in bituminous sandstone
- Existing fills have eroded where no vegetation is present
- Washout area noted at pad (see photo and drawing)

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for pad construction

N

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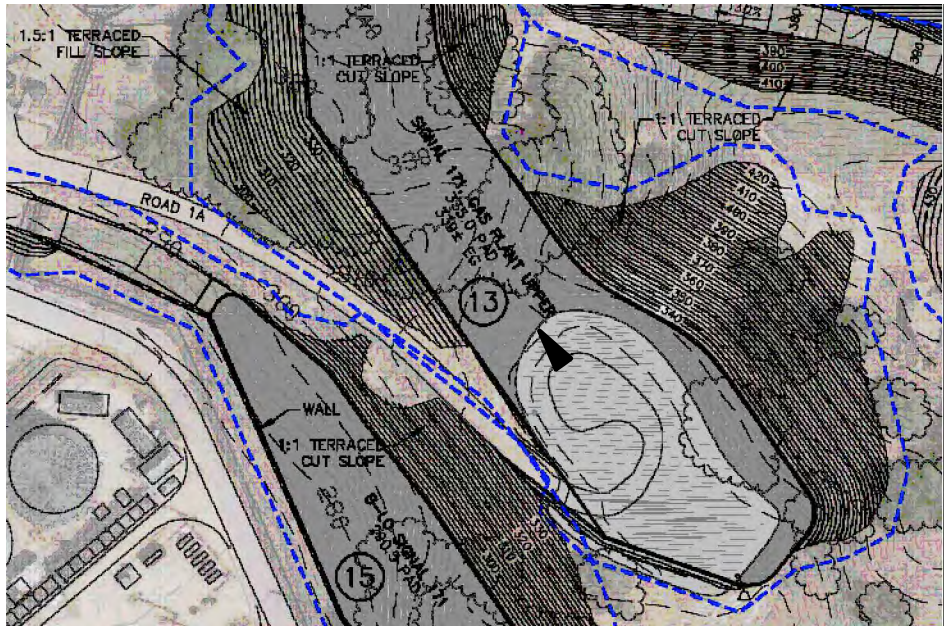

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking northwest

PAD I.D.: 13

PAD NAME: Signal 171, Gas Plant Upper

PROPOSED IMPROVEMENTS: Extend pad towards the north with fills up to 26 feet along west side of pad and cuts up to 25 feet along east side.

Photo Location and Direction

FIELD OBSERVATIONS:

- Fill to be placed on existing 50 percent slopes
- Existing slope covered with grass, trees, and shallow bedrock
- Existing cut slope into quartz sandstone
- Steep slopes to north of existing pad

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for pad construction

N

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Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking southwest

PAD I.D.: 14

PAD NAME: Signal 125

PROPOSED IMPROVEMENTS: Cuts up to 16 feet along west side. Fill up to 16 feet at southeast corner. Midpad terrace to be created.

Photo Location and Direction

FIELD OBSERVATIONS:

- Existing stockpile/wastepile pad
- Brush and trees beyond existing pad
- Existing slopes reveal quartz sandstone with overlying soil

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for pad construction

N

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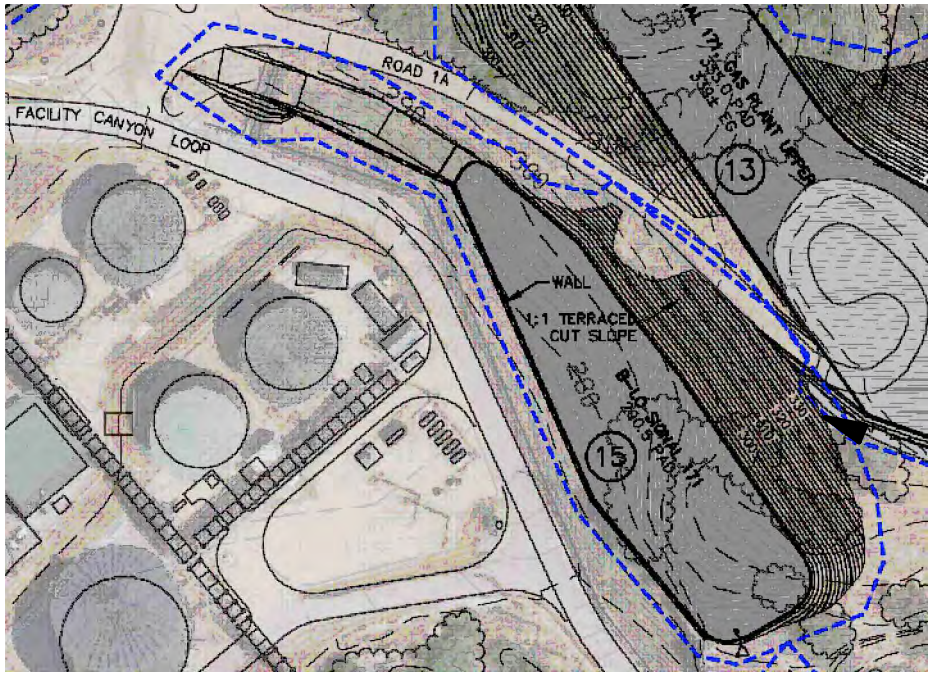

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking northwest

PAD I.D.: 15

PAD NAME: B-Lo Signal 171

PROPOSED IMPROVEMENTS: Cut along the east side up to 32 feet. Fill along the west side up to 15 feet bound by retaining wall of similar height. Proposed 1:1 cut into existing fill.

Photo Location and Direction

FIELD OBSERVATIONS:

- Existing fill slope on road to Signal 171
- Fill along the west edge overlying alluvium adjacent to existing pipe lines
- Large rock outcrop within pad area

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for pad construction
- Reduce cut slope angle to 2:1 where existing fill is present

N

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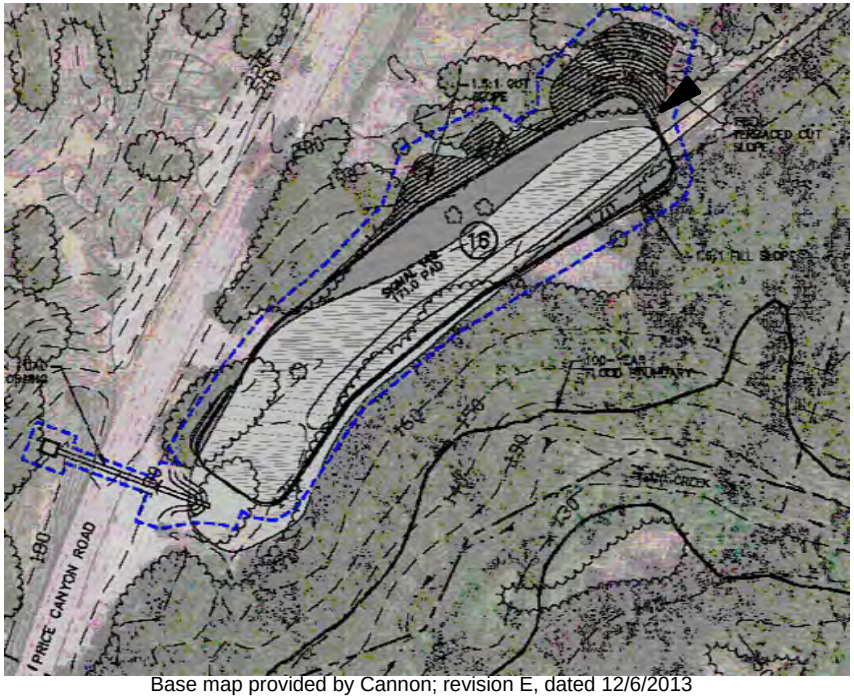

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 5/17/2013, looking southwest

PAD I.D.: 16

PAD NAME: Signal 149

PROPOSED IMPROVEMENTS: Cuts along the northeast side ut to 14 feet. Fill along the southeast side up to 3 feet.

Photo Location and Direction

FIELD OBSERVATIONS:

- Existing bituminous sandstone rock along cut area at or near vertical
- Tar seeps in exposed rock
- Proposed fill area on sloping vegetated ground
- Adjacent to proposed Price Canyon Road undercrossing

RECOMMENDATIONS:

- Prepare geotechnical recommendations for pad construction based upon observed conditions; subsurface investigation not warranted for pad
- Subsurface investigation should be performed for the undercrossing

N

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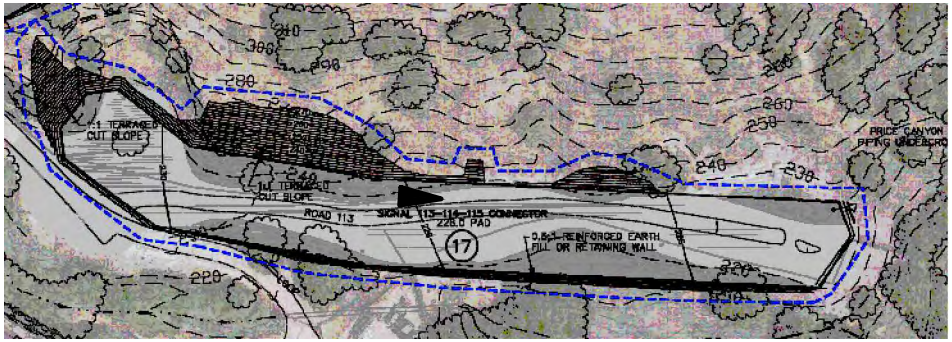

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking east

PAD I.D.: 17

PAD NAME: Signal 113-114-115 Connector

PROPOSED IMPROVEMENTS: Cuts up to 28 feet along north side. Fill up to 18 feet along south side. Reinforced earth or retaining wall planned for construction along south side of pad.

Photo Location and Direction

FIELD OBSERVATIONS:

- Existing cut slopes into very fractured bituminous sandstone
- Existing block failures on slopes at and along toe
- Moderate to high potential to spalling and/or toppling failures
- Rock fall hazards to existing pipe lines
- Swale/drainage area along toe of proposed fill

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for pad construction

N

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FMOG PHASE V-120713Pads

FMOG - ARROYO GRANDE OIL FIELD - PHASE V

1821 Price Canyon Road
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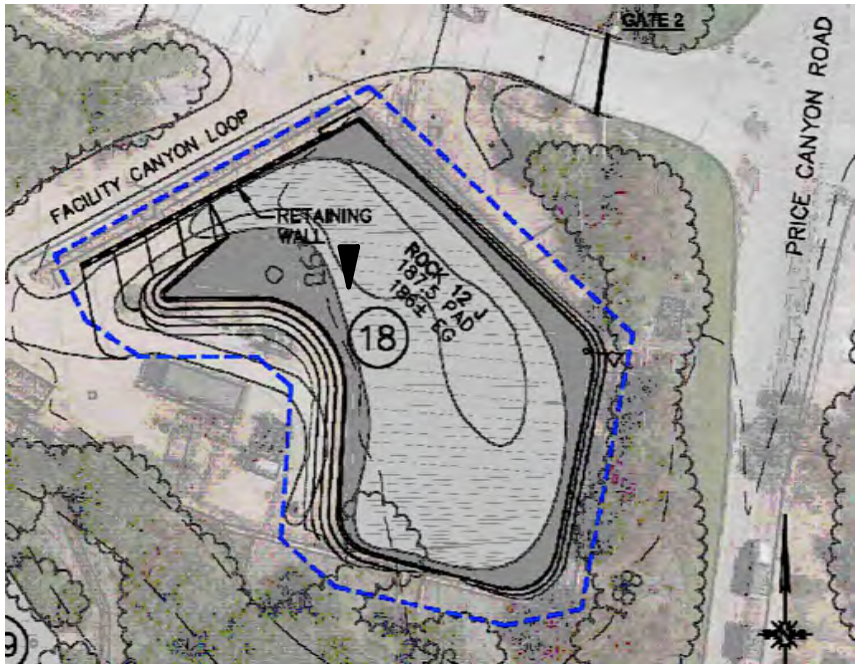

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking south

PAD I.D.: 18

PAD NAME: Rock 12 J

PROPOSED IMPROVEMENTS: Pad clearing and grubbing. Cut along west side up to 7 feet. Fill along southeast up to 4 feet. Retaining wall planned along Facility Canyon Loop.

Photo Location and Direction

FIELD OBSERVATIONS:

- Shallow subsurface water likely along the southwest corner

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for pad construction

N

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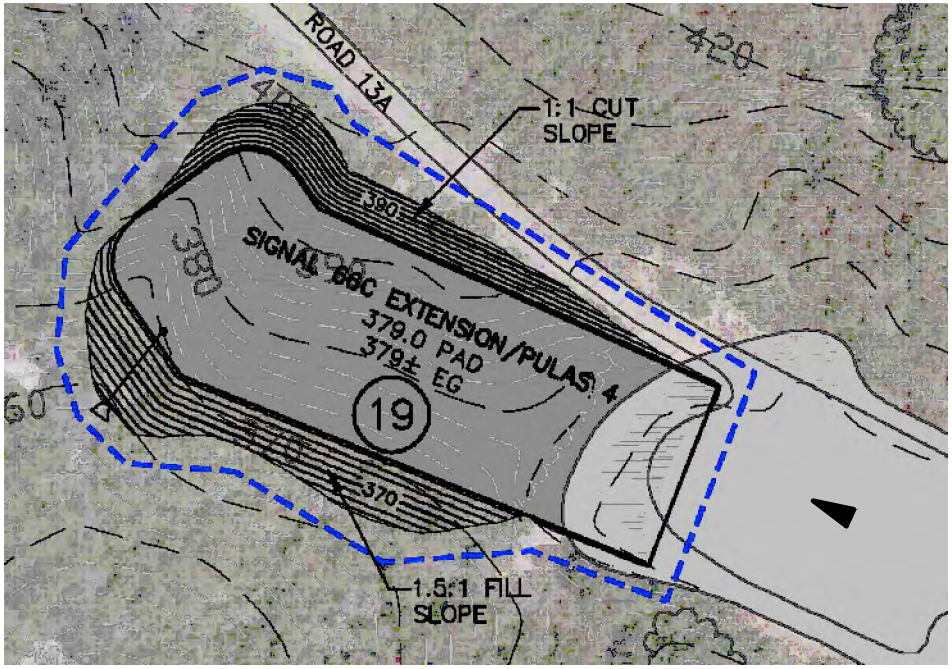

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking northwest

PAD I.D.: 19

PAD NAME: Signal 66 C Extension / Pulas 4

PROPOSED IMPROVEMENTS: Extend the pad towards the northwest. Fill along southwest area up to 11 feet. Cut along north side up to 14 feet.

FIELD OBSERVATIONS:

- Existing north slope covered in brush
- Shallow cut along the north side with the existing road above into quartz sandstone
- Existing fill up to 15 feet on the south side

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for pad construction

Photo Location and Direction

N

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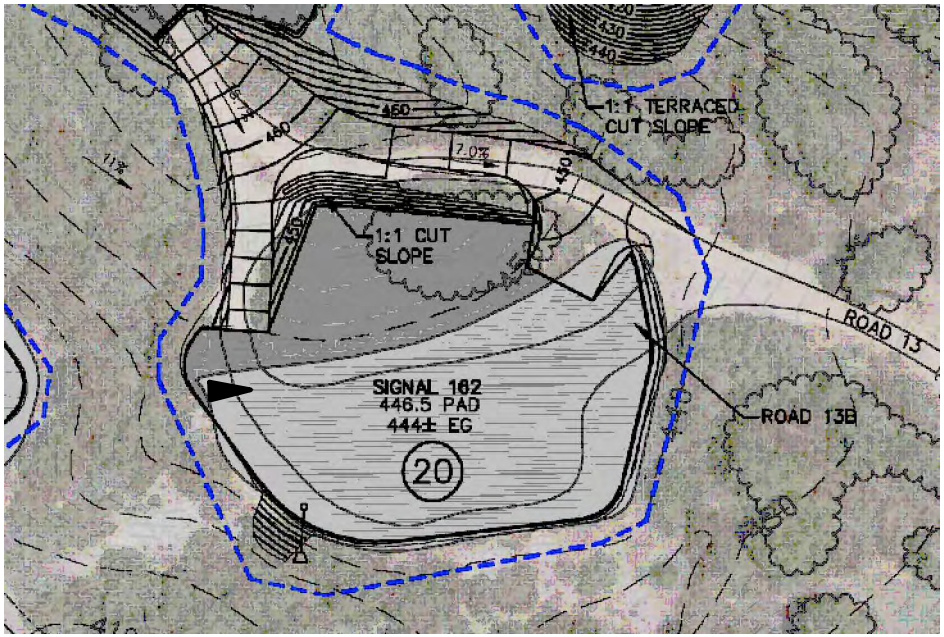

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 12/9/2013, looking east

PAD I.D.: 20

PAD NAME: Signal 162

PROPOSED IMPROVEMENTS: Cut along the north side up to 12 feet. Fill at southwest corner up to 6 feet.

FIELD OBSERVATIONS:

- Existing cuts into bituminous sandstone along the north side

RECOMMENDATIONS:

- Prepare geotechnical recommendations for pad construction based upon observed conditions; subsurface investigation not warranted

Photo Location and Direction

N

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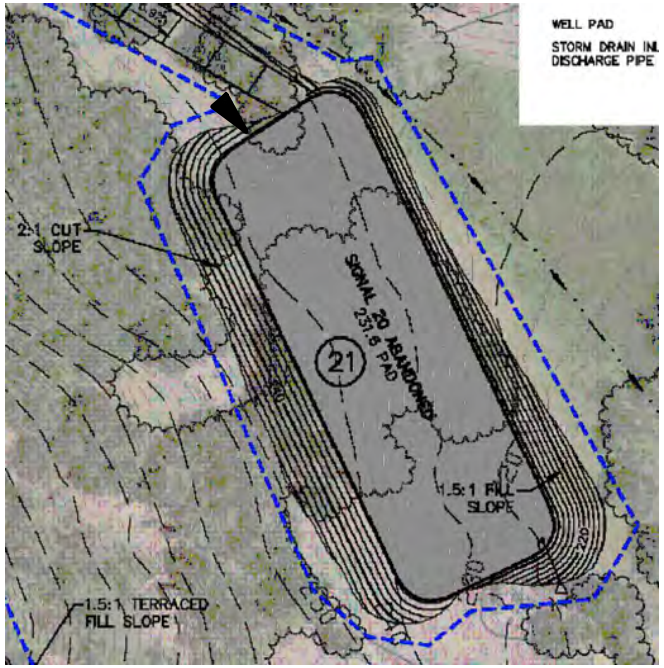

Base map provided by Cannon; revision E, dated 12/7/2013

Photo dated 4/18/2013, looking southeast

PAD I.D.: 21

PAD NAME: Signal 20 Abandoned

PROPOSED IMPROVEMENTS: Fills up to 15 feet along the southeast. Cut along west side up to 11 feet.

Photo Location and Direction

FIELD OBSERVATIONS:

- Shallow sandstone outcropping and grasses at the well pad
- Roadway follows the north side of a swale with several crossing and signs of seepage
- Possible seepage from the existing pond above which may drain into potential cuts/fills along the roadway

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for pad construction

N

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Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking southeast

PAD I.D.: 22

PAD NAME: Signal P1-I1

PROPOSED IMPROVEMENTS: Cut into southeast corner of pad up to 23 feet. Fill up to 20 feet along northeast corner.

Photo Location and Direction

FIELD OBSERVATIONS:

- Existing cut in bituminous sandstone up to 40 feet in the southeast corner
- Existing cuts at approximately ½:1 to 1:1, with some locations near vertical
- Top of cut is fractured
- Potential for bedding plane failure (see photo)
- Strike: N 75 W, Dip: 53 NE

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for pad construction

N

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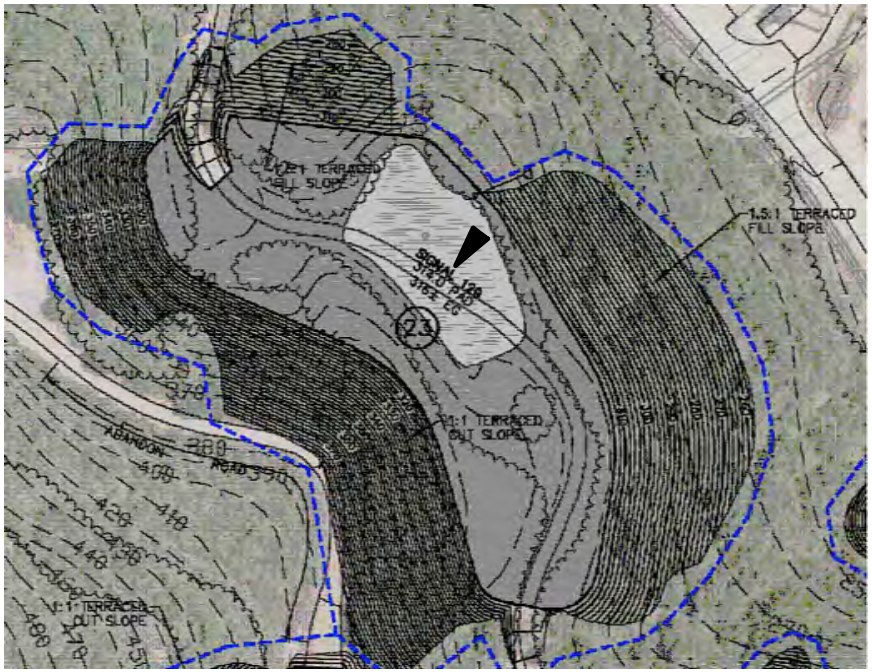

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking southwest

PAD I.D.: 23

PAD NAME: Signal 129

PROPOSED IMPROVEMENTS: Cuts along the west side of the pad up to 46 feet. Fill along north and east side up to 28 feet.

Photo Location and Direction

FIELD OBSERVATIONS:

- Existing cut on west side up to 35 feet tall at ½:1 slope
- Bituminous sandstone and pebbly conglomerate exposed in several locations along the north and south ends
- Roadway above slated for abandonment
- Existing fill slope at 1.5:1 has loose soils and erosion on surface
- North end has topple failure of very weathered quartz sandstone/pebbly conglomerate
- Shallow culvert at north end

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for pad construction

N

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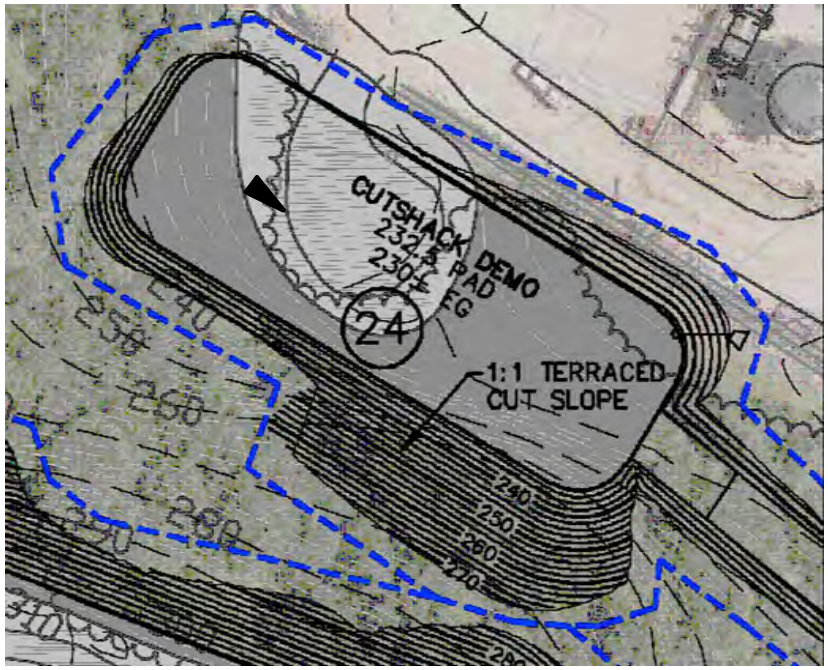

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking southeast

PAD I.D.: 24

PAD NAME: Cutshack Demo

PROPOSED IMPROVEMENTS: Cut along south and west sides up to 23 feet. Fill along the east end up to 10 feet. New roadway connection off of Rock 98.

Photo Location and Direction

FIELD OBSERVATIONS:

- Existing cuts into bituminous sandstone
- Soil, brush, and trees along the top of slopes

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for pad construction

N

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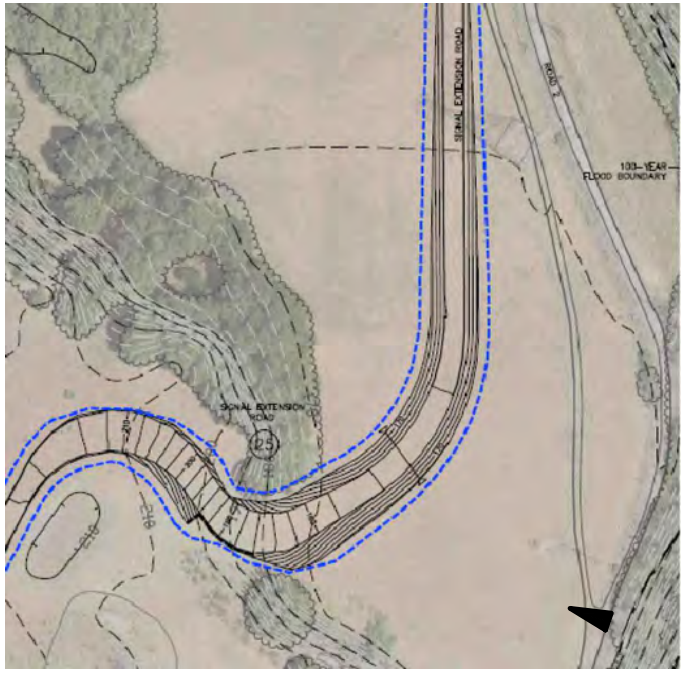

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking west

PAD I.D.: 25

PAD NAME: Signal Extension Road

PROPOSED IMPROVEMENTS: Extend signal road towards the south. Fill up to 10 feet. No planned cut areas.

FIELD OBSERVATIONS:

- Vegetation along route
- Grading along and over hill site near bituminous sandstone outcrops

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for pad construction

Photo Location and Direction

N

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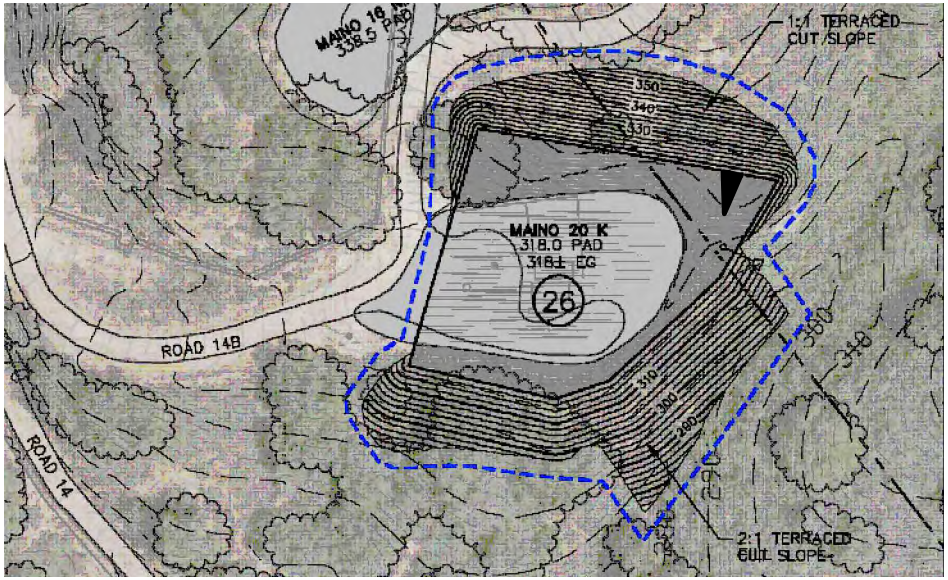

Base map provided by Cannon; revision E, dated 12/6/2013

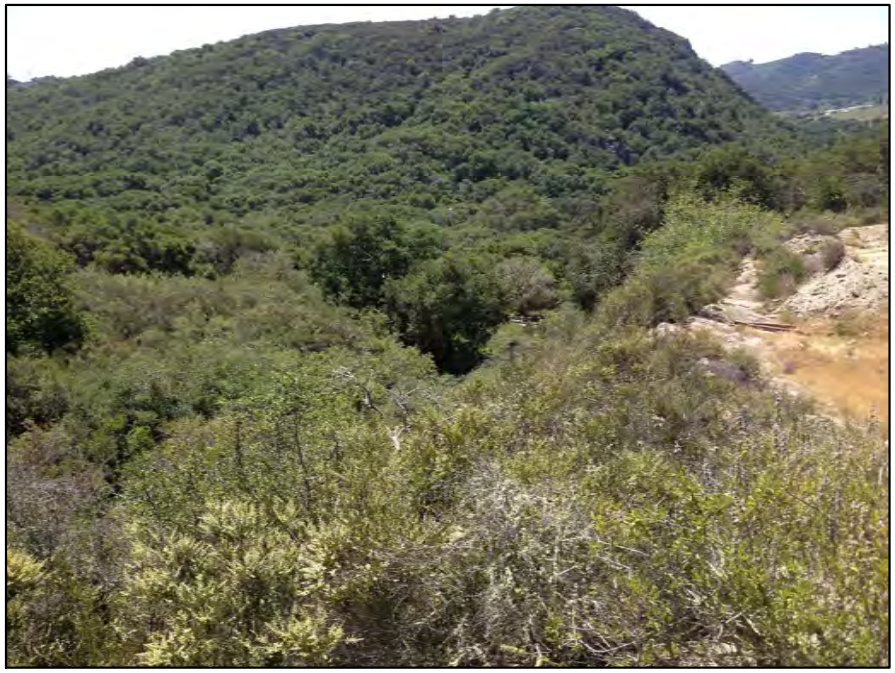

Photo dated 4/18/2013, looking south

PAD I.D.: 26

PAD NAME: Maino 20 K

PROPOSED IMPROVEMENTS: Cuts along the north side up to 25 feet. Fill along the southeast side up to 27 feet. Fill encroaches into drainage.

Photo Location and Direction

FIELD OBSERVATIONS:

- Existing cuts into fractured quartz sandstone
- Existing surficial erosion with bedding angled into the slope
- Southeast fill slope is heavily brushed and steep with surficial erosion features
- Toe of the slope encroaches into vegetated drainage

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for pad construction

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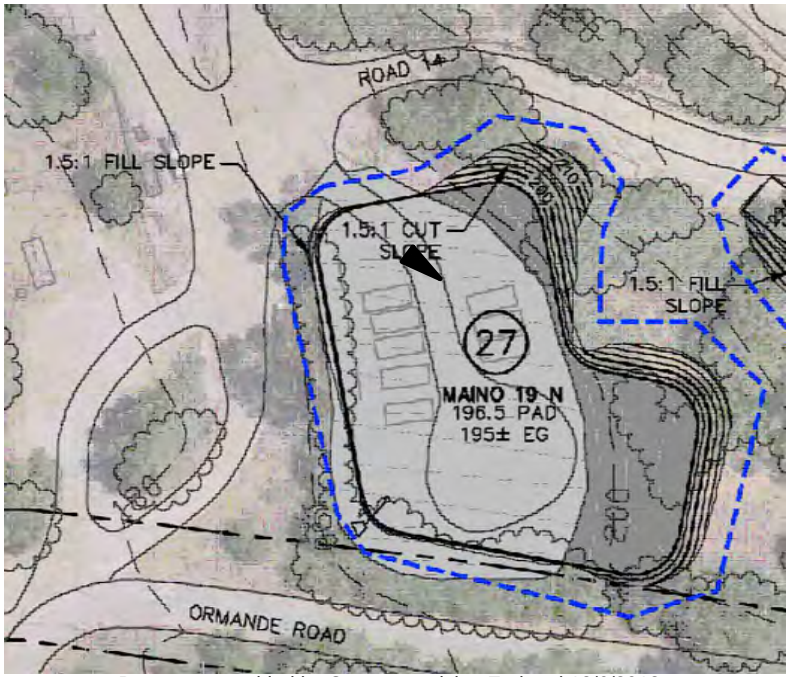

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking southeast

PAD I.D.: 27

PAD NAME: Maino 19 N

PROPOSED IMPROVEMENTS: Cut along the east side up to 9 feet. Fill up to 2 feet.

FIELD OBSERVATIONS:

- Soil stockpile along the east side of the pad

RECOMMENDATIONS:

- Prepare geotechnical recommendations for pad construction based upon observed conditions; subsurface investigation not warranted

Photo Location and Direction

N

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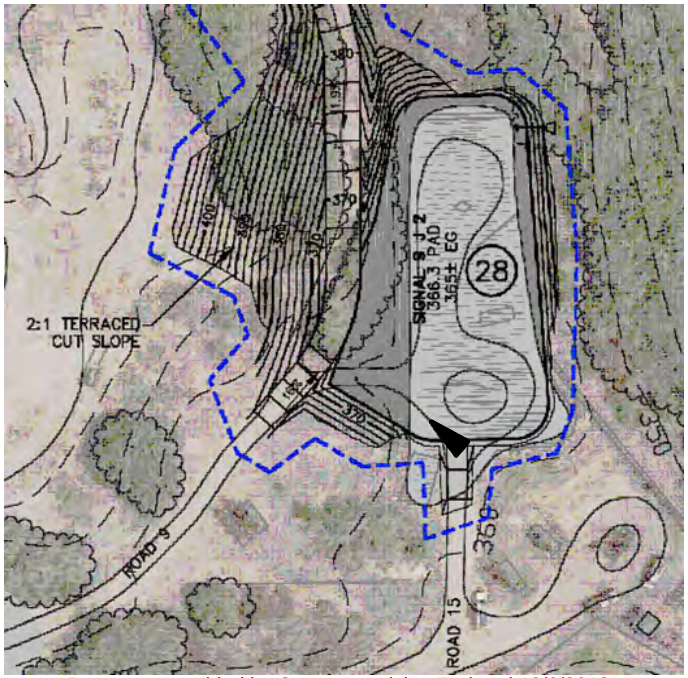

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 5/17/2013, looking west

PAD I.D.: 28

PAD NAME: Signal 9 J 2

PROPOSED IMPROVEMENTS: Clean up of stockpiles and grubbing. Cut along west side up to 15 feet. Fill along east side up to 2 feet. Reconstruction of existing roadway.

Photo Location and Direction

FIELD OBSERVATIONS:

- Loose fill slope exposed along west side of pad

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for pad construction

N

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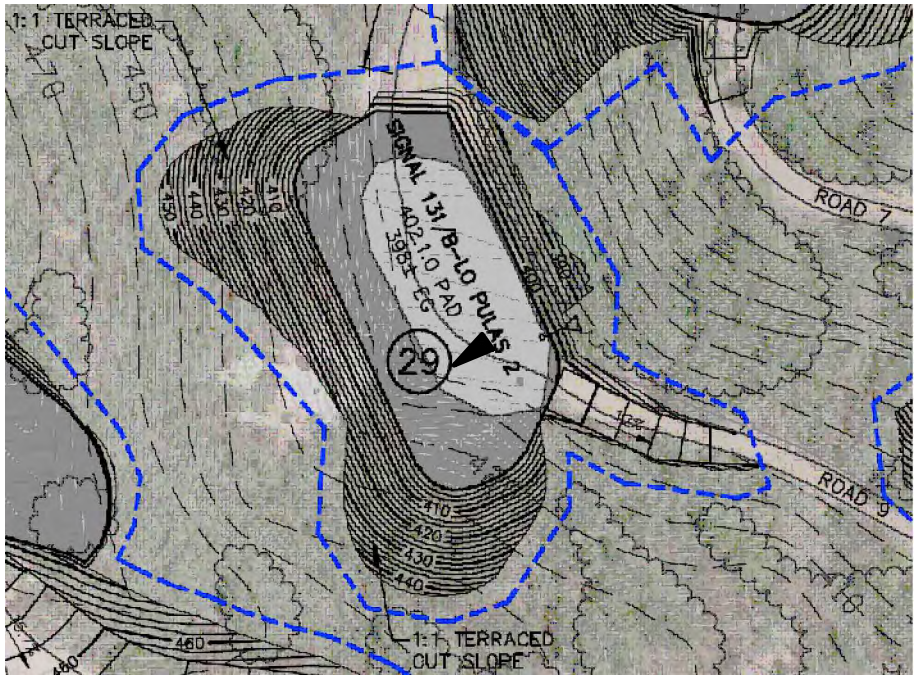

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking southwest

PAD I.D.: 29

PAD NAME: Signal 131 / B-Lo Pulas 2

PROPOSED IMPROVEMENTS: Cut up to 24 feet on the west and south sides. Fill up to 4 feet on the east side.

FIELD OBSERVATIONS:

- Existing cuts at approximately 1:1 to 1.5:1
- Cuts into bituminous sandstone with contact of pebbly conglomerate
- Erosion of conglomerate along the west cut face

RECOMMENDATIONS:

- Perform subsurface investigation and analysis
- Prepare geotechnical recommendations for pad construction

Photo Location and Direction

N

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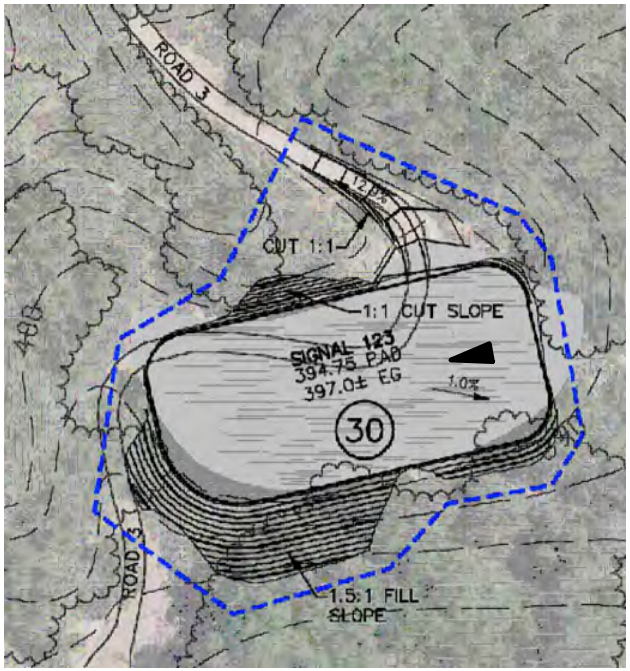

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking west

PAD I.D.: 30

PAD NAME: Signal 123

PROPOSED IMPROVEMENTS: Cut along north side up to 7 feet. Fill along southwest up to 3 feet.

FIELD OBSERVATIONS:

- Fill slope planned over heavily vegetated slopes

RECOMMENDATIONS:

- Prepare geotechnical recommendations for pad construction based upon observed conditions; subsurface investigation not warranted

Photo Location and Direction

N

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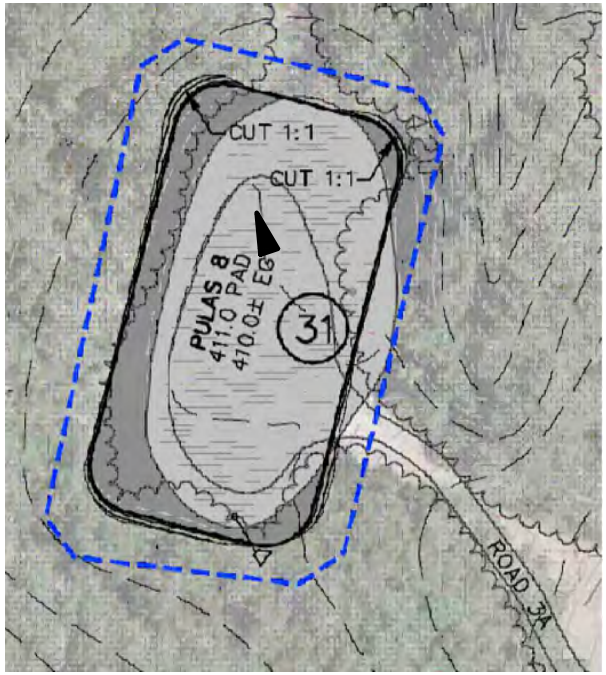

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking northwest

PAD I.D.: 31

PAD NAME: Pulas 8

PROPOSED IMPROVEMENTS: Minor pad clearing and grubbing. Cut along north, west, and south sides up to 5 feet.

FIELD OBSERVATIONS:

- Cut areas in alluvium

RECOMMENDATIONS:

- Prepare geotechnical recommendations for pad construction based upon observed conditions; subsurface investigation not warranted

Photo Location and Direction

N

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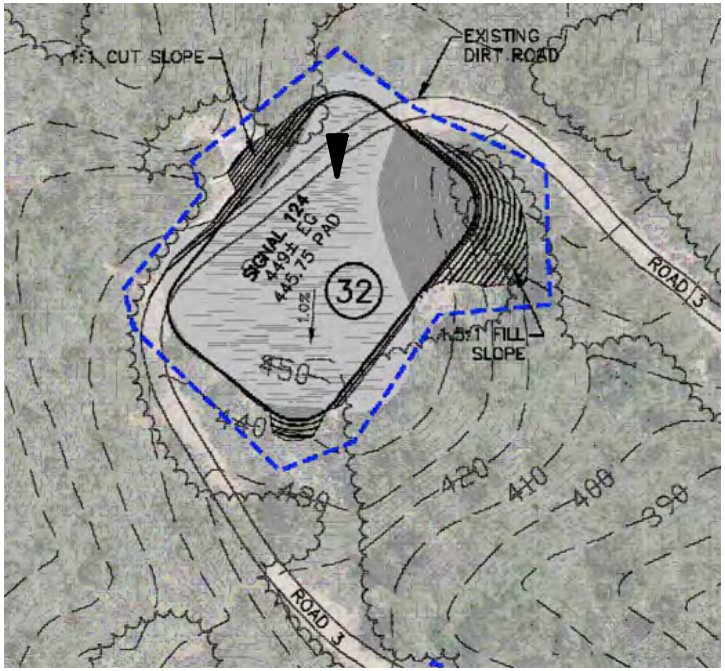

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 5/17/2013, looking south

PAD I.D.: 32

PAD NAME: Signal 124

PROPOSED IMPROVEMENTS: Fill along east corner up to 16 feet. Cut along northwest side up to 6 feet.

FIELD OBSERVATIONS:

- Steep existing fill slope with stockpile of woodchips
- Block failures/erosion of quartz sandstone cut

RECOMMENDATIONS:

- Perform subsurface investigation and analysis
- Prepare geotechnical recommendations for pad construction

Photo Location and Direction

N

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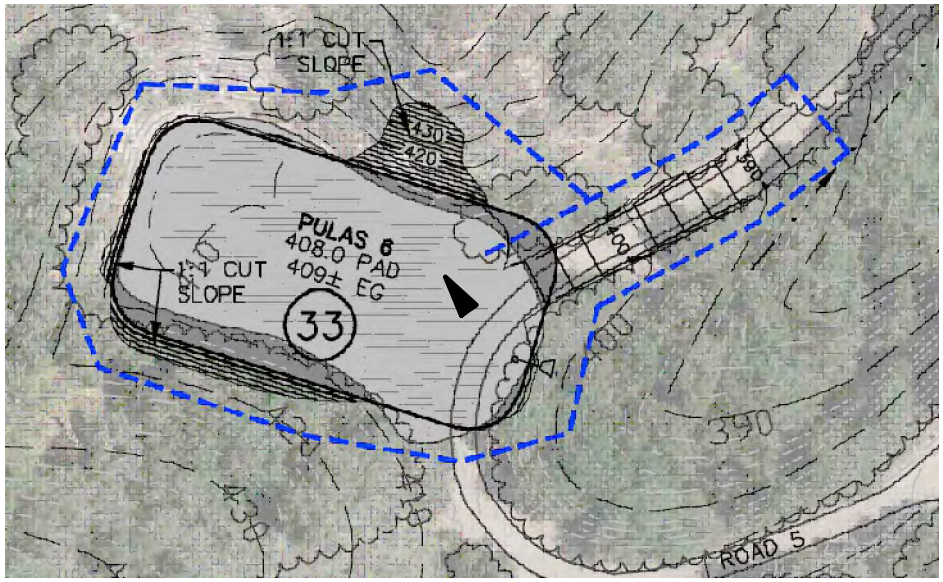

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 5/17/2013, looking towards the northwest

PAD I.D.: 33

PAD NAME: Pulas 6

PROPOSED IMPROVEMENTS: Minor pad clearing and grubbing. Cut along north and south sides up to 4 feet.

FIELD OBSERVATIONS:

- Exposed quartz sandstone in existing cuts
- Existing cuts at ½:1

RECOMMENDATIONS:

- Prepare geotechnical recommendations for pad construction based upon observed conditions; subsurface investigation not warranted

Photo Location and Direction

N

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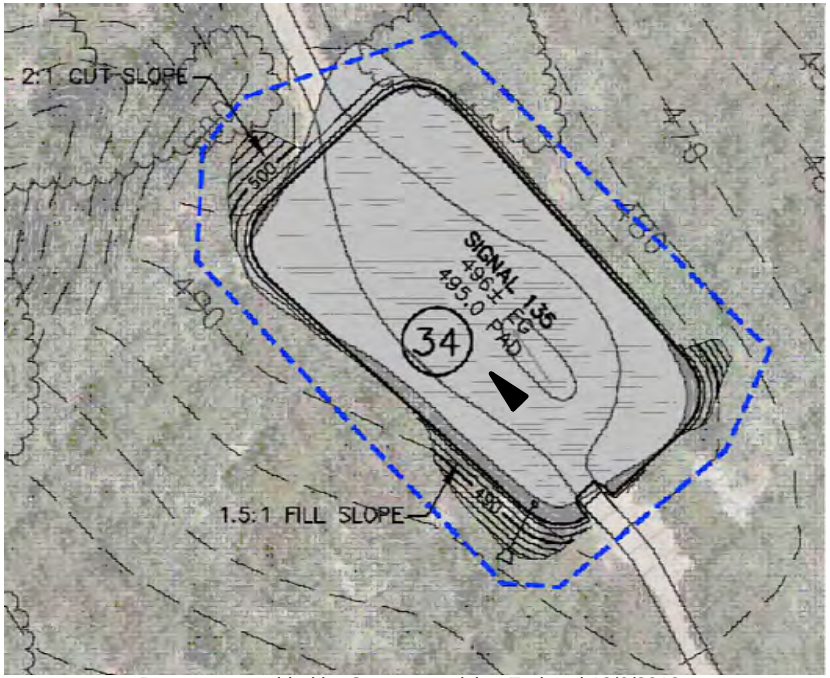

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 5/17/2013, looking northwest

PAD I.D.: 34

PAD NAME: Signal 135

PROPOSED IMPROVEMENTS: Minor pad clearing and grubbing. Cut along northwest up to 5 feet. Fill along south side up to 5 feet.

FIELD OBSERVATIONS:

- Vegetation along proposed cut/fill areas
- Pad along cut ridgeline of quartz sandstone

RECOMMENDATIONS:

- Prepare geotechnical recommendations for pad construction based upon observed conditions; subsurface investigation not warranted

Photo Location and Direction

N

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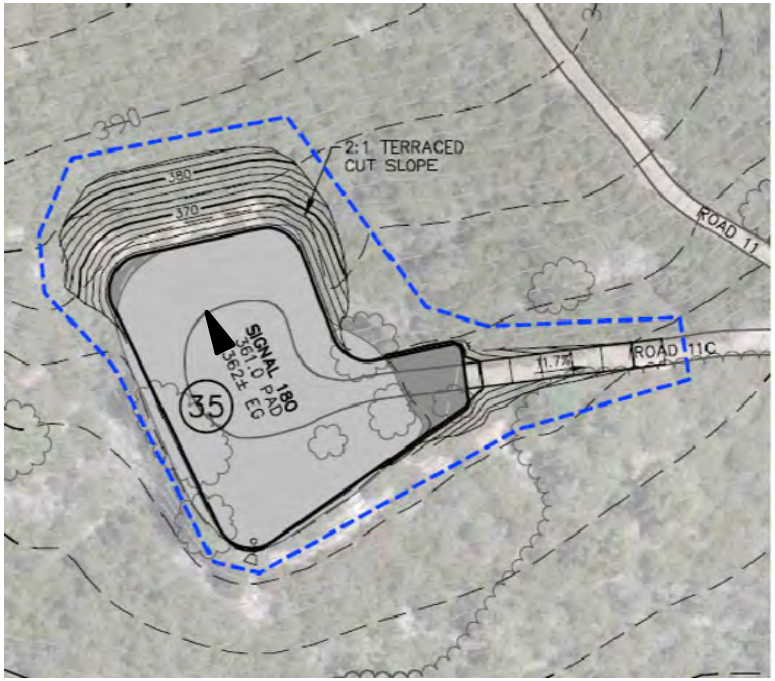

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 5/17/2013, looking north

PAD I.D.: 35

PAD NAME: Signal 180

PROPOSED IMPROVEMENTS: Improvements to the entrance road and cut along the north end up to 8 feet. Fill along southeast up to 4 feet on roadway.

FIELD OBSERVATIONS:

- Existing cuts into quartz sandstone at ½:1 to vertical
- Exposed cut in various stages of erosion

RECOMMENDATIONS:

- Prepare geotechnical recommendations for pad construction based upon observed conditions; subsurface investigation not warranted

Photo Location and Direction

N

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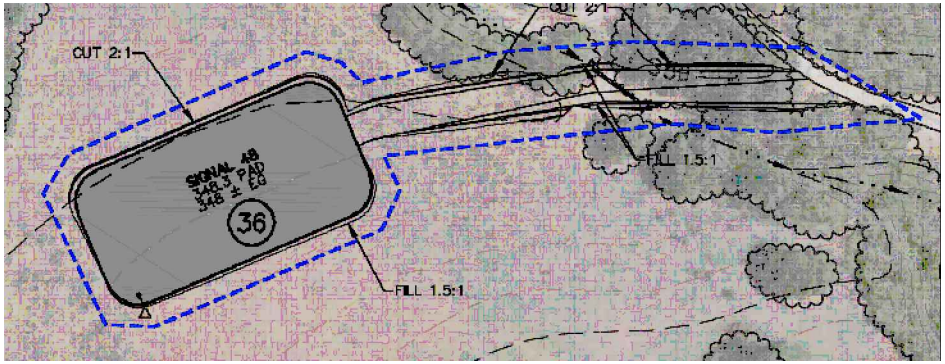

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 9/17/2011, Europa Technologies, 2011

PAD I.D.: 36

PAD NAME: Signal 48

PROPOSED IMPROVEMENTS: New access road and signal pad with fill along south side up to 2 feet. Cut along north side up to 3 feet.

FIELD OBSERVATIONS:

- Crossing of 5' to 8' deep swale
- Top soil along swale has eroded during rain events
- Potential for springs due to green grass in pad area amongst brown grass

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for pad construction

N

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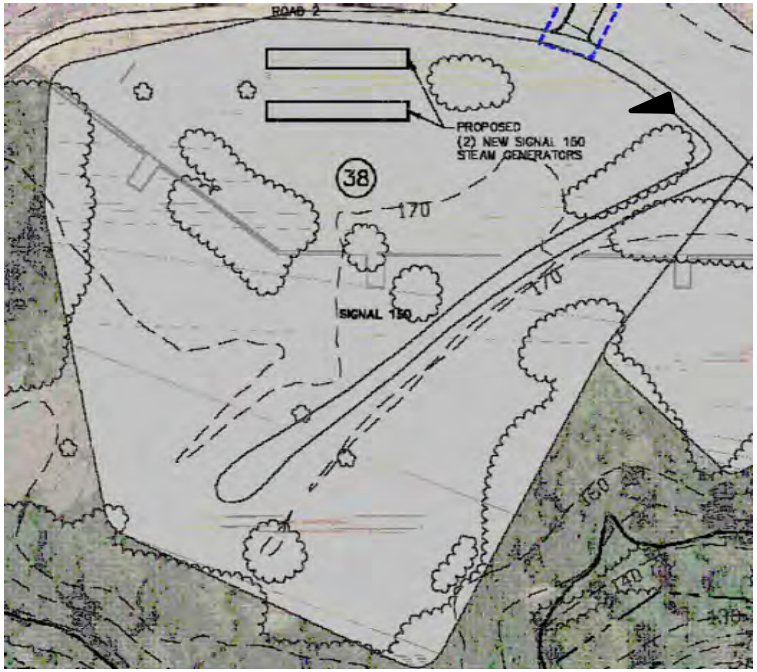

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 5/17/2013, looking west

PAD I.D.: 38

PAD NAME: Signal 150

PROPOSED IMPROVEMENTS: Minor pad clearing and grubbing. Proposed location for two steam generators.

FIELD OBSERVATIONS:

- Existing pad with little to no improvement planned

RECOMMENDATIONS:

- No further geotechnical information warranted for pad construction
- Perform geotechnical investigation and develop recommendations for steam generator pads

Photo Location and Direction

N

NOT TO SCALE

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FMOG - ARROYO GRANDE OIL FIELD - PHASE V

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Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 5/17/2013, looking southwest

PAD I.D.: 39

PAD NAME: Rock 401

PROPOSED IMPROVEMENTS: Minor pad clearing and grubbing.

FIELD OBSERVATIONS:

- Existing contractor lay down yard

RECOMMENDATIONS:

- No further geotechnical information warranted

Photo Location and Direction

N

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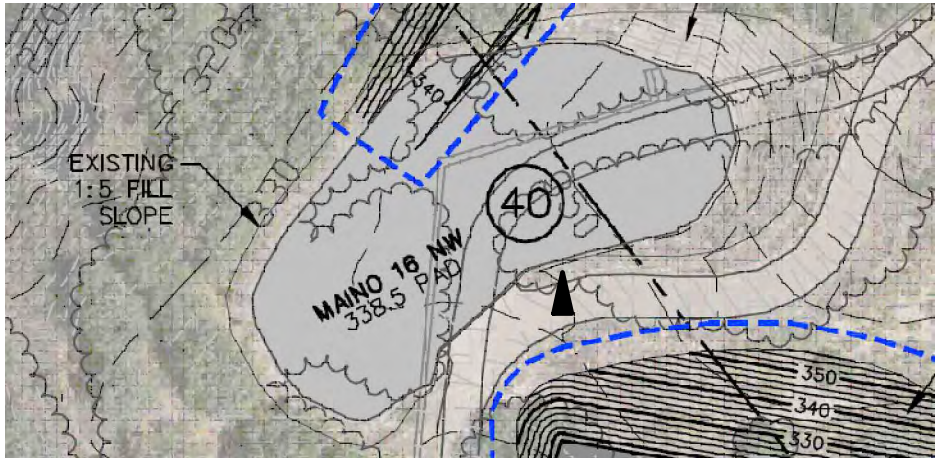

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking north

PAD I.D.: 40

PAD NAME: Maino 16 NW

PROPOSED IMPROVEMENTS: New road to Maino 16 NW upper pad. No proposed changes to existing pad.

FIELD OBSERVATIONS:

- Existing cut slope at 1:1 surfaced with erosion control blanket

RECOMMENDATIONS:

- No further geotechnical information warranted

Photo Location and Direction

N

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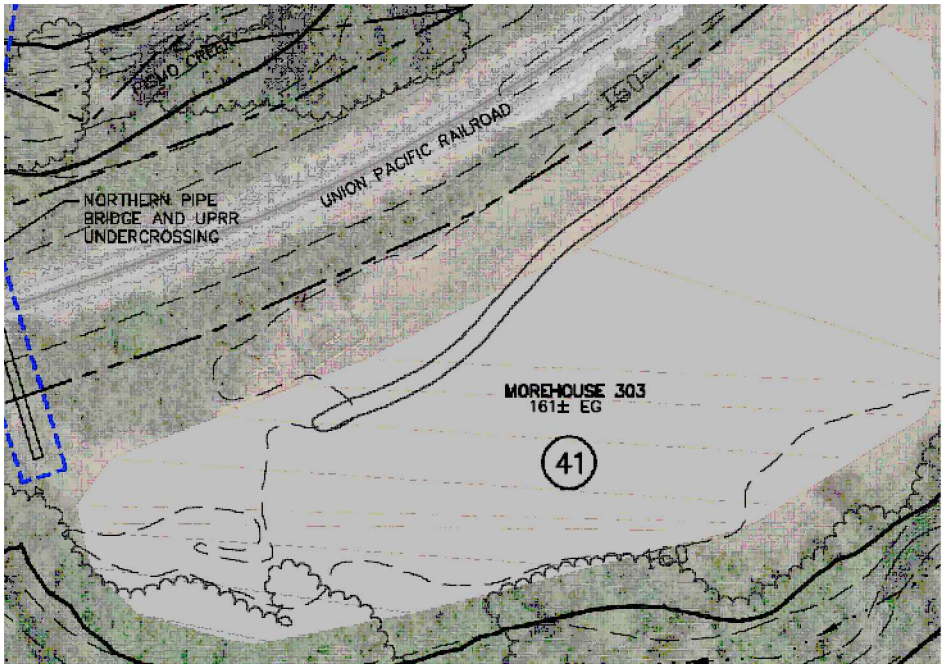

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 9/17/2011, Google, Inc.

PAD I.D.: 41

PAD NAME: Maino Morehouse 303

PROPOSED IMPROVEMENTS: Fill along southwest up to 2 feet. Cut along northeast up to 1 foot.

FIELD OBSERVATIONS:

- Site not accessible at time of visit, based upon aerial photograph
- Currently used for grazing cattle

RECOMMENDATIONS:

- Prepare geotechnical recommendations for pad construction based upon observed conditions; subsurface investigation not warranted

N

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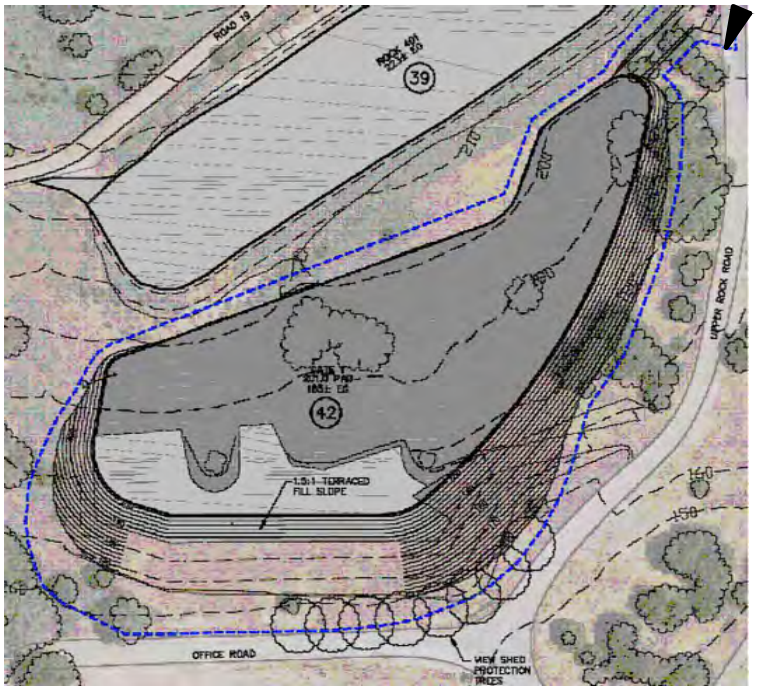

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 12/9/2013, looking southwest

PAD I.D.: 42

PAD NAME: Gate 1

PROPOSED IMPROVEMENTS: Fill pad for excess material; up to 20 feet along the south side.

Photo Location and Direction

FIELD OBSERVATIONS:

- Recent grading constructed fill pad
- Shallow bituminous sandstone with intermittent soil cap to north of existing pad

RECOMMENDATIONS:

- Prepare geotechnical recommendations for pad construction based upon observed conditions; subsurface investigation not warranted

N

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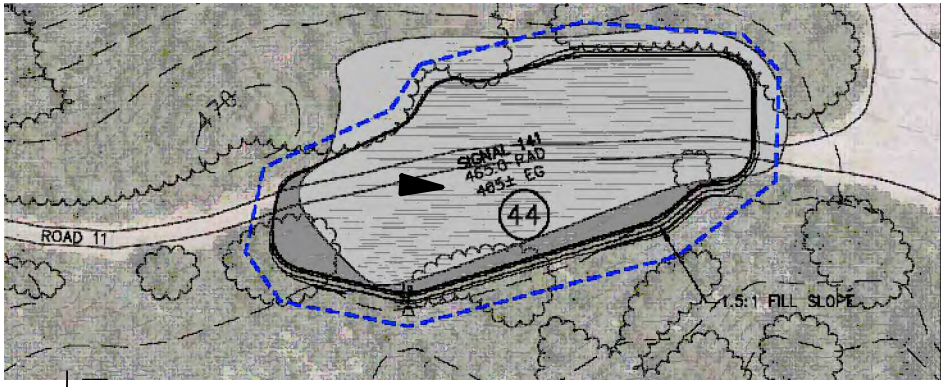

Base map provided by Cannon; revision E, dated 12/6/2013

N

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Photo dated 5/17/2013, looking east

PAD I.D.: 44

PAD NAME: Signal 141

PROPOSED IMPROVEMENTS: Minor pad clearing and grubbing. Fill along the south side up to 5 feet.

Photo Location and Direction

FIELD OBSERVATIONS:

- Existing vegetated fill slopes
- Cut quartz sandstone pad along ridgeline

RECOMMENDATIONS:

- Prepare geotechnical recommendations for pad construction based upon observed conditions; subsurface investigation not warranted

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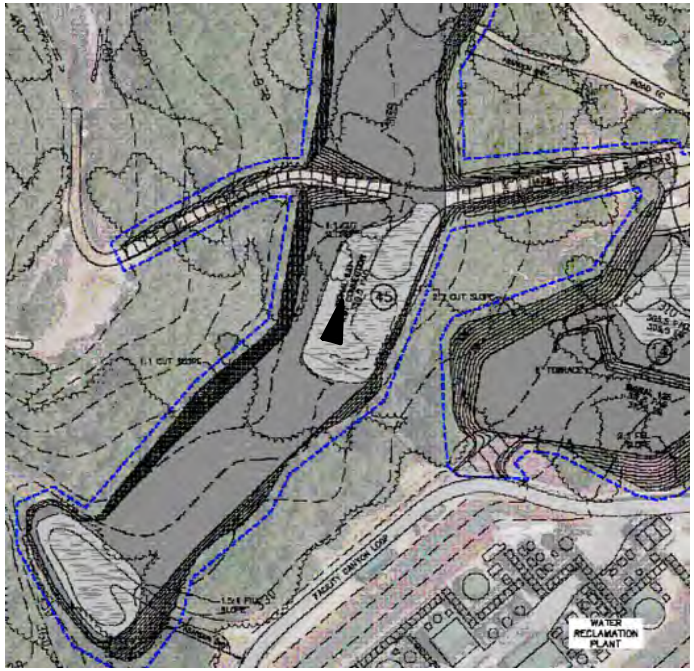

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking northeast

PAD I.D.: 45

PAD NAME: Signal 121 AWT Connection

PROPOSED IMPROVEMENTS: Fills up to 8 feet along south and east sides. Cuts up to 24 feet along the west side.

Photo Location and Direction

FIELD OBSERVATIONS:

- Existing fill along the east slope covered in brush
- Lush vegetation along west side could indicate shallow groundwater
- Existing cut along the west side into fractured sandstone with overlying soil
- Large areas of cut and fill in heavily vegetated areas

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for pad construction

N

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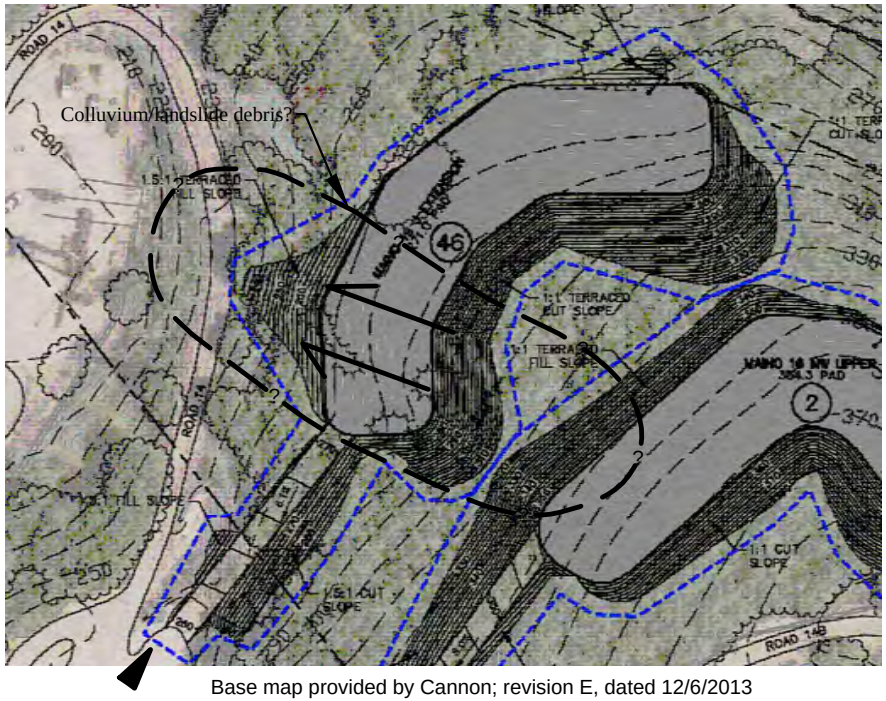

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking northeast

PAD I.D.: 46

PAD NAME: Maino 19 J Extension

PROPOSED IMPROVEMENTS: Cuts along the south and southeast sides up to 37 feet. Fill along the north and west sides up to 9 feet.

Photo Location and Direction

FIELD OBSERVATIONS:

- Existing cuts along the roadway into fractured quartz sandstone
- Existing topography is heavily vegetated and sloped at approximately 20 to 40 percent
- Colluvium/landslide debris
- Steep cuts could be prone to gross failure
- Toe of existing fill present on roadway exposes colluvium/landslide debris?

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for pad construction

N

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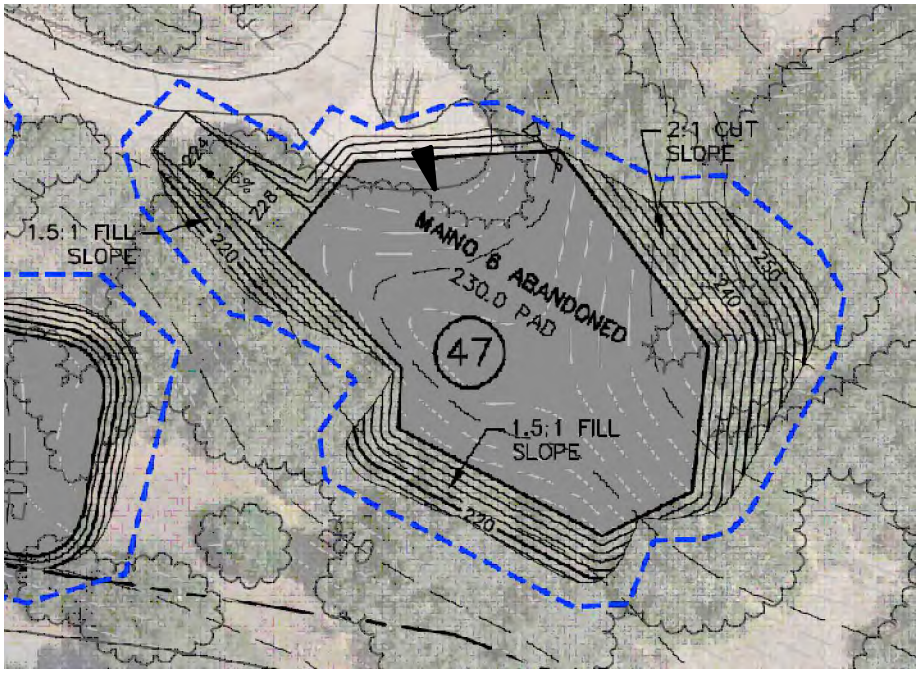

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 5/17/2013, looking southeast

PAD I.D.: 47

PAD NAME: Maino 6 Abandoned

PROPOSED IMPROVEMENTS: Cut along the northeast side up to 15 feet. Fill along the south side up to 6 feet.

FIELD OBSERVATIONS:

- Existing slopes at 5 to 10 percent with heavy vegetation
- Cut/fill pad planned

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for pad construction

Photo Location and Direction

N

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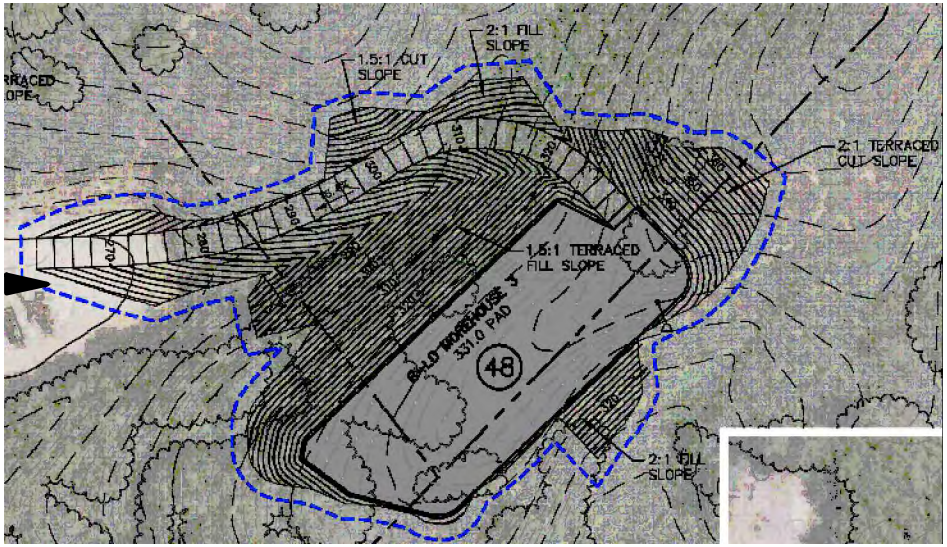

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking east

PAD I.D.: 48

PAD NAME: B-Lo Morehouse 3

PROPOSED IMPROVEMENTS: Access road up canyon to the north then to the east to the pad. Fill along the southwest and south sides up to 13 feet. Cuts along the northeast end up to 22 feet.

Photo Location and Direction

FIELD OBSERVATIONS:

- Existing cuts into quartz sandstone with soil above
- Ridge line with slopes up to 40 percent
- Existing slope is heavily vegetated
- Proposed 1.5:1 to 2:1 cut/fill slopes

RECOMMENDATIONS:

- Perform subsurface investigation and analysis
- Prepare geotechnical recommendations for pad construction

N

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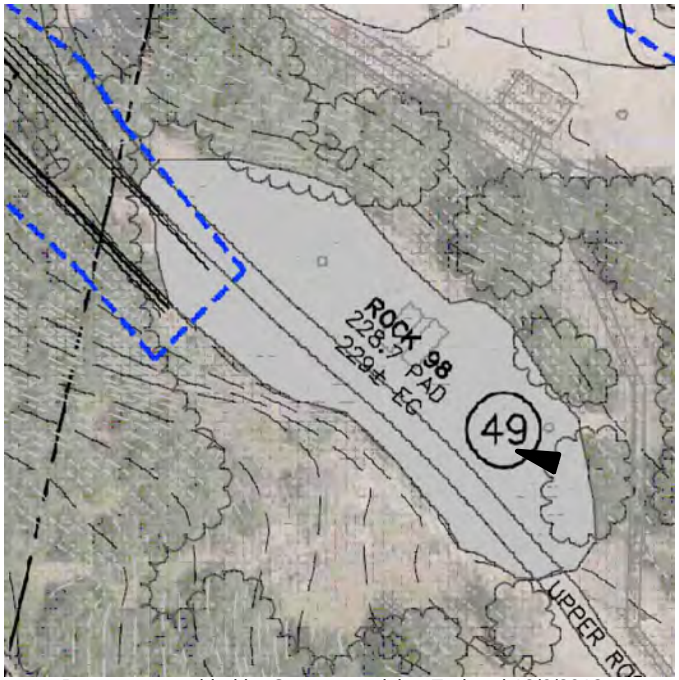

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking northwest

PAD I.D.: 49

PAD NAME: Rock 98 Expansion

PROPOSED IMPROVEMENTS: Provide access to road for Cutshack Demo Pad.

FIELD OBSERVATIONS:

- Overhang along southwest side of pad

RECOMMENDATIONS:

- No further geotechnical information warranted

Photo Location and Direction

N

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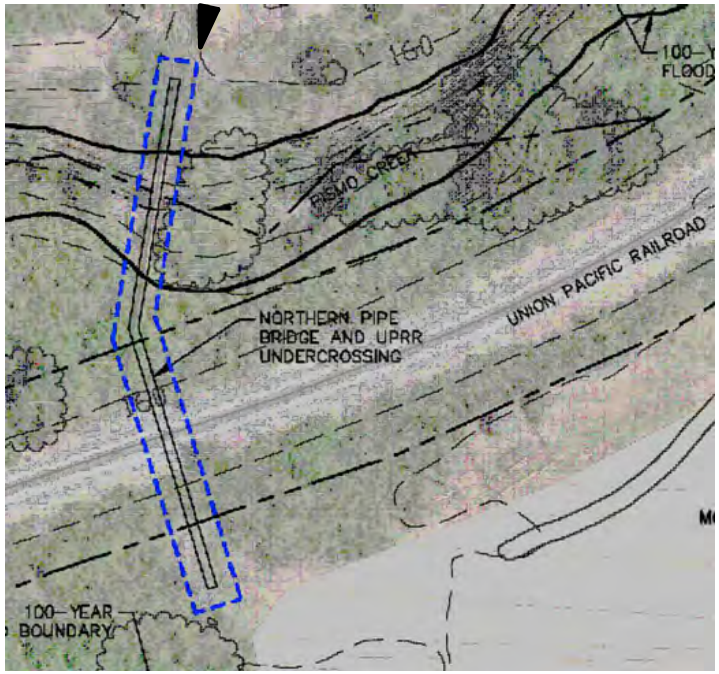

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 4/18/2013, looking southwest

PAD I.D.: N/A

PAD NAME: Northern Pipe Bridge

PROPOSED IMPROVEMENTS: Construct pipe bridge to cross Pismo Creek.

FIELD OBSERVATIONS:

- Site area is heavily vegetated
- Exposed quartz sandstone / pebbly conglomerate at existing grade

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for pipe bridge construction

Photo Location and Direction

N

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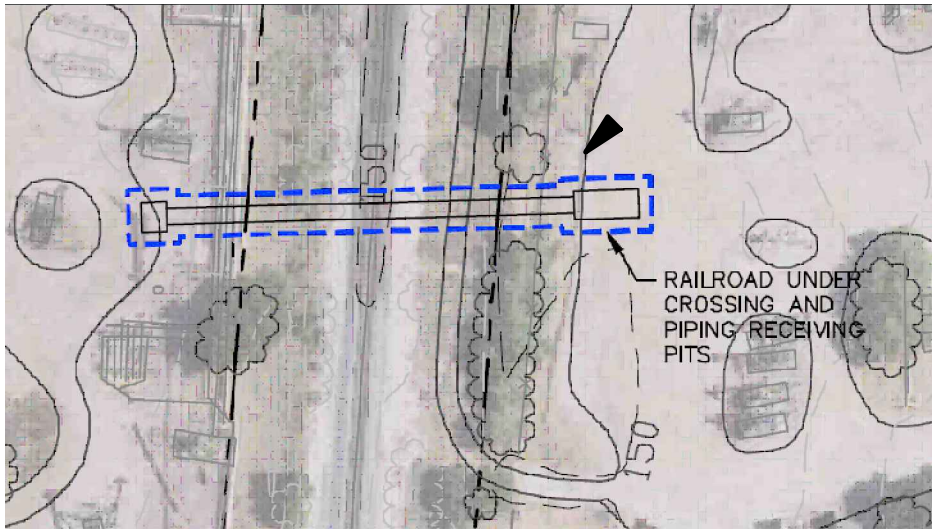

Base map provided by Cannon; revision E, dated 12/6/2013

Photo dated 5/17/2013, looking southwest

PAD I.D.: N/A

PAD NAME: UPRR Crossing

PROPOSED IMPROVEMENTS: Construct pipe under UPRR.

FIELD OBSERVATIONS:

- Surrounding topography at similar elevation as UPRR tracks

RECOMMENDATIONS:

- Perform subsurface investigation and analyses
- Prepare geotechnical recommendations for UPRR pipe crossing

Photo Location and Direction

N

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APPENDIX D

Typical Bench and Keyway Detail
Typical Back Drain Detail

BENCH and KEYWAY DETAIL, TYPICAL

FMOG - ARROYO GRANDE OIL FIELD - PHASE V

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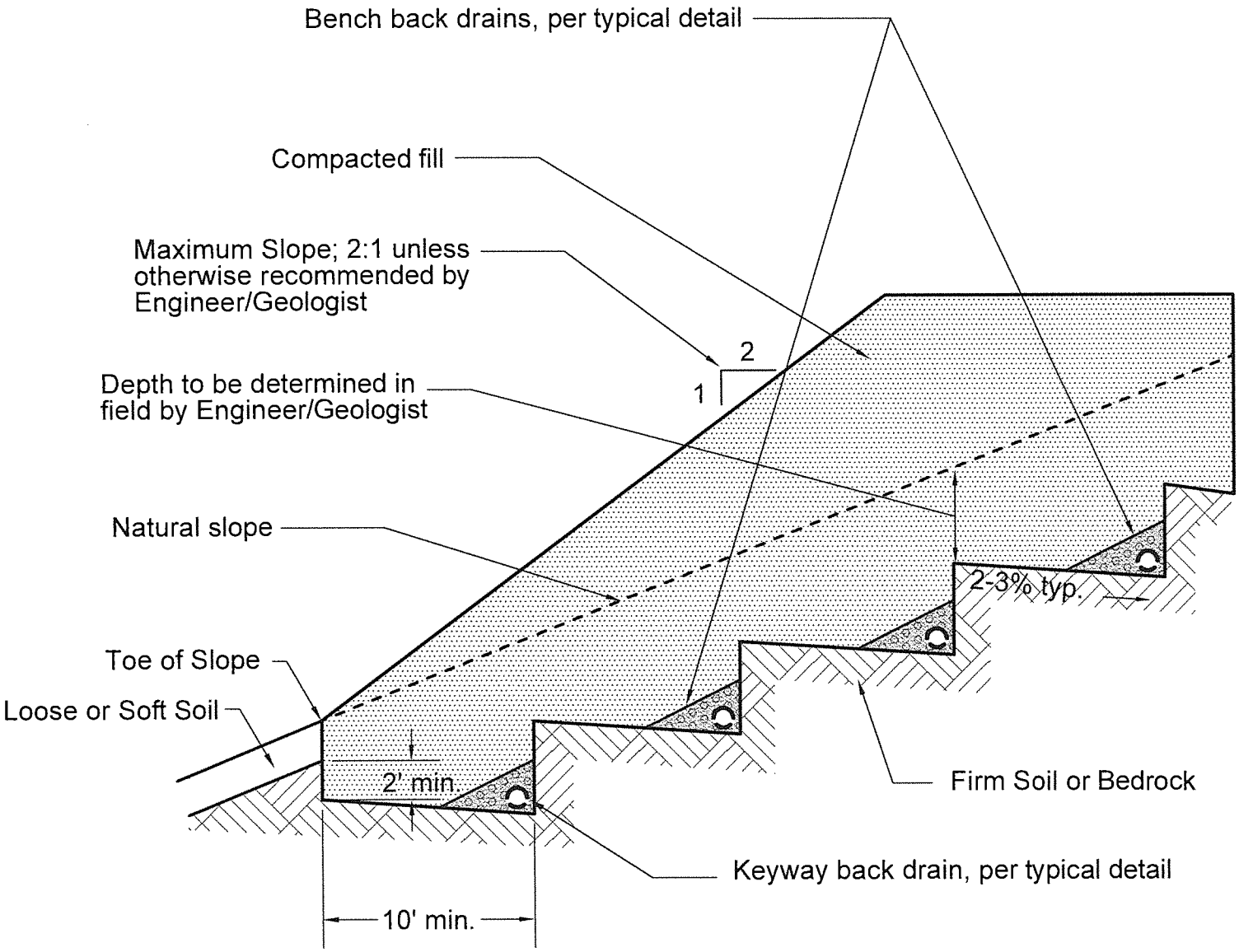

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TYPICAL BACK DRAIN DETAIL

FMOG - ARROYO GRANDE OIL FIELD - PHASE V

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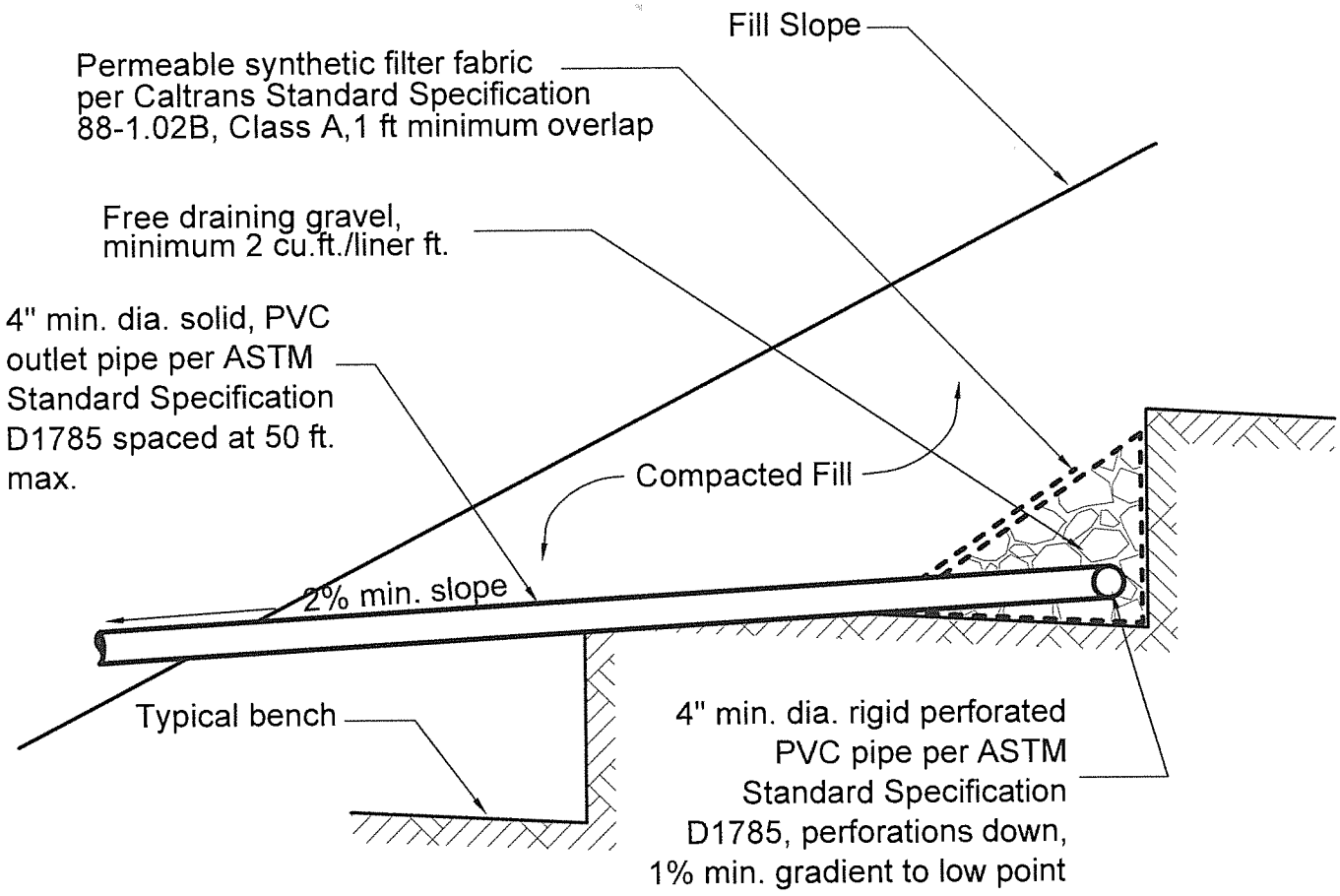

Note: A prefabricated panel drainage system (Advanedge, Miradrain, etc.) may be substituted for the gravel / pipe system, provided it is installed in accordance with the manufacturer's recommendations

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