APPENDIX E

Geotechnical Documentation:

GEOTECHNICAL INVESTIGATION

FRESNO CANYON FLOOD MITIGATION PROJECT VENTURA COUNTY, CALIFORNIA

GEOCON
WEST, INC.

GEOTECHNICAL
ENVIRONMENTAL
MATERIALS

PREPARED FOR

VENTURA COUNTY WATERSHED PROTECTION DISTRICT VENTURA, CALIFORNIA

PROJECT NO. A8919-06-01

JANUARY 17, 2013

GEOCON
WEST, INC.
GEOTECHNICAL ■ ENVIRONMENTAL ■ MATERIALS

Project No. A8919-06-01
January 17, 2013

VIA OVERNIGHT COURIER

Masood Jilani, Project Manager
Ventura County Watershed Protection District
800 South Victoria Avenue
Ventura, California

Subject: GEOTECHNICAL INVESTIGATION
FRESNO CANYON FLOOD MITIGATION PROJECT
VENTURA COUNTY, CALIFORNIA

Dear Mr. Jilani:

In accordance with your authorization of our proposal dated April 24, 2012, we have performed a geotechnical investigation for the proposed Fresno Canyon Flood Mitigation Project located near the community of Casitas Springs in Ventura County, California. The accompanying report presents the findings of our study and our conclusions and recommendations pertaining to the geotechnical aspects of proposed design and construction. Based on the results of our investigation, it is our opinion that the proposed project can be constructed as proposed, provided the recommendations of this report are followed and implemented during design and construction.

If you have any questions regarding this report, or if we may be of further service, please contact the undersigned.

Very truly yours,

GEOCON WEST, INC.

Jelisa M. Thomas	Gerald A. Kasman	Neal D. Berliner
PE 74946	CEG 2251	GE 2576

(5+CD) Addressee

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GEOTECHNICAL INVESTIGATION

1. PURPOSE AND SCOPE

This report presents the results of a geotechnical investigation for the proposed Fresno Canyon Flood Mitigation project located near the community of Casitas Springs in Ventura County, California. The proposed drainage conveyance structure extends from an existing basin at the mouth of Fresno Canyon westward approximately 925 linear feet to the Ventura River. The approximate location of the proposed alignment is depicted on the Vicinity Map, Figure 1. The purpose of our investigation was to evaluate the prevailing subsurface soil and geologic conditions encountered at the project site, and based on conditions encountered to provide conclusions and recommendations pertaining to the geotechnical aspects of proposed design and construction.

The recommendations presented herein are based on analysis of the data obtained during the investigation and our experience with similar soil and geologic conditions. References reviewed to prepare this report are provided in the *List of References* section. If project details vary significantly from those described above, Geocon should be contacted to determine the necessity for review and possible revision of this report.

2. SITE & PROJECT DESCRIPTION

The subject site is located between the mouth of Fresno Canyon and the Ventura River, near the community of Casitas Springs, California. The Fresno Canyon drainage area has been subject to flooding, as evidenced in January 2005. The Ventura County Watershed Protection District (VCWPD) is proposing to construct a replacement drainage structure to convey stormwater runoff from Fresno Canyon to the Ventura River. The project has been designed to mitigate the potential for flooding by increasing the drainage capacity with new drainage conveyance structures.

An existing drainage conveyance system is located within the project limits and consists of a debris basin located near the mouth of Fresno Canyon. The basin is connected to an open channel structure which conveys stormwater to the Ventura River. The existing drainage conveyance structures will be left intact to provide an emergency overflow path.

The proposed alignment extends approximately 925 linear from the existing basin at the mouth of Fresno Canyon to the Ventura River. The alignment will cross under State Route 33 (SR-33), several private properties, and the Ojai Valley Bike Trail.

The proposed drainage conveyance system will include the construction of an outlet structure where the proposed alignment terminates at the Ventura River; a 12 foot diameter pipeline constructed with open-cut techniques along an existing County easement; a 12 foot diameter pipeline constructed with pipe jacking methods to cross under SR-33 and a hillside area; and a floodwall and channel structure at the mouth of the canyon. The proposed drainage conveyance structures will also cross under multiple existing utilities which must be protected during construction activities.

Our understanding of the proposed project is based on review of the design drawings prepared by VCWPD, as well as email correspondence and a meeting with VCWPD. Detailed descriptions of each section of the proposed drainage conveyance structures are provided below. The proposed drainage conveyance structures are depicted on the Site Plan / Geologic Map (see Figure 2) as well as on the Geologic Cross-Sections (see Figures 4 through 11).

2.1 Station 10+00 through Station 15+70

The proposed drainage conveyance structures will outlet at the Ventura River. The outlet structure will include non-grouted rock riprap and 10 foot high retaining wall. The riprap will be constructed in a trapezoidal shape to direct water flow into the river. The riprap construction will include a 4 foot wide cutoff wall at the toe of the riprap and 3 foot wide cutoff walls at each side of the riprap.

Immediately to the east of the non-grouted rock riprap, an approximately 120 foot long, north-south trending concrete headwall will be constructed. The wall will retain the proposed access road and bike path and will be up to 10 feet in height above the riprap.

The area of the proposed outlet structure and headwall is currently occupied by the Ventura River eastern riverbank. The Ojai Valley Bike Path also intersects the alignment at approximately Station 12+00. This area is roughly level, however densely vegetated. A north-south trending, 42 inch reinforced concrete (RC) gravity water main is located directly under the proposed riprap.

Beyond the outlet structure, between Station 11+75 and Station 15+70, the proposed drainage conveyance structure will consist of a 12 foot diameter reinforced concrete pipe (RCP). The proposed pipeline invert will be at depths between 4 and 14 feet below the existing ground surface and is proposed to be constructed with cut and cover techniques.

The area located between Station 12+00 and Station 15+70 is currently occupied by a densely vegetated hillside. The existing ground surface slopes to the south at a gradients ranging between 1½:1 and 1:1 (horizontal to vertical). The hillside extends approximately 90 vertical feet above the top of the proposed alignment. Between Stations 12+60 and Station 15+75, an existing 21 inch sewer line is located adjacent to the proposed drainage conveyance structures at a depth of approximately 8 feet below the proposed pipeline invert elevation. The drainage conveyance pipeline will cross over the existing sewer line near Station 12+60. It is our understanding that a new sewer line is proposed to be constructed, and the existing line abandoned in place.

Between Station 15+00 and Station 15+50, there is an existing 20 foot high, north-facing retaining wall supporting the SCE substation pad located to the south of the proposed alignment. It is our understanding that VCWPD has requested information from SCE on the construction and foundation details of the existing retaining wall.

2.2 Station 15+70 through Station 21+50

Within this portion of the proposed alignment, the proposed drainage conveyance structure consists of a 12 foot diameter reinforced concrete (RC) pipe and is proposed to be constructed using pipe jacking methods. This section of the proposed drainage conveyance structure begins near Edison Drive, crosses under an existing vegetated slope, continues under SR-33 with less than 10 feet of cover, continues under an existing hillside with up to approximately 25 feet of cover, and terminates near the existing debris basin.

Near station 15+70, there is an existing 8 foot high, north-facing retaining wall located at the end of Edison Drive. Above the 8 foot wall is an ascending slope with a series of 3 to 5 foot high stacked retaining walls. These existing retaining walls will be removed during construction.

There is an existing single-family residential lot to the south of the proposed pipeline near Station 16+00, as well as to the north of the proposed pipeline near Station 16+50. Based on observations during site exploration, the existing one-story structures which occupy each of the lots are currently unoccupied; however, the structures may require protection during construction activities.

Between Station 17+00 and Station 17+75, the proposed pipeline will be advanced under SR-33, a northwest trending asphalt paved highway with one lane of travel in each direction. It is our understanding that pipe jacking methods will be utilized to construct the drainage conveyance structure in this section of the project in order to keep SR-33 operational throughout construction of the project.

To the east of SR-33, the pipeline will continue to be advanced with pipe jacking methods below an existing graded hillside. The slopes in this area are generally inclined at approximate gradients of 8:1 to locally 2:1 (horizontal to vertical) towards the north and northwest towards the drainage basin and SR-33. The hillside is currently vacant of existing structures, however is occupied by a paved access road and an underground gas line.

This section of the proposed drainage conveyance structures will be advanced under several existing utilities including: a 10 inch gas line located along the west shoulder of SR-33, a 6 inch gas line located along the east shoulder of SR-33, wood power piles supporting overhead lines located at the intersection of SR-33 and Parkview Drive, a 36 inch storm drain servicing Parkview Drive and located just north of the intersection of SR-33 and Parkview Drive, and a 20 inch gas line located near Station 20+30.

2.3 Station 21+50 through Station 25+20

At the termination of the 12 foot diameter RCP, a drainage inlet structure will be constructed. The inlet structure will consist of an open channel structure and floodwall structure.

The proposed inlet structure consists of an open channel structure with vertical sidewalls between Station 20+50 and Station 22+00. Beyond Station 22+00, the channel structure transitions to a trapezoidal shaped channel structure with sidewalls inclined at a slope of 2:1. The area of the proposed channel structure is currently occupied by the existing debris basin with a moderate growth of grasses and bushes, as well as by the naturally occurring drainage path for stormwater and debris generated within Fresno Canyon.

An emergency flow path outlet channel will be constructed at Station 21+70 to connect the existing drainage conveyance structures to the proposed channel structures.

The proposed floodwall will be constructed along the eastern edge of an existing unpaved access road. The floodwall will range from approximately 4 feet to 11½ feet in height above the existing ground surface. The area of proposed construction is currently vacant of existing structures and moderately vegetated with shrubs and trees.

2.4 Operations and Maintenance Access Road

A proposed Operations and Maintenance (O&M) access road will be constructed directly over a portion of the proposed drainage conveyance structure. The O&M access road will have a driveway entry off of SR-33 and will continue westward to the proposed outlet structure at the Ventura River. The proposed O&M access road will cross the existing Ojai Valley Bike Path and will have a turnaround immediately north of the proposed outlet structure.

Along the length of the proposed O&M access road, several slopes and retaining walls are proposed to support the proposed access road and to provide sufficient width to the access road.

An embankment is proposed along the north side of the proposed O&M access road between Station 12+00 and Station 14+95. The proposed slope will be up to 15 feet in height above the existing grade and will be constructed at a gradient of 2:1 (horizontal to vertical).

Between Station 14+95 and Station 16+00, 160 linear feet of retaining wall is proposed to be constructed along the north side of drainage conveyance structure to support the access road. The retaining wall will be up to 17 feet in height. Additionally, between Station 15+50 and Station 16+00, a retaining wall of up to 4 feet in height will be constructed along the south side of the proposed access road. This retaining wall will support an ascending cut slope with gradients ranging from 1½:1 to nearly level.

To the east of the proposed retaining walls, between Station 16+00 and Station 17+20, cut slopes are proposed on the south side of the O&M access road, and fill slopes are proposed on the north side of the O&M access road. The cut slopes will be up to 8 feet in height and constructed at a gradient of 1½:1 or flatter; and the fill slopes will be up to 20 feet in height and will be constructed at gradients of 2:1 or flatter.

2.5 Bike Path Modifications

The Ojai Valley Bike Path is located along the eastern bank of the Ventura River. The existing bike path is paved with asphalt concrete. Due to the proposed drainage conveyance structures, the existing bike path will be elevated by constructing a small embankment such that the bike path crosses over the proposed pipeline structure. The elevation of the bike path will be increased by up to 9 feet where crossing over the crown of the proposed pipeline.

3. FIELD EXPLORATION & LABORATORY TESTING PROGRAM

3.1 Field Exploration

The site was initially explored on July 17, 2012 and July 19, 2012 by excavating two 24 inch diameter borings using a truck-mounted bucket-auger drilling machine. Due to the presence of large cobbles within the soil deposits, the bucket auger drill rig was replaced by a Lodrill equipped with a 24-inch solid auger to complete the boring excavation. The borings were conducted to depths of 50 and 51 feet below the existing ground surface. Upon completion, the borings were down-hole logged by a California licensed Certified Engineering Geologist (CEG) to observe the subsurface conditions and geologic structure of the bedrock.

A second phase of site exploration was performed on August 28, 29, and September 5, 2012 by excavating six 7-inch diameter borings using a track-mounted limited access hollow stem-auger drilling machine. The borings were conducted to depths of 12 and 40½ feet below the existing ground surface. Relatively undisturbed samples were obtained by driving a 3-inch outer-diameter California Modified split-tube sampler into the “undisturbed” soil mass with blows from a 140-pound autohammer freefalling a distance of 30 inches. The California Modified Sampler was equipped with 1-inch high by 2³/₈-inch diameter brass sampler rings to facilitate removal and testing. Bulk samples were also collected.

Slope inclinometer and borehole extensometer casing was installed in boring B2. The annular space around the casing was filled with cement-bentonite grout, and a flush-mount well cover installed at the ground surface.

A third phase of site exploration was performed on September 6, 2012 by excavating three test pits using a rubber tired backhoe. The lowest portion of the test pits were excavated to depths between 5 and 9 feet below the existing ground surface.

Relatively undisturbed soil samples were collected in all borings and test pits at select depths. Bulk samples of representative soils at select depths were also obtained. The approximate locations of the borings and test pits are depicted on the Site Plan / Geologic Map (see Figure 2). A detailed discussion of the field exploration, including boring and test pit logs, is presented in Appendix A.

3.2 *In Situ* Testing

In situ testing consisted of recording blow counts during sampling in the field. Relatively undisturbed soil samples were obtained by driving a 3-inch outer-diameter California Modified split-tube sampler into the "undisturbed" soil mass with blows from a weight. The California Modified Sampler was equipped with 1-inch high by 2$^{3}/_{8}$-inch diameter brass sampler rings to facilitate removal and testing. The bottom 6 inches of each sample was retained for laboratory testing.

Blows to drive the sampler in the bucket-auger borings were provided by the kelly bar on the drill rig. Blows to drive the sampler in the hollow stem-auger borings were provided by an automatic 140-pound hammer falling a distance of 30 inches. Blows to drive the sampler in the test pits were provided by a slide hammer.

3.3 Laboratory Testing

Soil samples obtained during site exploration were packaged and sealed in the field to prevent moisture loss or disturbance, and transported to our laboratory where they were further examined and classified. All testing was performed in general accordance with ASTM, California Test Method (CTM), or other applicable standard procedures. Our laboratory testing program was designed to include testing on representative samples of all geologic materials encountered, and included the following tests:

- In-Place Dry Density and Moisture Content: ASTM D2937 (CTM 226)
- Direct Shear: ASTM D 3080
- Unconsolidated-Undrained Triaxial Shear: ASTM D2850
- Unconfined Compressive Strength of Rock: ASTM D 2938
- Consolidation: ASTM D 2435 (CTM 219)
- Particle Size Analysis: ASTM D 422 (CTM 202 and 203)
- Atterberg Limits: ASTM D4318
- Expansion Index: ASTM D 4829
- Maximum Dry Density/Optimum Moisture Content: ASTM D 1557
- Sand Equivalent: ASTM D 2419
- Permeability, Flexible Wall: ASTM D5084
- Organics Content
- Potential of Hydrogen (pH) and Resistivity: CTM 643
- Chloride Content: EPA No. 325.3
- Water Soluble Sulfate Content: CTM 417
- Mohs Hardness

Detailed discussions of each type of testing performed, as well as the test results, are provided in Appendix B of this report.

4. PHYSICAL SETTING

4.1 Topography and Drainage

The project area is situated between the east bank of the Ventura River and the mouth of the Fresno Canyon drainage area. The proposed project is intended to direct stormwater flow from Fresno Canyon through the drainage structure and outlet to the Ventura River. Currently, stormwater enters the project site from Fresno Canyon and passes through a debris basin where the majority of the sediment load is dropped, then directed to the Ventura River via a series of culverts and channels.

Topographically, the site can be divided into two areas, with SR-33 acting as a general boundary. The area east of SR-33 consists of a fairly large natural/graded hillside area surrounding a debris basin and the existing Fresno Canyon drainage. The slopes in this area of the subject site are generally inclined at approximate gradients of 8:1 to locally 2:1 (horizontal to vertical) towards the north and northwest towards the drainage basin or SR-33. North of the drainage, the site generally slopes gently toward the west at gradients of 6:1 or flatter.

West of SR-33, the alignment is proposed along the toe of a relatively large north-facing slope. To the north of the slope, the site is relatively flat alluvial floodplain. The slope ascends up to 90 feet from the relatively flat floodplain at gradients of 3:1 to locally as steep as 1:1. South of the alignment, between Stations 14+50 and Station 15+50, the slope ascends to a large retaining wall which supports existing SCE substation pad. In addition, a series of stacked retaining walls are located between the southern terminus of Edison Drive and the existing SCE substation (Stations 15+73 and Station 16+00).

5. GEOLOGIC SETTING

The project area is located at the southern end of the community of Casitas Springs. The Casitas Springs area is a north-south trending alluvial filled valley along the Ventura River. The area formed as a result of meandering of the Ventura River during Early Holocene to Late Pleistocene period (10,000 to 40,000 years before present). More recent uplift of the Transverse Ranges due to regional tectonics has shifted the river to its current position with respect to the project site.

The site is located within the northern Ventura River Valley. The Ventura River Valley is a long, narrow, north-south trending alluvial filled valley extending from Matilija Reservoir and Ojai Valley to the north to the Oxnard Plain and Pacific Ocean to the south. The Ventura River Valley has been continually formed through the episodic periods of erosion and deposition of sediments by the Ventura River. The alluvial sediments within the Ventura River Valley are derived from the many tributary streams that drain the surrounding Santa Ana Mountains, Sulfur Mountain Range and adjoining Ojai Valley. Rock units underlying the alluvial sediments and surrounding areas consist primarily of uplifted late Eocene to early Miocene age sedimentary bedrock.

Regionally the site is located within the Transverse Ranges geomorphic province. The province is characterized by east-west trending mountain ranges and valleys that extend from Point Conception and the Pacific Ocean to the Cajon Pass. These mountain ranges include the Santa Ynez, Topa Topa, Santa Susana, San Gabriel, San Bernardino, and Santa Monica Mountains. The regional east-west trend of the range is reflected by the nearby San Cayetano Fault and Santa Paula River Valley.

6. GEOLOGIC MATERIALS

Based on our field investigation and published geologic maps of the area, the earth materials underlying the site consist of artificial fill, debris basin slough, active wash deposits, colluvium, and terrace deposits underlain by sedimentary bedrock units of the Miocene Age Rincon Shale (Tan, 2003). The site is shown with respect to local geologic conditions on Figure 3, Local Geologic Map. The soil and geologic units encountered at the site are discussed below. General soil profiles are provided on the boring logs in Appendix A. The aerial distribution of geologic materials is depicted on Figure 2 and geologic cross sections are provided on Figures 4 through 11.

6.1 Artificial Fill (af)

Various amounts of artificial fill were encountered throughout the area of the proposed development. The artificial fill was observed in our field explorations to depths between 3½ and 13½ feet below the ground surface. However, a review of the as-built sewer plans (copies of which were provided by the client) indicates that deeper artificial fill may be present in areas surrounding a buried 21-inch sewer line, as well as other utilities which run adjacent to and which traverse the proposed drainage structure. Based on a comparison of the invert elevation indicated on the as-built sewer plans with the current ground surface elevation at manhole 27-A, located at the end of Edison Drive, there appears to be artificial fill on the order of 15 to 18 feet in depth below the existing ground surface. Furthermore, based on our interpretation of the geologic conditions along the proposed drainage conveyance structure presented as Geologic Cross Sections (Figures 4 through 11), artificial fill on the order of 14 feet in depth below the ground surface may be present along the proposed alignment near Station 12+50 and Station 13+00.The locations of the various utility lines are indicated on Figure 2.

The artificial fill generally consists of varying amounts of yellowish brown silty sand and clay with varied amounts of gravel, cobbles and boulders. Debris, such as concrete, clay pipe, glass, and metal were commonly observed in the fill between Station 12+75 and Station 15+50. The artificial fill is characterized as dry to moist and loose to medium dense or very soft to hard. The fill is likely derived from a combination of utility line backfill as well as soil and debris dumped over the slope from the adjacent SCE substation. The thickest accumulations of fill were encountered along the graded hillside slope between Stations 18+00 and Station 21+00 and along the buried 21-inch sewer line west of Edison Drive. However, deeper fill may exist between excavations and in other portions of the site that were not directly explored.

6.2 Debris Basin Slough

Debris basin slough was encountered within the graded stormwater debris basin along the western portion of the drainage facility alignment between Station 20+75 and Station 22+00. The debris basin slough was encountered during our field exploration to depths between 6 and 7 feet below the ground surface. The slough generally consists of brown to reddish brown silt with sand and sandy clay with varied amounts of gravel and decomposing organic material. The slough is characterized as moist to wet and soft to firm. The debris basin slough is the result of the accumulation of soils, plants and debris from Fresno Canyon and surrounding slopes that have washed into the debris basin.

6.3 Active Wash Deposits (Qw)

Based on our review of available geologic maps and onsite observations of the surficial geology along the Ventura River, active wash deposits are expected to be encountered along the western most extent of the drainage facility alignment. The active wash deposits consist of unconsolidated sand and silt with varied amounts of gravel, cobbles and boulders primarily composed of sedimentary bedrock such as sandstone, siltstone and shale that have been transported from upstream sources.

6.4 Colluvium (Qcol)

The artificial fill is partially underlain by colluvial deposits derived from the in-situ weathering of the underlying bedrock and slow downhill movement due to gravity. The colluvium was encountered along the sloped area east of SR-33 at depths ranging between 3½ and 12 feet beneath the existing ground surface. The colluvium generally consists of dark brown to dark gray sandy silt and clay. The soils are primarily slightly moist to moist and stiff.

6.5 Terrace Deposits (Qht)

Holocene Age stream terrace deposits were encountered along alignment west of SR-33 at depths between 3 and 18 feet below the existing ground surface. These deposits generally consist of light yellowish brown to grayish brown unconsolidated sand and silt with abundant gravel, cobbles and boulders. These clasts are composed of well cemented sedimentary bedrock (sandstone, siltstone and shale) originating from the Red Mountain Range, Sulfur Mountain Range and various drainages up river from the site. The terrace deposits are primarily unbedded, dry to slightly moist and loose

The terrace deposits are expected to be encountered within the open trench portion of the drainage conveyance structure and within the western portion of the pipe jacking portion of the alignment.

6.6 Older Terrace Deposits (Qpt)

Pleistocene Age older stream terrace deposits were encountered along the eastern portion of the alignment between Stations 17+50 and 21+00 at depths between 12½ and 27 feet below the existing ground surface. These deposits generally consist of dark yellowish brown clayey sand and silty sand with varied amounts of gravel, cobbles and boulders composed of sedimentary bedrock. The soils are primarily unbedded, dry to slightly moist and medium dense to dense. The Pleistocene terrace deposits are remnant sediment material deposited from an eastern meander if the ancestral Ventura River.

The older terrace deposits are expected to be encountered along the pipe jacked portion of the drainage conveyance structure.

6.7 Rincon Shale

The artificial fill and surficial deposits are underlain by sedimentary bedrock units of the Miocene Age Rincon shale (Tan, 2003). The Rincon shale is exposed on the slopes adjacent to the alignment and underlies the entire project site. The bedrock was encountered at depths ranging between 6 to 28 feet below the existing ground surface. As observed during our field investigation, the upper portion of the bedrock consists of light gray to gray shale and siltstone which can be characterized as poorly-bedded, thinly- to thickly-bedded, moderately to highly weathered and fractured, soft to moderately hard and brittle. Below about 4 to 6 feet of the bedrock contact, the shale was observed to be dark grey, poorly bedded, moderately hard and brittle as the amount of oxidation, weathering, and fracturing of the bedrock decreased significantly.

Onsite observations of the geologic structure indicate that the bedrock strikes (orientation with respect to north) from N10°W to N27°W with inclinations of 40° to 53° to the northeast. Based on our review of available geologic maps, the bedrock in the site vicinity generally strikes between N27°W and N3°E with dips of 40° to 45° to the east (Tan, 2003) which is consistent with the onsite observations of the geologic structure.

The Rincon shale is expected to be encountered throughout portions of the alignment. The bedrock will likely exhibit neutral bedding conditions with respect to the proposed north and south facing excavations so long as the bedrock follows observed and regional trends. Proposed excavations into the bedrock should be observed by a licensed geologist (a representative of Geocon West, Inc.) during construction to verify the existing bedding conditions at the site.

It should be noted that localized zones of mild petroliferous odor from gasses within the bedrock were observed during downhole inspection of the large diameter borings. The presence of the localized gases in the bedrock may impact the health and safety of personnel assigned to conduct the pipe jacking portion of the project. A formal study should be conducted at the site to determine the potential impact of gases on the project prior to the construction phase of the project.

7. GROUNDWATER

Based on a review of the Seismic Hazard Zone Report for the Ventura 7.5 Minute Quadrangle, Ventura County, California (California Geological Survey, 2002), the historically highest groundwater in the area is less than 10 feet beneath the ground surface. Groundwater information presented in this document is generated from data collected in the early 1900's to present.

Minor groundwater seepage was encountered in Bucket Auger boring BA1 at a depth of 36 feet below the ground surface and in BA2 at depths of 24, 38 and 43 below the ground surface. These depths correspond to elevations of 265 feet MSL (Mean Sea Level) for BA1 and 277, 263 and 258 feet MSL for BA2. The seepage was encountered along joints and fractures within the bedrock and is not considered representative of the regional groundwater regime. However, it is not uncommon for groundwater levels to vary seasonally or for groundwater conditions to develop where none previously existed, especially in impermeable fine-grained soils and bedrock which are subjected to irrigation, precipitation and inflow of groundwater from the adjacent Ventura River and Fresno Canyon drainage. Based on these considerations, minor seepage conditions can be expected within the pipe jacking phase of portion of the proposed alignment.

8. GEOLOGIC HAZARDS

8.1 Surface Fault Rupture

The numerous faults in Southern California include active, potentially active, and inactive faults. The criteria for these major groups are based on criteria developed by the California Geological Survey (formerly known as California Division of Mines and Geology (CDMG)) for the Alquist-Priolo Earthquake Fault Zone Program (Hart, 1999). By definition, an active fault is one that has had surface displacement within Holocene time (about the last 11,000 years). A potentially active fault has demonstrated surface displacement during Quaternary time (approximately the last 1.6 million years), but has had no known Holocene movement. Faults that have not moved in the last 1.6 million years are considered inactive.

The closest surface trace of an active fault to the site is the Red Mountain Fault located approximately 0.8 mile south of the site (Ziony & Jones, 1989). Other nearby active faults are the Javon Fault, the Pita Point-Ventura Fault, the San Cayetano Fault, and the Oak Ridge Fault located approximately 5.2 miles southwest, 6.3 miles south, 9.0 miles northeast and 9.0 miles south of the site, respectively (Ziony & Jones, 1989).

The site is not within a currently established Alquist-Priolo Earthquake Fault Zone for surface fault rupture hazards. No active or potentially active faults with the potential for surface fault rupture are known to pass directly beneath the site. Therefore, the potential for surface rupture due to faulting occurring beneath the site during the design life of the proposed development is considered low.

The site, however, is located in the seismically active Southern California region, and could be subjected to moderate to strong ground shaking in the event of an earthquake on one of the many active Southern California faults. The faults in the vicinity of the site are shown in Figure 12, Regional Fault Map.

8.2 Seismicity

As with all of Southern California, the site has experienced historic earthquakes from various regional faults. The seismicity of the region surrounding the site was formulated based on research of an electronic database of earthquake data. The epicenters of recorded earthquakes with magnitudes equal to or greater than 4.0 within a radius of 60 miles of the site are depicted on Figure 13, Regional Seismicity Map. A number of earthquakes of moderate to major magnitude have occurred in the Southern California area within the last 100 years. A partial list of these earthquakes is included in the following table.

LIST OF HISTORIC EARTHQUAKES

Earthquake (Oldest to Youngest)	Date of Earthquake	Magnitude	Distance to Epicenter (Miles)	Direction to Epicenter
Tejon Pass area	October 23, 1916	6.0	44	NE
Santa Barbara area	June 29, 1925	6.3	28	W
Carpentaria	July 1, 1941	5.9	16	W
Tehachapi	July 21, 1952	7.7	47	NNE
West of Wheeler Ridge	January 12, 1954	5.9	47	N
San Fernando	February 9, 1971	6.4	52	E
Santa Barbara area	February 21, 1973	5.9	26	W
Northridge	January 17, 1994	6.7	45	ESE

The site could be subjected to strong ground shaking in the event of an earthquake. However, this hazard is common in Southern California and the effects of ground shaking can be mitigated if the proposed structures are designed and constructed in conformance with current building codes and engineering practices.

8.3 Seismic Design Criteria

The following table summarizes site-specific design criteria obtained from the 2010 California Building Code (CBC; Based on the 2009 International Building Code [IBC]), Chapter 16 Structural Design, Section 1613 Earthquake Loads. The values were derived using the computer program Seismic Hazard Curves and Uniform Hazard Response Spectra, provided by the USGS. The short spectral response uses a period of 0.2 second.

CBC SEISMIC DESIGN PARAMETERS

Parameter	Value	2010 CBC Reference
Site Class	C	Table 1613.5.2
Spectral Response – Class B (short), S_S	2.566g	Figure 1613.5(3)
Spectral Response – Class B (1 sec), S_1	0.931g	Figure 1613.5(4)
Site Coefficient, F_a	1.0	Table 1613.5.3(1)
Site Coefficient, F_v	1.3	Table 1613.5.3(2)
Maximum Considered Earthquake Spectral Response Acceleration (short), S_{MS}	2.566g	Section 1613.5.3 (Eqn 16-36)
Maximum Considered Earthquake Spectral Response Acceleration – (1 sec), S_{M1}	1.210g	Section 1613.5.3 (Eqn 16-37)
5% Damped Design Spectral Response Acceleration (short), S_{DS}	1.711g	Section 1613.5.4 (Eqn 16-38)
5% Damped Design Spectral Response Acceleration (1 sec), S_{D1}	0.806g	Section 1613.5.4 (Eqn 16-39)

Conformance to the criteria in the above table for seismic design does not constitute any kind of guarantee or assurance that significant structural damage or ground failure will not occur if a large earthquake occurs. The intent of the code is "Life Safety," not to completely prevent damage to the structure, since such design may be economically prohibitive.

8.4 Liquefaction Potential

Liquefaction is a phenomenon in which loose, saturated, relatively cohesionless soil deposits lose shear strength during strong ground motions. Primary factors controlling liquefaction include intensity and duration of ground motion, gradation characteristics of the subsurface soils, in-situ stress conditions, and the depth to groundwater. Liquefaction is typified by a loss of shear strength in the liquefied layers due to rapid increases in pore water pressure generated by earthquake accelerations.

Based on a review of the State of California Seismic Hazard Zone, Ventura Quadrangle Map (CGS, 2003) as well as the Ventura County General Plan (Ventura County, 2004), the site is located in an area designated as "liquefiable". However, as previously stated, the earth materials underlying the proposed bypass drainage facility consists of dense terrace deposits and Miocene Age sedimentary bedrock units. Bedrock by its nature is not subject to liquefaction. Based on these considerations, it is our opinion that the potential for liquefaction of the site soils is very low. Further, no surface manifestations of liquefaction are expected at the subject site.

8.5 Slope Stability

According to the Hazards Appendix of the Ventura County General Plan (2004), and the State of California Seismic Hazard Zone, Ventura Quadrangle Map (CGS, 2003) the site is not located within an area identified as having a potential for slope instability. No landslides were observed during our field explorations. There are no known landslides near the site, nor is the site in the path of any known or potential landslides. However, areas of potential slope instability have been identified by the California Geological Survey (CDMG, 1999) along the slopes south and southeast of the subject site.

The subject site is located along toe of two north to north-northwest facing slopes situated between the east bank of the Ventura River and the mouth of the Fresno Canyon drainage and bisected by SR-33. The area east of SR-33 consists of a large natural/graded hillside area surrounding a debris basin and the existing Fresno Canyon drainage. The north and north-northwest facing slopes in this area of the subject site are generally inclined at approximate gradients of 8:1 to locally 2:1 (horizontal to vertical) with approximately 670 feet of vertical relief from the bottom of the drainage basin to the top of the first intermediate ridge southeast of the site. North of the drainage, the site generally slopes gently toward the west at gradients of 6:1 or flatter.

West of SR-33, the alignment is situated along the toe of a relatively large north-facing slope. The slope ascends up to 90 feet from the relatively flat floodplain at gradients of 3:1 to locally as steep as 1:1. South of the alignment, between Stations 14+50 and 15+50, the slope ascends to a large retaining wall which supports the SCE substation pad. In addition, a series of stacked retaining walls are located between the southern terminus of Edison Drive and the existing SCE substation (Stations 15+73 and Station 16+00).

Based on our review of available geologic maps and our field exploration, the earth material underlying the site slopes consists of varying thicknesses of artificial fill, colluvium and terrace deposits over Rincon Shale bedrock. As observed during our field investigation, the artificial fill, colluvium and terrace deposits along the slope face consist primarily of interlayered sands, silts and clays with varying amounts gravel, cobbles and boulders. The underlying bedrock consists of well-bedded to massive shale and siltstone. Onsite observations of the geologic structure and a review of available geologic maps indicate that the bedding is oriented from N27°W and N3°E with dips of 40° to 53° to the east and northeast. Soil and bedrock contacts likely follow general slope topography at the site and are inclined to the north and northwest.

Based on this information, the bedrock will likely exhibit neutral bedding conditions with respect to proposed north and south facing excavations so long as the bedrock follows observed and regional trends. However, proposed north and south facing excavations will remove lateral support of the overlying surficial soils which may become susceptible to raveling and sloughing. Proposed north facing excavations will also expose an unfavorable bedding condition that exists along the soil and bedrock contact. In addition, erosion and minor surficial stability may be encountered along the adjacent slopes steeper than 2:1 during construction. Excavations within the surficial soil will likely require special excavation measures to maintain stability during construction.

8.6. Oil Fields & Methane Potential

Based on a review of the California Division of Oil, Gas and Geothermal Resources (DOGGR) Oil and Gas Well Location Map W2-1 Sheet 215, the site is located just outside the vertical projection of the Ojai oilfield. However, according to the map, a well is located 45 feet south of the eastern portion of the drainage facility alignment (California Department of Conservation, 2006). The onsite well is identified as ER Cary ‘Well No. 1’ and is indicated on the map as “Plugged and abandoned - gas”. The approximate location of the oil well is depicted on the Site Plan (Figure 2). Due to the voluntary nature of record reporting by the oil well drilling companies, wells may be improperly located or not shown on the location map. Other unreported/undocumented wells could be encountered during construction.

Based on the location of the site with respect to the Ojai oilfield and the observation of localized petroliferous odors within the Rincon Shale, there could be a potential for methane and other volatile gases to occur at the site which may impact the construction and personnel during the pipe jacking construction phase for the project. Should it be determined that a natural gas study is required for the proposed development it is recommended that a qualified methane consultant be retained to perform the study and provide mitigation measures as necessary.

9. ENGINEERING PROPERTIES OF PRINCIPLE GEOLOGIC UNITS

A summary of the engineering properties of the principle geologic units encountered during site exploration and anticipated to be encountered during construction of the proposed project summarized below. The design recommendations and engineering analyses presented herein are based on the properties presented in the table below.

Geologic Unit	Average In-Place Density (pcf)	Friction Angle (degrees)	Cohesion (psf)
Artificial Fill (Af)	115	25°	650
Engineered Fill	115	28°	250
Colluvium (Qcol) Clay and Silt with varying amounts of Sand	110	32°	390
Holocene Age Stream Terrace Deposits (Qht) Sand with Silt to Silt with Sand	125	40°	140
Pleistocene Age Stream Terrace Deposits (Qpt)	140	30°	340
Rincon Shale (Tr) Highly Weathered	100	32°	100
Rincon Shale (Tr)	115	38° - 47°	220 - 1500

10. CONCLUSIONS AND RECOMMENDATIONS

10.1 General

10.1.1 It is our opinion that neither soil nor geologic conditions were encountered during the investigation that would preclude the construction of the proposed project provided the recommendations presented herein are followed and implemented during design and construction.

10.1.2 This section of the report (Section 10) is intended to provide general soil characteristics and recommendations applicable to the design and construction of the proposed drainage conveyance structures. Due to the variable geologic and geotechnical conditions anticipated along different sections of the proposed project, detailed recommendations relating to grading, foundation design, and other special recommendations are presented in subsequent sections of this report as described below.

10.1.3 The proposed drainage conveyance structures located between Station 10+00 and Station 15+70 consist of the outlet structure and approximately 570 feet of 12 foot diameter RCP constructed with cut and cover methods. Recommendations specific to proposed construction between Station 10+00 and Station 15+70 are provided in Section 11 of this report.

10.1.4 The proposed drainage conveyance structures located between Station 15+70 and Station 21+50 consist of a 12 foot diameter RCP constructed with pipe jacking methods. Recommendations specific to proposed construction between Station 15+70 and Station 21+50 are provided in Section 12 of this report.

10.1.5 The proposed drainage conveyance structures located between Station 21+50 and Station 25+20 consist of an open channel structure and floodwall. Recommendations specific to proposed construction between Station 21+50 and Station 25+20 are provided in Section 13 of this report.

10.1.6 During site exploration we encountered the following major geologic units: debris basin slough, existing artificial fill, colluvium, Holocene and Pleistocene Age terrace deposits, and Rincon Shale bedrock. As presently proposed, the proposed drainage conveyance structures are anticipated to encounter all of the geologic units at various locations along the alignment. In general, the existing debris basin slough and artificial fill materials are not considered suitable for support of proposed structures or additional fill. With the exception of the debris basin slough, the soils and bedrock encountered during site exploration are considered suitable for re-use as engineered fill. Recommendations for earthwork are provided in Section 10.4 through Section 10.8 of this report.

10.1.7 Fill slopes comprised of newly placed engineered fill constructed at gradients of 2:1 or flatter are proposed at various locations throughout the area of proposed construction. Recommendations for slope construction are provided in Section 10.8.

10.1.8 Excavations of up to 30 feet in vertical height are anticipated as a part of this project. Due to the depth of the proposed excavation, as well as the site topography, it is anticipated that stable excavations may be achieved through the use of sloping and shoring measures. Excavation recommendations are provided in the Temporary Sloped Excavations and Temporary Shored Excavations sections of this report (see Section 10.10 and 10.11).

10.1.9 Paving recommendations for construction of proposed access roads and for realignment of the Ojai Valley Bike Path are provided in *Paving Design* sections of this report (see Sections 10.18 and 10.19).

10.1.10 Minor groundwater seepage was encountered during site exploration activities and could be encountered during construction, particularly during pipe jacking. Groundwater should be collected and controlled as necessary and discharged in accordance with local regulations. If the contractor is not familiar with dewatering measures, a qualified dewatering consultant should be retained.

10.1.11 Any changes in the design, location or elevation, as outlined in this report, should be reviewed by this office. Geocon should be contacted to determine the necessity for review and possible revision of this report.

10.2 Soil and Excavation Characteristics

10.2.1 The in-situ soils and bedrock can be excavated with moderate effort using conventional excavation equipment. The upper portions of the bedrock are moderately weathered and highly fractured. Medium to heavy-duty excavation equipment may be required if thick zones of well cemented bedrock or clasts over 4-feet in size are encountered. Caving and sloughing should be anticipated in unshored vertical excavations, especially where loose, granular, or uncemented soils are encountered.

10.2.2 It is the responsibility of the contractor to ensure that all excavations and trenches are properly shored in accordance with applicable OSHA rules and regulations to maintain safety and stability of adjacent existing improvements.

10.2.3 All onsite excavations must be conducted in such a manner that potential surcharges from existing structures, construction equipment, and vehicle loads are resisted. The surcharge area may be defined by a 1:1 projection down and away from the bottom of an existing foundation or vehicle load. Penetrations below this 1:1 projection will require special excavation measures such as sloping and shoring. Temporary sloping and shoring recommendations are provided in Sections 10.10 and 10.11 of this report.

10.2.4 Laboratory testing was performed on representative samples of site soils to generally evaluate the soil expansive potential. The 2010 California Building Code (CBC) Section 1803.5.3 defines soils with an expansive potential of less than 20 as “non-expansive”, and greater than 20 as “expansive”. Based on the laboratory test results, the existing site soils and bedrock have a “low” to “very high” expansive potential and are classified as “expansive”. The recommendations in this report are based on consideration that the existing soils are expansive at proposed slab and foundation locations. The possibility that foundations and slabs may derive support in engineered fill comprised of a blend of soils and bedrock has also been accounted for.

10.3 Soil Corrosion Potential

10.3.1 Potential of Hydrogen (pH) and resistivity testing, as well as chloride content testing, was performed on representative samples of soil and bedrock anticipated to be encountered along the proposed drainage conveyance structure alignment to generally evaluate the corrosion potential. The tests were performed in accordance with California Test Method Nos. 643 and 422 and indicate that a potential for corrosion of buried ferrous metals exists on site. The results are presented in Appendix B (Figure B24) and should be considered for design of underground structures.

10.3.2 Laboratory tests were performed on representative samples of soil and bedrock anticipated to be encountered along the proposed drainage conveyance structure alignment to measure the percentage of water-soluble sulfate content. Results from the laboratory water-soluble sulfate tests are presented in Appendix B (Figure B24) and indicate that the on-site artificial fill, colluvium, and terrace deposits generally possess “negligible” sulfate exposure to concrete structures as defined by 2010 CBC Section 1904.3 and ACI 318-08 Sections 4.2 and 4.3. However, laboratory test results indicate that the Rincon Shale bedrock possesses a “very severe” sulfate exposure to concrete structures. The following table presents a summary of concrete requirements set forth by 2010 CBC Section 1904.3 and ACI 318. The presence of water-soluble sulfates is not a visually discernible characteristic; therefore, other soil samples from the site could yield different concentrations.

REQUIREMENTS FOR CONCRETE EXPOSED TO SULFATE-CONTAINING SOLUTIONS

Sulfate Exposure	Exposure Class	Water-Soluble Sulfate Percent by Weight	Cement Type	Maximum Water to Cement Ratio by Weight	Minimum Compressive Strength (psi)
Negligible	S0	0.00-0.10	--	--	2,500
Moderate	S1	0.10-0.20	II	0.50	4,000
Severe	S2	0.20-2.00	V	0.45	4,500
Very Severe	**S3**	**> 2.00**	**V+Pozzolan or Slag**	**0.45**	**4,500**

10.3.3 Geocon West, Inc. does not practice in the field of corrosion engineering and mitigation. It is recommended that a corrosion engineer be retained to evaluate corrosion test results and incorporate the necessary precautions to avoid premature corrosion of buried metal pipes and concrete structures in direct contact with the soils and bedrock.

10.4 Grading - General

10.4.1 Earthwork should be observed, and compacted fill tested by representatives of Geocon West, Inc.

10.4.2 A preconstruction conference should be held at the site prior to the beginning of grading operations with the owner, contractor, civil engineer, building official, and geotechnical engineer in attendance. Special soil handling requirements can be discussed at that time.

10.4.3 It shall be the sole responsibility of the Contractor to provide adequate equipment and methods to accomplish the work in accordance with applicable grading codes or agency ordinances, as well as the recommendations presented herein and on the approved grading plans.

10.5 Suitability of Excavated Materials / Import Material Recommendations

10.5.1 The existing debris basin slough was observed to be loose and soft with an organics content of up to 22.6 percent. Based on this consideration, the existing debris basin slough is not considered suitable for re-use as an engineered fill. Excavated debris basin slough may be stockpiled and used only as nonstructural fill, or disposed of offsite.

10.5.2 The placement history of the existing artificial fill observed along the base of the existing hillside west of Edison Drive is unknown at this time. Portions of the fill may be associated with the construction of the sewer line that runs parallel to the proposed drainage conveyance structure. During site exploration, this fill was observed to be of poor quality with substantial quantities of oversized and deleterious material, which is considered unsuitable. In order to re-use the existing artificial fill, the contractor should be prepared to process and screen the artificial fill to remove all unsuitable materials prior to use as an engineered fill. All unsuitable materials should not be used in engineered backfill.

10.5.3 The existing colluvium, terrace deposits, and Rincon Shale bedrock encountered during site exploration are considered suitable for re-use as an engineered fill, provided any encountered deleterious debris or oversized material (rocks greater than six inches) is removed. Rocks larger than six inches should not be placed as engineered fill.

10.5.4 The contractor should be aware that oversize material is anticipated when excavating into the colluvium and terrace deposits. The contractor should be prepared to screen soil as necessary prior to placement as engineered fill. This can be accomplished with a skeleton bucket or similar screening technique which has been approved by the Geotechnical Engineer.

10.5.5 Oversized materials generated during construction may be re-used as riprap, provided the materials meet the material specifications provided by the design professional responsible for the riprap design.

10.5.6 If bedrock is to be utilized as an engineered fill, it will likely be blocky and will need to be crushed and moisture conditioned prior to utilization as a fill material.

10.5.7 Deleterious debris such as wood, root structures, and trash should be exported from the site and should not be mixed with the fill soils. Asphalt and concrete should not be mixed with the fill soils unless approved in writing by the Geotechnical Engineer.

10.5.8 All materials utilized as engineered fill should be well-blended to create relatively uniform fill material prior to placement and compaction, and soils must be placed uniformly and at equal thickness at the direction of the Geotechnical Engineer (a representative of Geocon West, Inc.).

10.5.9 All imported soil shall be observed, tested and approved in writing by Geocon West, Inc. prior to use as backfill. Rocks larger than 6 inches in diameter shall not be used in the fill. If necessary, import soils placed as engineered fill that will placed as backfill behind retaining walls should have an expansion index of less than 20, and import that will be placed as backfill providing direct support of proposed structures should have an expansion index of less than 50. Import to be used for other purposes onsite should have an expansion index of less than 90. Import soil should also have corrosive characteristics that are equally or less detrimental than that of the existing onsite soils (see Figure B24).

10.5.10 Import soil to be utilized as engineered fill placed as part of a slope construction should be tested for shear strength properties and slope stability analyses should be performed as necessary to evaluate the suitability of the material prior to use as slope backfill. Strength criteria for import soils to be used as slope backfill are provided in Section 11.6.

10.6 Preparation of Areas for Grading Activities

10.6.1 Grading should commence with the removal of all existing vegetation and existing improvements from the area to be graded. All existing underground improvements planned for removal should be completely excavated and the resulting depressions properly backfilled in accordance with the procedures described herein. Deleterious debris such as wood and root structures should not be mixed with the soils to be placed as engineered fill. Deleterious debris may be stockpiled and used only as nonstructural fill, or disposed of offsite. Asphalt and concrete should not be mixed with the fill soils unless approved in writing by the Geotechnical Engineer.

10.6.2 Trash and deleterious debris are anticipated to be encountered in the existing artificial fill at the base of the hill between Station 12+00 and Station 15+50. Any encountered trash or deleterious debris may be stockpiled and used only as nonstructural fill, or disposed of offsite.

10.6.3 All existing underground improvements planned for removal should be completely excavated and the resulting depressions properly backfilled in accordance with the procedures described herein.

10.7 Placement of Engineered Fill

10.7.1 During grading operations, the Geotechnical Engineer (a representative of Geocon) should be onsite to observe that soil and geologic conditions do not differ significantly from those anticipated. If conditions are found to be variable, modification to the grading recommendations described herein may be required and will be provided as necessary.

10.7.2 Prior to placing any fill, all excavation bottoms must be observed and approved in writing by the Geotechnical Engineer (a representative of Geocon).

10.7.3 All fill and backfill soils should be placed in horizontal loose layers approximately 6 to 8 inches thick, moisture conditioned, and properly compacted. If soils are granular and confirmed to be non-expansive by the geotechnical engineer, soils should be moisture conditioned to near optimum moisture content. If soils are fine-grained or expansive, soils should be moisture conditioned to approximately 2 to 3 percent above optimum moisture content. All man-made fill shall be compacted to a minimum 90 percent of the maximum dry density per ASTM D 1557 (latest edition).

10.7.4 Engineered fill may not be placed and compacted on sloping ground surface. The existing sloping ground surface must be benched such that all fill is placed and compacted on a horizontal surface.

10.7.5 The contractor should be prepared to encounter localized areas of soft or unsuitable soils at excavation bottoms. Since we do not know the extent of potential locally soft or unstable areas, a Geocon representative will observe the excavation bottom and provide mitigation recommendations at the time of inspection. Typical mitigation alternatives include over-excavation and replacement with engineered fill or slurry, or stabilization of the excavation bottom.

10.7.6 Subgrade stabilization, if necessary, may be achieved by introducing a thin lift of three to six-inch diameter crushed angular rock into the soft excavation bottom. The use of crushed concrete will also be acceptable. The crushed rock should be spread thinly across the excavation bottom and pressed into the soils by track rolling or wheel rolling with heavy equipment. It is very important that voids between the rock fragments are not created so the rock must be thoroughly pressed or blended into the soils.

10.7.7 Where new paving is to be placed, the upper 12 inches of paving subgrade should be moisture conditioned as required and property compacted to at least 95 percent relative compaction in accordance with ASTM D 1557 (latest edition) where placing and compacting granular soils, and 92 percent relatively compaction where placing and compacting fine-grained soils.

10.8 Slope Construction

10.8.1 Prior to construction of slopes, it is recommended that all existing artificial fill be excavated within the footprint of the proposed slope. However, based on discussions with VCWPD, it is our understanding that all artificial fill may not be removed prior to placement of additional fill for construction of proposed slopes. The Client should be aware that placement of additional engineered fill over the existing artificial fill could induce settlement of the existing artificial fill that could adversely affect proposed improvements. If settlement of the existing artificial fill occurs, the overlying improvements may experience distress such as settlement or, in extreme circumstances, slope failure may occur. It is our understanding that VCWPD is willing to assuming the risks associated with leaving the existing artificial fill in place. Recommendations for earthwork are provided in Sections 10.4 through 10.8 of this report.

10.8.2 A keyway is required at the toe of all proposed fill slopes which are not directly underlain by newly placed engineered fill. The keyway should be cut a minimum of two feet into competent material and must be observed and approved in writing by the Geotechnical Engineer prior to placement of any fill. A detail is provided on Figure 14.

10.8.3 All engineered fill must be placed and compacted on a horizontal surface; benching into the existing ground surface must be performed as necessary such that all fill is placed and compacted on a horizontal surface.

10.8.4 Fill slopes comprised of on-site materials should be constructed at a gradient of 2:1 or flatter. Fill slopes should be overbuilt by at least 3 feet measured perpendicular to the slope face and trimmed back to the tight fill core. This procedure is considered preferable to track-walking of slopes, as described in the following paragraph.

10.8.5 As an alternative, fill slope faces may be compacted by track-rolling with a loaded sheepsfoot roller at vertical intervals not to exceed 4 feet, and should be track-walked at the completion of each slope such that the fill is compacted to a dry density of at least 90 percent of the laboratory maximum dry density.

10.8.6 All slopes should be planted, drained, and property maintained to reduce erosion. It is recommended that finished slopes be planted as soon after completion of grading as possible. Planting on the slope stabilizes the surface and reduces the potential for erosion. It is further suggested that a jute or mesh product be placed on the slope face prior to planting. The planting of the slope should be performed at the direction of a qualified landscaping consultant.

10.9 Estimated Earthwork Volume Shrinkage

10.9.1 To aid in earthwork quantity estimates, we have estimated the amount of volume shrinkage and bulking expected from onsite, in-situ volumes to compacted soil volumes. We used average in-situ soil density and moisture content and maximum dry density based on American Society for Testing and Materials (ASTM) D1557 test procedure. The following table presents the shrinkage and bulking factors to be anticipated when excavating and compacting the earth materials per the recommendations of this report.

Material	Shrinkage (-) / Bulking (+) Factors
Artificial Fill (Af)	-5% to -10%
Colluvium (Qcol)	-4% to +6%
Holocene Age Terrace Deposits (Qht)	+5% to +10%
Pleistocene Age Terrace Deposits (Qht)	-5% to -10%
Rincon Shale (Tr)	-10% to +10%

10.9.2 It should be understood that volume shrinkage factors presented above are estimates only and are based on a limited number of soil samples. Actual volume changes can vary from our estimates due to variations in soil density, moisture content, and the degree of compaction achieved during grading.

10.9.3 Removal of oversize materials and deleterious materials may result in a higher shrinkage factor based on loss of material.

10.10 Temporary Sloped Excavations

10.10.1 Excavations of up to 30 feet in vertical height are anticipated as a part of this project. The excavations are anticipated to expose existing artificial fill, colluvium, terrace deposits, and shale. The contractor may attempt vertical excavations up to 5 feet in height where loose fill or sands are not present and where excavations are not surcharged by structures, construction equipment, or other surcharge loads.

10.10.2 As discussed in Section 6.7 of this report, based on observations during site exploration the bedrock may exhibit unfavorable bedding conditions with respect to east facing excavations. Bedrock will likely exhibit neutral bedding conditions with respect to proposed north and south facing excavations; however, proposed north facing excavations will also expose an unfavorable bedding condition that exists along the soil and bedrock contact. All excavations into bedrock should be observed by a licensed geologist (a representative of Geocon West, Inc.) during construction to verify the existing bedding conditions at the site.

10.10.3 Vertical excavations greater than five feet or where surcharged by existing structures or a sloping ground surface will require sloping or shoring measures in order to provide a stable excavation. Shoring is addressed in the following section.

10.10.4 Where sufficient space is available, temporary unsurcharged embankments up to 12 feet in height may be sloped back at a uniform 1:1 slope gradient or flatter. A uniform slope does not have a vertical portion. Where sloped excavations exceed 12 feet in height, temporary excavations should be constructed at a uniform gradient of 2:1 or flatter.

10.10.5 Where sloped embankments are utilized, the top of the slope should be barricaded to prevent vehicles and storage loads at the top of the slope within a horizontal distance equal to the height of the slope. If the temporary construction embankments are to be maintained during the rainy season, berms are suggested along the tops of the slopes where necessary to prevent runoff water from entering the excavation and eroding the slope faces. Geocon personnel should inspect the soils exposed in the cut slopes during excavation so that modifications of the slopes can be made if variations in the soil conditions occur. All excavations should be stabilized within 30 days of initial excavation.

10.11 Temporary Shored Excavations – Design and Installation

10.11.1 Where insufficient space is available to perform required excavations with sloping measures, temporary shoring will be required. It is anticipated that temporary shoring will be required at the jacking and receiving pits, as well as along the south side of the cut and cover trench.

10.11.2 The following information on the design and installation of shoring is preliminary. Review of the final shoring plans and specifications should be made by this office prior to bidding or negotiating with a shoring contractor.

10.11.3 Shoring consisting of a solider pile system is considered feasible for this project. Soldier pile shoring systems would consist of steel soldier piles placed in drilled holes and backfilled with concrete. Where maximum excavation heights are less than 15 feet, shoring can typically designed as cantilevered. Where excavations exceed 15 feet or are surcharged, shoring may require lateral bracing to maintain an economical steel beam size and prevent excessive deflection. The need for lateral bracing is up to the discretion of the shoring engineer.

10.11.4 Lateral bracing consisting of drilled tie-back anchors is considered feasible. However, due to the presence of oversized material within the artificial fill and terrace deposits as well as the very dense nature of the bedrock, installation of tie-backs may be difficult and require the use of medium to heavy-duty drilling equipment. Recommendations for the design of tie-back anchors are provided in Section 10.12.

10.11.5 Installation of shoring on a sloping ground surface requires careful consideration of excavation sequencing. Prior to installation of shoring, grading to create a relatively flat pad for equipment access may be required. Excavation of unsupported vertical cuts into a sloping ground surface would remove support from the ascending portion of the slope and create a potentially unstable condition. Unsupported vertical excavation into a slope is not permitted. Equipment access can be created by placement of additional fill to build up a temporary equipment pad against the existing slope.

10.11.6 The design embedment of the shoring pile toes must be maintained during excavation activities. The toes of the shoring piles should be deepened to take into account any additional excavations required for subgrade preparation and placement of bedding materials.

10.11.7 Drilled cast-in-place soldier piles should be placed no closer than 2 diameters on center. The minimum diameter of the piles is 18 inches. Structural concrete should be used for the soldier piles below the excavation; lean-mix concrete may be employed above that level. As an alternative, lean-mix concrete may be used throughout the pile where the reinforcing consists of a wideflange section. The slurry must be of sufficient strength to impart the lateral bearing pressure developed by the wideflange section to the soil. For design purposes, an allowable passive value for the Rincon Shale bedrock anticipated to be encountered below the bottom plane of excavation may be assumed to be 500 pounds per square foot per foot. The allowable passive value may be doubled for isolated piles, spaced a minimum of twice the pile diameter. To develop the full lateral value, provisions should be implemented to assure firm contact between the soldier piles and the undisturbed bedrock.

10.11.8 The contractor should be aware that difficult drilling conditions will likely be encountered due to the presence of oversized material within the artificial fill and terrace deposits, as well as due to the very dense nature of the bedrock.

10.11.9 Based on the loose, granular nature of the existing artificial fill and terrace deposits, casing is anticipated to be required for excavation through these materials to control the diameter of the boring. The contractor should have casing available prior to commencement of drilling activities. If casing is used, extreme care should be employed so that the pile is not pulled apart as the casing is withdrawn. At no time should the distance between the surface of the concrete and the bottom of the casing be less than five feet. Continuous observation of the drilling and pouring of the piles by the Geotechnical Engineer (a representative of Geocon West, Inc.) is required.

10.11.10 Groundwater seepage may be encountered during construction; therefore, the contractor should be prepared for groundwater during pile installation should the need arise. Piles placed below the water level require the use of a tremie to place the concrete into the bottom of the hole. A tremie should consist of a rigid, water-tight tube having a diameter of not less than 6 inches with a hopper at the top. The tube should be equipped with a device that will close the discharge end and prevent water from entering the tube while it is being charged with concrete. The tremie should be supported so as to permit free movement of the discharge end over the entire top surface of the work and to permit rapid lowering when necessary to retard or stop the flow of concrete. The discharge end should be closed at the start of the work to prevent water entering the tube and should be entirely sealed at all times, except when the concrete is being placed. The tremie tube should be kept full of concrete. The flow should be continuous until the work is completed and the resulting concrete seal should be monolithic and homogeneous. The tip of the tremie tube should always be kept about 5 feet below the surface of the concrete and definite steps and safeguards should be taken to insure that the tip of the tremie tube is never raised above the surface of the concrete.

10.11.11 A special concrete mix should be used for concrete to be placed below water. The design should provide for concrete with an unconfined compressive strength psi of 1,000 pounds per square inch (psi) over the initial job specification. An admixture that reduces the problem of segregation of paste/aggregates and dilution of paste should be included. The slump should be commensurate to any research report for the admixture, provided that it should also be the minimum for a reasonable consistency for placing when water is present.

10.11.12 Where tie-back anchors are used, the frictional resistance between the soldier piles and retained soil may be used to resist the vertical component of the anchor load. The coefficient of friction may be taken as 0.3 based on uniform contact between the lean-mix concrete and artificial fill, 0.4 based on contact with the terrace deposits and Rincon Shale bedrock. The portion of soldier piles below the plane of excavation may also be employed to resist the downward loads. The downward capacity may be determined using a frictional resistance of 400 pounds per square foot.

10.11.13 Due to the nature of the site soils, it is expected that continuous lagging between soldier piles will be required. However, it is recommended that the exposed soils be observed by the Geotechnical Engineer (a representative of Geocon West, Inc.), to verify the presence of any cohesive soils and the areas where lagging may be omitted, such as within the stable Rincon Shale bedrock.

10.11.14 The time between lagging excavation and lagging placement should be as short as possible. Soldier piles should be designed for the full-anticipated pressures. Due to arching in the soils, the pressure on the lagging will be less. It is recommended that the lagging be designed for the full design pressure but be limited to a maximum of 450 pounds per square foot.

10.11.15 For design of shoring, it is recommended that an equivalent fluid pressure based on the following table, be utilized for design.

APPROXIMATE LOCATION	HEIGHT OF SHORING (FEET)	EQUIVALENT FLUID PRESSURE (Pounds Per Cubic Foot) (ACTIVE PRESSURE)	EQUIVALENT FLUID PRESSURE (Pounds Per Cubic Foot) (AT-REST PRESSURE)
Station 13+00	Up to 15 ft Supporting a 35° slope	26	64
Station 13+50	Up to 18 ft Supporting a 35° slope	32	67
Station 14+00	Up to 20 ft Supporting a 33° slope	32	67
Station 14+50	Up to 20 ft Supporting a 30° slope	30	65
Station 15+00	Up to 20 ft Supporting a 24° slope	25*	60*
Station 15+50	Up to 25 ft Supporting a 33° slope	35	70
Station 15+74 (jacking pit)	Up to 30 ft Supporting a 30° slope	35	70
Station 21+70 (receiving pit / channel structure)	Up to 15 ft Supporting a 17° slope	20	50

*Does not include surcharge from elevated SCE substation pad

10.11.16 In order to simplify the shoring design, the shoring engineer may design a length of shoring for the greatest anticipated pressure along that length. For example, for the shoring anticipated to be constructed along the south side of the cut and cover excavation between Station 13+00 and Station 15+70, the shoring engineer may design unrestrained shoring for an equivalent fluid pressure of 35 pcf (active pressure), and restrained shoring for an equivalent fluid pressure of 70 pcf (at-rest pressure).

10.11.17 It is very important to note that active pressures can only be achieved when movement in the soil (earth wall) occurs. If movement in the soil is not acceptable, such as adjacent to an existing structure or utility, or the pile is restrained from movement by bracing or a tie back anchor, the at-rest pressure should be considered for design purposes.

10.11.18 Where a combination of sloped embankment and shoring is utilized, the pressure will be greater and must be determined for each combination. Additional active pressure should be added for a surcharge condition due to sloping ground conditions not addressed in the above table, vehicle or equipment loads, or adjacent structures and must be determined for each combination. As the design progresses, additional recommendations can be provided addressing specific surcharge conditions throughout the project, if necessary.

10.11.19 The surcharge from the adjacent, elevated SCE substation pad should be evaluated as the project progresses. At this time, information regarding the wall construction and foundation details for the existing retaining wall supporting the elevated pad are unknown. This information is critical for calculation of the anticipated surcharge pressure. The Client should request information on the existing wall construction from SCE, otherwise conservative assumptions will be required.

10.11.20 It is difficult to accurately predict the amount of deflection of a shored embankment. It should be realized that some deflection will occur. It is recommended that the deflection be minimized to prevent damage to existing structures and adjacent improvements. Where movement of the soil behind the shoring is tolerable, such as where public right-of-ways are present or adjacent offsite structures do not surcharge the shoring excavation, the shoring deflection should be limited to less than 1 inch at the top of the shored embankment. Where movement of the soil behind the shoring is not tolerable, such as where offsite structures are within the shoring surcharge area of where soil movement could affect slope stability, it is recommended that the beam deflection be limited to less than ½ inch at the top of the shored embankment or elevation of the adjacent offsite foundation, whichever is more stringent, or be limited to no deflection at all if deflections will damage existing structures. The allowable deflection is dependent on many factors, such as the presence of structures and utilities near the top of the embankment, and will be assessed and designed by the project shoring engineer.

10.11.21 Based on the depth of the excavation, some means of monitoring the performance of the shoring system is suggested. The monitoring should consist of periodic surveying of the lateral and vertical locations of the tops of all soldier piles and the lateral movement along the entire lengths of selected soldier piles. The geotechnical engineer and shoring engineer should be copied with all survey monitoring reports.

10.11.22 The Client should also consider periodic monitoring / surveying of adjacent structures and significant topographic features located behind the shoring system. Monitoring of the adjacent offsite structures and ground surface will provide information on soil movement. Installation of temporary monuments can be used to survey the ground surface. An initial baseline survey should be performed to establish preconstruction conditions prior to commencement of any shoring excavations.

10.12 Tie-Back Anchors

10.12.1 Tie-back anchors may be used to resist lateral loads. Provided anchors derive capacity exclusively in the competent Rincon Shale bedrock, anchors may be utilized to provide resistance of lateral loads acting on temporary shoring or permanent retaining walls.

10.12.2 For design of anchors installed along the face of temporary shoring or of a retaining wall, it may be assumed that the active wedge adjacent to the shoring or retaining wall is defined by a plane drawn 35 degrees with the vertical through the bottom plane of the excavation. Friction anchors should extend a minimum of 20 feet beyond the potentially active wedge and to greater lengths if necessary to develop the desired capacities. The locations and depths of all offsite utilities should be thoroughly checked and incorporated into the drilling angle design for the tie-back anchors.

10.12.3 The capacities of the anchors should be determined by testing of the initial anchors as outlined in the following section. Only the frictional resistance developed beyond the active wedge would be effective in resisting lateral loads. Anchors should be placed at least 6 feet on center to be considered isolated. Based on the height of the proposed excavations, two rows of anchors may be required

10.12.4 It is anticipated that anchors will derive capacity in the Rincon Shale bedrock. Although post-grouting techniques are recommended to create a strong grout-to-ground anchor bond, post-grouting is not anticipated to significantly increase the grout-bulb diameter due to the bedrock properties. If additional anchor capacity is required, consideration should be given to the use of belled (underreamed) anchors. Construction of belled anchors requires the use of specialized equipment capable of forming the enlarged bells within the bonded zone of the anchor. Care must be taken to form and clean the bells and should be performed by an experienced contractor.

10.12.5 For preliminary design purposes, it is estimated that drilled friction anchors penetrating into the Rincon Shale bedrock will develop an average skin friction value of 900 pounds per square foot. The maximum allowable friction capacities are as follows:

- Straight Anchor Constructed with Post-Grouting Techniques – 1.4 kips per linear foot
- Belled Anchor Constructed with 12 inch Underream – 2.9 kips per linear foot

10.12.6 The maximum allowable friction capacities assume an anchor length of 20 feet beyond the active wedge. Only the frictional resistance developed beyond the active wedge should be utilized in resisting lateral loads.

10.13 Anchor Installation

10.13.1 Tie-back anchors are typically installed between 20 and 40 degrees below the horizontal; however, occasionally alternative angles are necessary to avoid existing improvements and utilities. The locations and depths of all offsite utilities should be thoroughly checked prior to design and installation of the tie-back anchors. Caving of the anchor shafts, particularly within sand and gravel deposits or seepage zones, should be anticipated during installation and provisions should be implemented in order to minimize such caving.

10.13.2 Difficult drilling conditions should be anticipated where drilling through the artificial fill and terrace deposits due to the presence of oversized material such as large concrete debris, cobbles, and boulders. Additionally, difficult drilling is also anticipated to penetrate into the Rincon Shale. The contractor should select appropriate drilling equipment based on the anticipated conditions.

10.13.3 It is suggested that hollow-stem auger drilling equipment be used to install the anchors. The anchor shafts should be filled with concrete by pumping from the tip out, and the concrete should extend from the tip of the anchor to the active wedge. In order to minimize the chances of caving, it is recommended that the portion of the anchor shaft within the active wedge also be backfilled prior to anchor testing. Backfill consisting of concrete, slurry, or sand may be utilized within the active wedge provided the material is placed by pumping and so that this portion of the shaft is filled tightly and flush with the face of the excavation.

10.14 Anchor Testing

10.14.1 All of the anchors should be tested to at least 150 percent of design load. The total deflection during this test should not exceed 12 inches. The rate of creep under the 150 percent test load should not exceed 0.1 inch over a 15-minute period in order for the anchor to be approved for the design loading.

10.14.2 At least ten percent of the anchors should be selected for "quick" 200 percent tests and three additional anchors should be selected for 24-hour 200 percent tests. The purpose of the 200 percent tests is to verify the friction value assumed in design. The anchors should be tested to develop twice the assumed friction value. These tests should be performed prior to installation of additional tiebacks. Where satisfactory tests are not achieved on the initial anchors, the anchor diameter and/or length should be increased until satisfactory test results are obtained.

10.14.3 The total deflection during the 24-hour 200 percent test should not exceed 12 inches. During the 24-hour tests, the anchor deflection should not exceed 0.75 inches measured after the 200 percent test load is applied.

10.14.4 For the "quick" 200 percent tests, the 200 percent test load should be maintained for 30 minutes. The total deflection of the anchor during the 200 percent quick tests should not exceed 12 inches; the deflection after the 200 percent load has been applied should not exceed 0.25 inch during the 30-minute period.

10.14.5 After a satisfactory test, each anchor should be locked-off at the design load. This should be verified by rechecking the load in the anchor. The load should be within 10 percent of the design load. A representative of this firm should observe the installation and testing of the anchors.

10.15 Retaining Wall Design

10.15.1 Retaining walls are proposed to be constructed at Station 11+75 for the outlet structure headwall, between Station 14+50 and Station 15+75 for support of the proposed O&M access road, between Station 15+50 and Station 16+00 above the proposed O&M access road, and between Station 21+50 and Station 22+00 for the channelized portion of the drainage conveyance structure.

10.15.2 Recommendations for retaining wall foundation design are discussed separately for each anticipated wall location. Recommendations for design of the foundation for the retaining wall at the headwall structure, for support of the O&M access road, for the retaining wall located above the access road are provided in Section 11 of this report. Recommendations for the design of the foundation for the channelized portion of the drainage conveyance structure are provided in Section 13 of this report.

10.15.3 The recommendations presented below are generally applicable to the design of rigid concrete or masonry retaining walls having a maximum height of 20 feet. In the event that walls higher than 20 feet are planned, Geocon should be contacted for additional recommendations.

10.15.4 As a means to generate resistance of lateral loads acting on proposed retaining walls, permanent anchors deriving support exclusively in Rincon Shale bedrock can be used. Recommendations for the design of permanent anchors are provided in Section 10.12.

10.15.5 Retaining walls should be designed utilizing the equivalent fluid pressures indicated in the following tables. The wall pressures provided in the following tables assume that the retaining walls will be properly drained preventing the buildup of hydrostatic pressure. If retaining wall drainage is not implemented, walls should be designed for the undrained pressure provided in paragraph 10.15.7 below. Walls not restrained at the top (cantilevered) may utilize the active pressure. Restrained walls are those that are not allowed to rotate more than 0.001H (where H equals the height of the retaining portion of the wall in feet) at the top of the wall. Where walls are restrained from movement at the top the at-rest pressure should be considered.

RETAINING WALL
WITH LEVEL BACKFILL

HEIGHT OF WALL (FEET)	EQUIVALENT FLUID PRESSURE (Pounds Per Cubic Foot) (ACTIVE PRESSURE)	EQUIVALENT FLUID PRESSURE (Pounds Per Cubic Foot) (AT-REST PRESSURE)
Up to 15 Headwall at Outlet Structure Backfill Comprised of Engineered Fill	30	50
Up to 20 Below O&M Access Road Backfill Comprised of Engineered Fill	36	55

RETAINING WALL
WITH SURCHARGE FROM 1½:1 SLOPE

HEIGHT OF WALL (FEET)	EQUIVALENT FLUID PRESSURE (Pounds Per Cubic Foot) (ACTIVE PRESSURE)	EQUIVALENT FLUID PRESSURE (Pounds Per Cubic Foot) (AT-REST PRESSURE)
Up to 5 Above O&M Access Road	55	75

RETAINING WALL WITH
SURCHARGE FROM 2:1 SLOPE

HEIGHT OF WALL (FEET)	EQUIVALENT FLUID PRESSURE (Pounds Per Cubic Foot) (ACTIVE PRESSURE)	EQUIVALENT FLUID PRESSURE (Pounds Per Cubic Foot) (AT-REST PRESSURE)
Up to 12 Channel Structure Backfill Comprised of Bedrock	30	65
Up to 12 Channel Structure Backfill Comprised of Engineered Fill	42	78

10.15.6 As indicated in the above tables, where retaining walls will be backfilled with engineered fill, the recommended wall pressures are based on the assumption that the backfill materials within an area bounded by the wall and a 1:1 plane extended upward from the base of the wall will be comprised of materials with the minimum assumed properties for *Engineered Fill* presented in Section 9 (γ = 115 pcf, φ = 28°, c = 250 pcf). The recommended wall pressures also assume that the backfill materials within the same limits will be non-expansive (EI<20).

10.15.7 The wall pressures provided above assume that the retaining walls will be properly drained preventing the buildup of hydrostatic pressure. Recommendations for retaining wall drainage are provided in Section 10.17. If retaining wall drainage is not implemented, the equivalent fluid pressure to be used in design of undrained walls is 90 pcf. The value includes hydrostatic pressures plus buoyant lateral earth pressures.

10.15.8 Where not already accounted for, additional active pressure should be added for a surcharge condition due to sloping ground, vehicular traffic or adjacent structures and should be designed for each condition as the project progresses.

10.15.9 The surcharge from the adjacent, elevated SCE substation pad should be evaluated as the project progresses. At this time, information regarding the wall construction and foundation details for the existing retaining wall supporting the elevated pad are unknown. This information is critical for calculation of the anticipated surcharge pressure. The Client should request information on the existing wall construction from SCE, otherwise conservative assumptions will be required.

10.15.10 Seismic lateral forces should be incorporated into the design as necessary, and recommendations for seismic lateral forces are presented below.

10.16 Dynamic (Seismic) Lateral Forces

10.16.1 In accordance with the 2010 California Building Code, if the project possesses a seismic design category of D, E, or F, the proposed retaining walls should be designed with seismic lateral earth pressure. The structural engineer should determine the seismic design category for the project. The dynamic (seismic) lateral pressure is equal to the sum of the static active pressure and the dynamic (seismic) pressure increment.

10.16.2 Braced retaining walls should be designed for the greater of either the at-rest earth pressure or the dynamic (seismic) lateral earth pressure (sum of the static active pressure and the dynamic (seismic) pressure increment).

10.16.3 The application of seismic loading should be performed at the discretion of the project Structural Engineer and in accordance with the requirements of the Building Official. If seismic loading is to be applied, we recommend the seismic loads indicated in the following table be used for design. The indicated loads are equivalent fluid pressures and may be applied as a triangular distribution of pressure along the wall height. The seismic pressures are based on a peak ground acceleration of 0.68g (S_{DS}/2.5). It is very important to note that the values in the table represent dynamic (seismic) pressure increment; these values do not include the static active pressure.

RECOMMENDED DYNAMIC LATERAL PRESSURE

Slope Inclination Behind Wall	Dynamic (Seismic) Pressure Increment Equivalent Fluid Density (pcf)
Level Backfill	40
2:1 Channel Structure Backfill Comprised of Bedrock	120
1½:1 4ft High Wall Above O&M Access Road	No Increase

10.16.4 If retaining wall configurations, including backfill properties, other than those indicated in the above table are proposed, Geocon should be contacted to provide additional recommendations.

10.17 Retaining Wall Drainage

10.17.1 Retaining walls should be provided with a drainage system extended at least two-thirds the height of the wall. At the base of the drain system, a subdrain covered with a minimum of 12 inches of gravel should be installed, and a compacted fill blanket or other seal placed at the surface (see Figure 15). The clean bottom and subdrain pipe, behind a retaining wall, should be observed by the Geotechnical Engineer (a representative of Geocon), prior to placement of gravel or compacting backfill.

10.17.2 As an alternative, a plastic drainage composite such as Miradrain or equivalent may be installed in continuous, 4-foot wide columns along the entire back face of the wall, at 8 feet on center. The top of these drainage composite columns should terminate approximately 18 inches below the ground surface, where either hardscape or a minimum of 18 inches of relatively cohesive material should be placed as a cap (see Figure 16). These vertical columns of drainage material would then be connected at the bottom of the wall to a collection panel or a one-cubic-foot rock pocket drained by a 4-inch subdrain pipe.

10.17.3 Subdrainage pipes at the base of the retaining wall drainage system should outlet to an acceptable location via controlled drainage structures.

10.18 Paving Design - CMB Access Roads

10.18.1 Where new paving is to be placed, it is recommended that all existing fill and soft or unsuitable alluvial soils be excavated and properly compacted for paving support. The client should be aware that excavation and compaction of all soft or unsuitable soils in the area of new paving is not required, however, paving constructed over existing unsuitable soils may experience increased settlement and/or cracking, and may therefore have a shorter design life and increased maintenance costs.

10.18.2 As a minimum, the upper 12 inches of paving subgrade soils should be properly compacted to at least 95 percent relative compaction, as determined by ASTM Test Method D 1557 (latest edition).

10.18.3 The access road paving section should consist of at least 6 inches of Crushed Miscellaneous Base (CMB) placed over a properly compacted subgrade. Thicker paving sections may be required by VCWPD. The base material should be compacted to at least 95 percent relative compaction as determined by ASTM Test Method D 1557 (latest edition). Crushed Miscellaneous Base should conform to Section 200-2.4 of the "*Standard Specifications for Public Works Construction*" (Green Book).

10.18.4 The performance of pavements is highly dependent upon providing positive surface drainage away from the edge of pavements. Ponding of water on or adjacent to the pavement will likely result in saturation of the subgrade materials, subsidence, and pavement distress.

10.19 Paving Design - Bike Path Asphalt Concrete

10.19.1 The pavement design section presented in the table below assumes that the grading and engineering of subgrade soils have been performed in accordance with the recommendations in Section 10.7. Thicker paving sections may be required by VCWPD and/or the County of Ventura.

BIKE PATH PAVEMENT DESIGN SECTION

Location	Asphalt Concrete (inches)	CMB (inches)
Bike Path	2	4

10.19.2 Asphalt concrete should conform to Section 203-6 of the "*Standard Specifications for Public Works Construction*" (Green Book). Crushed Miscellaneous Base should conform to Section 200-2.4 of the "*Standard Specifications for Public Works Construction*" (Green Book).

10.19.3 The performance of pavements is highly dependent upon providing positive surface drainage away from the edge of pavements. Ponding of water on or adjacent to the pavement will likely result in saturation of the subgrade materials and subsequent cracking, subsidence and pavement distress.

11. STATION 10+00 THROUGH STATION 15+70

11.1 General

11.1.1 General soil characteristics and recommendations are provided in Section 10 of this report. The recommendations are applicable to the design and construction of this segment of the proposed drainage conveyance structure, and should be considered in addition to the recommendations presented below. Where the recommendations of this section conflict with those of Section 10, the recommendations of this section take precedence.

11.1.2 It is anticipated that shoring will be required to provide a stable excavation for the cut and cover section of the proposed alignment. Where required, shoring may be designed in accordance with the recommendations provided in Section 10.11 of this report.

11.1.3 Based on information obtained from our exploratory borings, the trench excavation bottom for construction of the proposed pipe between Station 11+75 and Station 15+70 is anticipated to expose artificial fill and Rincon Shale bedrock. During exploration activities, the existing artificial fill was observed to be of poor quality with substantial quantities of oversized and deleterious material. It is our opinion that this existing artificial fill is not considered suitable for support of the proposed RCP or additional fill. 11.1.3 Artificial fill is also anticipated to underlie the area of the proposed headwall construction at Station 11+75, the proposed slope construction between Station 12+00 and Station 14+50, as well as the area of proposed retaining wall construction between Station 14+50 and Station 15+70. Grading to achieve proposed elevations will require the placement of up to 15 feet of additional engineered fill over the existing artificial fill. The additional load of the engineered fill is anticipated to cause the underlying existing artificial fill to settle, resulting in settlement of engineered fill and any overlying structures or improvements. Based on information provided by VCWPD, it is our understanding that settlement of the proposed drainage conveyance structures is not tolerable. Therefore, removal of some of the existing fill will be required prior to construction of the proposed pipe, slopes, and retaining walls between Station 11+75 and Station 15+70. Recommendations for earthwork prior to pipeline and slope construction are provided in Section 11.2.

11.1.4 The proposed outlet structure headwall at Station 11+75 may be supported on a conventional spread foundation system deriving support in either the competent terrace deposits or newly placed engineered fill. Recommendations for conventional foundation design for support of the proposed headwall are provided in Section 11.8.

11.1.5 Where designed to derive support in terrace deposits, the footing excavation for the outlet structure headwall should be deepened as necessary to expose competent terrace deposits throughout the excavation bottom.

11.1.6 Where the outlet structure headwall foundation is designed to derive support in newly placed engineered fill, the existing artificial fill and any soft or unsuitable terrace deposits must be removed and replaced with properly compacted engineered fill. Excavations on the order of 5 to 7 feet are anticipated; however, the contractor should be prepared for deeper excavation to completely remove all unsuitable materials at the direction of the Geotechnical Engineer. Where excavation and compaction is to be conducted, the excavation should extended laterally a minimum distance of 5 feet beyond the foundation area for a distance equal to the depth of fill below the foundation, whichever is greater. Recommendations for earthwork are provided in Section 11.2.

11.1.7 An existing 42 inch diameter reinforced concrete (RC) gravity water main is located to the west of the proposed headwall and must be protected in place during proposed construction activities and placement of proposed riprap. Recommendations to protect the existing water line are provided in Section 11.2.

11.1.8 An existing 21 inch diameter sewer line is located adjacent to the proposed trench excavation between Station 12+75 and Station 15+75, and crosses under the proposed alignment between Station 12+55 and Station 12+75. It is our understanding that a new sewer line will be constructed parallel to the existing line, and the existing line will be abandoned in place upon completion of the new line.

11.1.9 A retaining wall up to 20 feet in height is proposed to be constructed between Station 14+50 and Station 15+75 for support of the proposed O&M access road. Based on information provided by VCWPD, it is our understanding that it is preferred to support the proposed retaining wall on a conventional spread foundation system. The use of a conventional foundation system will require the excavation and recompaction of existing artificial fill, and recommendations for earthwork are provided in Section 11.2. Where grading for the construction of a conventional spread foundation is not feasible, the proposed retaining wall may be supported on a deepened foundation system deriving support in the competent bedrock. Recommendations for deepened foundation design are provided in Sections 11.10 through 11.11.

11.1.10 Between Station 15+50 and Station 16+00, a retaining wall of approximately 4 feet in height will be constructed along the south side of the proposed O&M access road. This retaining wall will support an ascending slope with gradients ranging from 1½:1 to nearly level. Subsequent to construction of the RCP, it is anticipated that the majority of the proposed retaining wall will be underlain by newly placed engineered fill. However, the anticipated soil conditions underlying the proposed retaining wall should be reevaluated as the project progresses and once the placement of the jacking pit has been determined.

11.1.11 Based on these considerations, it is anticipated that the proposed 4 foot high retaining wall can be supported on a conventional spread foundation system deriving support in newly placed engineered fill. Grading should be conducted to remove all existing artificial fill underlying the proposed retaining wall foundation. Recommendations for foundation design are provided in Sections 11.7 through 11.9.

11.1.12 It is anticipated that the existing slopes located between Station 16+00 and Station 17+00 are mostly comprised of existing artificial fill. The history of this fill, including placement and compaction, is unknown at this time. Based on our discussions with VCWPD, it is our understanding that the existing artificial fill will not be removed prior to placement of additional fill for construction of proposed slopes.

11.1.13 Between Station 16+00 and Station 17+00, it is anticipated that the proposed pipe structure will be bounded laterally by competent terrace deposits to depths above the springline, and underlain by Rincon Shale bedrock. Based on these considerations, leaving the existing artificial fill place and placement of additional fill for slope construction is not anticipated to adversely affect the pipeline structure.

11.1.14 The Client should be aware that placement of additional engineered fill over the existing artificial fill could induce settlement of the existing artificial fill that could adversely affect proposed improvements, such as the O&M access road. If settlement of the existing artificial fill occurs, the proposed O&M access road may experience distress such as settlement or, in extreme circumstances, slope failure may occur. It is our understanding that VCWPD is willing to assuming the risks associated with leaving existing artificial fill in place.

11.1.15 Proposed retaining walls may be designed in accordance with the recommendations presented in Section 10.15 of this report.

11.2 Grading Prior to Pipeline, Slope, and Retaining Wall Construction

11.2.1 General recommendations for earthwork and slope construction are provided in Sections 10.4 through 10.8 of this report. The recommendations are considered applicable to the earthwork and slope construction along this section of the proposed drainage conveyance structure, and should be incorporated as necessary into the design and construction. Where the recommendations presented in this section conflict with those in Section 10, the recommendations in this section take precedence.

11.2.2 It is anticipated that artificial fill and Rincon Shale bedrock will be exposed at the trench excavation bottom between Station 11+75 and Station 15+70. Excavation should be conducted as necessary to remove all existing artificial fill, and soft or unsuitable terrace deposits and/or bedrock underlying the proposed pipeline. Where deep artificial fill is present, the excavation must extend laterally a minimum of 5 feet beyond the edge of the pipeline structure. Illustration of the recommended excavation limits is depicted on the Temporary Excavation Cross-Sections (see Figures 17 through 19).

11.2.3 Where the proposed 20 foot high retaining wall will be supported on a conventional foundation system, removal and recompaction of the existing artificial fill will be required. As a minimum, it is recommended that all existing artificial fill underlying the retaining wall foundation be excavated and properly compacted for foundation support. The excavation should extend laterally a minimum of 5 feet beyond the edge of the foundation. An illustration of the recommended excavation is provided on Figure 19.

11.2.4 It is recommended that all grading operations be performed prior to preparation of the RCP trench excavation bottom.

11.2.5 Prior to placing any fill, the excavation bottom must be observed and approved in writing by the Geotechnical Engineer (a representative of Geocon). Where existing utilities are not in conflict with the grading operations, the excavation bottom should be proof-rolled in the presence of the Geotechnical Engineer (a representative of Geocon) prior to placement of engineered fill. If determined to be soft, deeper excavation into the existing alluvium or stabilization of the excavation bottom may have to be performed at the direction of the Geotechnical Engineer.

11.2.6 During grading operations, the existing 21 inch diameter sewer line located between Station 12+75 and Station 15+75 must be protected in place until the proposed replacement sewer line is operational. If grading activities must be conducted prior to abandoning the sewer line, a minimum of 3 feet of soil cover over the top of the existing sewer line should be maintained during excavation activities. Excavations should not extend below this depth without written approval from the Geotechnical Engineer. Operation of construction equipment over the sewer line must be conducted carefully to prevent damaging the line. Rubber tire equipment is not recommended; the contractor should consider the use of track-mounted equipment which is more capable of distributing its load. The use of vibratory compaction equipment is also not recommended as it could induce settlement of the soil under the sewer line. The contractor is responsible for the evaluation and selection of construction equipment. Geocon is able to provide assistance in evaluating the equipment surcharge loads.

11.2.7 Where grading is conducted for support of the proposed headwall foundation, it is anticipated that excavations on the order of 5 to 7 feet in depth below the existing ground surface will be required to remove all existing artificial fill. Deeper excavation should be conducted as necessary to completely remove all existing artificial fill and soft or unsuitable soils at the direction of the Geotechnical Engineer. Where excavation and compaction is to be conducted, the excavation should extend laterally a minimum distance of five feet beyond the foundation area or for a distance equal to the depth of fill below the foundation, whichever is greater. The limits of existing fill and/or soft soil removal will be verified by the Geocon representative during site grading activities.

11.2.8 During grading operations, the existing 42 inch diameter water line located to the west of the proposed headwall must be protected in place. The water line is located approximately 15 feet away from the headwall retaining wall alignment and therefore is not anticipated to be located within the excavation performed for placement of engineered fill for support of the headwall foundation. However, based on project plans prepared by VCWPD, the water line has only 1 to 4 feet of soil cover and is therefore susceptible to damage if heavy construction equipment is operated over the top of the line.

11.2.9 In order to protect the existing water line, consideration should be given to encasing the line in concrete or slurry. If performed, encasement of the water line should be performed prior to other construction actives in this portion of the project. Encasement of the line would require a trench to be excavated around the existing reinforced concrete line. In order for the encasement to protect the line, the excavation bottom must penetrate into competent materials. The use of vacuum excavation equipment should be considered to conduct the excavation. Alternatively, consideration may also be given to the use of ground improvement techniques to protect the existing water line. Ground improvement is discussed in Section 12.10 of this report.

11.3 Bearing Conditions for Pipeline

11.3.1 Based on information obtained from our exploratory borings, the trench excavation bottom is anticipated to expose artificial fill and Rincon Shale bedrock. In order to minimize settlements of the soil supporting the proposed pipeline, it is recommended that all existing artificial fill underlying the proposed pipeline be removed prior to construction of the proposed pipe. Where deep artificial fill is present, the excavation must extend laterally a minimum of 5 feet beyond the edge of the pipeline structure. Illustration of the recommended excavation limits is depicted on the Temporary Excavation Cross-Sections (see Figures 17 through 19).

11.3.2 Engineered fill placed directly below the proposed RCP should be compacted to at least 95 percent relative compaction, as determined by ASTM D 1557 (latest edition).

11.3.3 The Rincon Shale bedrock anticipated to be exposed at the trench excavation bottom is generally considered suitable for support of the pipe. However, the quality of the exposed bedrock may be variable along length of the trench, ranging from soft, highly weathered bedrock to hard, moderately weathered bedrock. Locally soft or unsuitable trench bottom conditions may be encountered along portions of the alignment, and may require stabilization measures as described in Section 10.7.

11.3.4 In order to provide a uniform bearing condition, as a minimum it is recommended that a blanket of at least 12 inches of bedding material be placed below the RCP. Pipe bedding materials are discussed in Section 11.4.

11.3.5 The weight of the compacted backfill placed above the pipe for construction of proposed slopes will result in an increase in load over the present overburden. However, assuming remedial grading is conducted according the recommendations presented here in and any soft and/or unsuitable bedrock areas are mitigated, pipeline settlement is anticipated to be negligible.

11.4 Bedding and Shading Materials

11.4.1 The type and compaction requirements for the pipe bedding material should be specified by the project Civil Engineer or other applicable design professional in compliance with the manufacture's requirements, governing agency requirements, and/or the requirements of this report, whichever is more stringent.

11.4.2 Utility trenches should be properly backfilled in accordance with the requirements of the Green Book (latest edition). The pipe should be bedded with granular material that exhibits a Sand Equivalent Value of 30 or greater. Pipe bedding should extend to a depth of at least 24 inches below the pipeline invert and at least 12 inches above the springline of the pipe. The use of gravel as bedding material is acceptable provided it is used in conjunction with filter fabric to prevent the gravel from having direct contact with soil. The geotextile should be placed at the interface of the bedding material and excavate sidewalls, as well as over the top of the gravel. Geotextile is not required to be placed under the bedding material. The geotextile should be Mirafi 140N or equivalent.

11.4.3 In general, the existing onsite soils do not meet the required gradation and sand equivalent criteria for pipe bedding materials. Import material will be required for pipe bedding and shading.

11.4.4 Bedding material should be placed in horizontal loose layers approximately 6 to 8 inches thick where using sand, and approximately 12 inches thick where using gravel, and each lift compacted with vibratory compaction equipment. Consideration should be given to minimizing vibration of existing utilities when selecting compaction equipment used to densify the bedding material. Compaction equipment such as a vibratory plate (turtle) or other similar equipment would be considered suitable for densification of bedding materials. The use of jetting is not recommended, as the bedrock anticipated to be exposed at the trench excavation bottom is generally considered to be impermeable and ponding at the excavation bottom would likely occur.

11.4.5 The trench must be sufficiently large enough to facilitate proper compaction of the bedding materials below and along the sides of the RCP.

11.4.6 As an alternative, minimum 2-slack slurry may be used as bedding material. The use of slurry should be considered if insufficient space is available to properly density the bedding material.

11.5 Pipe Loading Design Criteria (Rigid Conduit)

11.5.1 The pipeline will consist of reinforced concrete (RCP) which is modeled as a rigid conduit. Pipeline loading will depend on depth of cover and unit weight of compacted backfill.

11.5.2 In areas where shoring is required or where a retaining wall will be constructed adjacent to the pipe, the pipe may be considered to be constructed in a “trench” condition. An average total unit weight of 120 pounds per cubic foot (pcf) and a kμ’ factor of 0.15 can be used to calculate load placed on the pipe in a “trench” condition.

11.5.3 In areas where sufficient space is available to perform the recommended excavation of existing artificial fill adjacent to the pipe trench, the pipe may be considered to be constructed in an “embankment” condition with complete positive projection. An average total unit weight of 120 pounds per cubic foot (pcf) and a kμ’ factor of 0.19 can be used to calculate load placed on the pipe in an “embankment” condition with complete positive projection.

11.5.4 In addition to the load from backfill, loads due traffic surcharges and other live loads should be considered.

11.6 Slope Construction and Stability

11.6.1 Slopes of up to 15 feet in height and constructed at gradients of 2:1 are proposed to be constructed for support of the proposed O&M access road. Provided the slopes are constructed according to the recommendations presented herein, the proposed slopes are anticipated to be stable with respect to deep seated and surficial instability.

11.6.2 As previously described, based on information provided by VCWPD, it is our understanding that settlement of the proposed drainage conveyance structures is not tolerable. Therefore, removal of all existing fill within the excavation limits described in Section 11.2 is required prior to construction of the proposed slopes between Station 11+75 and Station 15+70.

11.6.3 A keyway is required at the toe of all proposed fill slopes which are not directly underlain by newly place engineered fill. The keyway should be cut a minimum of two feet into competent material and must be observed and approved in writing by the Geotechnical Engineer prior to placement of any fill. A detail is provided on Figure 14.

11.6.4 All engineered fill must be placed and compacted on a horizontal surface; benching into the existing ground surface must be performed as necessary such that all fill is placed and compacted on a horizontal surface.

11.6.5 Fill slopes should be overbuilt by at least 3 feet measured perpendicular to the slope face and trimmed back to the tight fill core. This procedure is considered preferable to track-walking of slopes, as described in the following paragraph.

11.6.6 As an alternative, fill slope faces may be compacted by track-rolling with a loaded sheepsfoot roller at vertical intervals not to exceed 4 feet, and should be track-walked at the completion of each slope such that the fill is compacted to a dry density of at least 90 percent of the laboratory maximum dry density.

11.6.7 In general, it is our opinion that permanent, graded fill slopes at the site with gradients of 2:1 (horizontal to vertical) or flatter possess calculated Factors of Safety of 1.5 or greater provided the engineered fill placed for slope construction is comprised of materials with the minimum assumed properties for *Engineered Fill* presented in Section 9 (γ = 120 pcf, φ = 28°, c = 250 pcf).

11.6.8 The weight of the compacted backfill placed for construction of proposed embankments will result in an increase in load over the present overburden. However, assuming soft and/or unsuitable subgrade areas are mitigated in accordance with the recommendations presented herein, embankment settlement is anticipated to be less than 3 inches. If lesser settlements are required, fill placed and compacted for slope construction will require a higher degree of compaction above 90 percent. If desired, additional recommendations for fill placement to reduce the total anticipate settlement will be provided under separate cover.

11.6.9 Based on our discussions with VCWPD, it is our understanding that the existing artificial fill anticipated to be present within the existing slopes located between Station 16+00 and Station 17+00 will not be removed prior to placement of additional fill for construction of proposed slopes. Leaving the existing artificial fill in place, and placement of additional fill for slope construction is not anticipated to adversely affect the pipeline structure. However, the Client should be aware that placement of additional engineered fill over the existing artificial fill could induce settlement of the existing artificial fill that could adversely affect proposed improvements, such as the O&M access road. If settlement of the existing artificial fill occurs, the proposed O&M access road may experience distress such as settlement or, in extreme circumstances, slope failure may occur. It is our understanding that VCWPD is willing to assuming the risks associated with leaving the existing artificial fill in place.

.11.6.10 All slopes should be planted, drained, and property maintained to reduce erosion. It is recommended that finished slopes be planted as soon after completion of grading as possible. Planting on the slope stabilizes the surface and reduces the potential for erosion. It is further suggested that a jute or mesh product be placed on the slope face prior to planting. The planting of the slope should be performed at the direction of a qualified landscaping consultant.

11.7 Foundation Design - General

11.7.1 Subsequent to the recommended grading, the proposed 4 foot high retaining wall between Station 15+50 and Station 16+00 may be supported on a conventional spread foundation system deriving support in newly placed engineered fill. Recommendations for the design of a conventional spread foundation system are provided in Section 11.8.

11.7.2 Based on the proximity of the wall to the anticipated shoring, if a soldier beam shoring system is utilized the soldier beam must be trimmed to a depth of at least 18 inches below the bottom of the proposed retaining wall foundation. This will ensure no contact with the foundation and/or creation of eccentricity.

11.7.3 Based on input provided by VCWPD, it is preferred that the proposed 20 foot high retaining wall between Station 14+50 and Station 15+75 be supported on a conventional spread foundation. The retaining wall may be supported on a conventional foundation system provided grading is conducted in accordance with the recommendations of this report. Recommendations for the design of a conventional spread foundation system are provided in Section 11.8.

11.7.4 If the required grading cannot be performed, the proposed 20 foot high retaining wall may be supported on a deepened foundation system deriving support in the competent terrace deposits and/or the competent bedrock. Recommendations for deepened foundation design are provided in Section 11.10.

11.7.5 The proposed outlet structure headwall may be supported on a conventional spread foundation system deriving support in either the competent terrace deposits or newly placed engineered fill. If designed to derive support in the terrace deposits, footing excavations must be deepened as necessary to penetrate through any unsuitable materials at the direction of the Geotechnical Engineer. Recommendations for the design of a conventional spread foundation system are provided in Section 11.8.

11.7.6 Foundation excavations should be observed by the Geotechnical Engineer (a representative of Geocon West, Inc.), prior to the placement of reinforcing steel and concrete to verify that the excavations and exposed soil conditions are consistent with those anticipated. Footings excavations should be deepened as necessary to extend into the recommend bearing materials and should be cleaned of all loose earth materials prior to placing steel and concrete.

11.7.7 This office should be provided a copy of the final construction plans so that the foundation recommendations presented herein could be properly reviewed and revised if necessary.

11.8 Conventional Foundation Design

11.8.1 A reduced bearing capacity is recommended for the design of retaining wall foundations which could create an undesirable surcharge condition, such the foundation supporting the 4 foot high retaining wall above the RCP between Station 15+50 and Station 16+00. A reduced bearing capacity is also recommended for where settlements between adjacent structures must be minimized to less than ¼ inch, such as for the construction of the headwall at the termination of the RCP. Continuous footings may be designed for a maximum allowable bearing capacity of 1,500 pounds per square foot, and should be a minimum of 12 inches in width, 24 inches in depth below the lowest adjacent grade, and 18 inches into the recommended bearing material. Provided earthwork has been performed in accordance with the recommendations presented herein, settlement is anticipated to be less than ¼ inch over a distance of 20 feet.

11.8.2 Where larger settlements are tolerable, such as along the 20 foot high retaining wall to be constructed between Station 14+50 and Station 15+75, continuous foundations deriving support in newly placed engineered fill may be designed for a maximum allowable bearing capacity of 3,000 pounds per square foot. Foundations should be a minimum of 12 inches in width, 24 inches in depth below the lowest adjacent grade, and 18 inches into the recommended bearing material. Provided earthwork has been performed in accordance with the recommendations presented herein, settlement is anticipated to be less than ½ inch over a distance of 20 feet.

11.8.3 The headwall footing embedment below the ground surface should also consider the recommendations presented in Section 11.9 below.

11.8.4 Resistance to lateral loading may be provided by friction acting at the base of foundations, slabs and by passive earth pressure. An allowable coefficient of friction of 0.35 may be used with the dead load forces in the properly compacted engineered fill, and 0.4 may be used with the dead load forces in the competent terrace deposits.

11.8.5 Passive earth pressure for the sides of foundations and slabs poured against properly compacted engineered fill may be computed as an equivalent fluid having a density of 200 pcf with a maximum earth pressure of 2,000 pcf. Passive earth pressure for the sides of foundations and slabs poured against the competent terrace deposits may be computed as an equivalent fluid having a density of 270 pcf with a maximum earth pressure of 2,700 pcf. When combining passive and friction for lateral resistance, the passive component should be reduced by one-third.

11.8.6 If depth increases are utilized for the exterior wall footings, this office should be provided a copy of the final construction plans so that the excavation recommendations presented herein could be properly reviewed and revised if necessary.

11.8.7 The allowable bearing pressure may be increased by up to one-third for transient loads due to wind or seismic forces.

11.8.8 Continuous footings should be reinforced with a minimum of four No. 4 steel reinforcing bars, two placed near the top of the footing and two near the bottom. The project structural engineer should design reinforcement for spread footings.

11.8.9 The above foundation dimensions and minimum reinforcement recommendations are based on soil conditions and building code requirements only, and are not intended to be used in lieu of those required for structural purposes.

11.9 Special Considerations for Headwall Foundation Design

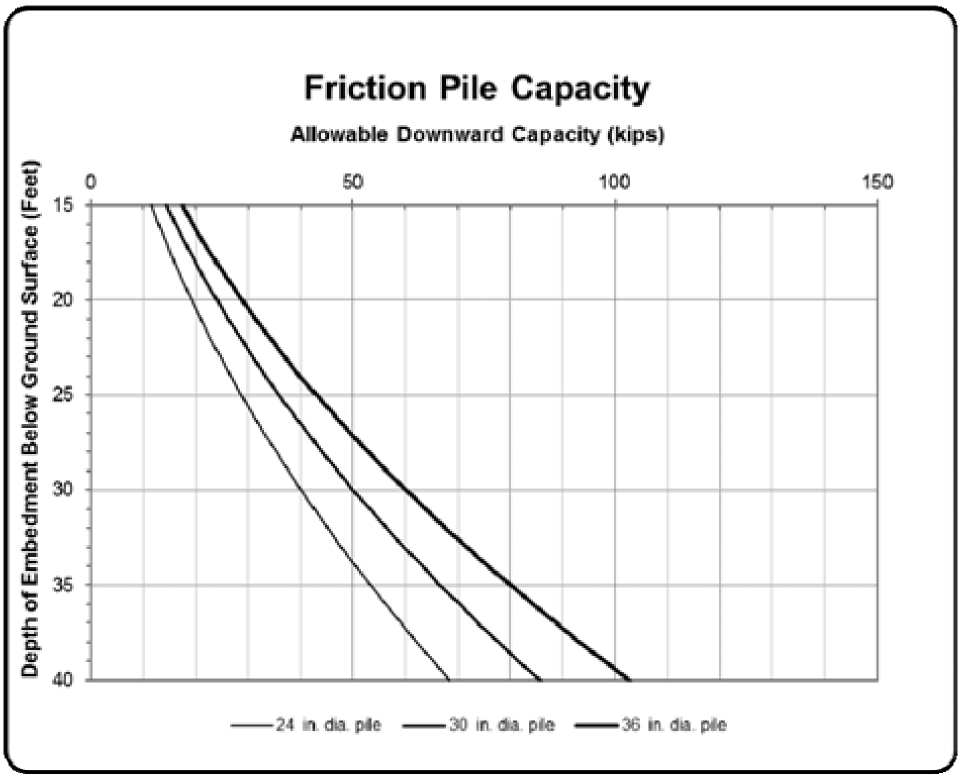
11.9.1 It is our opinion that there is a potential for scour to occur at the outlet structure which must be accounted for in the design of the headwall foundation embedment. It is our understanding that riprap will be designed and constructed for scour protection. The evaluation of the scour potential and the design of the riprap as a means of mitigating scour potential should be performed by the project hydrogeologist or other qualified professional. The evaluation of scour depth and riprap design is not the responsibility of the Geotechnical Engineer.

11.9.2 Provided the riprap is adequately designed for scour protection as described above, the headwall foundation should be embedded a minimum of 36 inches below the lowest portion of the riprap.

11.9.3 It is suggested that periodic observation of the riprap be performed by the agency responsible for operations and maintenance of the drainage conveyance structures. If observed to have been altered the riprap should be reconstructed per the intended design to restore scour protection of the floodwall foundation.

11.10 Deepened Foundation Design

11.10.1 Drilled cast-in-place, concrete piles should be a minimum of 24 inches in diameter and should derive support in the competent terrace deposits or bedrock. Piles may be designed based on the Pile Capacity chart presented below. The allowable axial capacities are based on skin friction.



11.10.2 Single pile uplift capacity may be taken as 50% of the allowable downward capacity. The allowable downward capacity and allowable uplift capacity may be increased by one-third when considering transient wind or seismic loads.

11.10.3 If necessary, a continuous grade beam foundation may be placed across the top of the caisson foundations and the appropriate span between caissons should be determined by a qualified structural engineer. The compressive and tensile strength of the pile sections should be checked to verify the structural capacity of the piles.

11.10.4 If pile spacing is at least 2½ times the maximum dimension of the pile, no reduction in axial capacity or lateral load capacity is considered necessary for group effects. If pile spacing is closer than 2½ pile diameters, an evaluation for group effects including appropriate reductions should be performed by Geocon based on pile dimension and spacing.

11.10.5 An allowable passive earth pressure for the sides of piles poured against newly placed engineered fill may be computed as an equivalent fluid having a density of 200 pounds per cubic foot with a maximum earth pressure of 2,000 pounds per square foot. The allowable capacity may be doubled for isolated caissons/piles spaced more than twice the diameter.

11.10.6 As a means to generate resistance of lateral loads acting on proposed retaining walls and foundations, permanent anchors deriving support exclusively in Rincon Shale bedrock can be used. Recommendations for the design of permanent anchors are provided in Section 10.12.

11.10.7 In addition to the anticipated structural loads, foundations which are constructed adjacent to a sloping ground surface and which penetrate through existing artificial fill will be subject to lateral loads due to the creep forces imposed by downslope creep of the fill, and must be designed to resist the load. Piles penetrating artificial fill which may be subject to creep should be designed to resist a creep force of 500 pounds per lineal foot for each foot of shaft exposed to the existing artificial fill. This condition could occur if earthwork to remove existing artificial fill underlying the proposed retaining wall above the access road is not performed.

11.10.8 All drilled pile excavations must be continuously observed by personnel of this firm to verify adequate depth and penetration into the recommended bearing materials. All loose soils must be completely removed from the bottom of all end-bearing foundation excavations and approved in writing by a representative of Geocon.

11.11 Pile Installation

11.11.1 All loose soils must be completely removed from the bottom of all end-bearing foundation excavations and approved in writing by the Geotechnical Engineer (a representative of Geocon West, Inc.). Casing may be required to prevent caving during excavation of the caisson foundations. The contractor should have casing available prior to the commencement of drilling activities.

11.11.2 Groundwater was not encountered during exploration; however, the contractor should be prepared for groundwater during pile installation should the need arise. Piles placed below the water level require the use of a tremie to place the concrete into the bottom of the hole. A tremie should consist of a rigid, water-tight tube having a diameter of not less than 6 inches with a hopper at the top. The tube should be equipped with a device that will close the discharge end and prevent water from entering the tube while it is being charged with concrete. The tremie should be supported so as to permit free movement of the discharge end over the entire top surface of the work and to permit rapid lowering when necessary to retard or stop the flow of concrete. The discharge end should be closed at the start of the work to prevent water entering the tube and should be entirely sealed at all times, except when the concrete is being placed. The tremie tube should be kept full of concrete. The flow should be continuous until the work is completed and the resulting concrete seal should be monolithic and homogeneous. The tip of the tremie tube should always be kept about 5 feet below the surface of the concrete and definite steps and safeguards should be taken to insure that the tip of the tremie tube is never raised above the surface of the concrete.

11.11.3 A special concrete mix should be used for concrete to be placed below water. The design should provide for concrete with an unconfined compressive strength psi of 1,000 pounds per square inch (psi) over the initial job specification. An admixture that reduces the problem of segregation of paste/aggregates and dilution of paste should be included. The slump should be commensurate to any research report for the admixture, provided that it should also be the minimum for a reasonable consistency for placing when water is present.

11.11.4 Closely spaced caissons should be drilled and filled alternately, with the concrete permitted to set at least eight hours before drilling an adjacent hole. Caisson excavations should be filled with concrete as soon after drilling and inspection as possible; the holes should not be left open overnight unless approved by the Geotechnical Engineer.

12. STATION 15+70 THROUGH STATION 21+50

12.1 General

12.1.1 General soil characteristics and recommendations are provided in Section 10 of this report. The recommendations are applicable to the design and construction of this segment of the proposed drainage conveyance structure, and should be considered in addition to the recommendations presented below. Where the recommendations presented in this section conflict with those in Section 10, the recommendations in this section take precedence.

12.1.2 It is our understanding that the proposed pipeline will be constructed using pipe jacking methods between Station 15+70 and Station 21+50.

12.1.3 Pipe jacking is anticipated to penetrate through existing artificial fill, terrace deposits, and Rincon Shale bedrock, with a mixed-face condition.

12.1.4 The proposed pipeline will cross under SR-33. The key issues relating to the design and construction of the undercrossing are the duration that the ground will stand unsupported at the face of the tunnel excavation, the method of initial ground support, and the ability to control ground deformation in order to minimize ground disturbance and surface settlement.

12.1.5 Groundwater seepage may be encountered during pipe jacking operations. It is suggested that pipe jacking operations be performed uphill to allow any encountered water to flow to the jacking shaft, and not collect in the heading.

12.1.6 A 140 ton crane, or larger, is anticipated to be required to set the RCP pipe segments in the jacking shaft. The location of the crane, and any surcharge imposed on the jacking pit and thrust block, should be considered. It is anticipated that there is sufficient space to create a relatively flat pad for temporary support of the crane to the north of the proposed jacking pit location.

7.1.5 The pipe jacking method and equipment to be used for this project is the responsibility of the contractor specializing in trenchless construction. A detailed plan should be forwarded to Geocon for preconstruction review.

12.2 Pipe Jacking Methods

12.2.1 The pipe jacking installation should be performed by a qualified contractor. It is recommended that the jacking/tunneling contractor have been in business for more than 10 years under the same name, and has successfully jacked multiple projects with large diameter RCP or casing over eight feet in diameter.

12.2.2 Pipe jacking is a general term that includes several methods for advancing a tunnel, then placing and jacking horizontal pipe sections in a single pass. Pipe jacking is accomplished by excavating vertical jacking (entry) and receiving (exit) pits or shafts, lowering and advancing a leading pipe section horizontally, excavating and removing soil as the lead pipe section is advanced, and successively placing and hydraulically pushing additional pipe sections from the jacking pit until reaching the receiving pit.

12.2.3 It is anticipated that an open face tunnel shield with extended brow would be used for construction. Extending the brow of the shield provides more support at the crown of the heading as the excavation is being performed and pipe is advanced. Due to the anticipated soil conditions, a longer than typical extended brow may be required and the cutting edge of the brow made from T-1 steel to withstand contact with large boulders. Depending on ground conditions, soils can be excavated at the lead pipe section by the use of an underground tunnel loader or shield mounted excavator. The shield should be equipped with breasting capabilities or sand shelves to help support the face if raveling ground is encountered. Pre-excavation grouting may also be considered to prevent raveling material at the heading.

12.2.4 To reduce friction during jacking, bentonite is usually injected through special ports in the casing. Tunneling can proceed intermittently, although prolonged periods of stoppage should be avoided to prevent the casing from adhering to the soil, particularly on long drives through cohesive soils. Due to the size of the proposed pipeline and very limited clearance above the pipe crown where undercrossing SR-33, it is anticipated that pipe jacking will advance the permanent pipe and will not use a temporary steel liner.

12.2.5 Based on the approximate location of the proposed jacking pit at Station 15+70, it is anticipated that the far side of the jacking pit, with respect to the direction of the pipe jacking, will daylight the ground surface. Based on this consideration, it is anticipated that a thrust block will be required to resist the jacking force.

12.2.6 Due to the length of the proposed drive, two or more intermediate jacking stations (IJS) may be required to complete the 580 foot pipeline drive. An IJS allows the contractor to separate and advance the pipe string segmentally, instead of pushing the entire string of pipe from one location. IJS stations should be considered if there is a concern that a single drive length will require jacking forces in excess of what can be provided and supported by the thrust block.

12.3 Anticipated Ground Conditions

7.1.4 Tunneling terminology is often used for evaluating different soil types for pipe jacking and tunneling. The *Tunnelman's Ground Classification of Soils* was first proposed by Terzaghi in 1950 and later modified by Heuer in 1974. A copy of the *Tunnelman's Ground Classification of Soils* is presented in Appendix C. According to this terminology, the pipe zone soils are generally classified as Firm (Shale) to Slow Raveling (Terrace Deposits).

12.4 Pipe Loads

12.4.1 It is assumed that the pipe being utilized is capable of withstanding all overburden surcharge loads. Geocon should be provided with pipe specifications once they become available.

12.5 Jacking and Exit Pit Design Parameters

12.5.1 It is anticipated that a combination of sloped and shored excavations will be required for the jacking and receiving pits. Sloped excavations can be designed in accordance with the recommendations presented in Section 10.10.

12.5.2 If shoring is installed for the jacking pit, anticipated to be located near Station 15+70, or at the receiving pit, anticipated to be located near Station 21+50, the recommendations provided in Section 10.11 may be utilized for the design of the temporary shoring.

12.6 Thrust Block

12.6.1 Pipe jacking will likely require a thrust block to provide the jacking force required to advance the pipe. The required jacking force may be estimated assuming an average friction coefficient of between 0.7 and 0.8 between the pipe segments and the soil and bedrock anticipated to be encountered along the pipeline. The design of the jacking system and thrust block is the responsibility of the contractor; however, preliminary estimates indicate that the jacking system and thrust block may need to be capable of providing 1,200 tons of thrust. Although it is a temporary system, the thrust block is essential to pipe jacking and therefore it is recommended that the thrust block be designed for a minimum Factor of Safety of 2.

12.6.2 Based on the proposed invert elevation of the pipeline, as well as the existing ground surface elevation near the jacking pit, anticipated to be located near Station 15+70, it is anticipated that the thrust block will have minimal embedment, if any, below the ground surface. Therefore, the proposed thrust block may be supported on drilled, cast-in-place piles deriving support in the underlying Rincon Shale bedrock. The design of the thrust block and supporting piles is the responsibility of the contractor; however, a typical configuration of piles supporting a thrust block is shown on Figure 20. Piles should be spaced at least 3 times the diameter in all horizontal directions.

12.6.3 The lateral resistance provided construction of the thrust block as indicated in Figure 20 may be estimated from the lateral capacity of the piles. Lateral capacities and maximum induced bending moments for drilled, cast-in-place piles with the top of the pile in a fixed-head condition are presented in the table below.

Pile Diameter (inches)	Pile Embedment Below Ground Surface (ft)	Lateral Load (kips)		Maximum Induced Bending Moment (feet-kips)	
		Pile Head Deflection		Pile Head Deflection	
		½ inch	1 inch	½ inch	1 inch
24	35	100	199	480	955
30	35	142	285	809	1,624
36	35	191	381	1,260	2,514

12.7 Tunneling Induced Ground Movement

12.7.1 Settlement of the ground surface may result from loss of ground associated with pipe jacking methods. Settlement associated with tunneling and pipe jacking is usually evaluated based on the available observational data and correlations. Good workmanship and positive control of conditions at the excavation face typically results in less settlement.

12.7.2 Surface settlements as a result of shield tunnel excavation are typically distributed in a settlement trough that can be roughly approximated as a bell-shaped curve with maximum settlements occurring over the centerline of the tunnel and decreasing laterally away from the centerline. Current literature indicates that the volume of the surface settlement trough is related to the volume of lost ground. In theory, the two volumes are equal; however, the resulting settlement trough volume is usually less than the volume of lost ground because of dilation within the ground as movements are translated to the surface.

12.7.3 Empirical methods have been developed for estimating tunneling-induced surface settlement based on past projects. Typical reported values of ground loss in soils like the anticipated colluvium and terrace deposits range from 0.5 to 1.0 percent. The values are generally considered appropriate for the site soils if good workmanship is assumed.

12.7.4 To estimate the settlement above the pipeline where undercrossing SR-33, a ground loss volume of 1 percent was assumed based on good workmanship practices. For the proposed 168 inch outer-diameter tunnel installed with approximately 7 to 9 feet of ground cover over the crown, the estimated ground surface settlement is less than 0.5 inches. The width of the settlement trough is estimated to be between 15 and 20 feet.

12.7.5 The tolerance of ground settlement depends on the structural makeup and existing conditions at the ground surface along the alignment. Due to the potential adverse effects of the magnitude of calculated settlement on the existing roadway, as well as the presence of settlement sensitive utilities at the SR-33 undercrossing, it is anticipated that additional measures to minimize tunneling induced surface settlements will be required. Ground improvement, such as chemical grouting, should be considered. Ground improvement to minimize surface settlement and for utility protection is discussed further in Section 12.10.

12.7.6 Since the magnitude of tunneling induced settlements relies on workmanship applied by the tunneling crew, settlements should be monitored closely and the Client should adapt guidelines for inspection during tunneling.

12.7.7 Serious settlement problems can result if uncontrolled ground movements, such as running or flowing ground conditions, are allowed to occur at the tunnel face. The potential for these conditions to develop has been discussed in the Anticipated Ground Conditions section of the report (see Section 12.3). Either condition could result in chimneying, partially or entirely to the ground surface, and locally large surface settlements. These problems are controllable by using careful tunneling methods, proper equipment and materials, and skilled tunnel crews. Where shield tunneling is used, adequate breasting capabilities, controlled independently of driving mechanisms, should be provided to mitigate face movement.

12.8 Instrumentation Monitoring Program

12.8.1 An instrumentation program should be implemented to monitor ground movements related to construction. The purpose of instrumentation is to assess the need for corrective action, verify design assumptions, demonstrate adherence to performance specifications, and document surface affects.

12.8.2 Surface settlements may be monitored by periodically surveying control points established prior to construction. Subsurface instrumentation should also be used to monitor settlements related to construction. Slope inclinometer and extensometer casing installed at boring B2 should be periodically monitored during construction. A baseline reading of the subsurface instrumentation should be established at least 1 week prior to construction.

12.9 Protection of Existing Utilities

12.9.1 The pipeline will be advanced under existing utilities including: a 10 inch gas line located along the west shoulder of SR-33; a 6 inch diameter gas line located along the east shoulder of SR-33; a 36 inch diameter storm drain servicing Parkview Drive, located just north of the intersection of SR-33 and Parkview Drive; wood power piles supporting overhead lines located at the intersection of SR-33 and Parkview Drive; and a 20 inch diameter gas line at approximate Station 20+30.

12.9.2 Based on the project plans and sections prepared by VCWPD, clearance above the crown of the pipeline is anticipated to be approximately 2.2 and 1.33 feet where crossing under the 10 and 6 inch diameter gas lines, respectively. If the existing gas lines are bedded and shaded with granular materials, there is a potential for partial or complete loss of the bedding material should caving or raveling occur at the tunnel face when advancing the pipeline under these utilities. Additionally, pipe jacking activities will induce pressure at the face during jacking activities, which may induce heaving of the ground surface where soil cover is minimal. The potential for increases in pressure and heave could both adverse effect the existing gas lines. It is the responsibility of the contractor to protect the existing gas lines during pipeline construction.

12.9.3 Based on the project plans and sections prepared by VCWPD, clearance above the crown of the pipeline is anticipated to be approximately 6 feet where crossing under the 20 inch diameter gas line located at approximate Station 20+30. If the existing gas line is bedded and shaded in granular material, there is a potential for partial or complete loss of the bedding material should caving or raveling chimney partially or entirely to the bedding material. It is the responsibility of the contractor to protect the existing gas line during pipeline construction.

12.9.4 The depth of the existing 36 inch diameter storm drain is unknown at this time. Although the section of storm drain is proposed to be abandoned, this will likely not occur until after pipe jacking is completed and therefore the existing storm drain should be protected during construction. Additional information on the depth of the existing 36 inch storm drain should be obtained by VCWPD so that recommendations for utility protection can be provided, if necessary. It is the responsibility of the contractor to protect the existing storm drain during pipeline construction.

12.9.5 The depth of embedment of the power-poles is unknown at this time, and therefore the clearance between the bottom of the power pole and pipeline is also unknown. Unless the power-pole can be sufficiently braced to prevent collapse, relocation should be considered. It is the responsibility of the contractor to protect the power-poles during pipeline construction.

12.10 Ground Improvement

12.10.1 At the undercrossing with SR-33, the pipeline will be advanced with approximately 7 to 9 feet of ground cover over the crown of the pipe, and will be advanced through a mixed-face comprised of terrace deposits over Rincon Shale bedrock. Based on the relatively dense nature of the bedrock as compared with the overlying artificial fill and terrace deposits, as well as the shallow depth of cover of the pipeline, the pipeline may deflect upwards during application of the pipe jacking load. Deflection towards the surface while advancing under SR-33 could result in ground surface deformations that are unacceptable for the roadway.

12.10.2 Additionally, the pipeline will be advanced below existing utilities with very little ground cover between the crown of the pipe and bottom of the utilities. Settlement or heave induced by tunneling activities could adversely affect the existing utilities.

12.10.3 Based on consideration of the potential for ground surface deformations, and as a means of protecting existing utilities, it is recommended that consideration be given to performing ground improvement, such as chemical grouting, prior to pipe jacking. If performed properly, the intention of chemical grouting will be create a massive block of in situ soil/cement mixture between the ground surface and the zone of planned tunneling activities. Advancing the pipeline through a more uniform material should minimize deflection from the proposed vertical and horizontal pipeline alignment. Additionally, chemical grouting may also protect existing utilities and help control ground loss at the tunnel face where granular soils are encountered. As such, the block of grouted material should include the existing artificial fill, terrace deposits, and utility bedding. Chemical grouting is not applicable to the bedrock.

12.10.4 Based on the results of the permeability tests performed on samples of the existing soil at depths of 4 and 7 feet below SR-33 (see Figure B23), the existing artificial fill and terrace deposits have a permeability which is close to the lower limit of what is considered suitable for grouting. Design analysis should be performed by a specialty contractor experienced in ground improvement by chemical grouting. For preliminary design purposes, it is recommended that grouting be performed across the width of the tunnel and throughout the existing artificial fill and terrace deposit materials.

13. STATION 21+50 THROUGH STATION 25+20

13.1 General

13.1.1 General soil characteristics and recommendations are provided in Section 10 of this report. The recommendations are applicable to the design and construction of this segment of the proposed drainage conveyance structure, and should be considered in addition to the recommendations presented below. Where the recommendations of this section conflict with those of Section 10, the recommendations of this section take precedence.

13.1.2 It is our opinion that the debris basin slough is not considered suitable for direct support of proposed structures or additional fill. Furthermore, the debris basin slough is not considered suitable for re-use as engineered fill due to the high organic content observed during site exploration. The existing colluvium and Rincon Shale bedrock are considered suitable for support direct support of proposed channel structures and additional fill. These materials are also considered suitable for re-use as engineered fill provided the recommendations in the *Grading* section of this report are followed (see Sections 10.4 through 10.7).

13.1.3 Based on this consideration, excavation should be conducted to completely remove all debris basin slough and soft or unsuitable terrace deposits and bedrock prior to construction of the channel structures. The depth to competent material should be verified by a representative of Geocon during construction activities. Engineered fill comprised of approved onsite materials may be placed as backfill to restore the required channel structure subgrade elevations. Engineered fill placed below the channel structures should have an expansion index (EI) of less than 50. Recommendations for earthwork are provided in the *Grading* section of this report (see Sections 10.4 through 10.7).

13.1.4 The proposed channel structure may be supported on a conventional foundation system or mat foundation system deriving support in newly placed engineered fill and/or the competent terrace deposits and bedrock. It is the intention of the Geotechnical Engineer to allow the foundation for the channel structure to derive support in newly placed engineered fill, competent terrace deposits, and bedrock if project conditions warrant such an occurrence. Recommendations for foundation design are provided in Sections 13.2 through 13.4 of this report.

13.1.5 The vertical walls of the channel structure are approximately 10 feet in height and will retain the adjacent ascending sloping ground surface along the south side of the channel structure. The vertical channel walls may be designed in accordance with the recommendations for retaining wall design provided in Section 10.15.

13.1.6 Due to the lack of surface improvements and structures, it is anticipated that there is sufficient space to perform the required excavations with sloping measures. Sloped excavations may be designed in accordance with the recommendations presented in Section 10.10.

13.1.7 Shoring measures should also be considered in order to minimize the volume of excavation required. The recommendations provided in Section 10.11 may be utilized for the design of the temporary shoring located between Station 21+50 and Station 22+00.

13.1.8 The proposed floodwall may be supported on a conventional spread foundation deriving support in the competent, undisturbed colluvium. Due to the sloping nature of the existing ground surface at the proposed floodwall, it is difficult to anticipate the depth to competent colluvium along the entire wall length. At boring B6, competent alluvium was found below a depth of 6 feet from existing ground surface (approximate elevation of 280 feet MSL). Recommendations for design of the floodwall foundation are provided in Sections 13.2 and 13.3.

13.1.9 The design of the floodwall foundation should consider the potential for scour of the surrounding soils. Discussion of these considerations is provided in Section 13.5.

13.2 Floodwall & Channel Foundation Design - General

13.2.1 Subsequent to the recommended grading, the proposed channel structure may be supported on a conventional foundation system deriving support in newly placed engineered fill and/or the competent terrace deposits and bedrock. It is the intention of the Geotechnical Engineer to allow the foundation for the channel structure to derive support in newly placed engineered fill, competent terrace deposits, and bedrock if project conditions warrant such an occurrence.

13.2.2 Alternatively, the channel structure may be supported on a mat foundation system. Recommendations for the design of a mat foundation system are provided in Section 13.4.

13.2.3 The proposed floodwall may be supported on a conventional spread foundation deriving support in the competent colluvium. Due to the sloping nature of the existing ground surface at the proposed floodwall, it is difficult to anticipate the depth to competent colluvium along the entire wall length. Foundation excavations should be deepened as necessary to penetrate into the competent colluvium and must be approved in writing by the Geotechnical Engineer (a representative of Geocon).

13.2.4 Based on consideration that the area of the proposed floodwall and channel structure may be subjected to saturation, the recommendations below have been adjusted for potential buoyancy.

13.2.5 Foundation excavations should be observed by the Geotechnical Engineer (a representative of Geocon West, Inc.), prior to the placement of reinforcing steel and concrete to verify that the excavations and exposed soil conditions are consistent with those anticipated. Footings excavations should be deepened as necessary to extend into the recommend bearing materials and should be cleaned of all loose earth materials prior to placing steel and concrete.

13.2.6 This office should be provided a copy of the final construction plans so that the foundation recommendations presented herein could be properly reviewed and revised if necessary.

13.3 Conventional Foundation Design

13.3.1 Continuous footings may be designed for an allowable bearing capacity of 2,500 pounds per square foot, and should be a minimum of 12 inches in width and 18 inches into the recommended bearing material. The soil bearing pressure above may be increased by 100 psf and 350 psf for each additional foot of foundation width and depth, respectively. In order to minimize settlement of the proposed foundations, a maximum allowable soil bearing value of 3,500 pounds per square foot is recommended.

13.3.2 The floodwall footing embedment below the ground surface should also consider the recommendations presented in Section 13.5 below.

13.3.3 The allowable bearing pressure may be increased by up to one-third for transient loads due to wind or seismic forces.

13.3.4 Continuous footings should be reinforced with a minimum of four No. 4 steel reinforcing bars, two placed near the top of the footing and two near the bottom. Reinforcement for spread footings should be designed by the project structural engineer.

13.3.5 If depth increases are utilized for the exterior wall footings, this office should be provided a copy of the final construction plans so that the excavation recommendations presented herein could be properly reviewed and revised if necessary.

13.3.6 The above foundation dimensions and minimum reinforcement recommendations are based on soil conditions and building code requirements only, and are not intended to be used in lieu of those required for structural purposes.

13.3.7 No special subgrade presaturation is required prior to placement of concrete. However, the slab and foundation subgrade should be sprinkled as necessary; to maintain a moist condition as would be expected in any concrete placement.

13.3.8 Settlement of the floodwall and channel structure is anticipated to be negligible as the structure will not be supporting any external loads.

13.3.9 Resistance to lateral loading may be provided by friction acting at the base of foundations, slabs and by passive earth pressure. An allowable coefficient of friction of 0.4 may be used with the dead load forces in the competent colluvium.

13.3.10 Passive earth pressure for the sides of foundations and slabs poured against the competent colluvium may be computed as an equivalent fluid having a density of 100 pcf with a maximum earth pressure of 1,000 pcf. When combining passive and friction for lateral resistance, the passive component should be reduced by one-third.

13.4 Mat Foundation Design

13.4.1 It is anticipated that channel structure will impart average pressure of less than 750 psf. The recommended maximum allowable bearing value for the design of a reinforced concrete mat foundation is 1,500 pounds per square foot. The allowable bearing pressure may be increased by up to one-third for transient loads due to wind or seismic forces.

13.4.2 It is recommended that a modulus of subgrade reaction of 100 pounds per cubic inch be utilized for the design of mat foundations deriving support in newly placed engineered fill and/or the competent terrace deposits and bedrock. The thickness of and reinforcement for the mat foundation should be designed by the project structural engineer.

13.4.3 Settlement of the channel structure is anticipated to be negligible as the structure will not be supporting any external loads.

13.5 Special Considerations for Floodwall Foundation Design

13.5.1 It is our opinion that there is a potential for scour to occur along the proposed floodwall alignment which must be accounted for in the design of the foundation embedment. It is our understanding that riprap will be designed and constructed at the base of the floodwall foundation for scour protection. The evaluation of the scour potential and the design of the riprap as a means of mitigating scour potential should be performed by the project hydrogeologist or other qualified professional. The evaluation of scour depth and riprap design is not the responsibility of the Geotechnical Engineer.

13.5.2 Provided the riprap is adequately designed for scour protection as described above, the floodwall foundation should be embedded a minimum of 36 inches below the lowest portion of the riprap.

13.5.3 It is suggested that periodic observation of the riprap be performed by the agency responsible for operations and maintenance of the drainage conveyance structures. If observed to have been altered the riprap should be reconstructed per the intended design to restore scour protection of the floodwall foundation.

13.5.4 Seepage analysis was performed to evaluate the typical seepage flow, pore pressures, and exit gradient at the floodwall during the highest anticipated stormwater flow conditions using finite element software (*SEEP/W*). Our analysis assumes a steady state flow condition provides a stable design; therefore, lower flows and storm durations will also be stable. A hydraulic conductivity (permeability) of 1.64×10^{-6}

cm/sec was used for the colluvium, based on correlations with grain size distribution. For the purpose of the seepage analysis, the Rincon Shale bedrock was assumed to be impermeable. A finite element mesh was generated to model a cross-section of the proposed floodwall and adjacent materials near Station 24+00 with a stormwater level of 289.3 91.4 feet (MSL) as illustrated by Figure D1. The calculated equipotential lines and flow lines through the model are depicted on Figures D2 through D5.The preliminary results indicate that a low exit hydraulic gradient is anticipated at the west side of the wall and piping of the soil due to exit gradients is not a design concern. These results should be verified as the final design of the floodwall and foundation progresses.

14. FURTHER GEOTECHNICAL SERVICES

14.1 Plan Review

14.1.1 Project plans and specifications, and other pertinent documents, should be reviewed by the Geotechnical Engineer (a representative of Geocon West, Inc.), prior to finalization to verify that the plans have been prepared in substantial conformance with the recommendations of this report and to provide additional analyses or recommendations.

14.2 Testing and Observation Services During Construction

14.2.1 The recommendations provided in this report are based on the assumption that we will continue as Geotechnical Engineer-of-Record throughout the construction phase. It is important to maintain continuity of geotechnical interpretation and confirm that field conditions encountered are similar to those anticipated during design. In accordance with 2010 CBC, testing and observation services by the Geotechnical Engineer-of-Record are required to verify that construction has been performed in accordance with this report, approved plans and specifications. If we are not retained for these services, we cannot assume any responsibility for other’s interpretation of our recommendations or the future performance of the project.

LIMITATIONS AND UNIFORMITY OF CONDITIONS

1. The recommendations of this report pertain only to the site investigated and are based upon the assumption that the soil conditions do not deviate from those disclosed in the investigation. If any variations or undesirable conditions are encountered during construction, or if the proposed construction will differ from that anticipated herein, Geocon West, Inc. should be notified so that supplemental recommendations can be given. The evaluation or identification of the potential presence of hazardous or corrosive materials was not part of the scope of services provided by Geocon West, Inc.

2. This report is issued with the understanding that it is the responsibility of the owner, or of his representative, to ensure that the information and recommendations contained herein are brought to the attention of the architect and engineer for the project and incorporated into the plans, and the necessary steps are taken to see that the contractor and subcontractors carry out such recommendations in the field.

3. The findings of this report are valid as of the present date. However, changes in the conditions of a property can occur with the passage of time, whether they are due to natural processes or the works of man on this or adjacent properties. In addition, changes in applicable or appropriate standards may occur, whether they result from legislation or the broadening of knowledge. Accordingly, the findings of this report may be invalidated wholly or partially by changes outside our control. Therefore, this report is subject to review and should not be relied upon after a period of three years.

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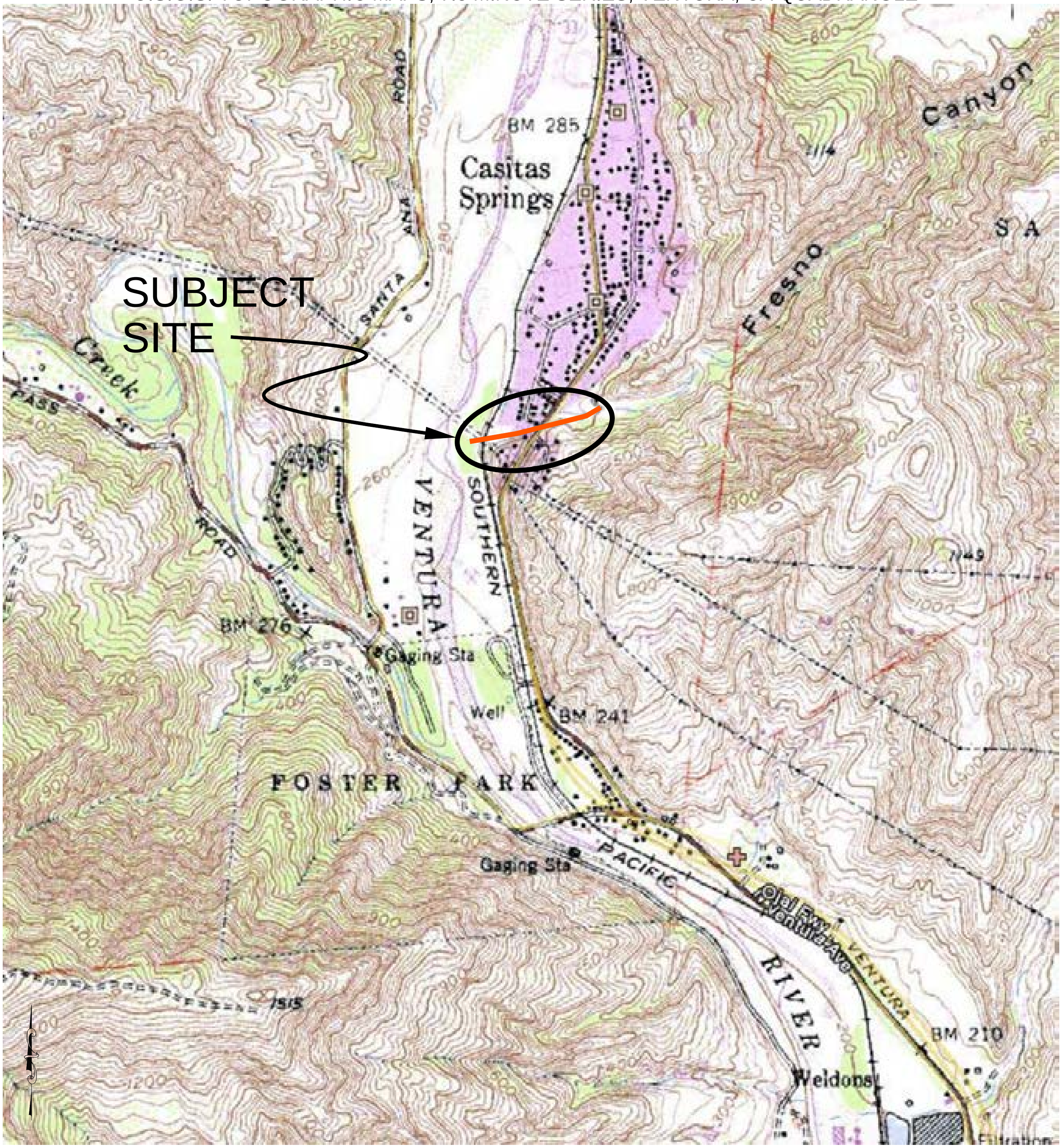

SCALE

0 1500' 3000'

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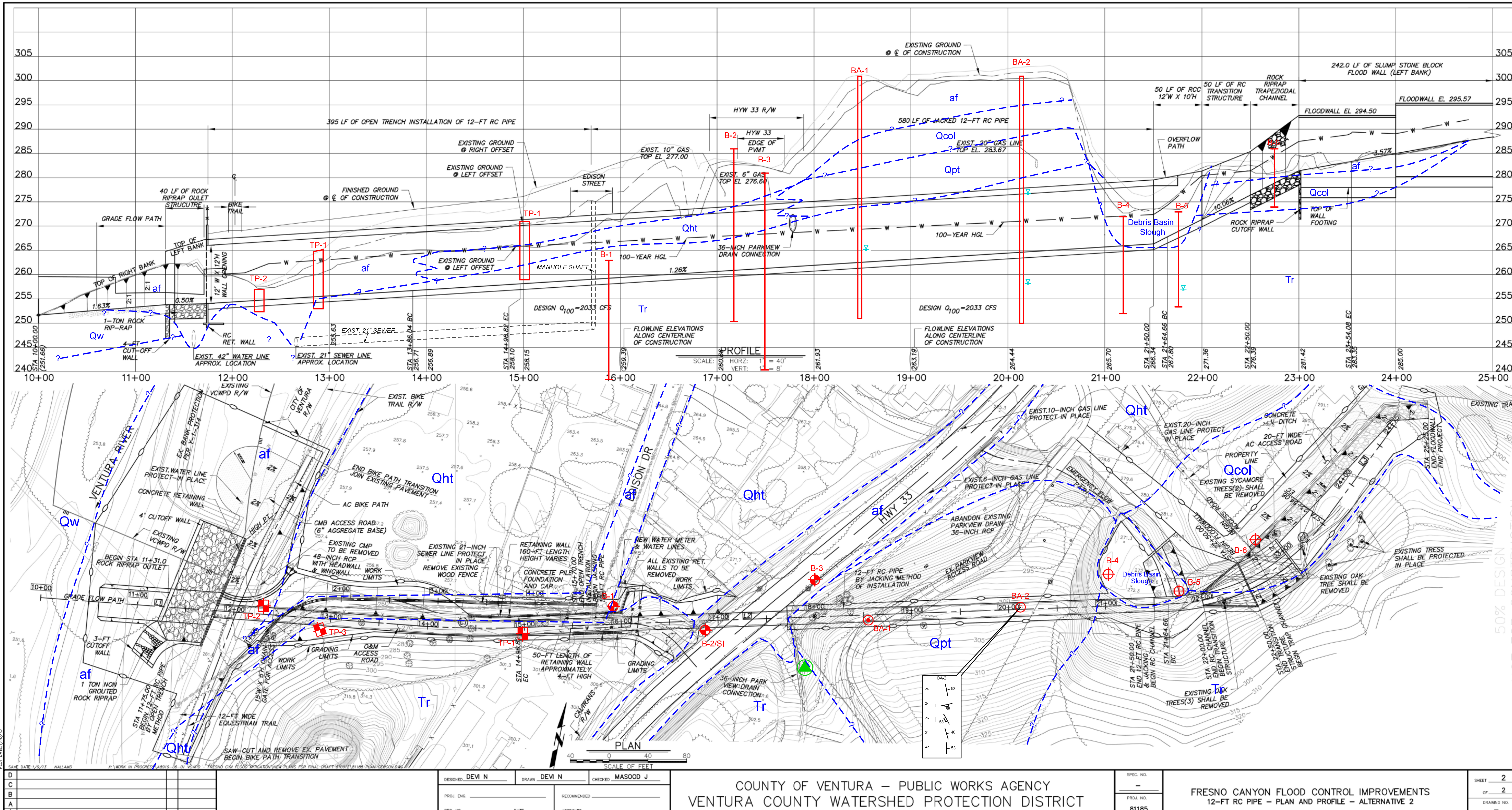
VICINITY MAP

FRESNO CANYON FLOOD MITIGATION PROJECT

VENTURA COUNTY WATERSHED PROTECTION DISTRICT

VENTURA COUNTY, CALIFORNIA

JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. 1



LEGEND

B-6	Hollow Stem Auger Boring
BA-2	Bucket Auger Boring
TP-3	Test Pit
SI	Slope Inclinometer/Extensometer
	Approximate Location of Reported Oil Well (DOGGR, 2006)
	Geologic Contact (Dashed where approx., queried where questionable)
af	Artificial Fill
Qw	Active Wash Deposits
Qcol	Colluvium
Qht	Terrace Deposits
Qpt	Older Terrace Deposits
Tr	Rincon Shale
	Strike/Dip of Bedding
	Strike/Dip of Joint

[redacted]

SITE PLAN / GEOLOGIC MAP

FRESNO CANYON FLOOD MITIGATION PROJECT
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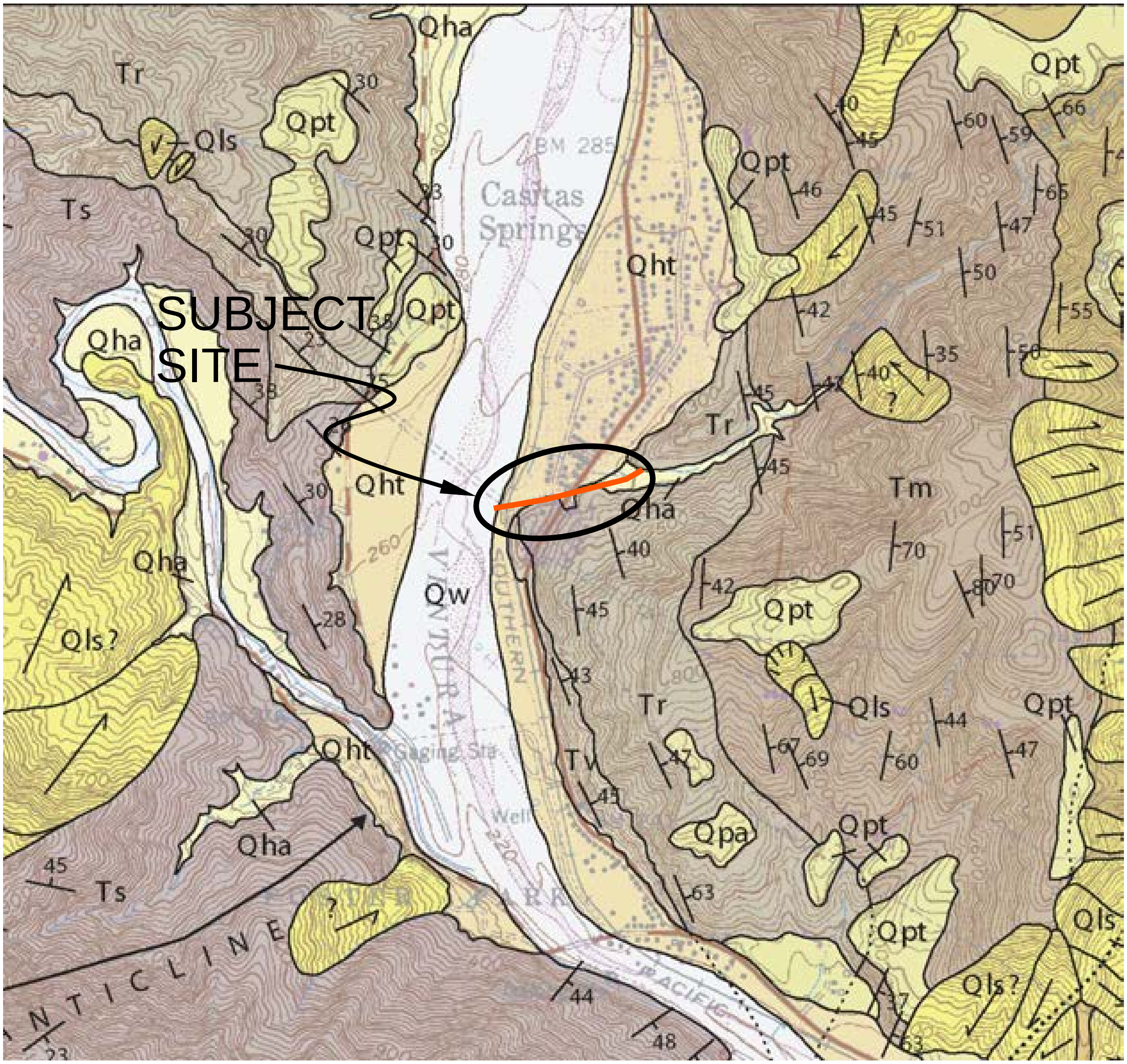
DRAFT	PROJECT NO. A8919-06-01	FIG. 2

REFERENCE: Tan, S, et.al, 2003, Geologic Map of the Ventura 7.5' Quadrangle, Ventura County, California



LEGEND

Qw - (Holocene) Active river wash deposits
Qha - (Holocene) Alluvium
Qls - (Holocene to Pleistocene) Landslide deposits
Qht - (Hlocene) Stream terrace deposits
Qpa - (Pleistocene) Older alluvium
Qpt - (Pleistocene) Older stream terrace deposits
Tm - (Miocene) Monterey Formation
Tr - (Miocene) Rincon Shale
Tv - (Miocene) Vaqueros Sandstone
Ts - (Oligocene) Sespe Formation
- LANDSLIDE
58 - STRIKE AND DIP OF BEDDING

SCALE
0 1500' 3000'

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LOCAL GEOLOGIC MAP

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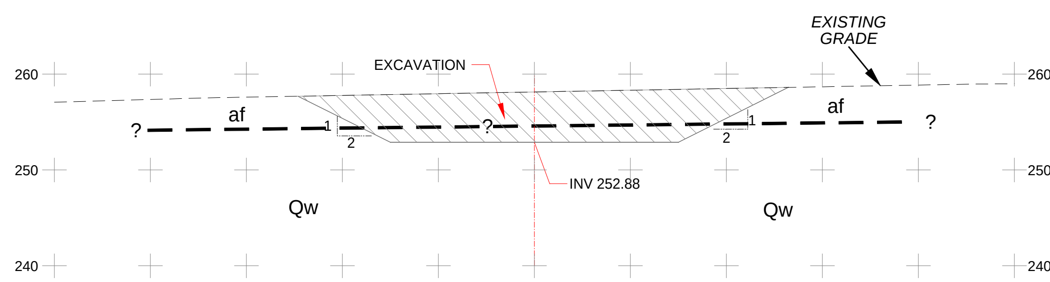
VENTURA COUNTY, CALIFORNIA

JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. 3



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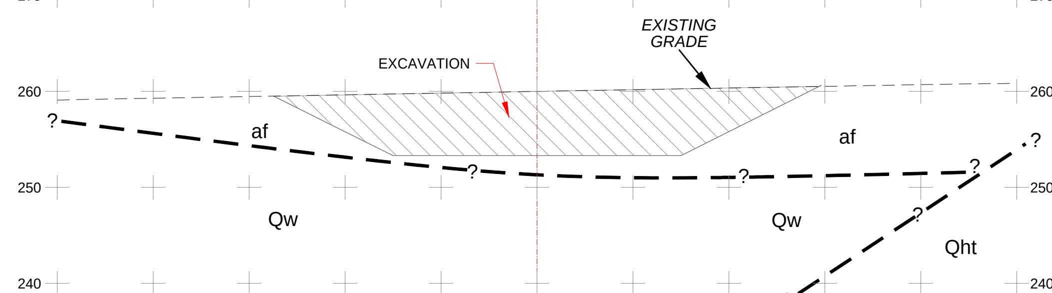

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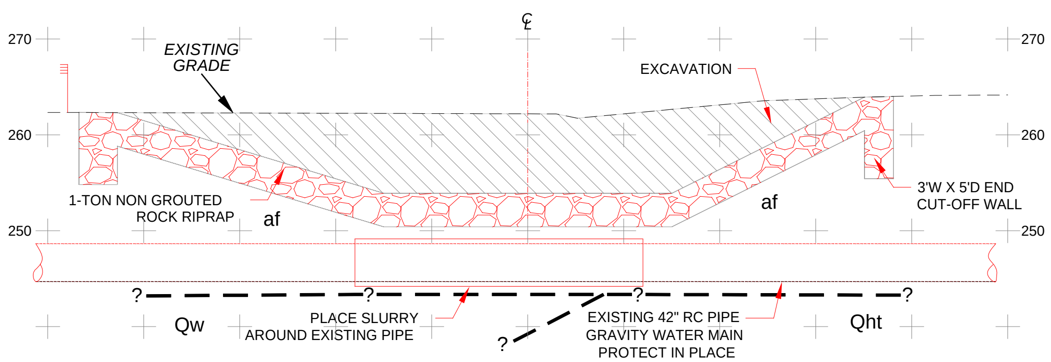

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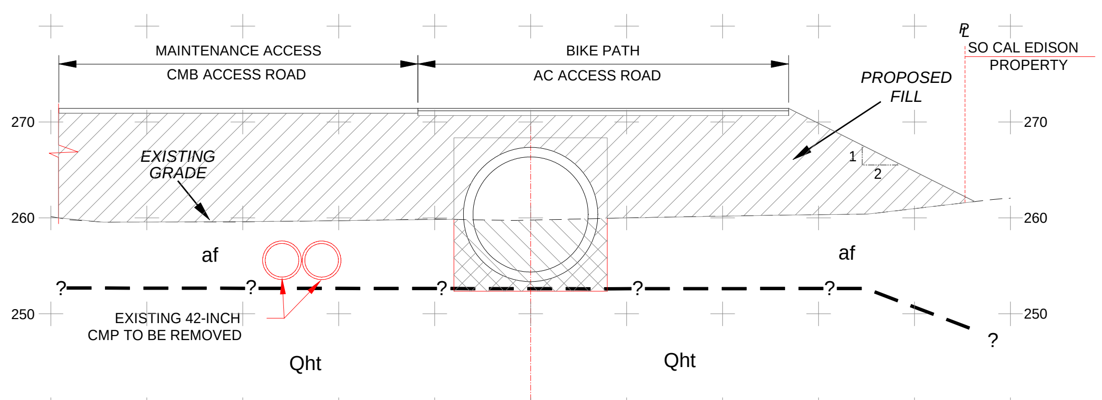

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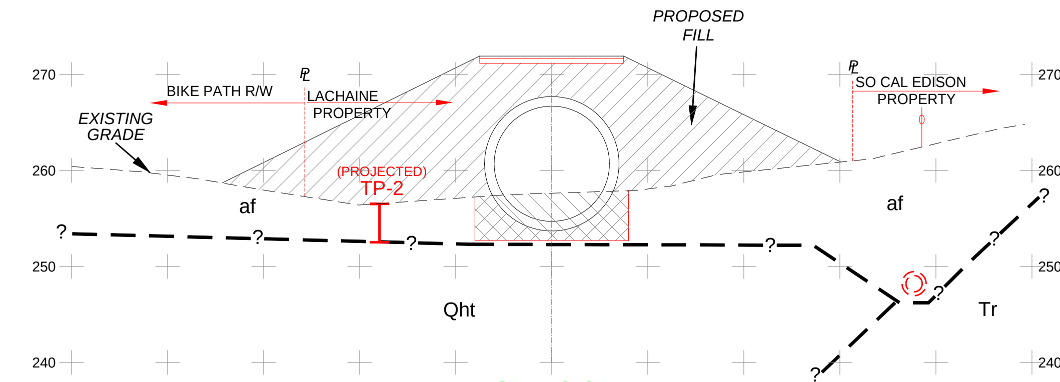
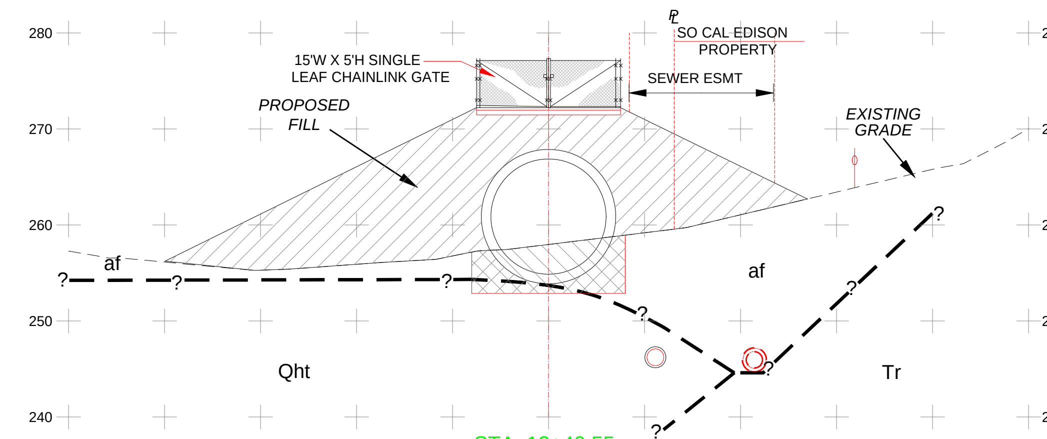


STA. 12+25



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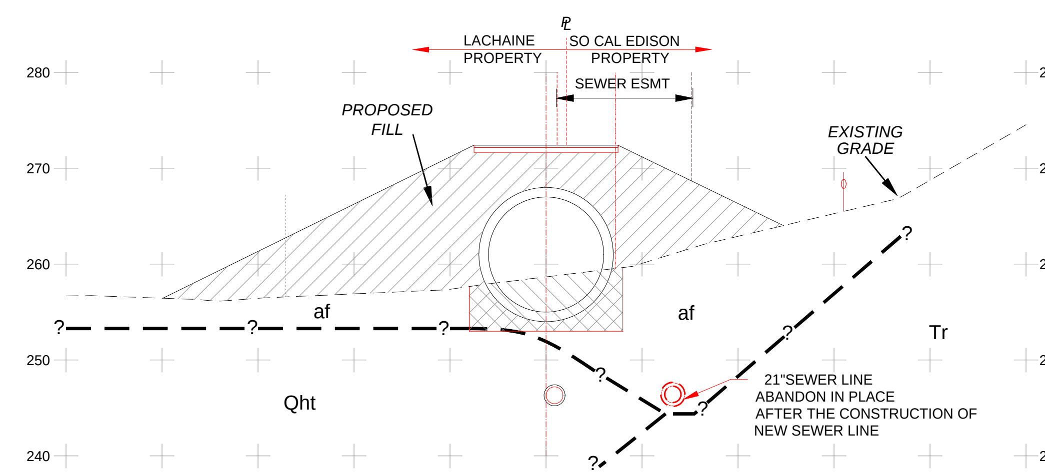

STA. 12+50

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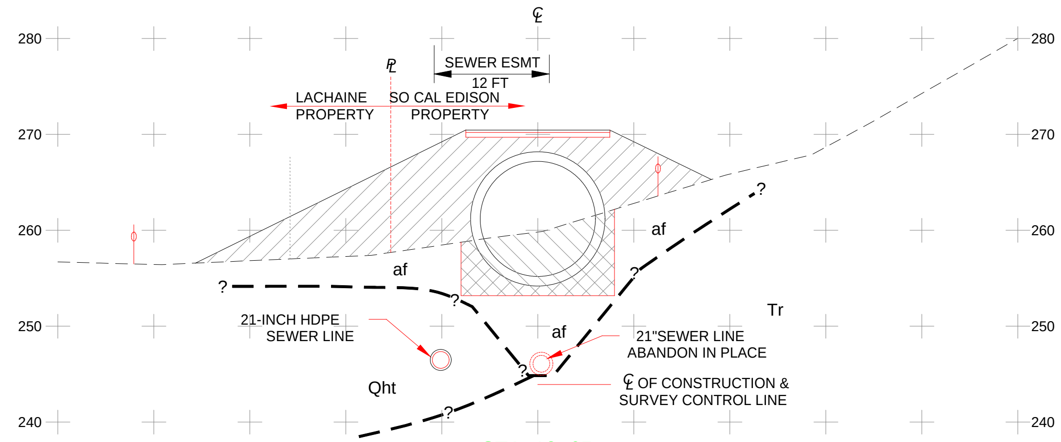
JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. 4



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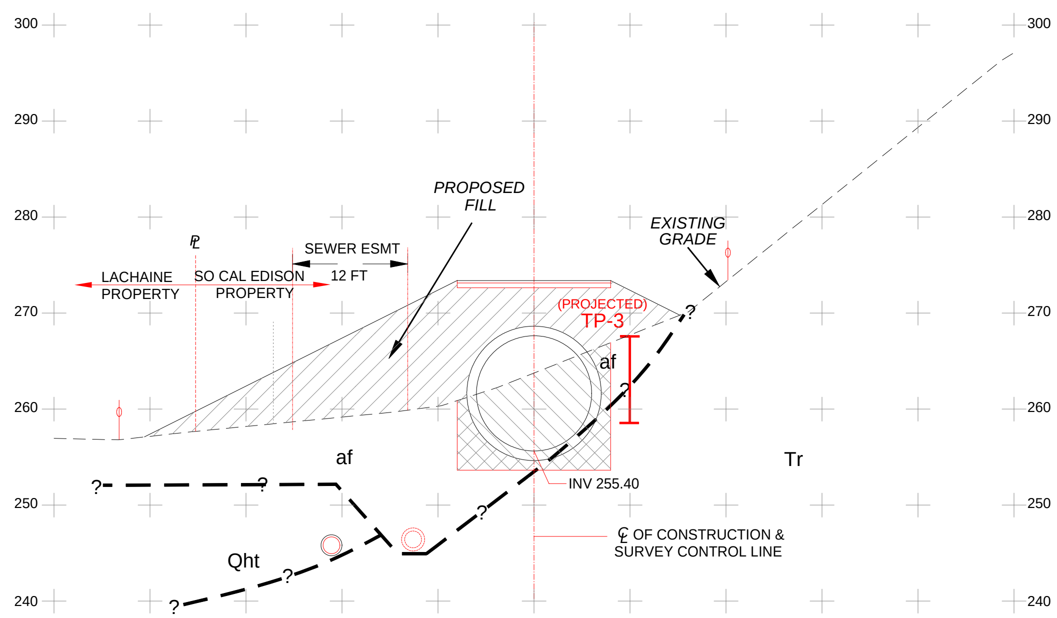

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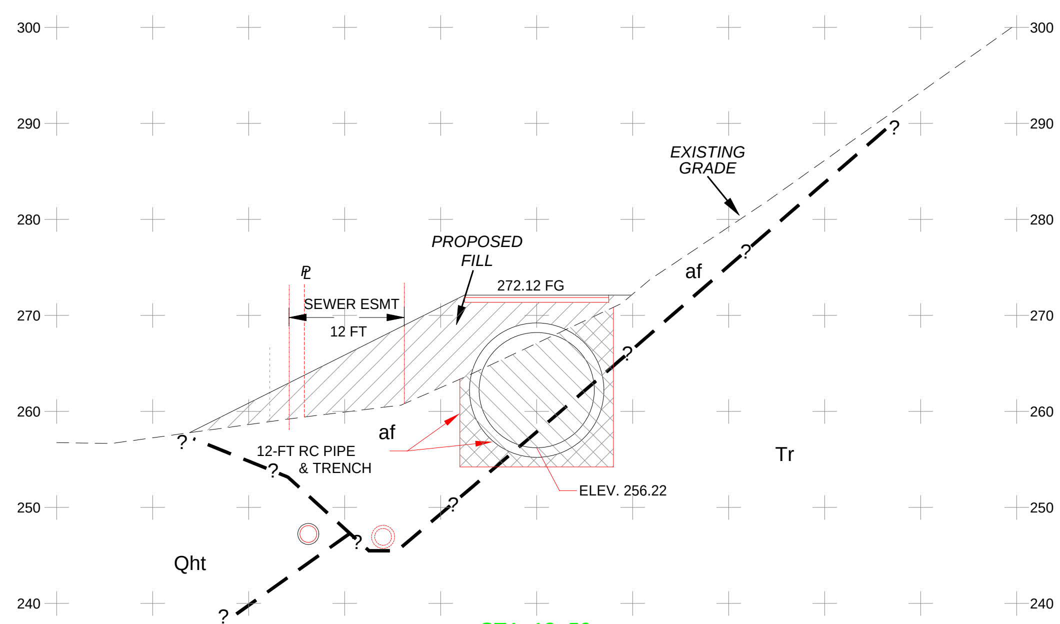

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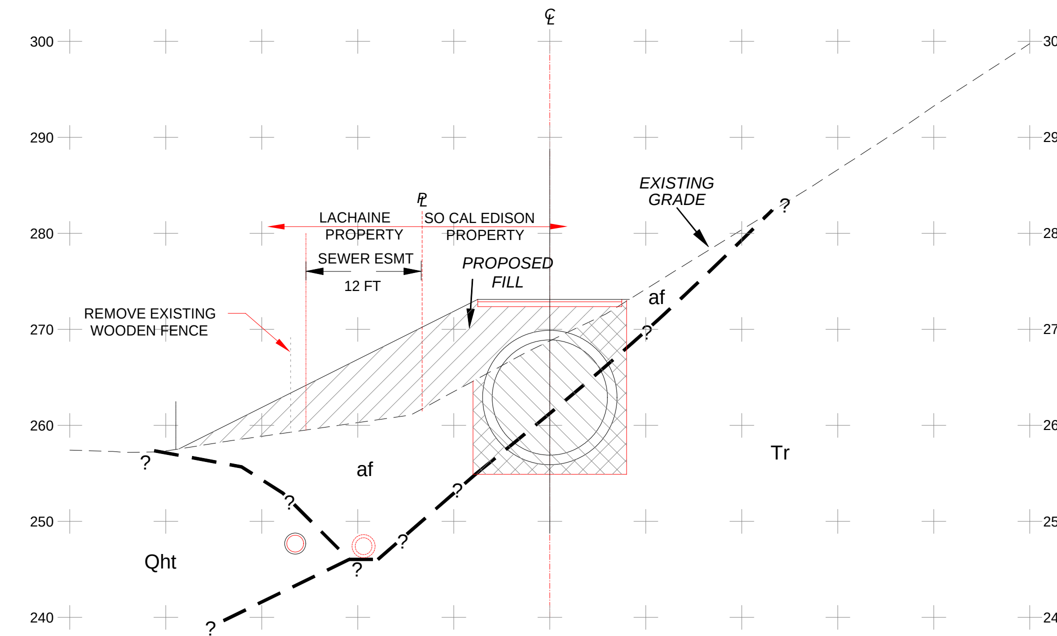

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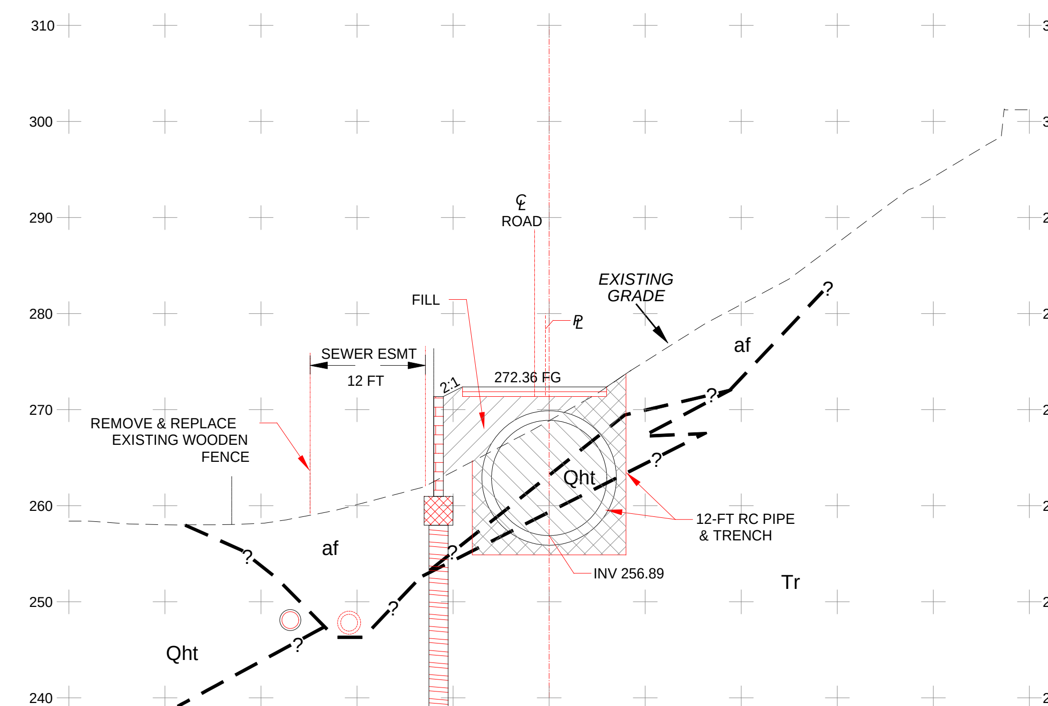

STA. 14+50

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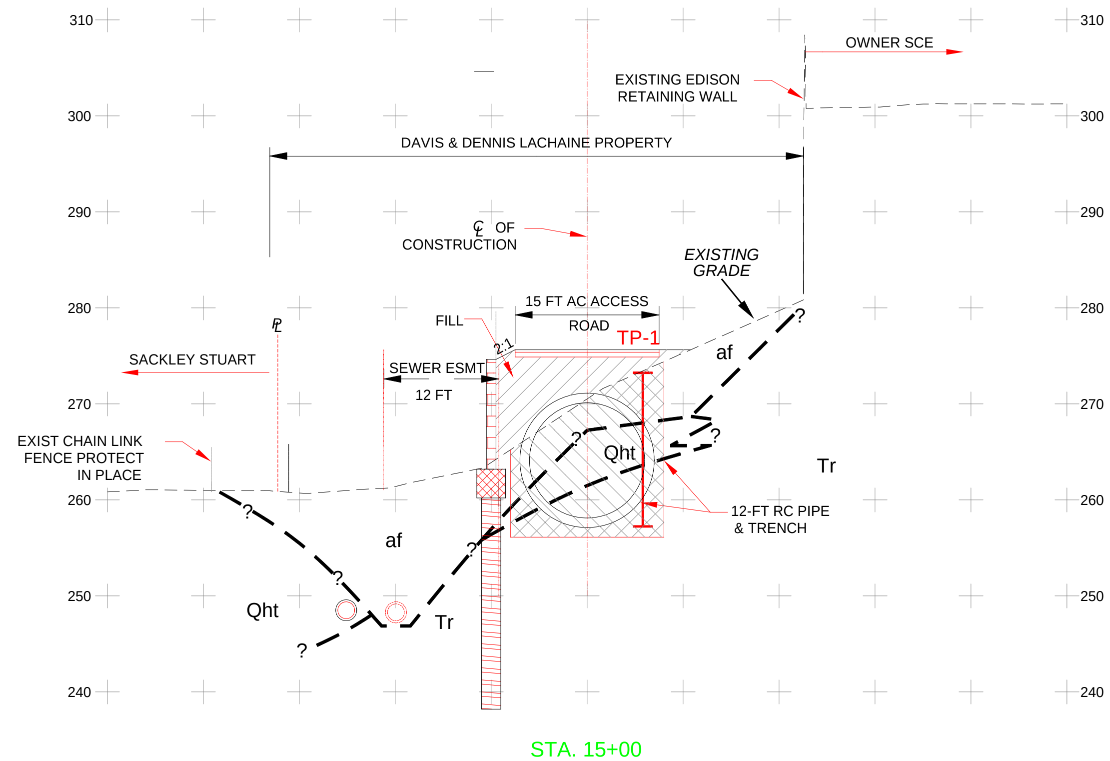
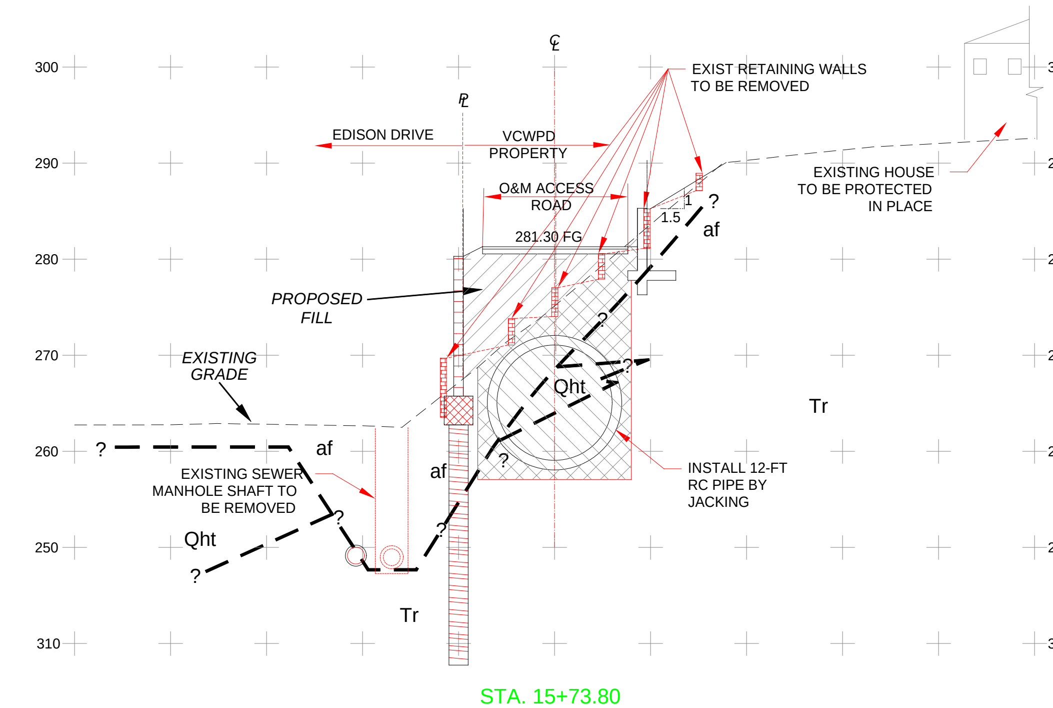
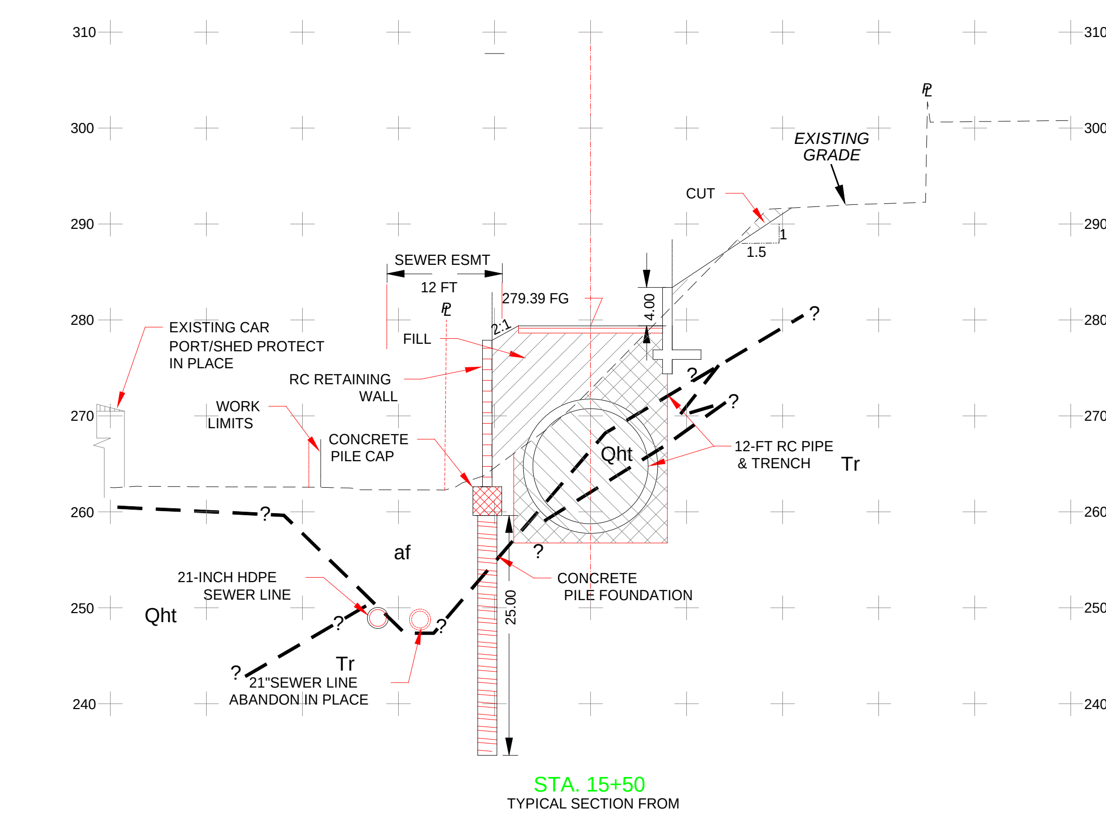
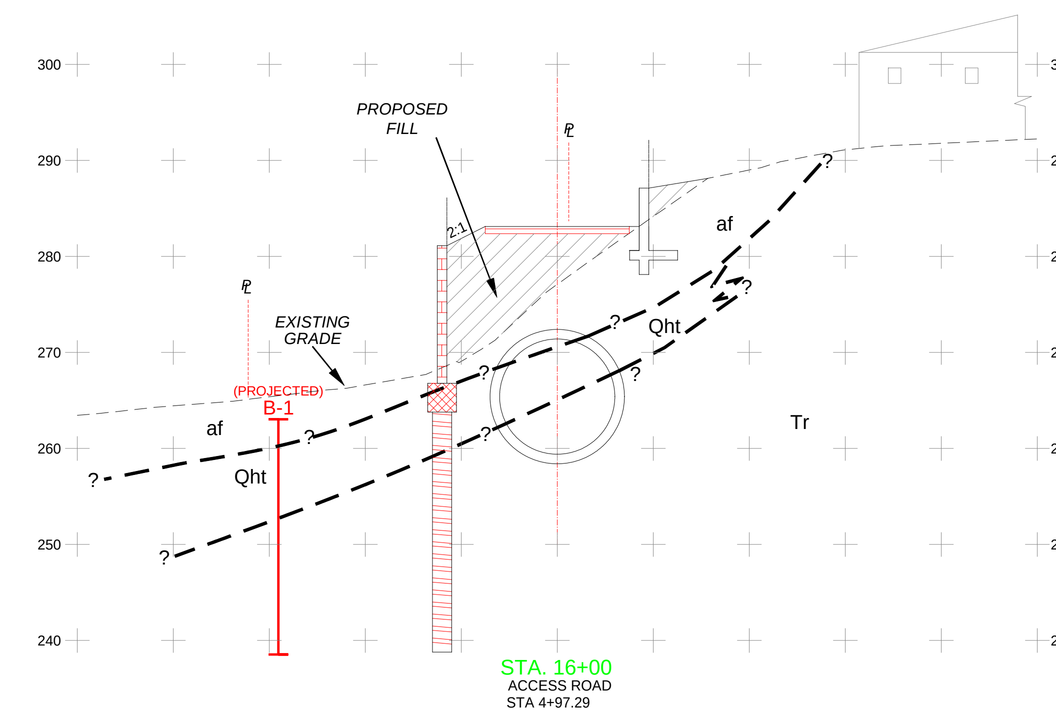
JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. 5









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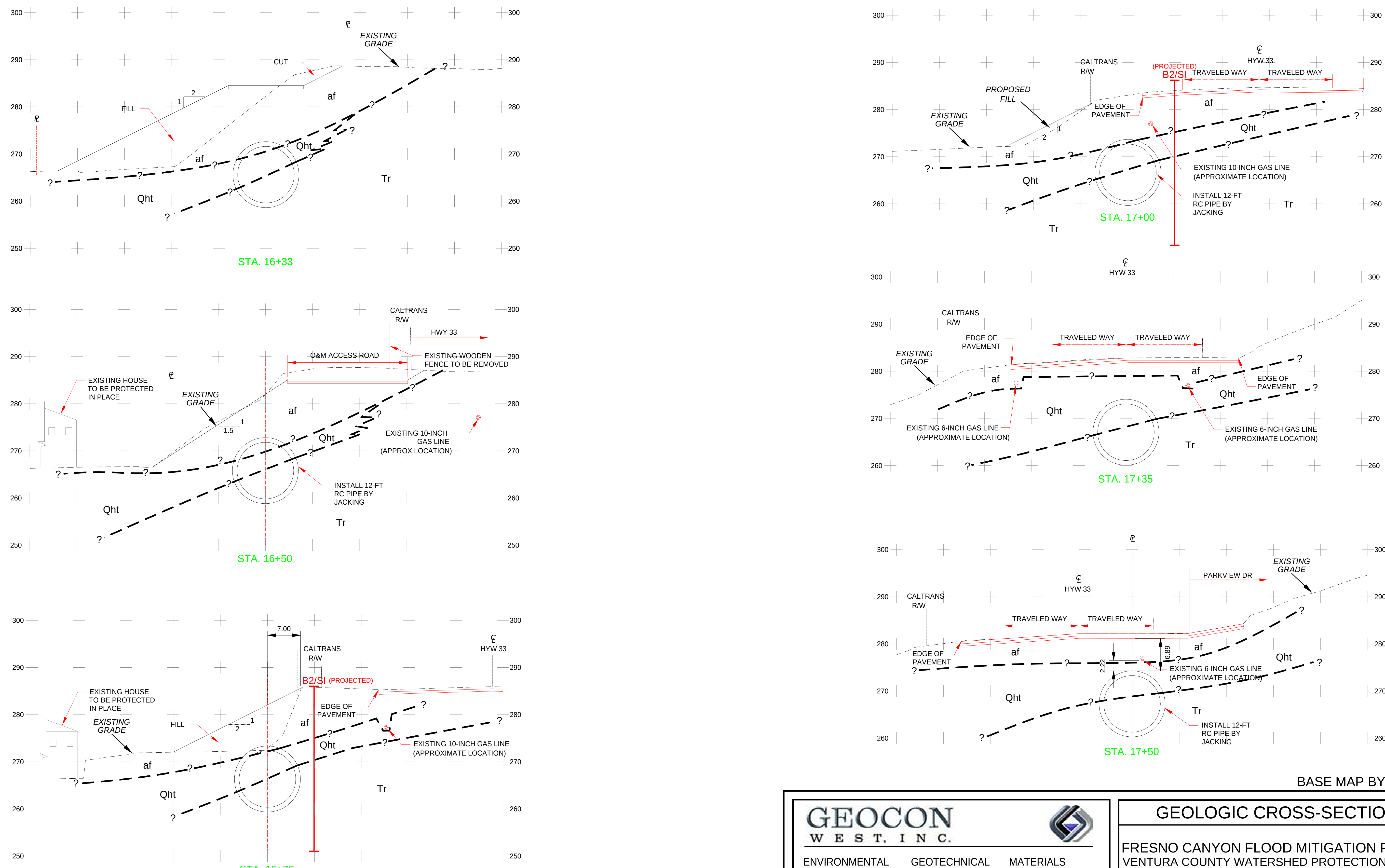
JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. 6



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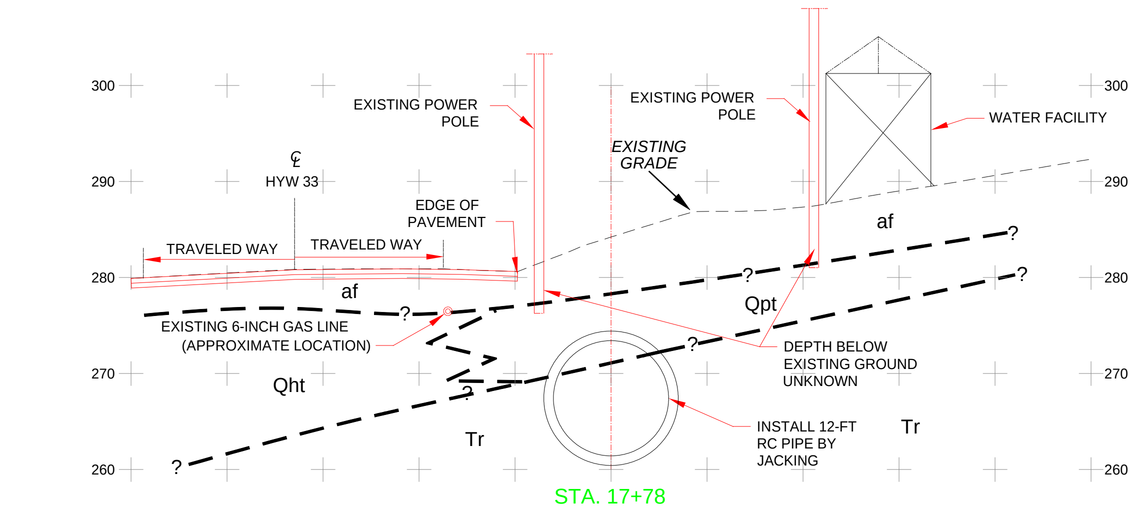
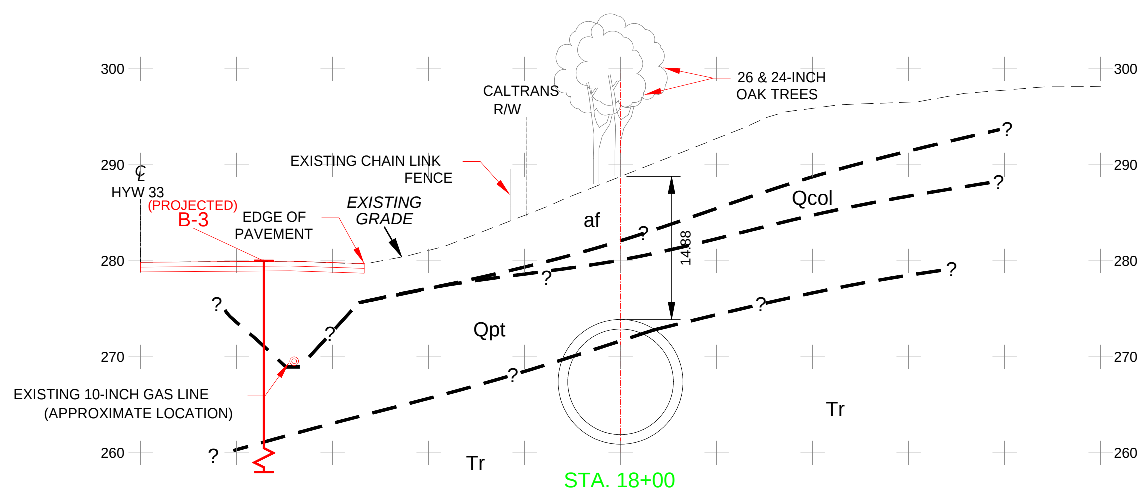
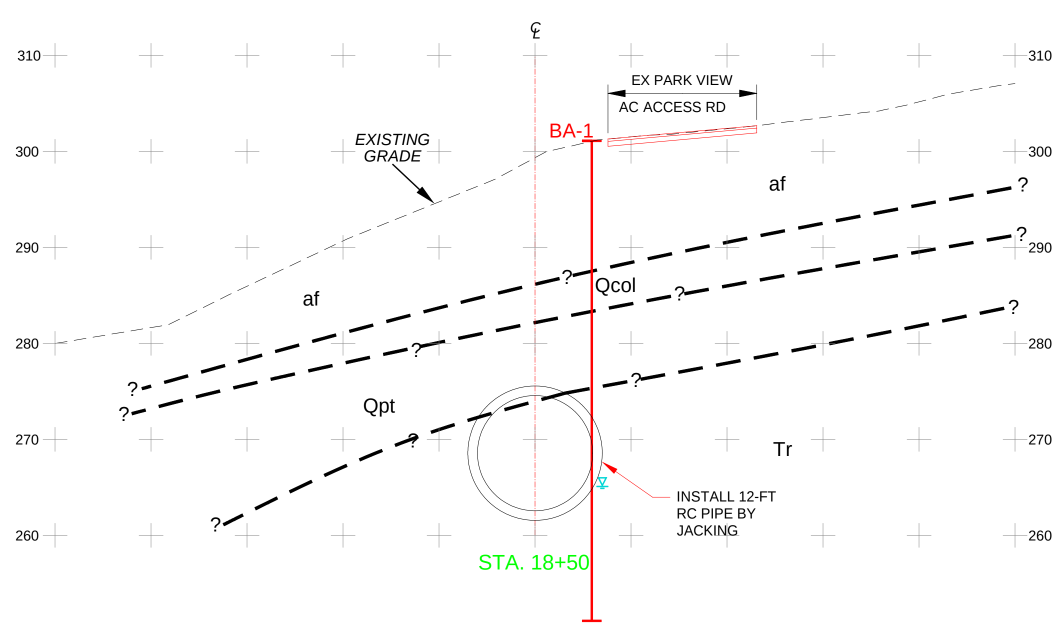
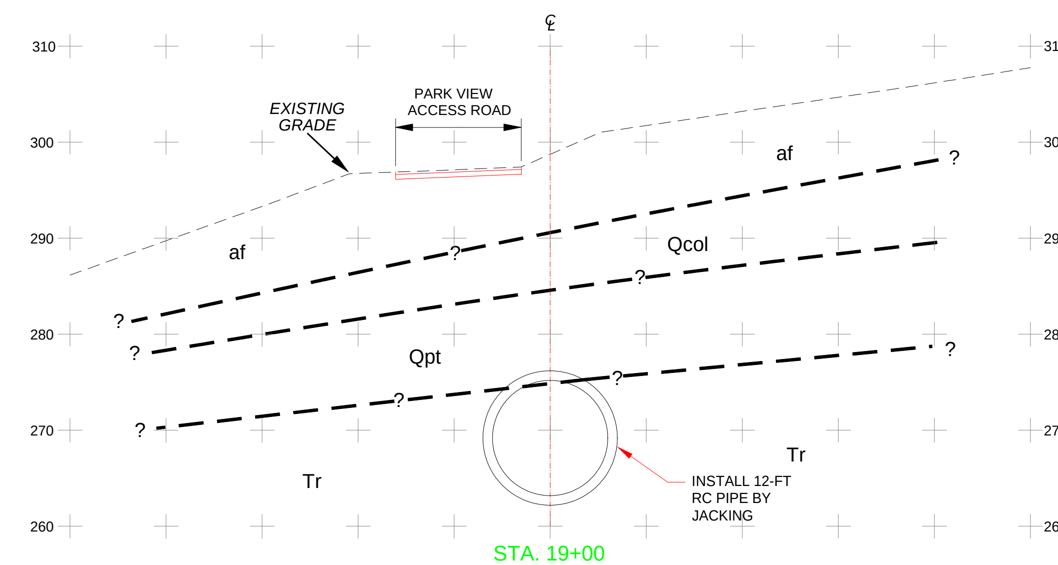
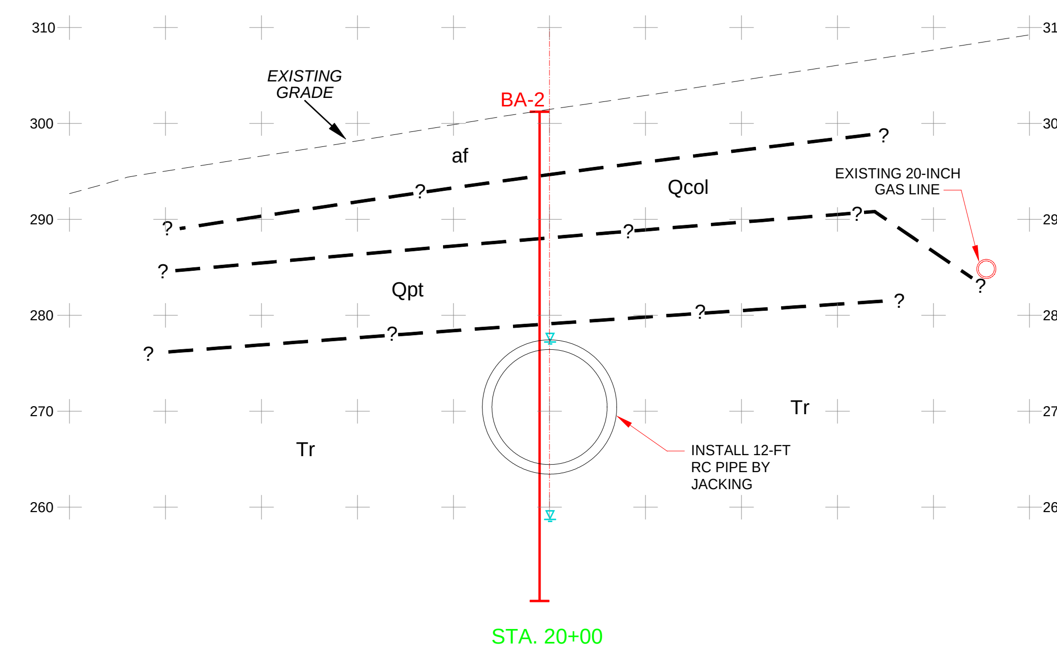
JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. 7











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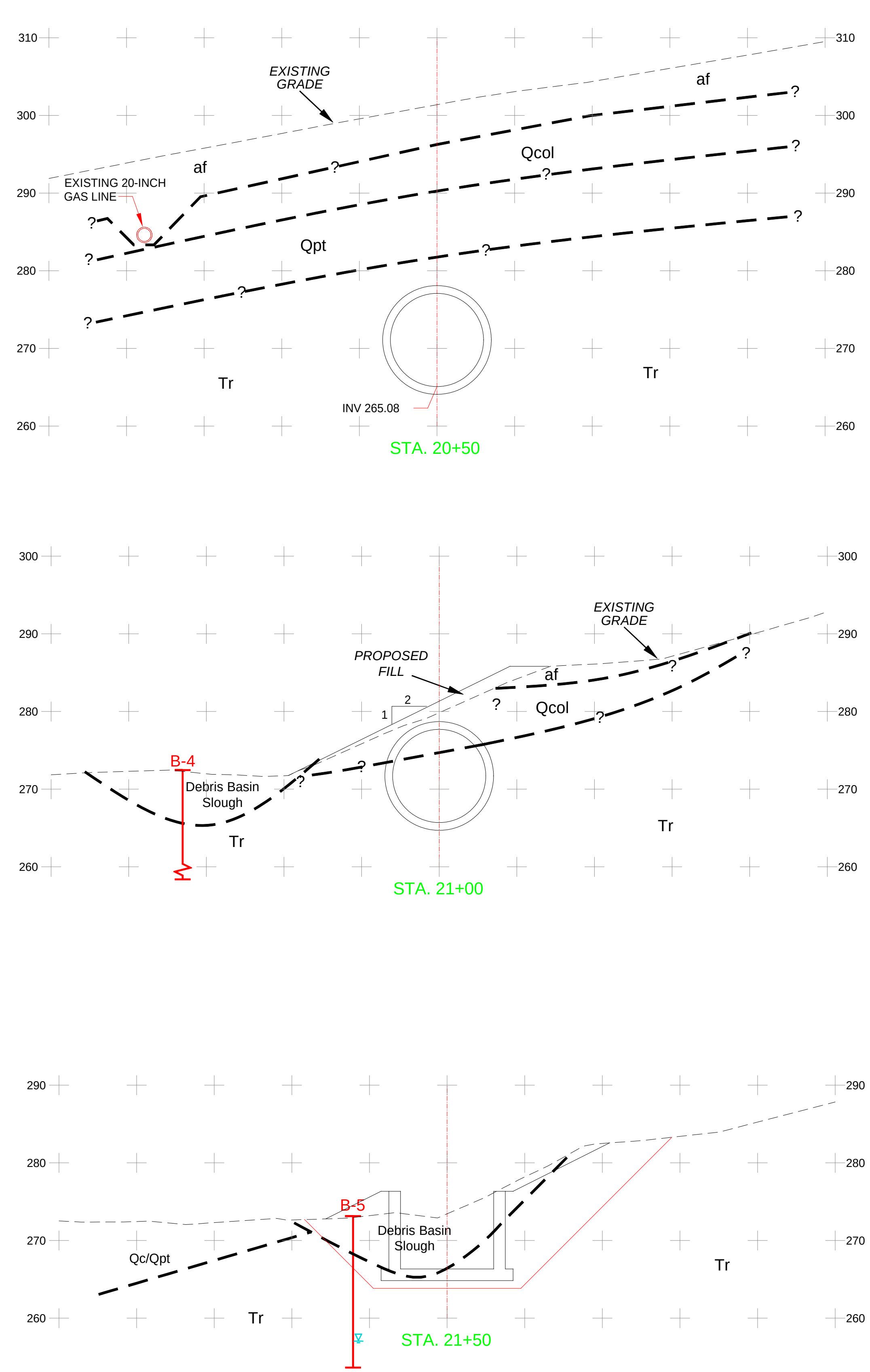
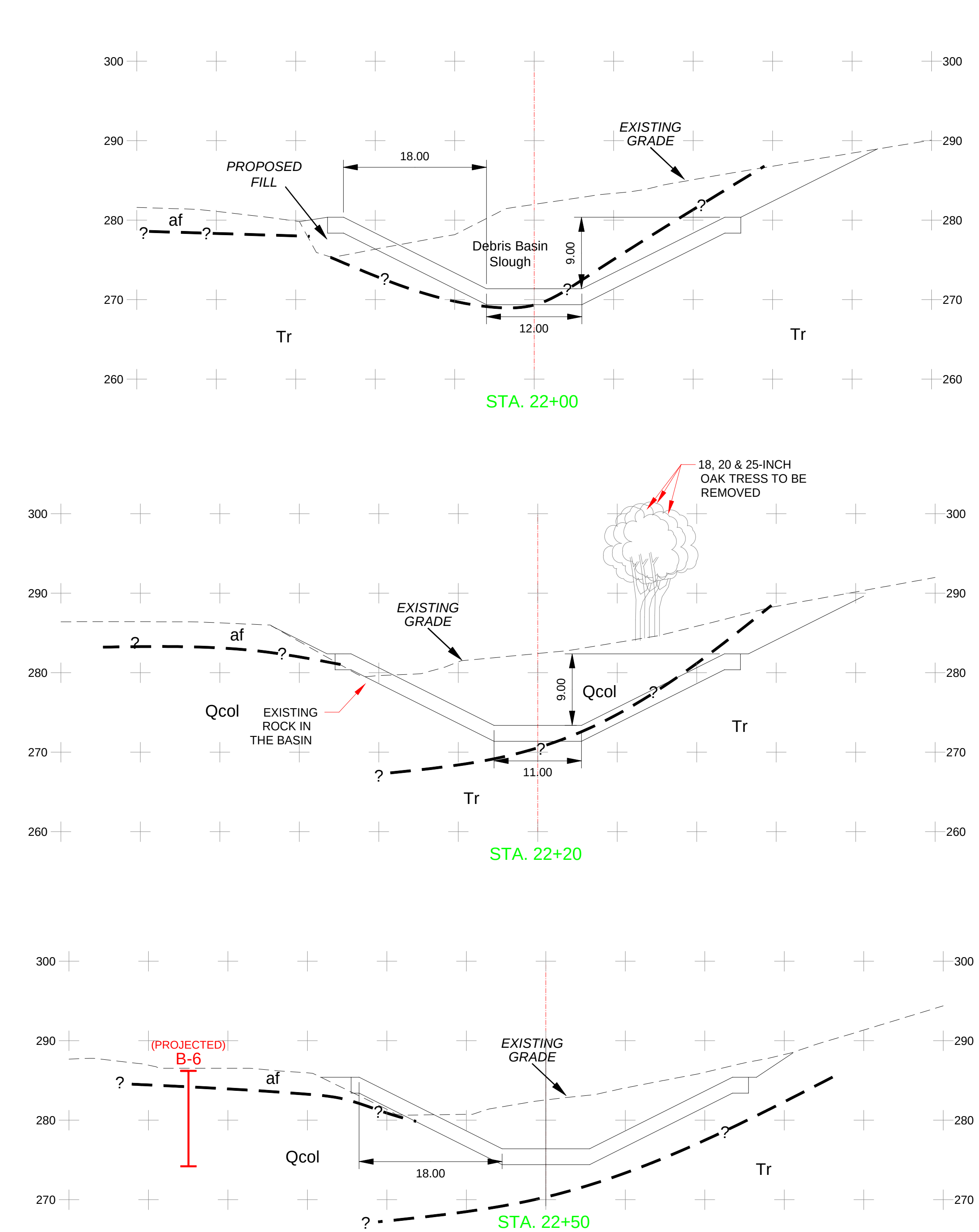
JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. 8





NOTE: CROSS-SECTIONS ARE FOR ILLUSTRATION PURPOSES ONLY,
NOT FOR CONSTRUCTION.

BASE MAP BY: VCWPD

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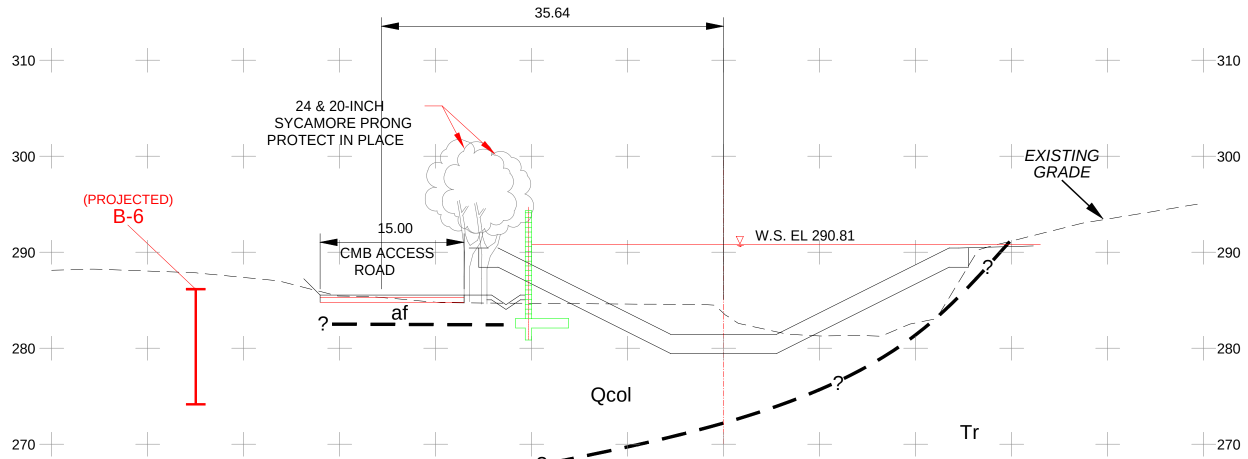
CHL		8000

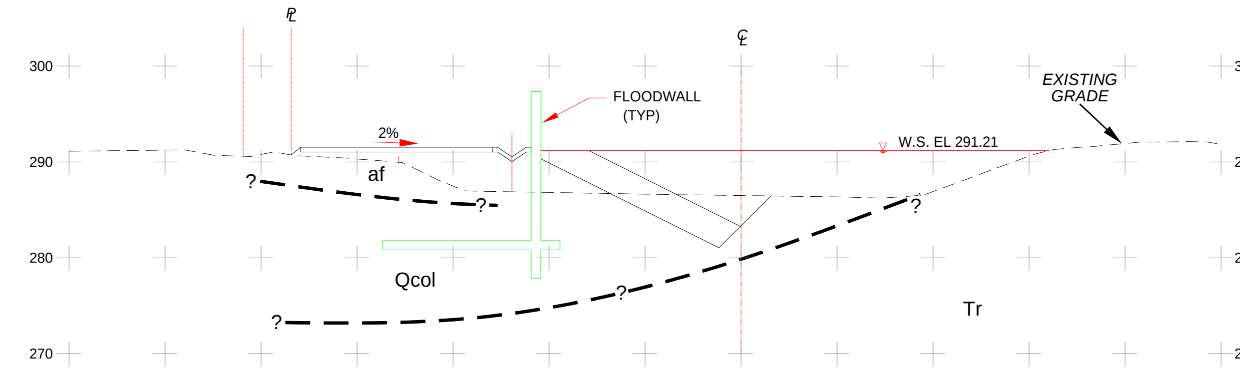
GEOLOGIC CROSS-SECTIONS

FRESNO CANYON FLOOD MITIGATION PROJECT
VENTURA COUNTY WATERSHED PROTECTION DISTRICT
VENTURA COUNTY, CALIFORNIA

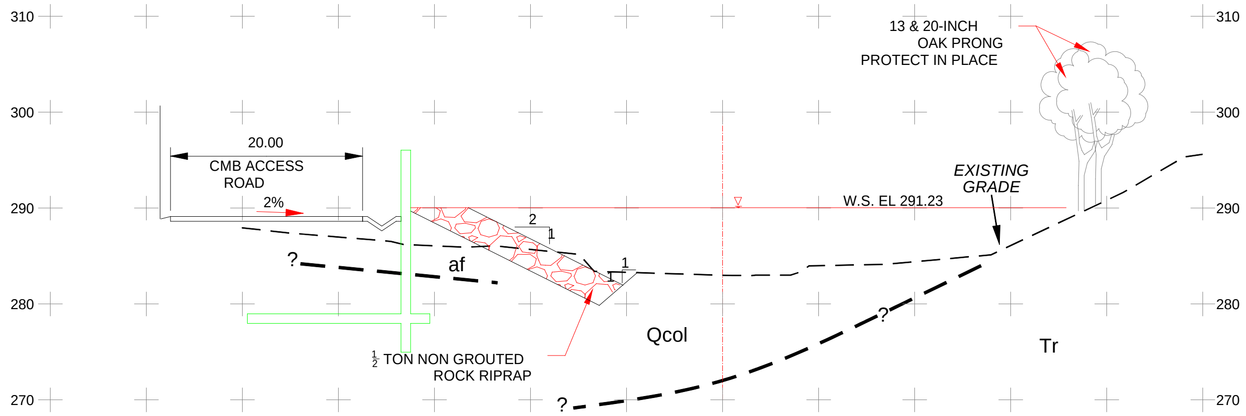
JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. 9



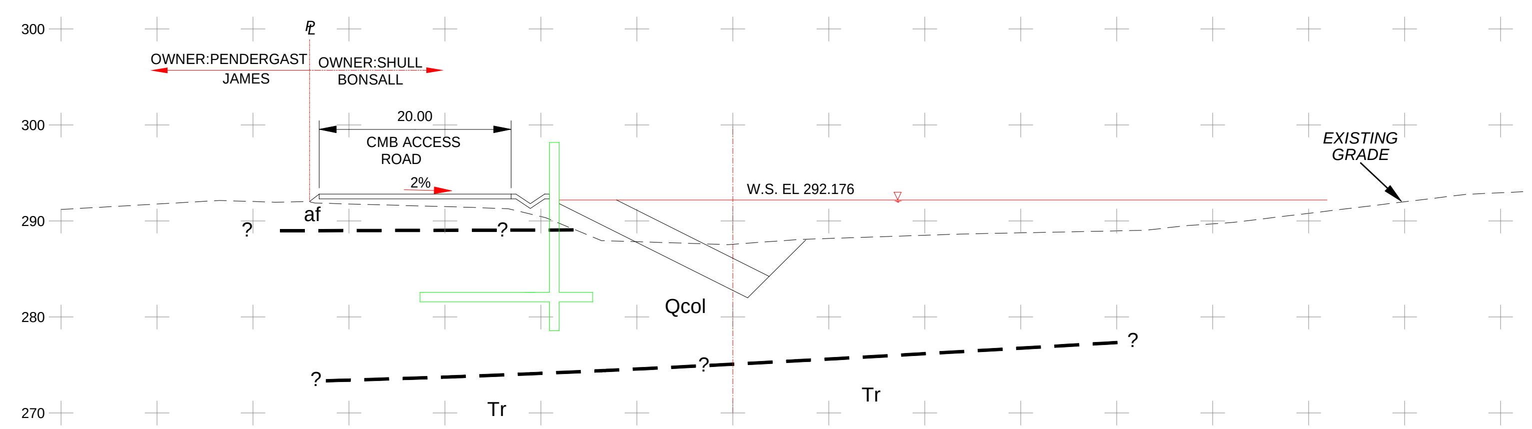
STA. 23+00



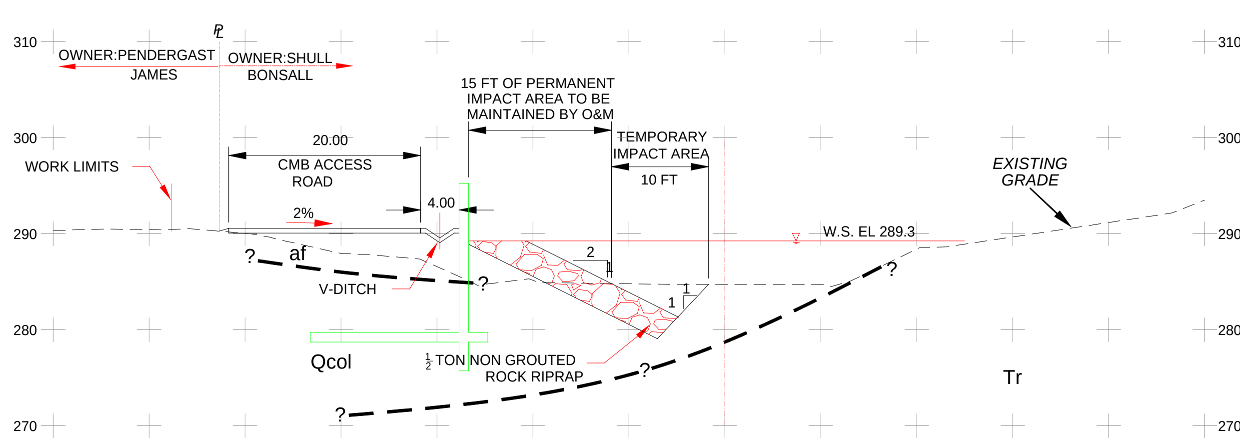
STA. 24+50



STA. 23+50



STA. 24+74



STA. 24+00
TYPICAL SECTION ALONG FLOOD WALL

NOTE: CROSS-SECTIONS ARE FOR ILLUSTRATION PURPOSES ONLY,
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GEOLOGIC CROSS-SECTIONS

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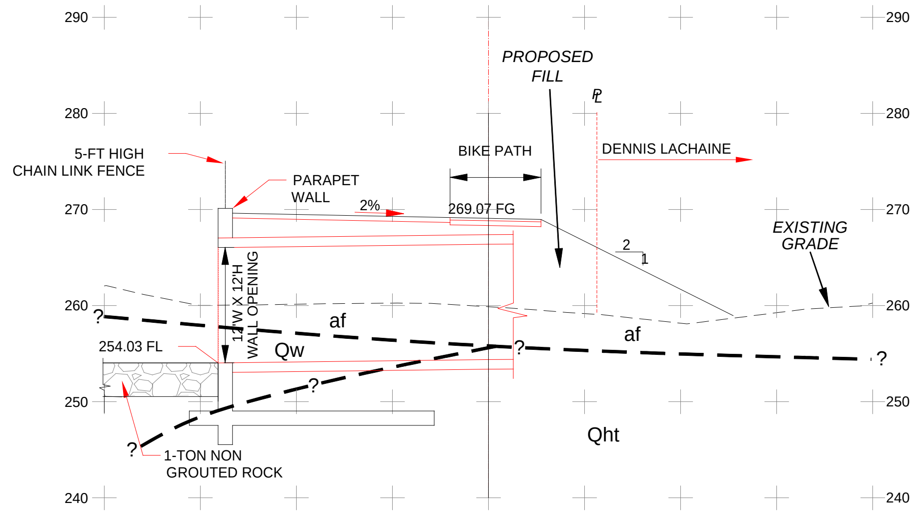
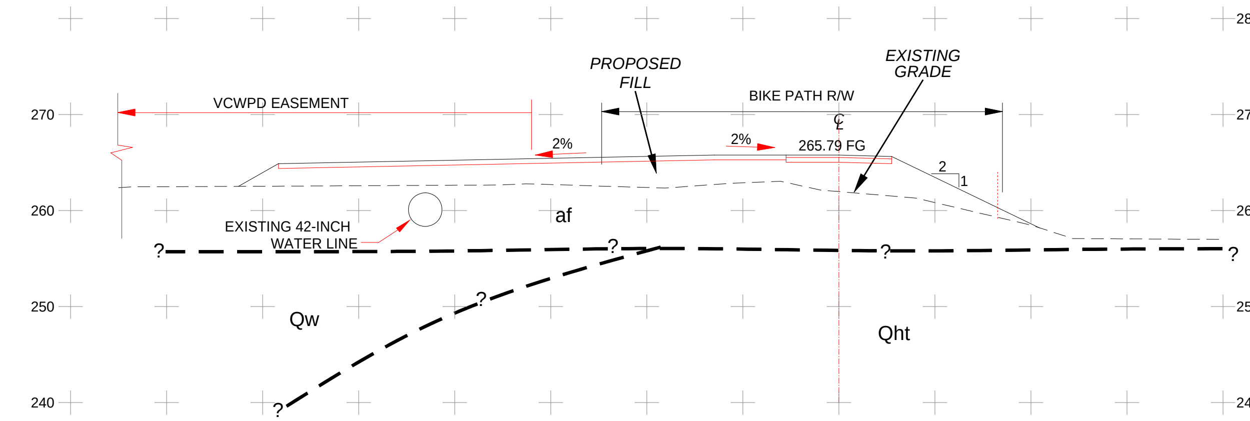
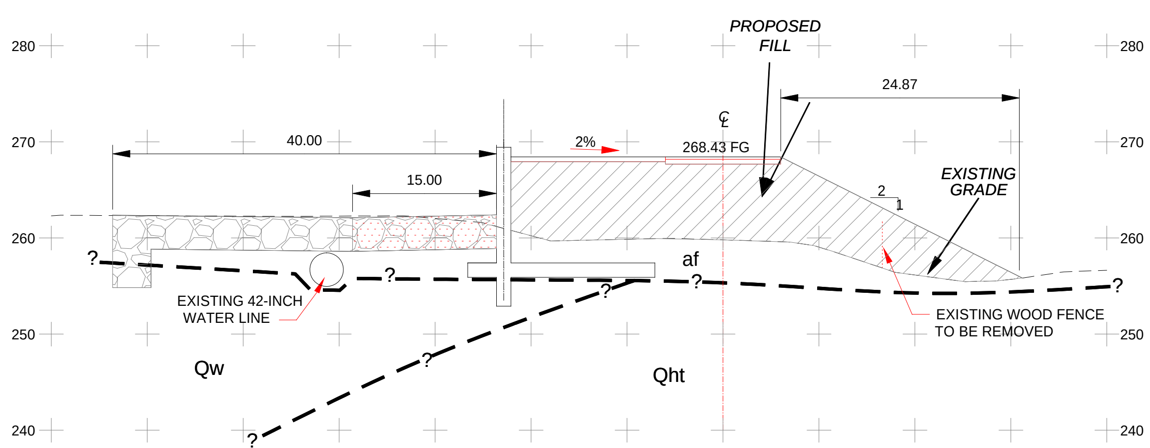
JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. 10



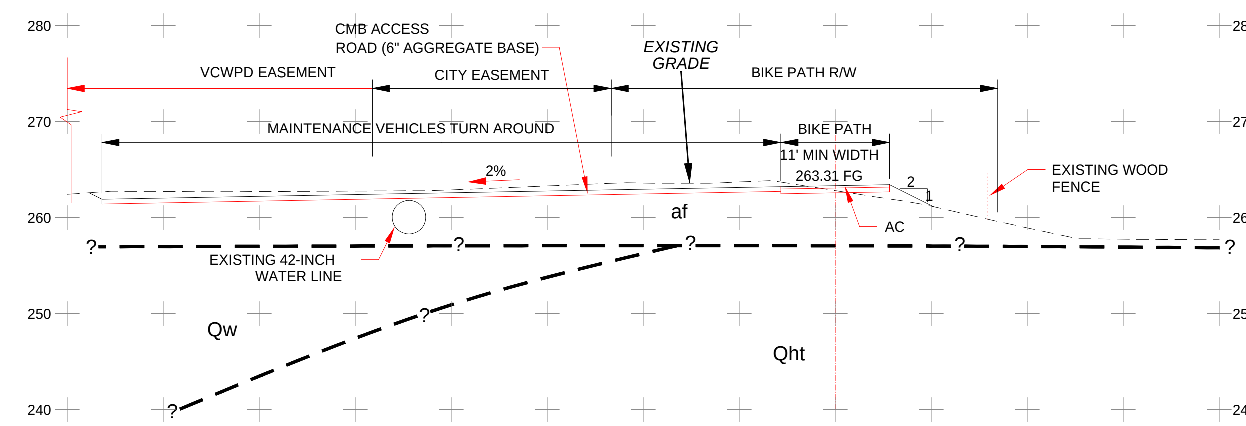
STA. 1+50



STA. 2+50



STA. 2+00



STA. 3+00

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BASE MAP BY: VCWPD

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GEOLOGIC CROSS-SECTIONS

FRESNO CANYON FLOOD MITIGATION PROJECT
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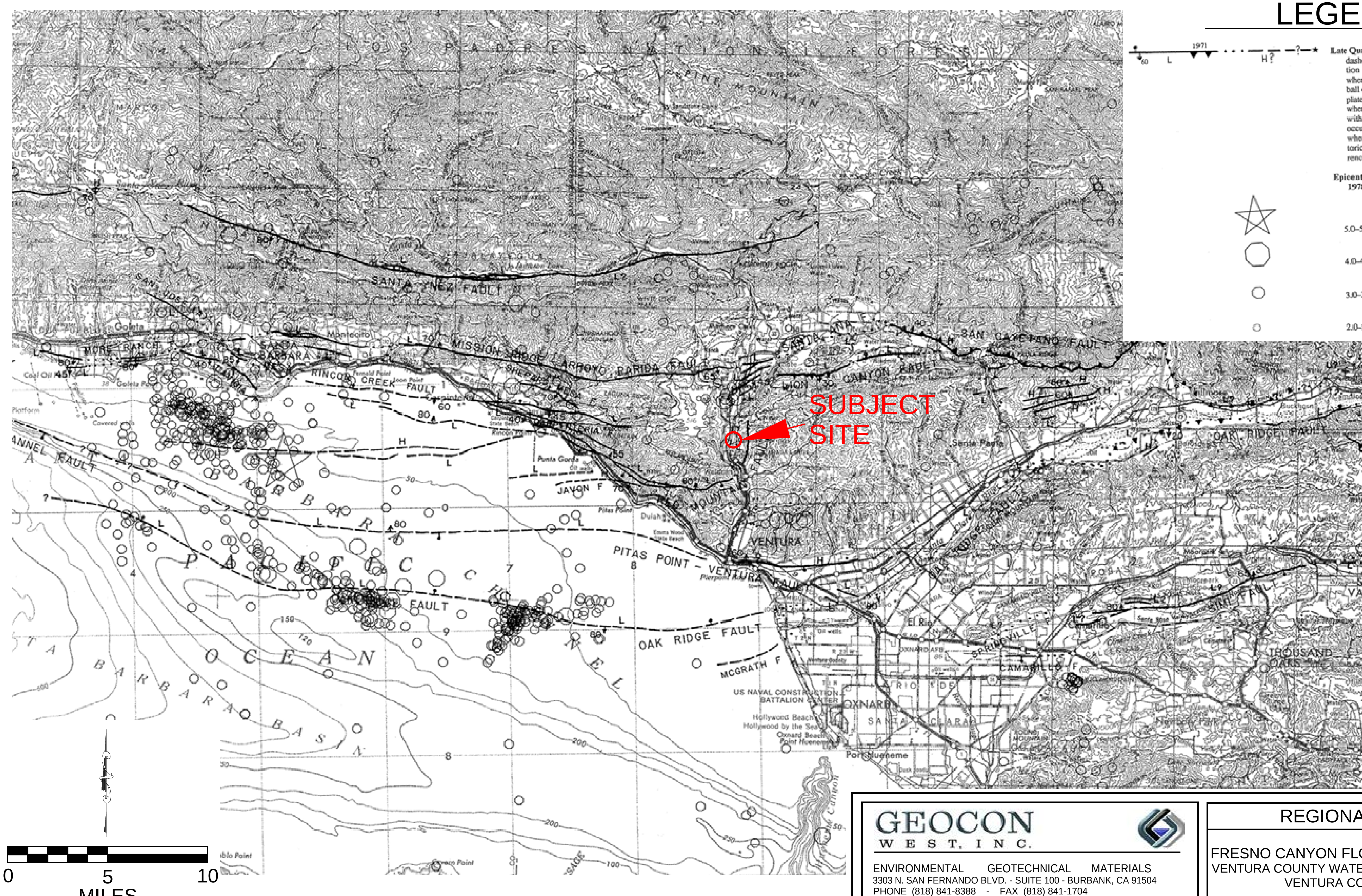
VENTURA COUNTY, CALIFORNIA

JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. 11

REFERENCE: Ziony, J. I., Jones, L. M., 1989, Map Showing Late Quaternary Faults and 1978-1984 Seismicity of the Los Angeles Region, California



LEGEND

Late Quaternary fault—Dotted where concealed onshore; dashed where offshore (inferred from acoustic-reflection profiles); queried where existence uncertain; star where fault trace too short to show at scale. Bar and ball on relatively downthrown side. Sawteeth on upper plate of thrust fault. Representative dip of fault shown where known. Letter indicates geologic time period within which latest surface faulting is known to have occurred: **H**, Holocene; **L**, late Quaternary; queried where age uncertain. Date indicates most recent historical surface faulting; queried where historical occurrence is uncertain

Epicenters of earthquakes ($M_L \geq 2.0$) occurring in 1978–84, showing corresponding magnitude range

5.0–5.9

4.0–4.9

3.0–3.9

2.0–2.9

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REGIONAL FAULT MAP

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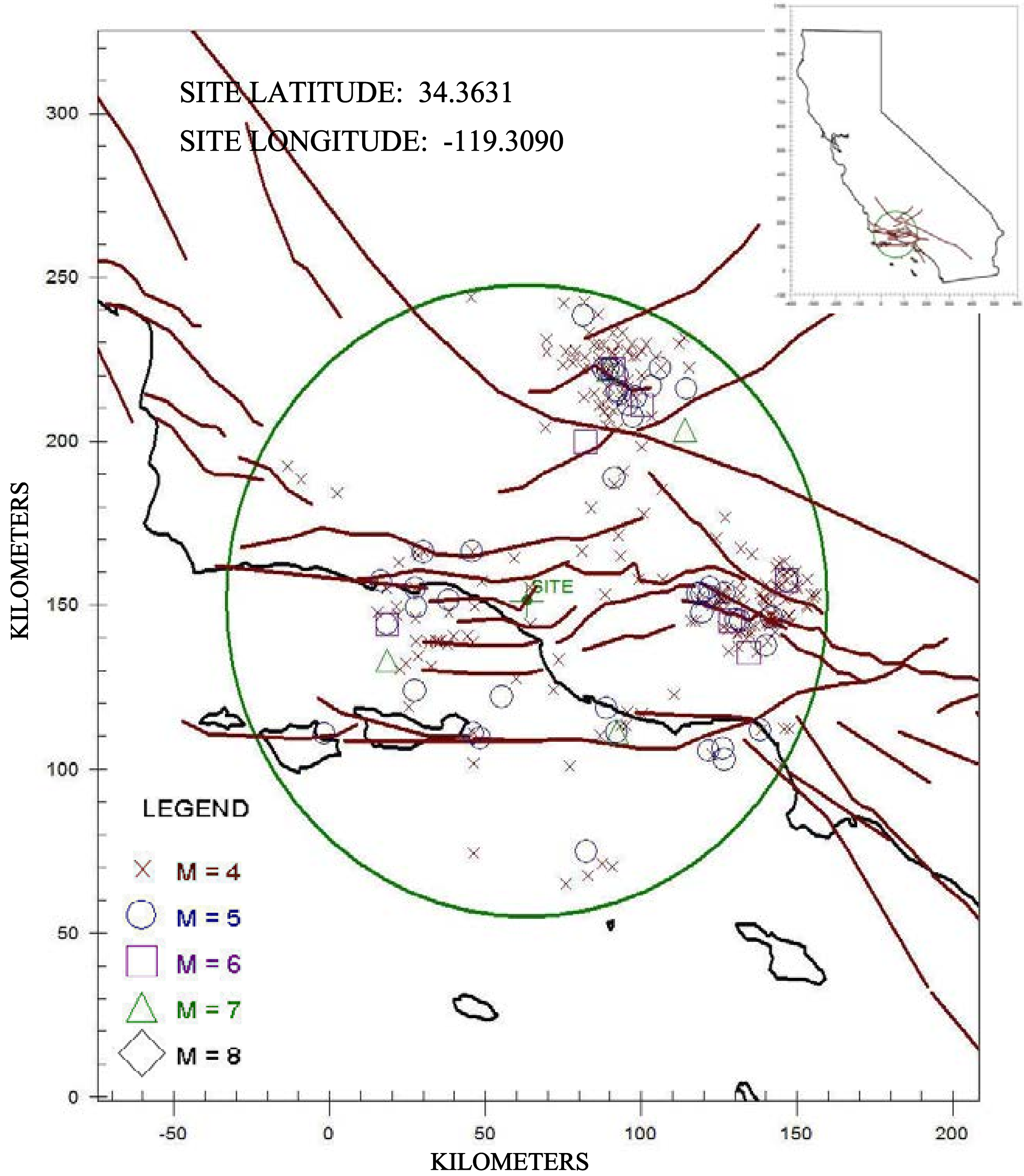
JAN 17, 2013 | PROJECT NO. A8919-06-01 | FIG. 12



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REGIONAL SEISMICITY MAP

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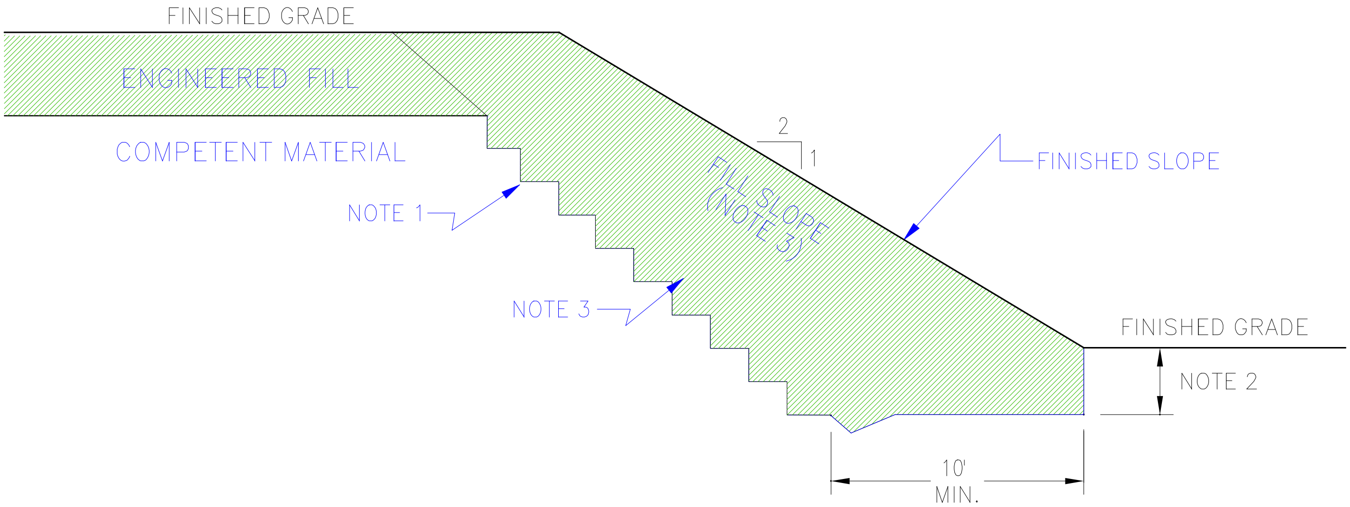
JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. 13



NOTES

1 EXCAVATE BENCHED BACKCUT AT 1:1 INCLINATION OR FLATTER

2 BASE OF SLOPE KEYWAY TO BE 2 FEET BELOW PAD GRADE

3 FILL SLOPE TO BE COMPOSED OF PROPERLY COMPACTED ENGINEERED FILL

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FILL SLOPE DETAIL

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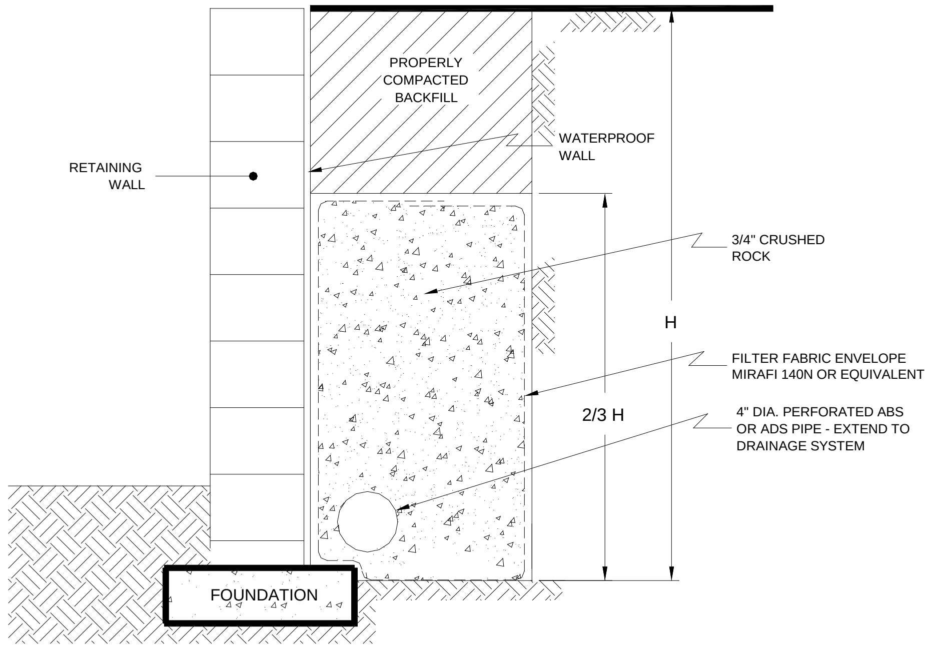
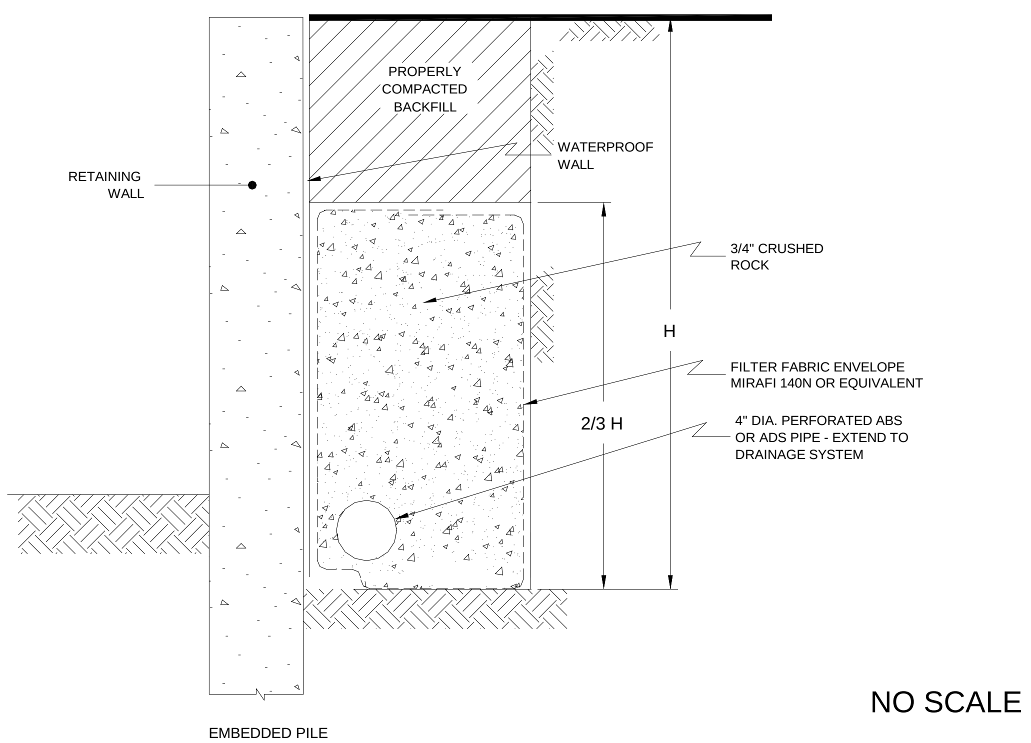
GAK		8000	JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. 14





NO SCALE

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RK		8000

RETAINING WALL DRAIN DETAIL

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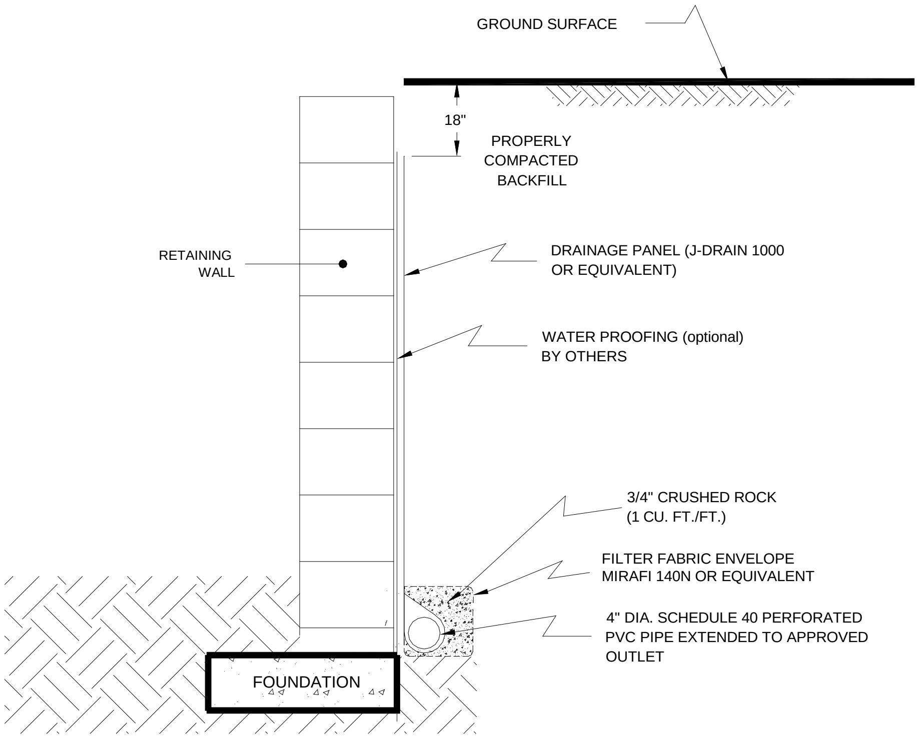
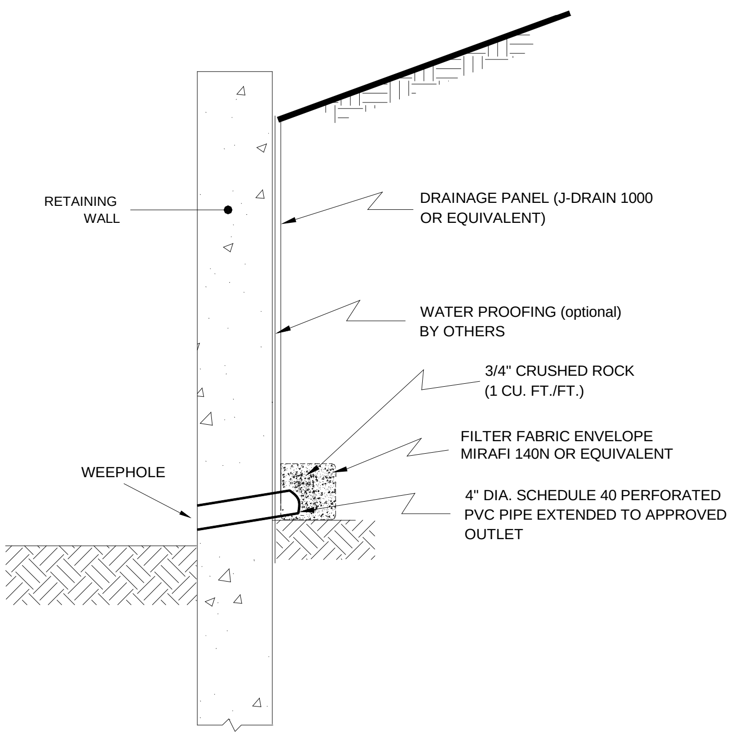
VENTURA COUNTY, CALIFORNIA

JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. 15





NO SCALE

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NDB		8000

RETAINING WALL DRAIN DETAIL

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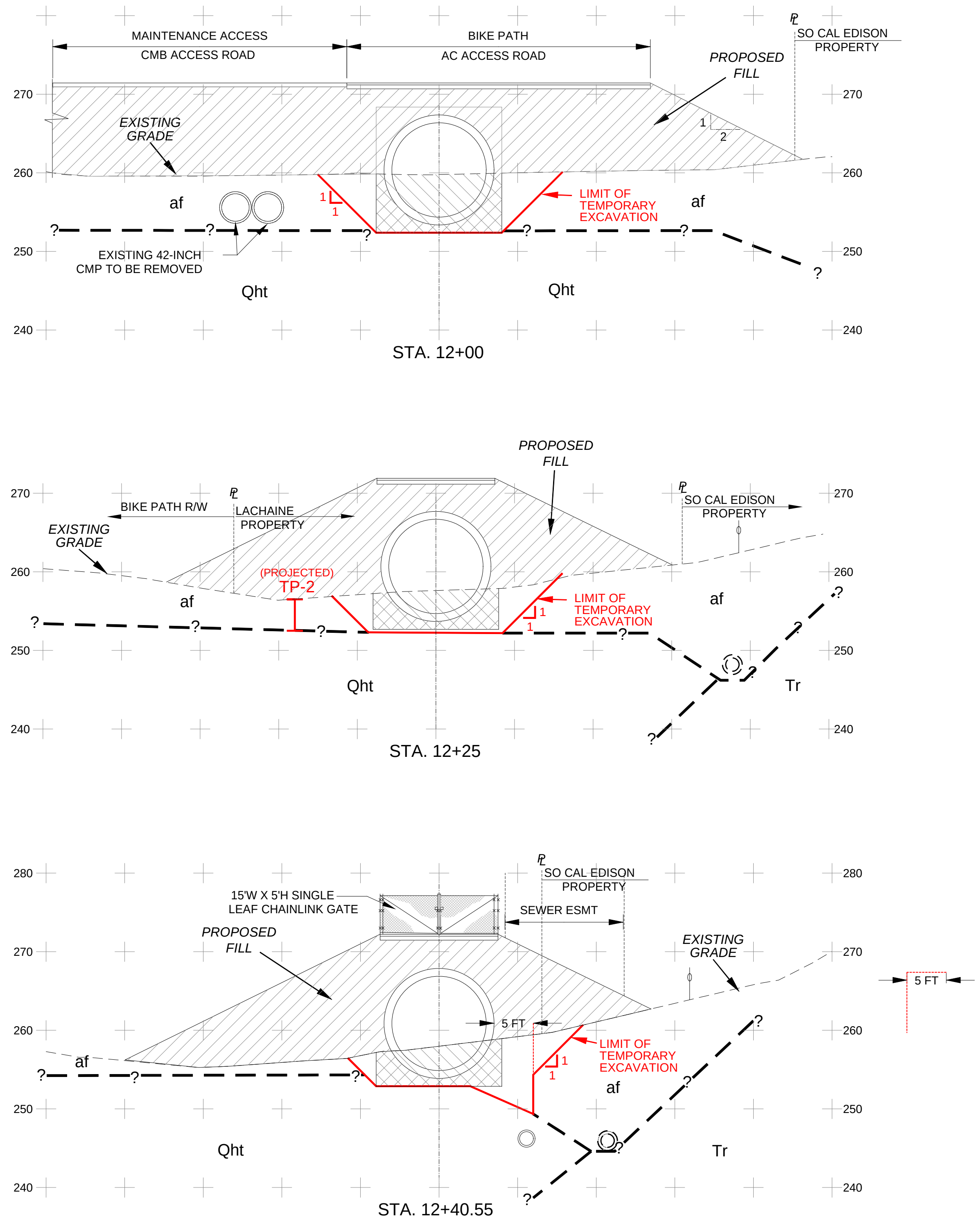
VENTURA COUNTY WATERSHED PROTECTION DISTRICT
VENTURA COUNTY, CALIFORNIA

JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. 16



NOTE: CROSS-SECTIONS ARE FOR ILLUSTRATION PURPOSES ONLY,
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BASE MAP BY: VCWPD

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TEMPORARY EXCAVATION CROSS-SECTIONS

FRESNO CANYON FLOOD MITIGATION PROJECT
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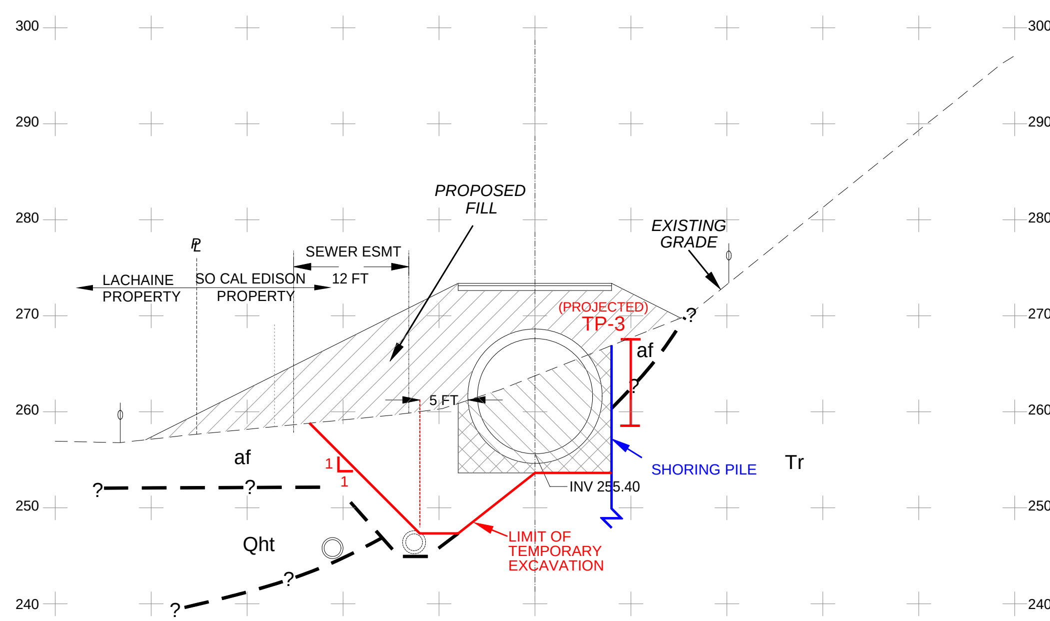
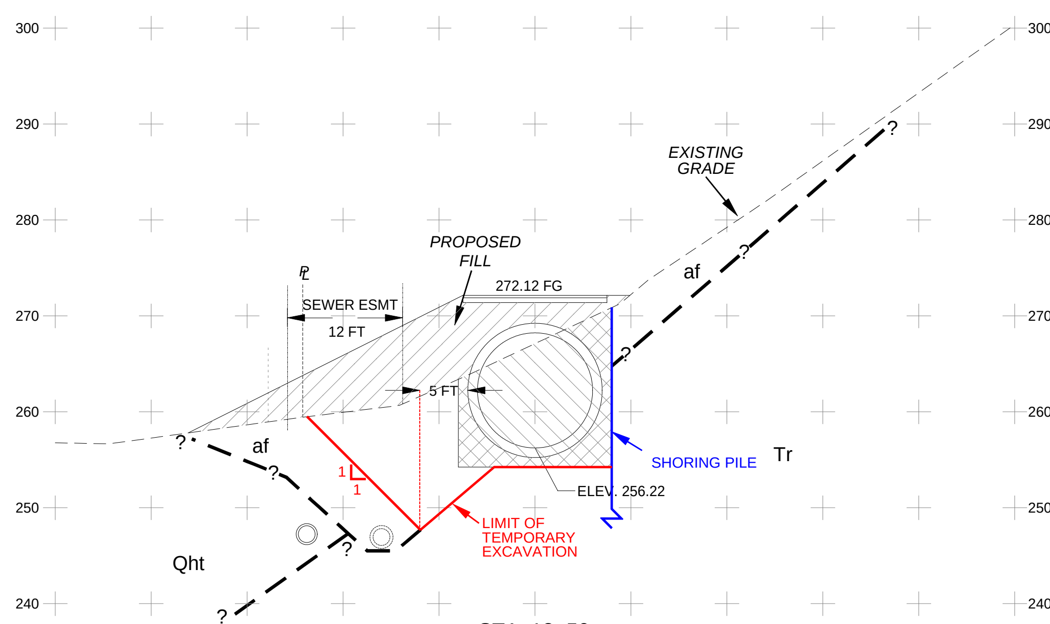
VENTURA COUNTY, CALIFORNIA

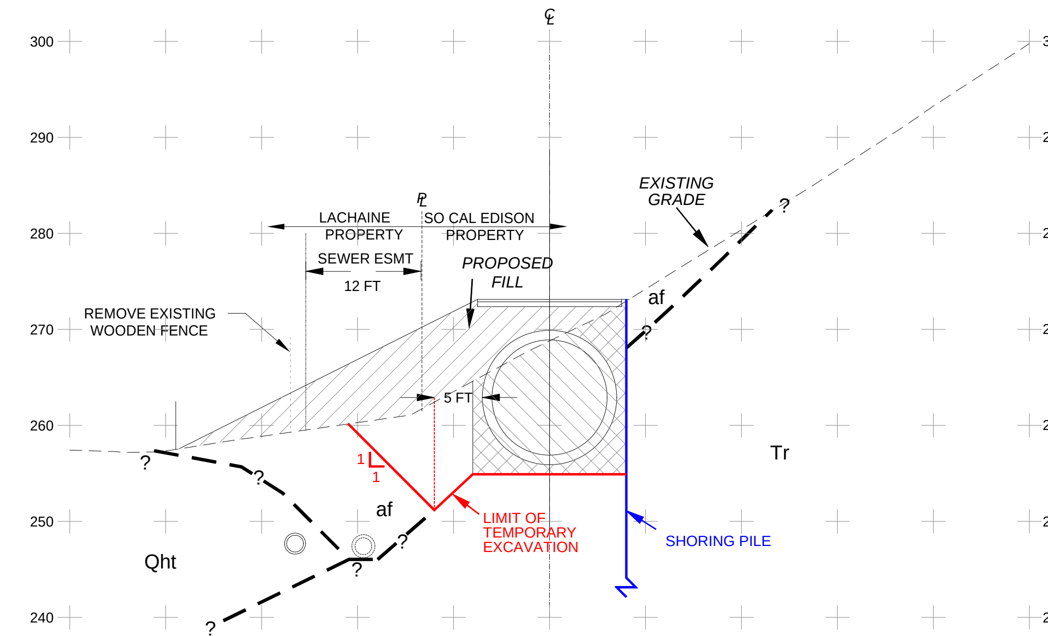
JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. 17



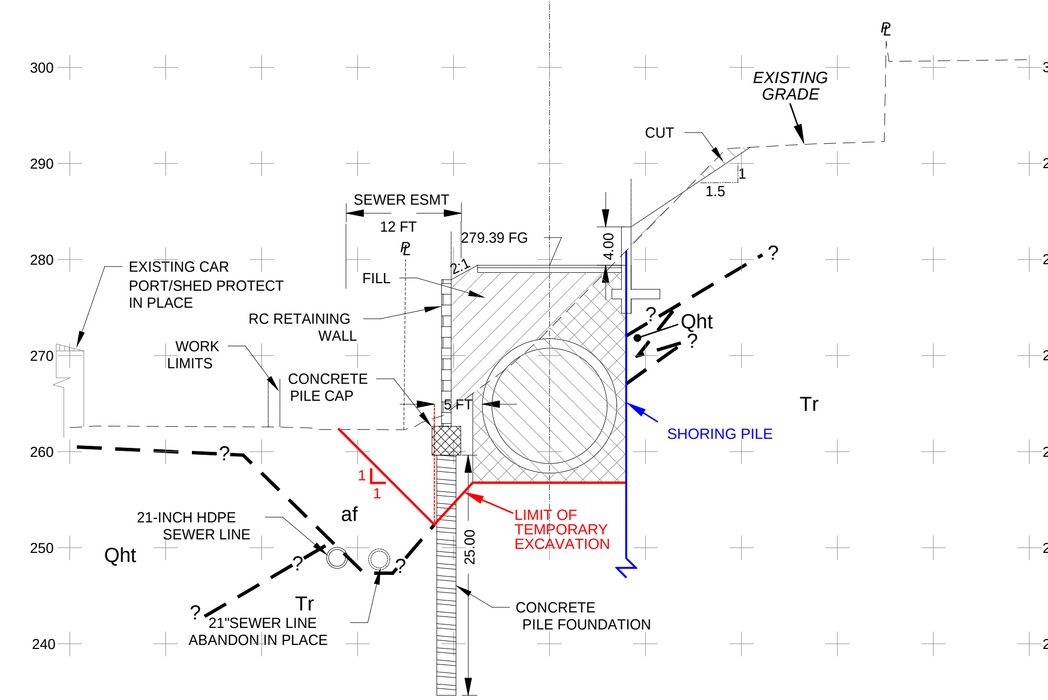
STA. 13+00



STA. 13+50



STA. 14+00



STA. 15+50
TYPICAL SECTION FROM
STA 14+50 -STA 16+00

NOTE: CROSS-SECTIONS ARE FOR ILLUSTRATION PURPOSES ONLY,
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BASE MAP BY: VCWPD

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TEMPORARY EXCAVATION CROSS-SECTIONS

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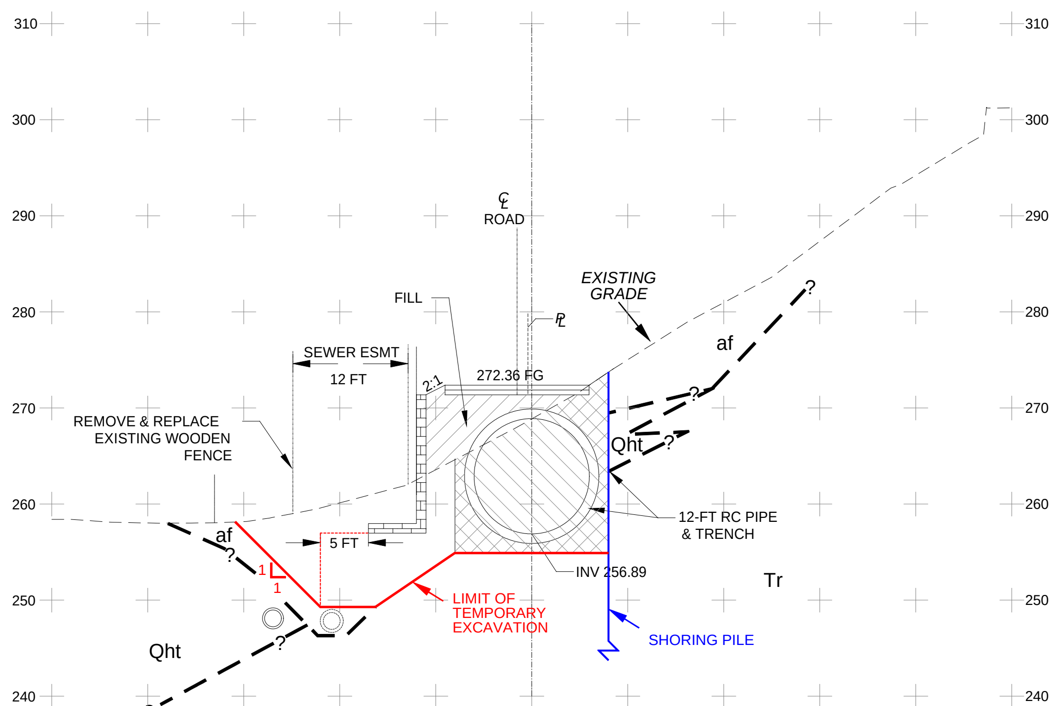
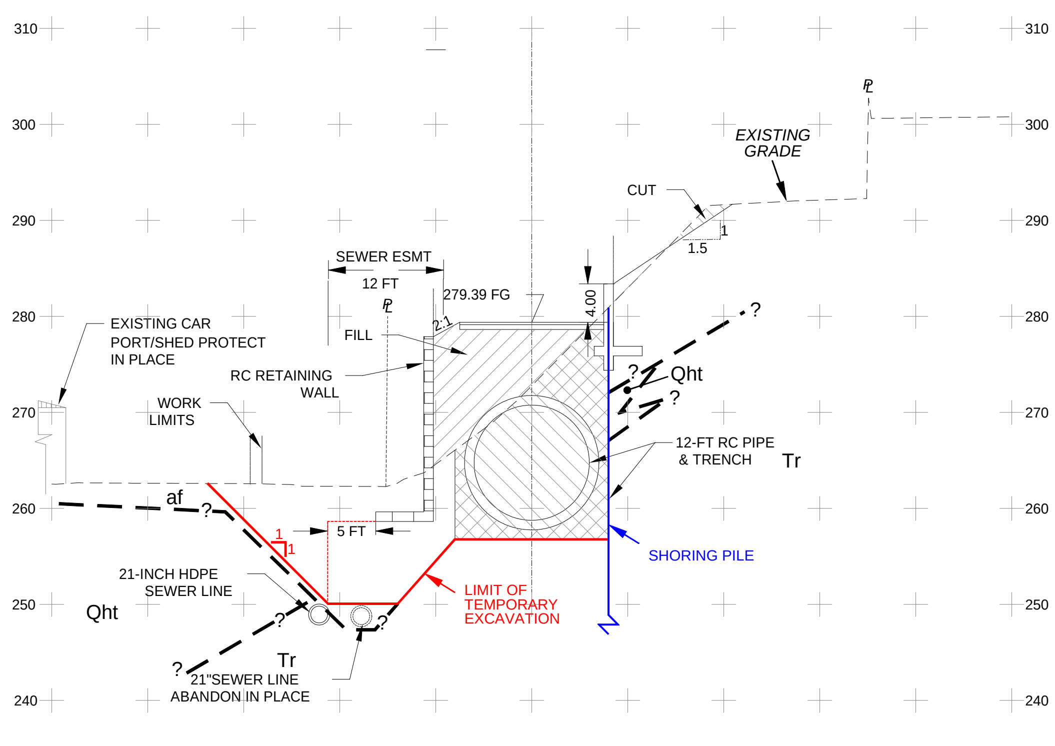
JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. 18

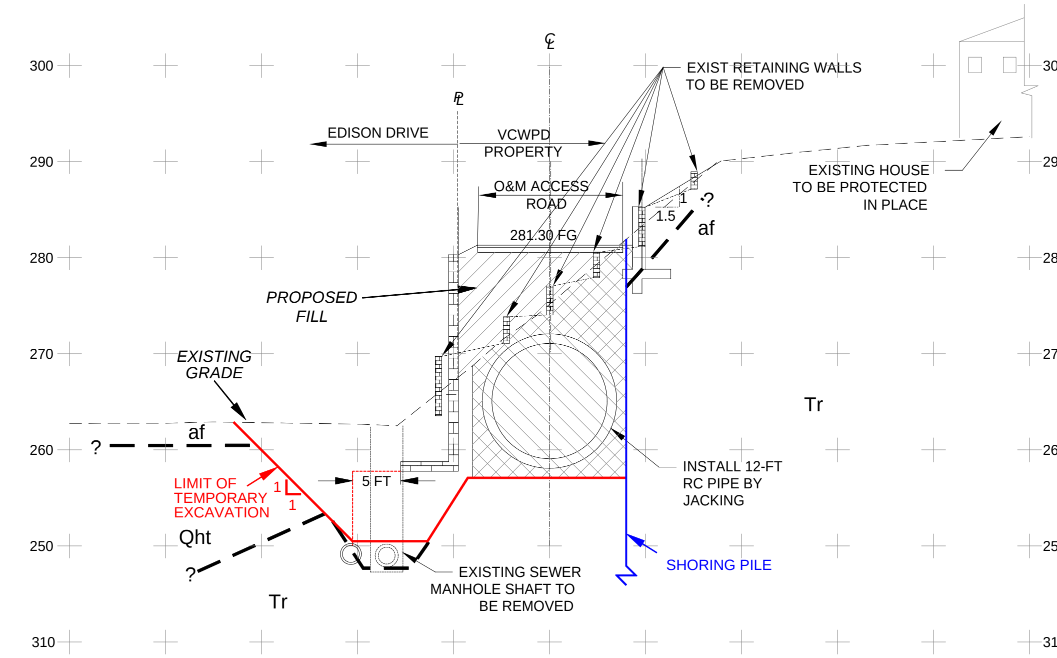
SPREAD FOUNDATION ALTERNATIVE



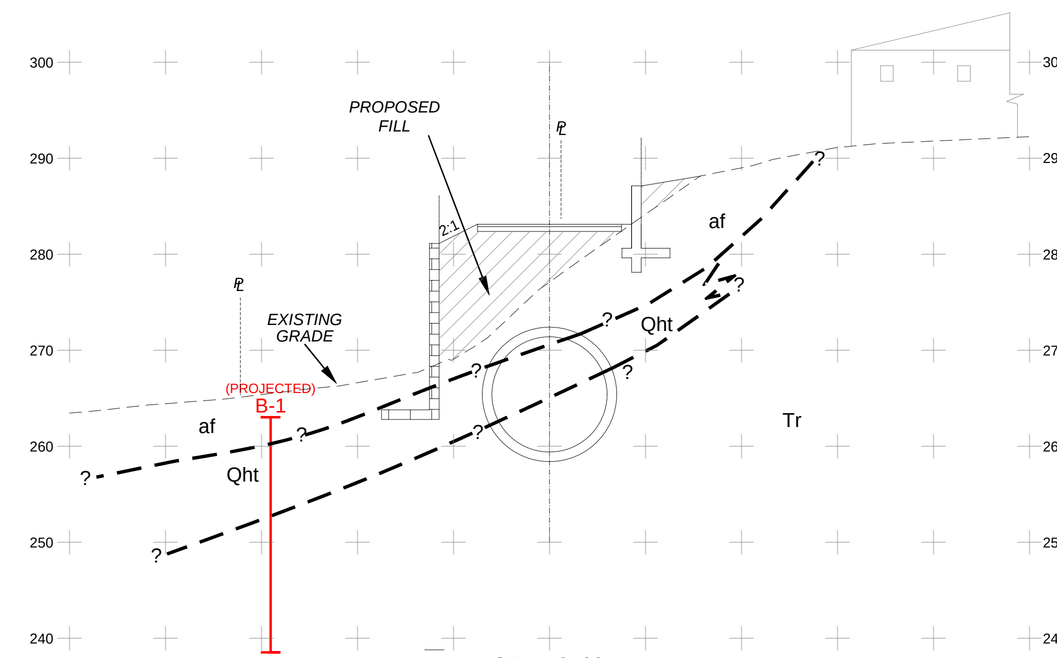
STA. 14+50



STA. 15+50
TYPICAL SECTION FROM
STA 14+50 -STA 16+00



STA. 15+73.80



STA. 16+00
ACCESS ROAD
STA 4+97.29

NOTE: CROSS-SECTIONS ARE FOR ILLUSTRATION PURPOSES ONLY,
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TEMPORARY EXCAVATION CROSS-SECTIONS

FRESNO CANYON FLOOD MITIGATION PROJECT
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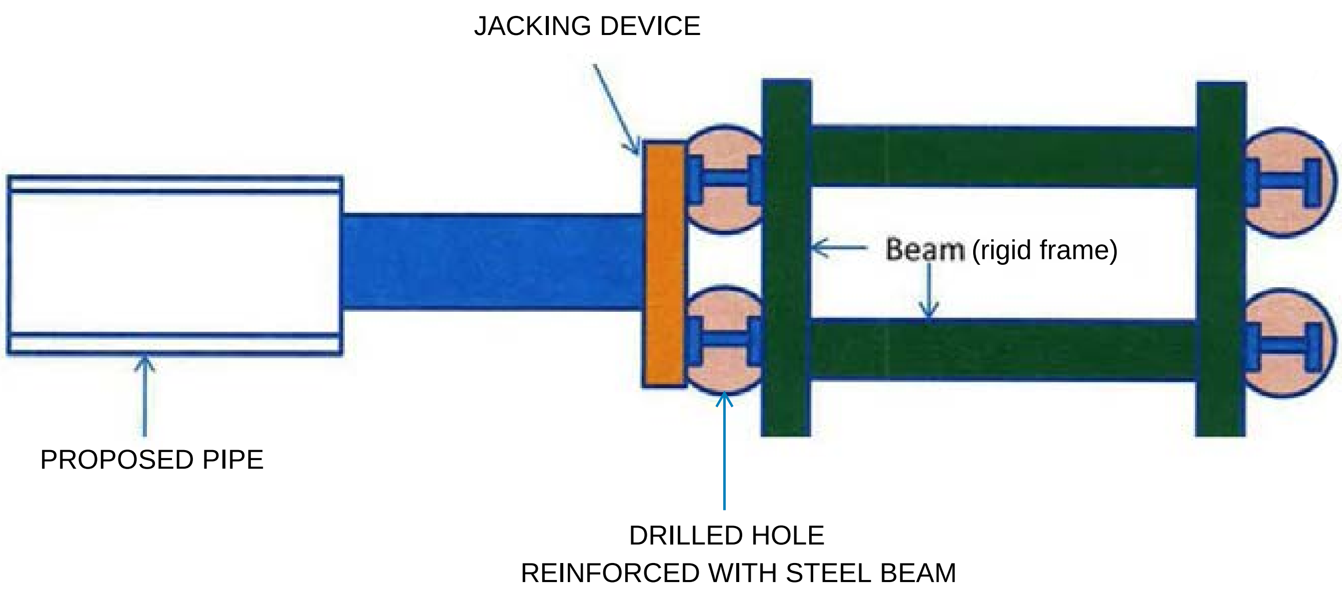
VENTURA COUNTY, CALIFORNIA

JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. 19



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THRUST BLOCK DESIGN CONCEPT

FRESNO CANYON FLOOD MITIGATION PROJECT
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JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. 20

APPENDIX A

FIELD INVESTIGATION

The site was initially explored on July 17, 2012 and July 19, 2012 by excavating two 24 inch diameter borings using a truck-mounted bucket-auger drilling machine. Due to the presence of large cobbles within the soil deposits, the bucket auger drill rig was replaced by a Lodrill equipped with a 24-inch solid auger to complete the boring excavation. The borings were conducted to depths of 50 and 51 feet below the existing ground surface. Upon completion, the borings were down-hole logged by a California licensed Certified Engineering Geologist (CEG) to observe the subsurface conditions and geologic structure of the bedrock.

Relatively undisturbed samples were obtained by driving a 3-inch outer-diameter California Modified split-tube sampler into the "undisturbed" soil mass with blows from the drilling machine Kelly Bar freefalling a distance of 12 and 18 inches with the bucket auger and Lodrill rig, respectively. The California Modified Sampler was equipped with 1-inch high by 2³⁄₈-inch diameter brass sampler rings to facilitate removal and testing. Bulk samples were also collected.

A second phase of site exploration was performed on August 28, 29, and September 5, 2012 by excavating six 7-inch diameter borings using a track-mounted limited access hollow stem-auger drilling machine. The borings were conducted to depths of 12 and 40½ feet below the existing ground surface. Relatively undisturbed samples were obtained by driving a 3-inch outer-diameter California Modified split-tube sampler into the "undisturbed" soil mass with blows from a 140-pound autohammer freefalling a distance of 30 inches. The California Modified Sampler was equipped with 1-inch high by 2³⁄₈-inch diameter brass sampler rings to facilitate removal and testing. Bulk samples were also collected.

Slope inclinometer and borehole extensometer casing was installed in boring B2. The annular space around the casing was filled with cement-bentonite grout, and a flush-mount well cover installed at the ground surface.

A third phase of site exploration was performed on September 6, 2012 by excavating three test pits using a rubber tired backhoe. The lowest portion of the test pits were excavated to depths between 5 and 9 feet below the existing ground surface. Relatively undisturbed samples were obtained by driving a 3-inch outer-diameter California Modified split-tube sampler into the "undisturbed" soil mass with blows from a slide hammer. The California Modified Sampler was equipped with 1-inch high by 2³⁄₈-inch diameter brass sampler rings to facilitate removal and testing. Bulk samples were also collected. Bulk samples were also collected.

BORING BA-1

ELEV. (MSL.) **301.0** DATE COMPLETED **7/17/12**

EQUIPMENT **BUCKET AUGER** BY: **GAK**

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	MATERIAL DESCRIPTION	PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
0					**ARTIFICIAL FILL (af)** Silty Sand, medium dense, slightly moist, brown, fine- to medium-grained			
4					-Sandy Silt, firm, slightly moist, light brown, fine- to medium-grained, trace shells, trace rootlets			
5	BA1@5'					12	105.5	14.4
10	BA1@10'				-Stiff	25	112.0	16.1
13				ML	**COLLUVIUM (Qcol)** Silt, stiff, slightly moist, dark brown to brown, moderate plasticity, abundant bedrock clasts			
15	BA1@15'					40	105.8	16.6
18	BA1@18'				-Hard	50	96.3	13.4
19				SC	**OLDER TERRACE DEPOSITS (Qpt)** Clayey Sand with subrounded to rounded Gravel and Cobbles, medium dense, dry, dark yellowish brown, trace boulders to 16"			
21	BA1@21'					36	--	--
24	BA1@24'					50	85.8	18.4
27					**RINCON SHALE (Tr)** Interbedded Shale and Siltstone, well bedded, thinnly bedded to laminated, highly weathered, moderately fractured			

A8919-06-01 FIG A1-A8 BORING LOGS.GPJ

Figure A1,
Log of Boring BA-1, Page 1 of 2

SAMPLE SYMBOLS
- ... SAMPLING UNSUCCESSFUL
- ... STANDARD PENETRATION TEST
- ... DRIVE SAMPLE (UNDISTURBED)
- ... DISTURBED OR BAG SAMPLE
- ... CHUNK SAMPLE
- ... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

GEOCON

PROJECT NO. A8919-06-01

BORING BA-1

ELEV. (MSL.) **301.0** DATE COMPLETED **7/17/12**

EQUIPMENT **BUCKET AUGER** BY: **GAK**

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	MATERIAL DESCRIPTION	PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
30								
	BA1@30.5					42	97.1	19.7
32					Clayey Siltstone, soft to moderately hard, poorly bedded, well indurated			
34								
36	BA1@35.5		▼		-Seepage	50	111.2	9.6
38								
40	BA1@40.5				-Proposed Invert Depth -Decreasing oxidation, dark olive gray to black, slightly petroliferous odor	38	106.9	10.7
42					-Poorly bedded to massive			
44	BA1@44.5					50	113.9	9.5
46								
48								
50	BA1@49.5					50	117.7	7.8

End at 50 feet.
Artificial fill to 13 feet.
Slight groundwater seepage encountered at 36 feet.
Downhole logged to 21 feet. Terminated due to unsafe condition below 21 feet.
Backfilled with soil cuttings and tamped.

*Penetration resistance for Kelly Bar falling 12 inches
Kelly Bar Weights: 0-8 feet, 1315 lbs; 8-15.5 feet, 1095 lbs; 15.5-23 feet, 897 lbs; 30.5-38 feet, 722 lbs;38-45.5 feet, 440 lbs; 45.5-53feet, 333 lbs.

A8919-06-01 FIG A1-A8 BORING LOGS.GPJ

Figure A1,
Log of Boring BA-1, Page 2 of 2

SAMPLE SYMBOLS			
	☐ ... SAMPLING UNSUCCESSFUL	◧ ... STANDARD PENETRATION TEST	■ ... DRIVE SAMPLE (UNDISTURBED)
	⊠ ... DISTURBED OR BAG SAMPLE	◣ ... CHUNK SAMPLE	▼ ... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

GEOCON

PROJECT NO. A8919-06-01

BORING BA-2

ELEV. (MSL.) 301.0 DATE COMPLETED 7/19/12

EQUIPMENT BUCKET AUGER BY: GAK

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	MATERIAL DESCRIPTION	PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
0					**ARTIFICIAL FILL (af)** Sandy Silt, firm, slightly moist, dark brown, fine-grained, trace clay, trace fine-gravel			
5	BA2@5'					10	103.6	18.6
6				CL	**COLLUVIUM (Qcol)** Clay, firm, slightly moist, brown, trace fine-gravel, moderate plasticity			
					-Sandy Clay, firm, slightly moist, brown, fine- to coarse-grained, trace fine-gravel, moderate plasticity			
10	BA2@10'					17	100.7	14.8
12.5				SM-SC	**OLDER TERRACE DEPOSITS (Qpt)** Silty Sand to Clayey Sand with abundant subround Gravel, loose, slightly moist, some cobbles 2" to 4", trace cobbles to 6"			
16	BULK 16-18'							
					-Some cobbles to 8"			
21					**RINCON SHALE (Tr)** Interbedded Shale and Siltstone, well bedded, soft to moderately hard, light gray, moderately weathered			
21.5	BA2@21.5					10	100.1	14.3
24			▼		-Bedding: N23W, 53NE; Joint: N 66E, 55SE; minor seepage on west wall			
25	BULK 25-28' BA2@25.5				-Olive gray to dark grayish brown, poorly bedded to massive, moderately hard -Joint: N40W, 58SW	25	108.5	7.9
28					-Increasing hardness			

A8919-06-01 FIG A1-A8 BORING LOGS.GPJ

Figure A2,
Log of Boring BA-2, Page 1 of 2

SAMPLE SYMBOLS: ☐ ... SAMPLING UNSUCCESSFUL; ◧ ... STANDARD PENETRATION TEST; ■ ... DRIVE SAMPLE (UNDISTURBED); ⊠ ... DISTURBED OR BAG SAMPLE; ◪ ... CHUNK SAMPLE; ▼ ... WATER TABLE OR SEEPAGE

NOTE: THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING OR TRENCH LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

GEOCON

PROJECT NO. A8919-06-01

BORING BA-2

ELEV. (MSL.) **301.0** DATE COMPLETED **7/19/12**

EQUIPMENT **BUCKET AUGER** BY: **GAK**

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	MATERIAL DESCRIPTION	PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
30								
	BA2@30.5				-Bedding: N27W, 40NE	40	107.9	13.2
32								
34								
36								
	BA2@36.5				-Proposed Invert Depth, slight petroliferous odor	42	114.6	14.6
38					-Minor seepage			
	BA2@38.5					100	122.7	10.1
40					Siltstone, moderately weathered to slightly weathered, highly fractured, well bedded, thinnly bedded, dark olive gray			
42			▼					
	BA2@42.5				Bedding: N10W, 43NE; moderate seepage along bedding	100	110.6	13.9
44								
46								
48								
50								

End at 14 feet on 7/19/12.
Resume drilling on 7/20/12.
End at 51 feet.
Artificial fill to 6 feet.
Groundwater seepage encountered below 24 feet.
Backfilled with soil cuttings and tamped.

*Penetration resistance for Kelly Bar falling 12 inches
Kelly Bar Weights: 0-8 feet, 1315 lbs; 8-14 feet.

*Penetration resistance for Kelly Bar falling 18 inches
Kelly Bar Weights: 14-22 feet, 1200 lbs; 22-51 feet, 800 lbs.

Figure A2,
Log of Boring BA-2, Page 2 of 2

A8919-06-01 FIG A1-A8 BORING LOGS.GPJ

SAMPLE SYMBOLS
- ... SAMPLING UNSUCCESSFUL
- ... STANDARD PENETRATION TEST
- ... DRIVE SAMPLE (UNDISTURBED)
- ... DISTURBED OR BAG SAMPLE
- ... CHUNK SAMPLE
- ... WATER TABLE OR SEEPAGE

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GEOCON

PROJECT NO. A8919-06-01

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	BORING B1 ELEV. (MSL.) 263.0 DATE COMPLETED 9/5/12 EQUIPMENT LIMITED ACCESS RIG BY: JMT	PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					MATERIAL DESCRIPTION			
0	B1@0-5'				**ARTIFICIAL FILL (af)** Silty Sand, loose, slightly moist, brown, fine- to medium-grained, some fine-gravel, some pods of silt			
2	B1@2.5'					12	101.2	6.7
4	B1@5'				-Proposed Invert Depth	20	97.0	15.4
6					-Medium dense, abundant gravel			
8	B1@7.5'					22	78.7	18.2
10	B1@10'					16	--	--
	BULK 10-15'				**TERRACE DEPOSITS (Qht)** Sand with Silt, dense, slightly moist, mottled brown to yellowish brown, fine- to coarse-grained, some gravel and cobbles			
12	B1@12.5'					56	118.6	12.4
14				SP-SM				
	B1@15'					62	108.6	17.4
16	B1@16.5'					100(3")	85.6	7.7
18					**RINCON SHALE (Tr)** Shale, well bedded, thinnly bedded to laminated, highly weathered			
20	B1@20'					100(5")	113.5	4.4
22								
24	B1@24'					100(5")	125.5	5.6
					End at 24.5 feet. Artificial fill to 11 feet. No groundwater encountered. Backfilled with soil cuttings and tamped. Ground surface patched with asphalt. *Penetration resistance for 140 pound hammer falling 30 inches by auto-hammer.			

A8919-06-01 FIG A1-A8 BORING LOGS.GPJ

Figure A3,
Log of Boring B1, Page 1 of 1

SAMPLE SYMBOLS			
	☐ ... SAMPLING UNSUCCESSFUL	◧ ... STANDARD PENETRATION TEST	■ ... DRIVE SAMPLE (UNDISTURBED)
	⊠ ... DISTURBED OR BAG SAMPLE	◪ ... CHUNK SAMPLE	▼ ... WATER TABLE OR SEEPAGE

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GEOCON

PROJECT NO. A8919-06-01

BORING B2

ELEV. (MSL.) **286.0** DATE COMPLETED **8/27/12**

EQUIPMENT **LIMITED ACCESS RIG** BY: **JMT**

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	MATERIAL DESCRIPTION	PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
0					**ARTIFICIAL FILL (af)** Clay with Sand, stiff, dry to slightly moist, dark brown, fine-grained, abundant rootlets and roots			
7	B2@7'				- Hard, mottled yellowish brown to grayish brown, slighly moist to dry, no sand	80	--	--
9					**TERRACE DEPOSITS (Qht)** Silt with Sand, hard, slightly moist, grayish brown, fine-grained			
9.5	B2@9.5'					50(5")	--	--
12.5	B2@12.5'			ML		50(3")	111.6	25.2
15.5	B2@15.5'					50(1")	122.2	12.0
18	B2@18'				**RINCON SHALE (Tr)** Shale, well bedded, thinnly bedded to laminated, highly weathered, brittle, light gray, dry	70(5")	83.9	26.5
21	B2@21'				- Moderatly weathered	50(4")	--	--
25	B2@25'					50(3")	98.5	7.8
26					-Proposed Invert Depth			

A8919-06-01 FIG A1-A8 BORING LOGS.GPJ

Figure A4,
Log of Boring B2, Page 1 of 2

SAMPLE SYMBOLS

- ... SAMPLING UNSUCCESSFUL
- ... STANDARD PENETRATION TEST
- ... DRIVE SAMPLE (UNDISTURBED)
- ... DISTURBED OR BAG SAMPLE
- ... CHUNK SAMPLE
- ... WATER TABLE OR SEEPAGE

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GEOCON

BORING B2

ELEV. (MSL.) **286.0** DATE COMPLETED **8/27/12**

EQUIPMENT **LIMITED ACCESS RIG** BY: **JMT**

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	MATERIAL DESCRIPTION	PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
30	B2@30'					50(4")	97.0	5.9
32								
34								
	B2@35'					100+	91.0	7.3

End at 35.5 feet.
Artificial fill to 9 feet.
No groundwater encountered.
Inclinometer and extensometer casing installed.
Annulus around casing backfilld with cement-bentonite grout.
Flush-mount well cover installed.

*Penetration resistance for 140 pound hammer falling 30 inches by down-hole hammer.

Figure A4,
Log of Boring B2, Page 2 of 2

A8919-06-01 FIG A1-A8 BORING LOGS.GPJ

SAMPLE SYMBOLS			
	☐ ... SAMPLING UNSUCCESSFUL	◧ ... STANDARD PENETRATION TEST	■ ... DRIVE SAMPLE (UNDISTURBED)
	⊠ ... DISTURBED OR BAG SAMPLE	◪ ... CHUNK SAMPLE	▼ ... WATER TABLE OR SEEPAGE

PROJECT NO. A8919-06-01

BORING B3

ELEV. (MSL.) **281.0** DATE COMPLETED **8/28/12**

EQUIPMENT **LIMITED ACCESS RIG** BY: **JMT**

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	MATERIAL DESCRIPTION	PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
0					12" ASPHALT OVER 10" SUBBASE **ARTIFICIAL FILL (af)** Clay, hard, slightly moist, mottled brown to yellowish brown to dark brown			
4	B3@4'					63	--	--
7	B3@7'				-Sandy Clay, hard, slightly moist, dark brown, fine- to medium-grained, some gravel	47	106.6	15.5
10	B3@10'					64	--	--
12	B3@12'			CL	**COLLUVIUM (Qcol)** Clay, hard, moist, mottled brown to olive brown to yellowish brown to reddish brown, trace shale pieces	71	99.9	21.7
16	B3@16'					62	101.7	21.1
18					**RINCON SHALE (Tr)** Shale, well bedded, thinnly bedded to laminated, highly fractured, moderately weathered			
18.5	B3@18.5'					75	--	--
20.5	B3@20.5'				- Increasing hardness -Proposed Invert Depth	53(3")	98.2	13.1
25	B3@25'					100(7")	91.7	9.5

Figure A5,
Log of Boring B3, Page 1 of 2

A8919-06-01 FIG A1-A8 BORING LOGS.GPJ

SAMPLE SYMBOLS
- ... SAMPLING UNSUCCESSFUL
- ... STANDARD PENETRATION TEST
- ... DRIVE SAMPLE (UNDISTURBED)
- ... DISTURBED OR BAG SAMPLE
- ... CHUNK SAMPLE
- ... WATER TABLE OR SEEPAGE

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GEOCON

BORING B3

ELEV. (MSL.) **281.0** DATE COMPLETED **8/28/12**

EQUIPMENT **LIMITED ACCESS RIG** BY: **JMT**

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	MATERIAL DESCRIPTION	PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
30	B3@30'				-Poorly bedded, moderately hard, dark gray	100(6")	93.5	9.6
32								
34								
	B3@35'					100(6")	101.6	10.4
36								
38								
40	B3@40'					100(8")	113.5	10.7

End at 40.5 feet.
Artificial fill to 11.5 feet.
No groundwater encountered.
Boring backfilled with cement-bentonite grout.
Ground surface patched with concrete.

*Penetration resistance for 140 pound hammer falling 30 inches by down-hole hammer.

Figure A5,
Log of Boring B3, Page 2 of 2

A8919-06-01 FIG A1-A8 BORING LOGS.GPJ

SAMPLE SYMBOLS
- ... SAMPLING UNSUCCESSFUL
- ... STANDARD PENETRATION TEST
- ... DRIVE SAMPLE (UNDISTURBED)
- ... DISTURBED OR BAG SAMPLE
- ... CHUNK SAMPLE
- ... WATER TABLE OR SEEPAGE

PROJECT NO. A8919-06-01

BORING B4

ELEV. (MSL.) 272.0 DATE COMPLETED 9/5/12

EQUIPMENT LIMITED ACCESS RIG BY: JMT

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	MATERIAL DESCRIPTION	PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
0					**DEBRIS BASIN SLOUGH** Silt with Sand, very soft, dry, dark brown, fine- to medium-grained, abundant roots and organics - Trace Sand, moist, gray, fine-grained, abundant decomposing organic material			
4	B4@4'					5	76.9	39.6
6					**RINCON SHALE (Tr)** Shale, well bedded, thinnly bedded to laminated, slighly moist, moderatly hard, gray -Proposed Invert Depth			
	B4@7'					50(5")	--	--
	B4@9'					100(5")	--	--
12	BULK 12-15'							
	B4@15'					100(4")	103.6	10.3
20	B4@19.5'					120(7")	113.7	9.7

End at 20 feet.
Debris basin slough to 6 feet.
No groundwater encountered.
Backfilled with soil cuttings and tamped.

*Penetration resistance for 140 pound hammer falling 30 inches by auto-hammer.

A8919-06-01 FIG A1-A8 BORING LOGS.GPJ

Figure A6,
Log of Boring B4, Page 1 of 1

SAMPLE SYMBOLS
... SAMPLING UNSUCCESSFUL
... STANDARD PENETRATION TEST
... DRIVE SAMPLE (UNDISTURBED)
... DISTURBED OR BAG SAMPLE
... CHUNK SAMPLE
... WATER TABLE OR SEEPAGE

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GEOCON

BORING B5

ELEV. (MSL.) **273.0** DATE COMPLETED **9/5/12**

EQUIPMENT **LIMITED ACCESS RIG** BY: **JMT**

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	MATERIAL DESCRIPTION	PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
0	BULK 0-5'				**DEBRIS BASIN SLOUGH** Silt with some Sand, very soft, dry, gray, fine- to coarse-grained, abundant gravel and shale pieces			
2	B5@2.5'				-Sandy Clay, firm, moist, mottled dark brown to reddish brown, fine- to medium-grained with some coarse-grained, some organic material	17	87.2	23.9
4	B5@5'				-Proposed Invert Depth - Abundant gravel	23	86.7	28.0
6								
8	B5@7.5'				**RINCON SHALE (Tr)** Shale, well bedded, thinnly bedded to laminated, moderatly weathered, gray, slightly moist, hard	100(3")	116.4	12.0
	B5@9'					200(5.5")	103.6	10.2
10								
12	B5@11.5'					139(7")	100.6	9.5
14	B5@14'					133(6")	109.7	9.3
16	B5@16'		▼		-Groundwater seepage	138(6")	95.6	14.2
18	B5@19'					135(4")	102.4	9.1

End at 19.5 feet.
Debris basin slough to 7 feet.
Groundwater seepage encountered at 16 feet.
Backfilled with soil cuttings and tamped.

*Penetration resistance for 140 pound hammer falling 30 inches by auto-hammer.

A8919-06-01 FIG A1-A8 BORING LOGS.GPJ

Figure A7,
Log of Boring B5, Page 1 of 1

SAMPLE SYMBOLS			
	☐ ... SAMPLING UNSUCCESSFUL	◧ ... STANDARD PENETRATION TEST	■ ... DRIVE SAMPLE (UNDISTURBED)
	⊠ ... DISTURBED OR BAG SAMPLE	◪ ... CHUNK SAMPLE	▼ ... WATER TABLE OR SEEPAGE

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GEOCON

BORING B6

ELEV. (MSL.) **286.0** DATE COMPLETED **9/5/12**

EQUIPMENT **LIMITED ACCESS RIG** BY: **JMT**

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	MATERIAL DESCRIPTION	PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
0					**ARTIFICIAL FILL (af)** Sandy Silt, stiff, slightly moist, mottled brown and yellowish brown, fine- to coarse-grained, some organic material			
2	B6@2' BULK 2-5'					31	93.6	12.5
4					**COLLUVIUM (Qcol)** Sandy Silt, stiff, slightly moist, dark brown, fine- to coarse-grained, trace fine-gravel			
	B6@5'					28	91.5	23.7
6					- Hard, increased gravel content			
	B6@7'					50(3")	89.1	11.4
8					- Sandstone pieces			
10	B6@10'				- Some cobbles	50(4")	103.2	11.9
12								

Refusal at 12 feet.
Artificial fill to 3.5 feet.
No groundwater encountered.
Backfilled with soil cuttings and tamped.

*Penetration resistance for 140 pound hammer falling 30 inches by auto-hammer.

A8919-06-01 FIG A1-A8 BORING LOGS.GPJ

Figure A8,
Log of Boring B6, Page 1 of 1

SAMPLE SYMBOLS
... SAMPLING UNSUCCESSFUL
... STANDARD PENETRATION TEST
... DRIVE SAMPLE (UNDISTURBED)
... DISTURBED OR BAG SAMPLE
... CHUNK SAMPLE
... WATER TABLE OR SEEPAGE

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GEOCON

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	TEST PIT 1 ELEV. (MSL.) - - DATE COMPLETED 09/06/12 EQUIPMENT BACKHOE BY: GAK	PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
					MATERIAL DESCRIPTION			
0					**ARTIFICIAL FILL (af)** Sand with Silt and Gravel, soft, dry, brown, abundant glass and steel debris			
2								
4					**TERRACE DEPOSITS (Qht)** Gravel and Cobbles in a fine-sand matrix, well graded, dry, brown, porous, few boulders to 24"			
6				GW				
8					**RINCON SHALE (Tr)** Shale, highly weathered, well bedded, intensely fractured, moderately hard, brittle, dark reddish brown to black with red oxidation rinds along fracture surfaces			
					End at 8.5 feet. Artificial fill to 3 feet. No groundwater encountered. Backfilled with soil cuttings and tamped.			

Figure A9,
Log of Test Pit 1, Page 1 of 1

A8919-06-01 TEST PITS.GPJ

SAMPLE SYMBOLS			
	... SAMPLING UNSUCCESSFUL	... STANDARD PENETRATION TEST	... DRIVE SAMPLE (UNDISTURBED)
	... DISTURBED OR BAG SAMPLE	... CHUNK SAMPLE	... WATER TABLE OR SEEPAGE

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GEOCON

PROJECT NO. A8919-06-01

TEST PIT 2

ELEV. (MSL.) - - DATE COMPLETED 09/06/12

EQUIPMENT BACKHOE BY: GAK

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	MATERIAL DESCRIPTION	PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
0					**ARTIFICIAL FILL (af)** Silty Sand with Gravel and Cobbles, soft to medium dense, slightly moist, brown, fine-grained, porous			
2								
	TP2@2.5'						113.5	10.6
	TP2@2-4'							
4					-Soft, moist, very fine- to fine-grained			
	TP2@4.5'						83.0	38.5

End at 5 feet.
All artificial fill encountered.
No groundwater encountered.
Backfilled with soil cuttings and tamped.

Figure A10,
Log of Test Pit 2, Page 1 of 1

A8919-06-01 TEST PITS.GPJ

SAMPLE SYMBOLS			
	☐ ... SAMPLING UNSUCCESSFUL	◧ ... STANDARD PENETRATION TEST	■ ... DRIVE SAMPLE (UNDISTURBED)
	⊠ ... DISTURBED OR BAG SAMPLE	◪ ... CHUNK SAMPLE	▼ ... WATER TABLE OR SEEPAGE

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GEOCON

TEST PIT 3

ELEV. (MSL.) - - DATE COMPLETED 09/06/12

EQUIPMENT BACKHOE BY: GAK

DEPTH IN FEET	SAMPLE NO.	LITHOLOGY	GROUNDWATER	SOIL CLASS (USCS)	MATERIAL DESCRIPTION	PENETRATION RESISTANCE (BLOWS/FT)*	DRY DENSITY (P.C.F.)	MOISTURE CONTENT (%)
0					**ARTIFICIAL FILL (af)** Sand with Gravel and Cobbles, poorly graded, soft, dry, brown, some concrete, clay pipe, and metal debris, few boulders and concrete clasts to 3'			
2								
4	TP3@3-4'							
6								
8								
					RINCON SHALE (Tr) Shale, highly weathered, well bedded, intensely fractured, moderately hard, brittle, dark reddish brown to black with red oxidation rinds along fracture surfaces			

End at 9.5 feet.
Artificial fill to 9 feet.
No groundwater encountered.
Backfilled with soil cuttings and tamped.

Figure A11,
Log of Test Pit 3, Page 1 of 1

A8919-06-01 TEST PITS.GPJ

SAMPLE SYMBOLS

- ... SAMPLING UNSUCCESSFUL
- ... DISTURBED OR BAG SAMPLE
- ... STANDARD PENETRATION TEST
- ... CHUNK SAMPLE
- ... DRIVE SAMPLE (UNDISTURBED)
- ... WATER TABLE OR SEEPAGE

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GEOCON

APPENDIX B

LABORATORY TESTING

Laboratory tests were performed in general accordance with the American Society for Testing and Materials (ASTM), California Test Method (CTMS), or other applicable standard procedures. We performed the following tests:

- In-Place Dry Density and Moisture Content: ASTM D2937 (CTM 226)
- Direct Shear: ASTM D 3080
- Unconsolidated-Undrained Triaxial Shear: ASTM D2850
- Unconfined Compressive Strength of Rock: ASTM D 2938
- Consolidation: ASTM D 2435 (CTM 219)
- Particle Size Analysis: ASTM D 422 (CTM 202 and 203)
- Atterberg Limits: ASTM D4318
- Expansion Index: ASTM D 4829
- Maximum Dry Density/Optimum Moisture Content: ASTM D 1557
- Sand Equivalent: ASTM D 2419
- Permeability, Flexible Wall: ASTM D5084
- Organic Content
- Potential of Hydrogen (pH) and Resistivity: CTM 643
- Chloride Content: EPA No. 325.3
- Water Soluble Sulfate Content: CTM 417
- Mohs Hardness

Test results are presented on the following tables and figures. Brief descriptions of the laboratory testing conditions and procedures are presented below:

- *In situ* moisture content and dry density tests were performed in general accordance with ASTM D 2937 (CTM 226). Results are presented on the boring logs in Appendix A.

- Direct shear tests were performed on selected soil samples in accordance with ASTM D 3080. Test results are summarized as Figures B1 through B6.

- An Unconsolidated-Undrained triaxial shear test was performed on a select bedrock sample in accordance with ASTM D2850. The sample was extruded from the brass rings used for sample collection during drilling. Additional samples were attempted to be extruded, however, this was unsuccessful due to the brittleness of the bedrock. Test results are provided as Figure B7.

- Unconfined compressive strength tests were performed on select rock samples representative of the anticipated cobbles and boulders onsite in accordance with ASTM D 2938. Core samples were obtained by coring the intact rock samples using a 1¾-inch I.D. diamond tipped core barrel and trimming the samples with a diamond tipped saw to obtain a length to diameter ratio of no less than 2:1. Core diameters ranged from 1.690 to 1.710 inches with lengths between 4.03 and 4.551 inches. Six core samples were tested, generally representing the rock composition of the gravel, cobbles and boulders underlying the site. All samples were tested at laboratory air dried moisture contents after coring and sawing. Test results are summarized on Figure B8. Photographs of the samples tested are provided as Figures B9 through B14.

The results of the compressive strength testing indicate that the cobbles and boulders are relatively strong, generally with compressive strengths that exceed 18,000 psi. It should be noted that upon examination of the specimens which yielded significantly lower compressive strengths, it was observed that the lower strength values were the result of internal fracturing and planes of weakness of the individual clasts from which the core was obtained.

- One-dimensional consolidation tests were performed on selected soil samples to determine compressive characteristics in accordance with ASTM D 2435. Test Results are presented as Figures B15 through B18.

- Grain size distribution tests were performed on selected soil samples in accordance with ASTM D 422 (CTM 202 and 203). Tests results are presented as Figures B19 and B20.

- Atterberg Limits tests were performed on selected soil samples in accordance with ASTM D 4318. Test results are presented as Figure B21

- Expansion Index test was performed on select soil samples in accordance with ASTM D 4829. The results are presented as Figure B22.

- Maximum Dry Density/Optimum Moisture Content testing was performed on select soil samples in accordance with ASTM D 1557. The results are presented on Figure B22.

- Sand Equivalent tests were performed on select soil samples in accordance with ASTM D 2419. The results are presented on Figure B23.

- Permeability tests were performed on select soil samples in accordance with ASTM D 5084. The results are presented on Figure B23.

- Organics content tests were performed on select soil samples to generally evaluate the percentage of material within the soil that is organic and therefore subject to decomposition over time. Test results are presented on Figure B23.

- Soil sulfate content tests were performed on selected soil samples in accordance with CTM 643, 417 and 422. Test results are presented on Figure B24.

- Potential of Hydrogen (pH) and resistivity tests were performed on selected soil samples in accordance with CTM 643. Test results are presented on Figure B24.

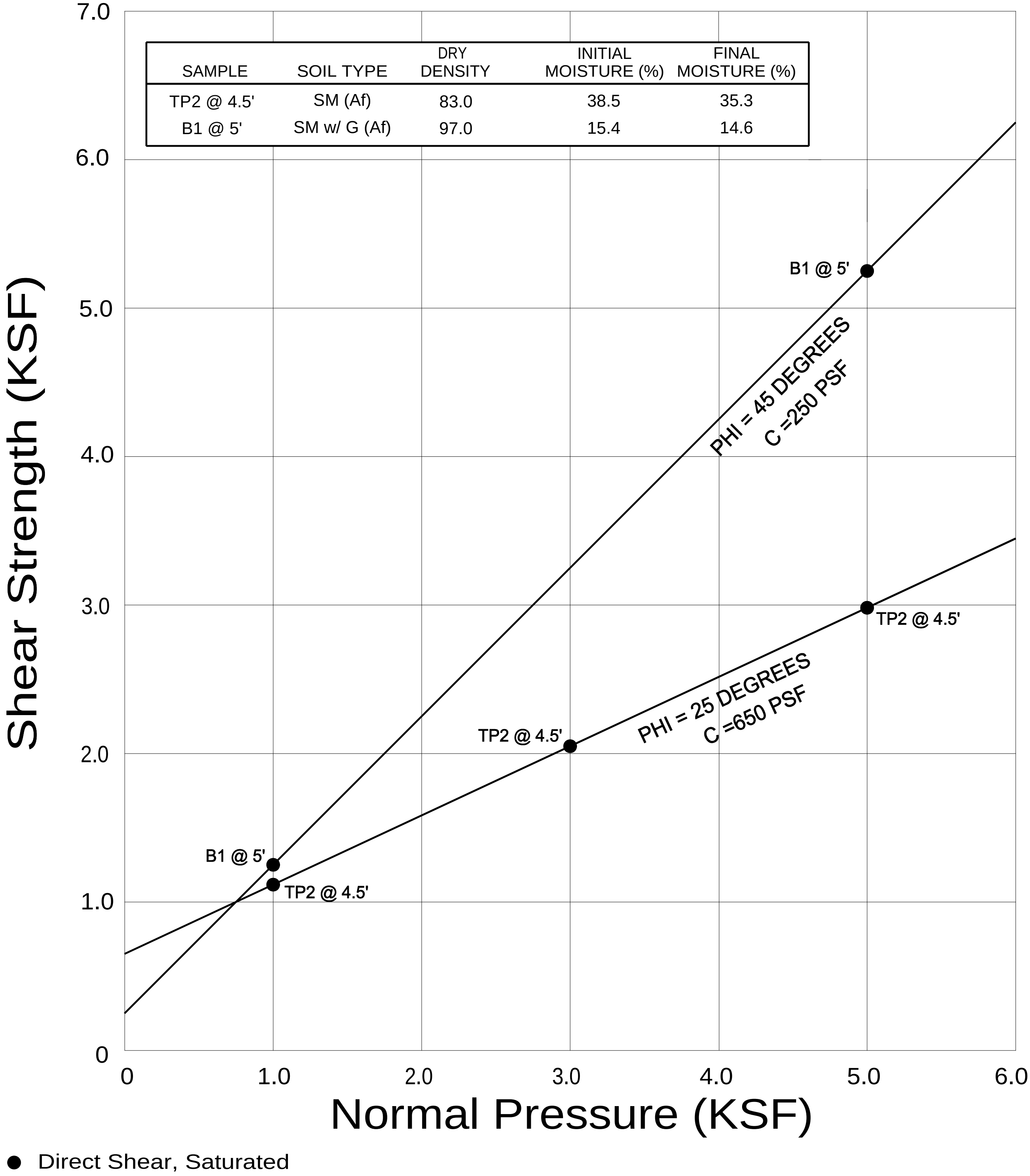
- Chloride content tests were performed on selected soil samples in accordance with EPA No. 325.3. Test results are presented on Figure B24.

- Mohs hardness scratch tests were conducted on a random sampling of 75 rock samples collected across the drainage facility alignment in order to evaluate the relative hardness of the gravel, cobbles and boulders anticipated to be encountered with the underlying terrace deposits. The Mohs hardness test is conducted by scratching a rock specimen with a set of minerals or materials of known hardness. The hardness of each material within the set is expressed as a number in a scale between 1-10, with 1 being the softest (talc) and 10 being the hardest (diamond). The hardness of the specimen is then measured against the scale by finding the hardest material that the specimen can scratch, and/or the softest material that can scratch the given specimen. Test results are presented on the table below.

Table B1 - Mohs Hardness Test Results

	Hardness Range	Hardness Average	Number of Samples
Sandstone	3-7	4.8	35 (47%)
Shale	3-6	3.8	21 (28%)
Siltstone	3-5	3.9	19 (25%)
	Total Weighted Ave.		4.3

The remaining soil samples are now stored in our laboratory for future reference and analysis if needed. Unless otherwise notified, all samples will be disposed of 60 days from the date of this report.



SAMPLE	SOIL TYPE	DRY DENSITY	INITIAL MOISTURE (%)	FINAL MOISTURE (%)
TP2 @ 4.5'	SM (Af)	83.0	38.5	35.3
B1 @ 5'	SM w/ G (Af)	97.0	15.4	14.6

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DIRECT SHEAR TEST RESULTS

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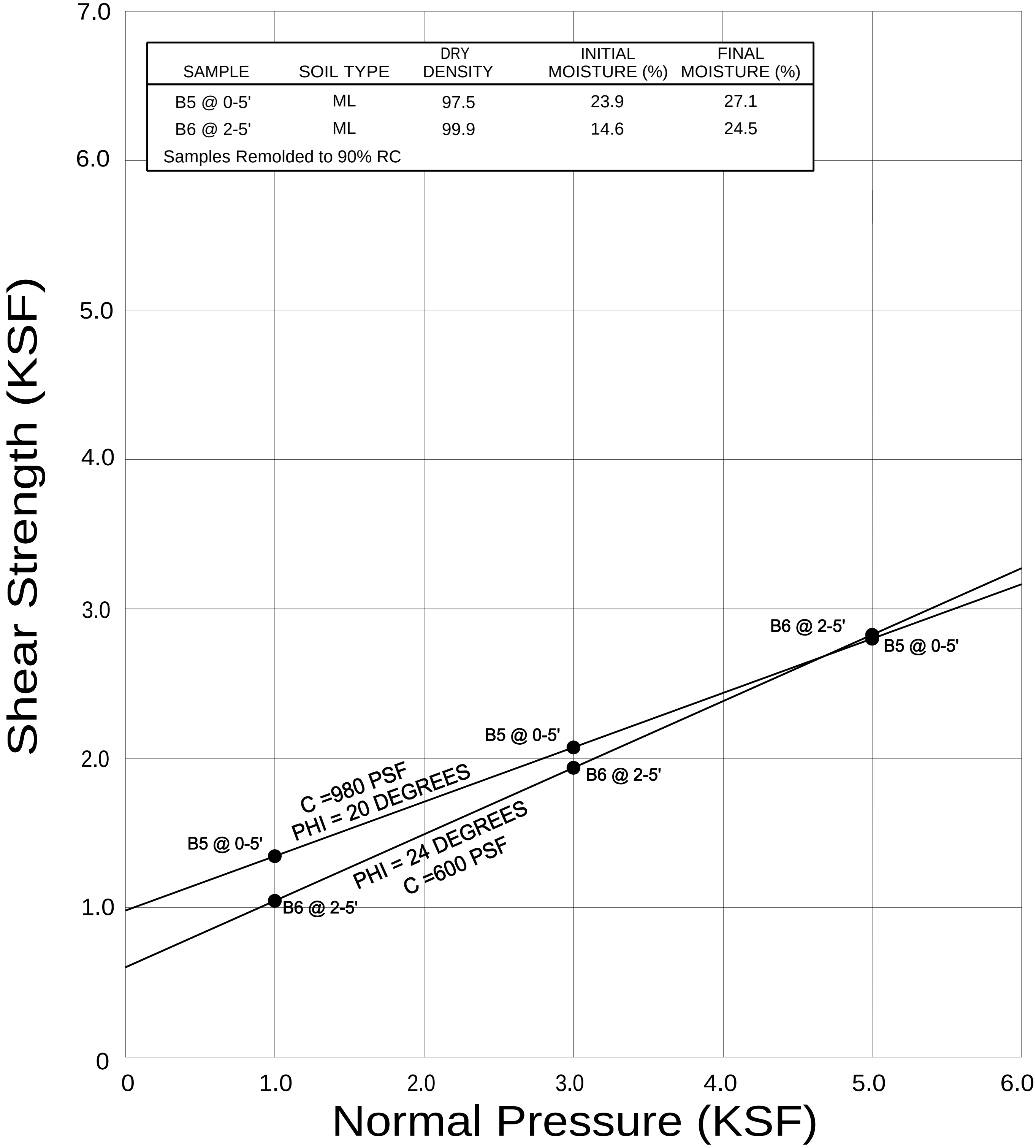
JMT		8000	JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. B1



SAMPLE	SOIL TYPE	DRY DENSITY	INITIAL MOISTURE (%)	FINAL MOISTURE (%)
B5 @ 0-5'	ML	97.5	23.9	27.1
B6 @ 2-5'	ML	99.9	14.6	24.5
Samples Remolded to 90% RC				

● Direct Shear, Saturated

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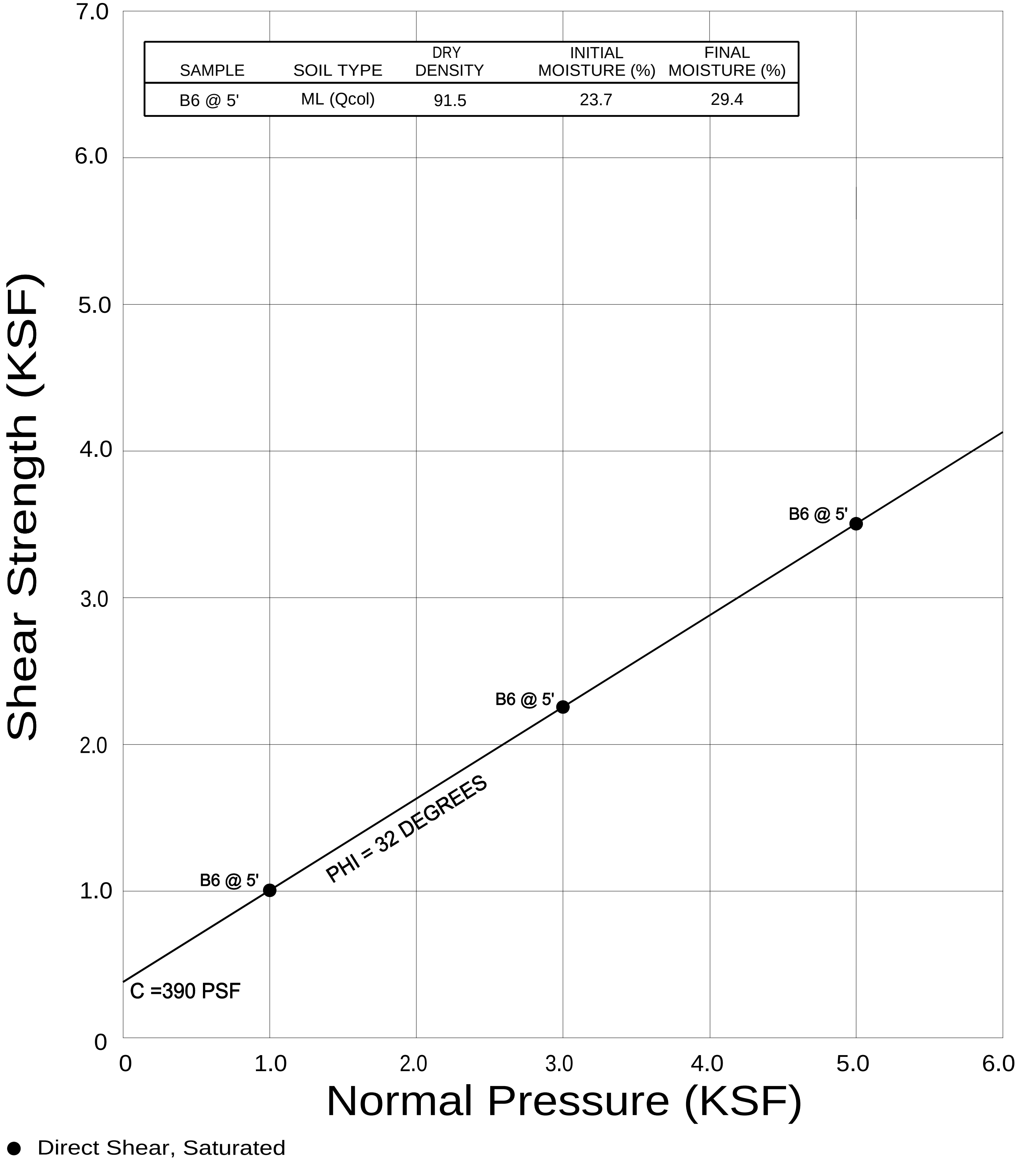
JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. B2

SAMPLE	SOIL TYPE	DRY DENSITY	INITIAL MOISTURE (%)	FINAL MOISTURE (%)
B6 @ 5'	ML (Qcol)	91.5	23.7	29.4



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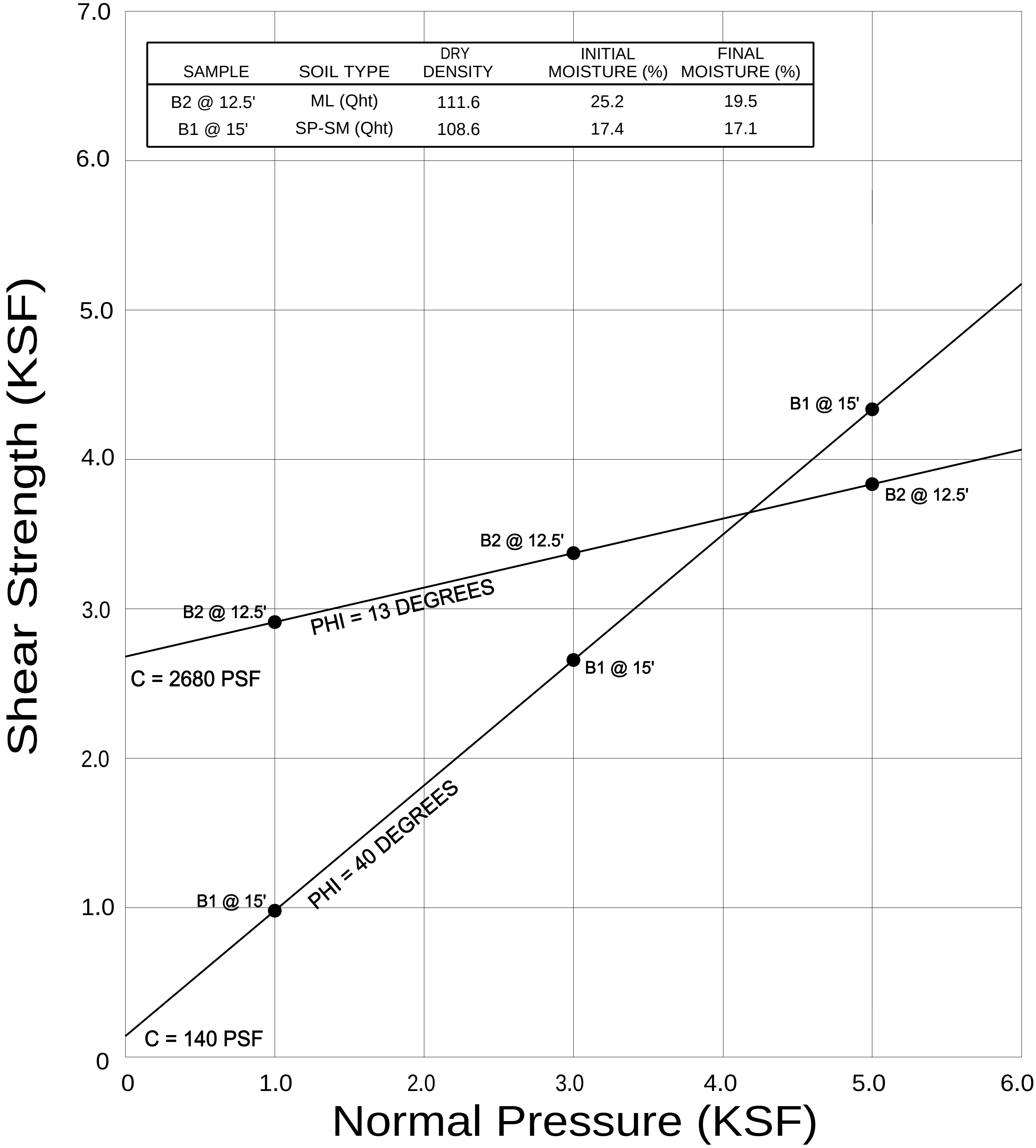
JMT		8000	JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. B3



SAMPLE	SOIL TYPE	DRY DENSITY	INITIAL MOISTURE (%)	FINAL MOISTURE (%)
B2 @ 12.5'	ML (Qht)	111.6	25.2	19.5
B1 @ 15'	SP-SM (Qht)	108.6	17.4	17.1

● Direct Shear, Saturated

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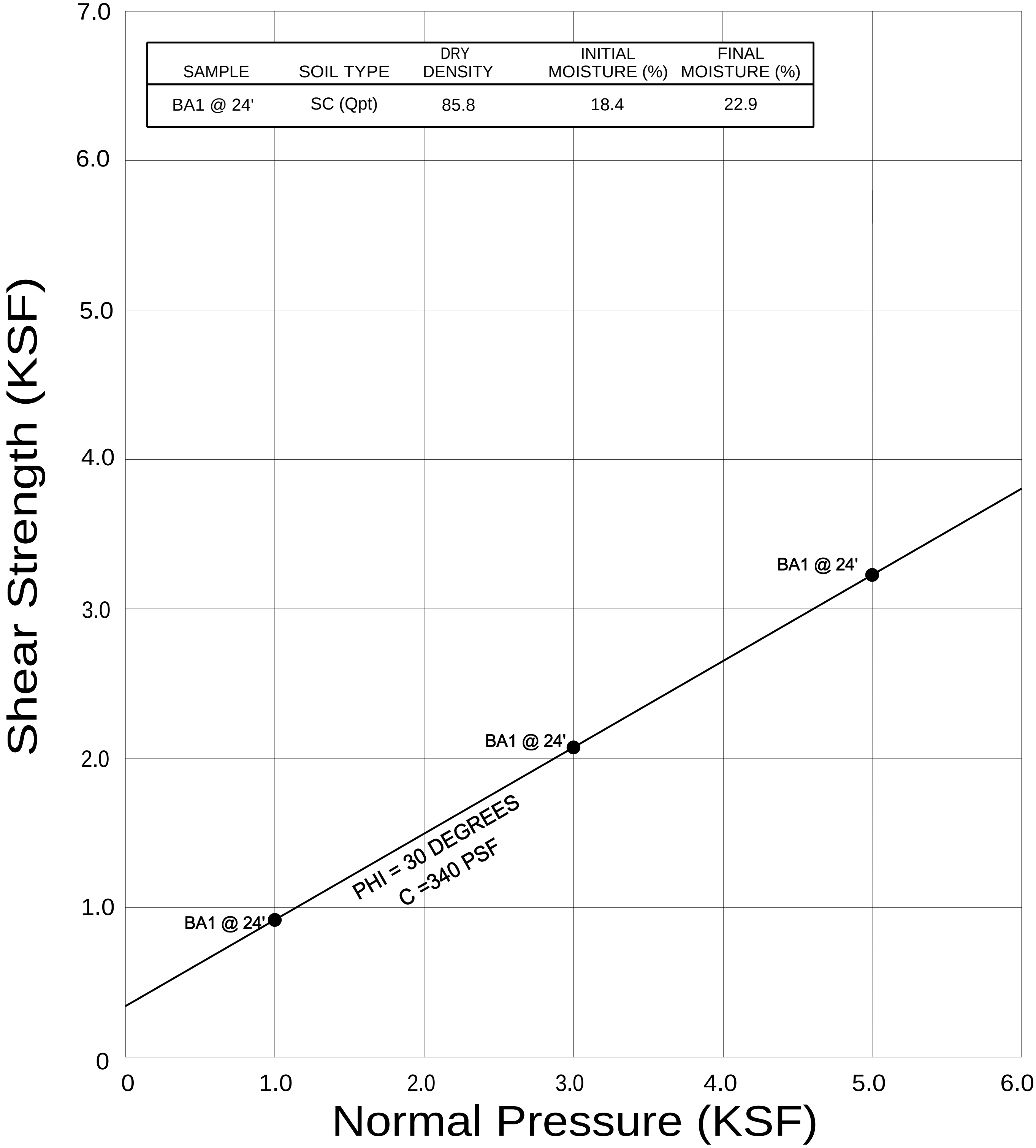
JAN 17, 2013 | PROJECT NO. A8919-06-01 | FIG. B4



SAMPLE	SOIL TYPE	DRY DENSITY	INITIAL MOISTURE (%)	FINAL MOISTURE (%)
BA1 @ 24'	SC (Qpt)	85.8	18.4	22.9

● Direct Shear, Saturated

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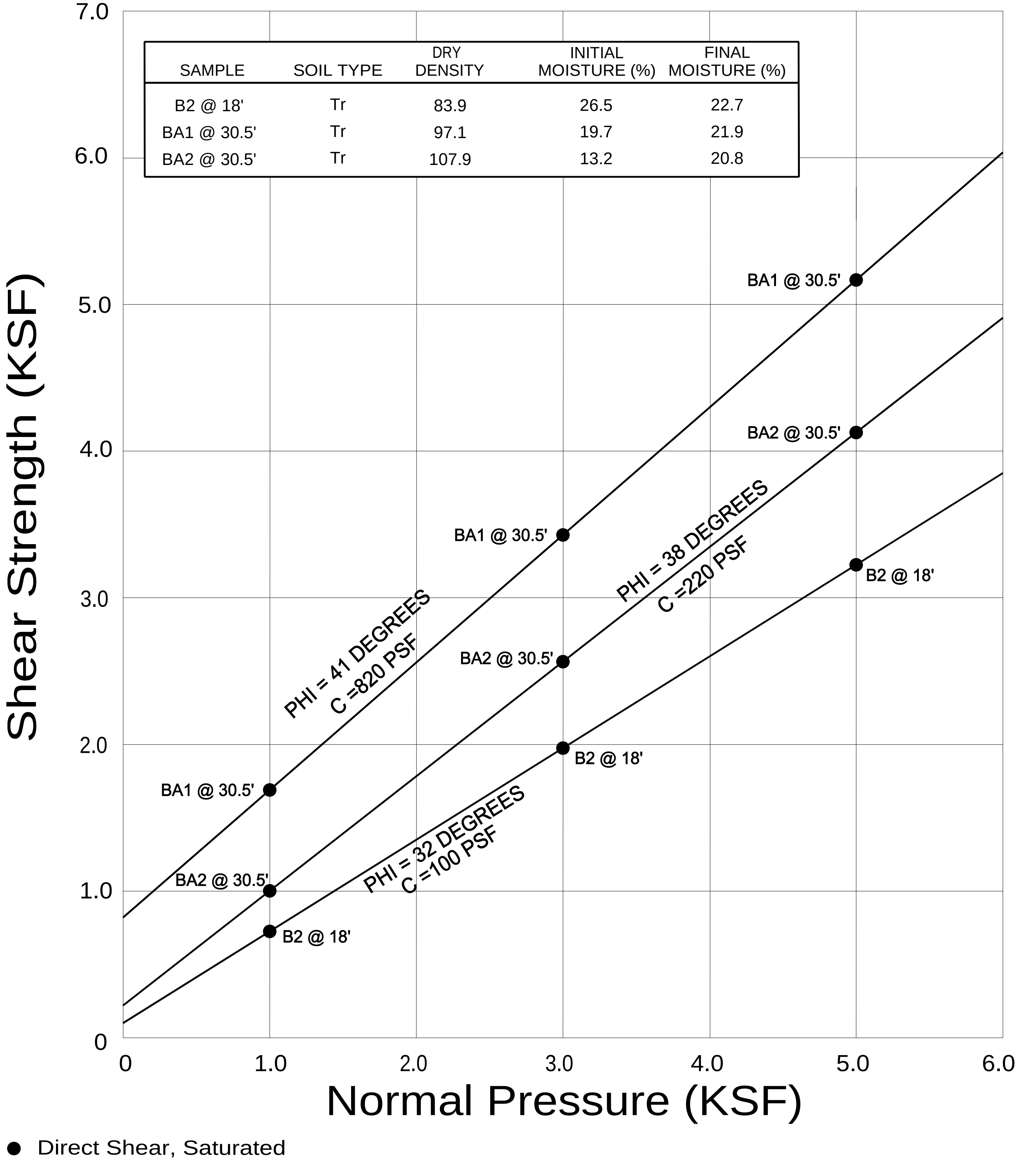
JMT		8000	JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. B5



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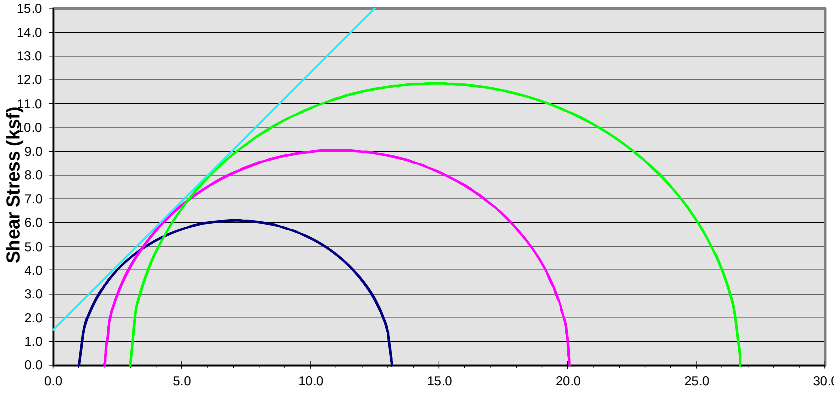
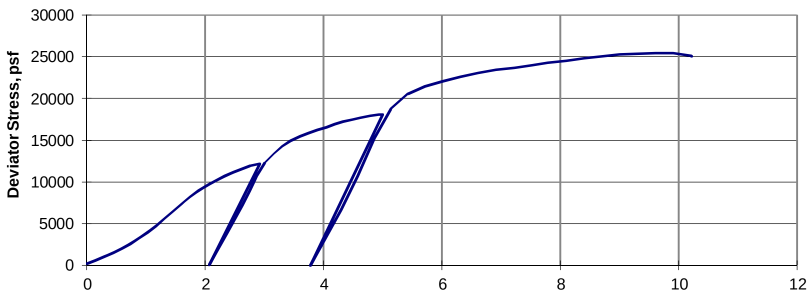
JMT		8000	JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. B6

MOHR'S CIRCLES



STRESS-STRAIN



Failure Photo

Test Results

	ϕ, degrees	**47.2**
	c, psf	**1500**

Sample Description

	Sample Number	B2
	Sample Depth (feet)	25
	Material Description	Rincon Shale Bedrock

Initial Conditions at Start of Stage

Sample ID (psf), minor principal stress	**1000**	**2000**	**3000**
Height (inch)	4.80	4.70	4.54
Diameter (inch)	2.36	2.385	2.427
Moisture Content (%)	7.8	7.8	7.8
Dry Density (pcf)	98.5	98.5	98.5
Saturation (%)	30.3	30.3	30.3

Shear Test Conditions

Strain Rate (%/min)	0.2898	0.2897	0.3009
Major Principle Stress at Failure (psf)	13170	20070	26690
Strain at failure (%)	2.91	4.93	7.22
Deviator Stress and Fail (psf)	12180	18080	23700

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Triaxial Shear Strength - UU Test (staged)

Project: Fresno Canyon Flood Protection
Location: Ventura, CA
Number: A8919-06-01
Figure: B7

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Test Specimen and Compressive Strength Test Report

Project Name: Fresno Canyon Flood Mitigation Project
Project Number: A8919-06-01
Project Location: Highway 33 between Fresno Canyon and the Ventura River
Civil:
Contractor:
Architect:
Structural:
Permit No:

Laboratory Compressive Strength Data Per ASTM C39

Sample No ID	Station & Offset	Sample Type	Specific Dimensions (in)[1]				Area (sq. In)	Ultimate Load (lbs)	F'c (psi)	Time	Break Type[2]
			1	2	3	4					
S1	22+75 0'	Sandstone	1.705	1.692	4.47	4.47	2.0276	37,710	18,599	7:00	IV
S2	15+00 0'	Sandstone	1.696	1.699	4.551	4.551	1.9891	19,535	9,821	7:05	IV
S3	15+00 0'	Sandstone	1.704	1.705	4.03	4.03	2.2648	57,790	25,516	7:10	II
S4	12+90 0'	Sandstone	1.710	1.700	4.529	4.529	2.0165	13,280	6,586	7:15	V
S5	12+25 60' N	Siltstone	1.701	1.699	4.454	4.454	2.0384	40,480	19,858	7:20	IV
S6	12+25 0'	Siltstone	1.700	1.690	4.526	4.526	1.9942	19,700	9,879	7:25	III

Notes:

[1]Dimensions 1 and 2 = Diameters; Dimensions 3 and 4 = Height; NA if cylinder 2.2>l/d>1.8 per ASTM C39

[3]Break Type designation per ASTM C39, Figure 2

BEFORE

AFTER

SAMPLE NUMBER: S1
ROCK CLASSIFICATION: Sandstone
COMPRESSIVE STRENGTH (ASTM C39): 18,599 psi
MOHS HARDNESS: 4-5

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ROCK STRENGTH TEST RESULTS

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CHL		8000	JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. B9

BEFORE

SAMPLE NUMBER: S2
ROCK CLASSIFICATION: Sandstone
COMPRESSIVE STRENGTH (ASTM C39): 9,821 psi
MOHS HARDNESS: 4-5

AFTER

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CHL		8000

ROCK STRENGTH TEST RESULTS

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JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. B10

BEFORE

AFTER

SAMPLE NUMBER: S3
ROCK CLASSIFICATION: Sandstone
COMPRESSIVE STRENGTH (ASTM C39): 25,516 psi
MOHS HARDNESS: 7

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CHL		8000

ROCK STRENGTH TEST RESULTS

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JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. B11

BEFORE

AFTER

SAMPLE NUMBER: S4
ROCK CLASSIFICATION: Sandstone
COMPRESSIVE STRENGTH (ASTM C39): 6,586 psi
MOHS HARDNESS: 6

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ROCK STRENGTH TEST RESULTS

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JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. B12

BEFORE

AFTER

SAMPLE NUMBER: S5
ROCK CLASSIFICATION: Siltstone
COMPRESSIVE STRENGTH (ASTM C39): 19,858 psi
MOHS HARDNESS: 4-5

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CHL		8000

ROCK STRENGTH TEST RESULTS

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JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. B13

BEFORE

AFTER

SAMPLE NUMBER: S6
ROCK CLASSIFICATION: Siltstone
COMPRESSIVE STRENGTH (ASTM C39): 9,879 psi
MOHS HARDNESS: 4-5

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ROCK STRENGTH TEST RESULTS

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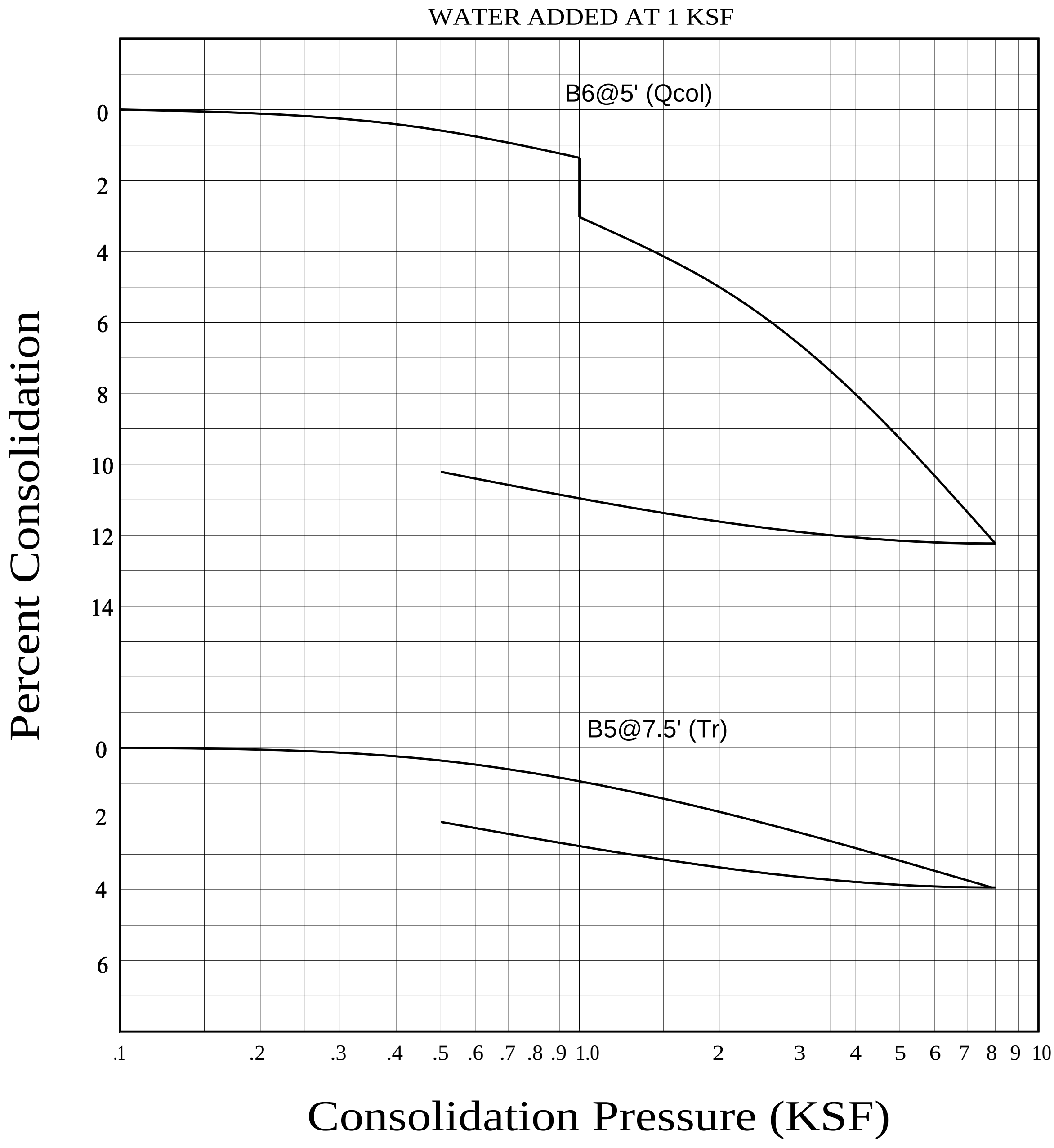
CHL		8000	JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. B14



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CONSOLIDATION TEST RESULTS

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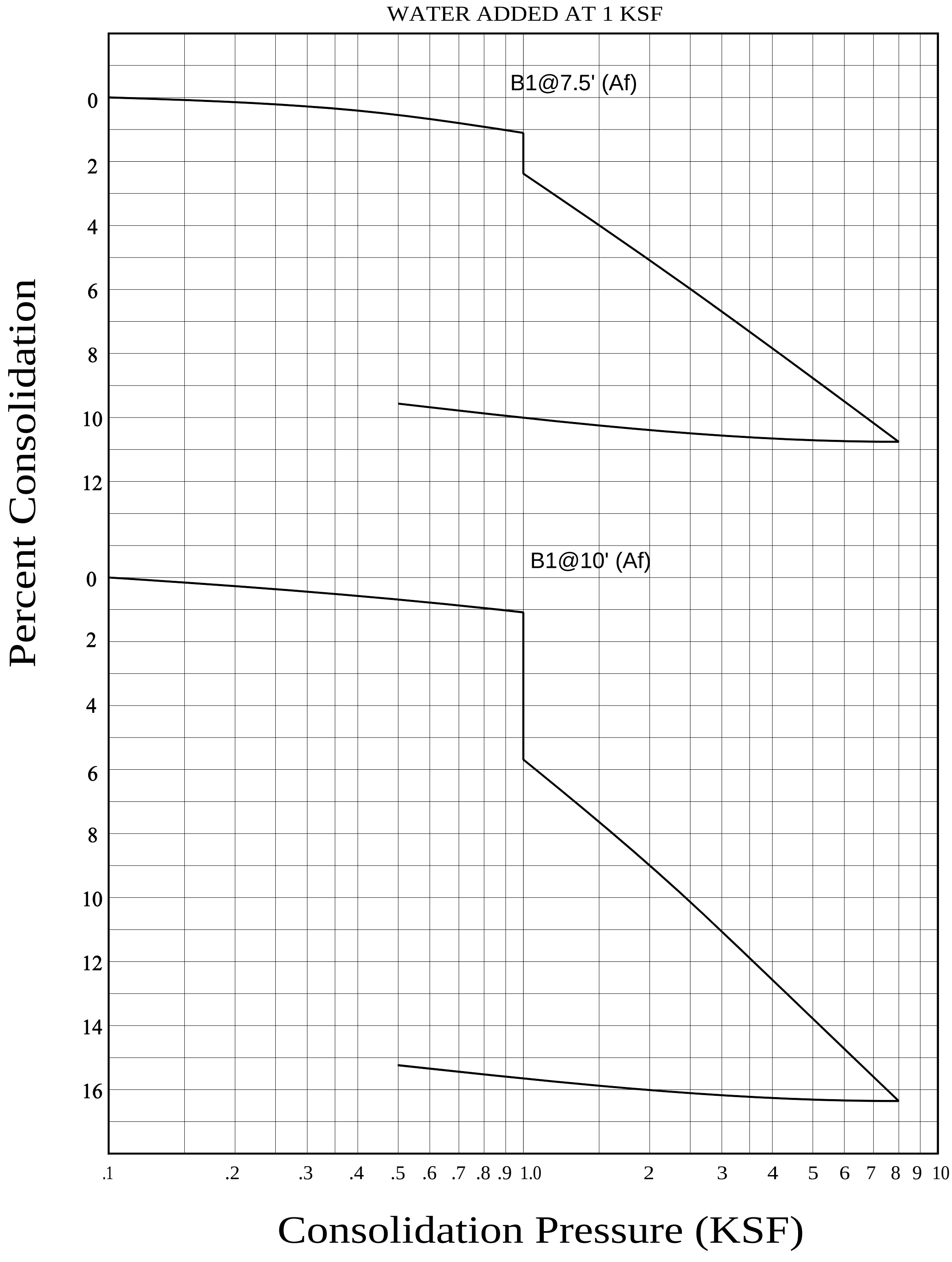
JMT		8000	JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. B15



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CONSOLIDATION TEST RESULTS

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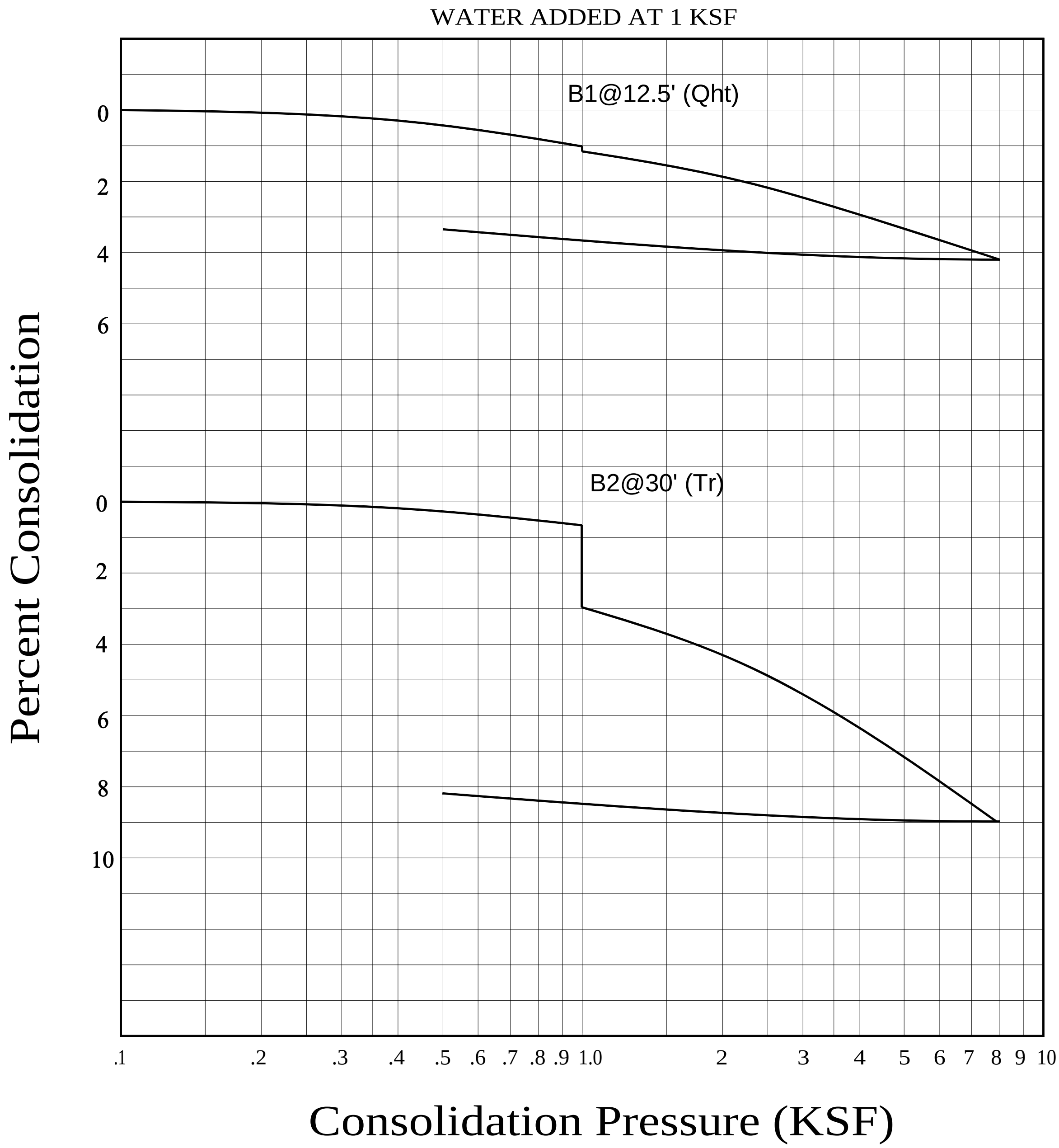
JMT		8000	JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. B16



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CONSOLIDATION TEST RESULTS

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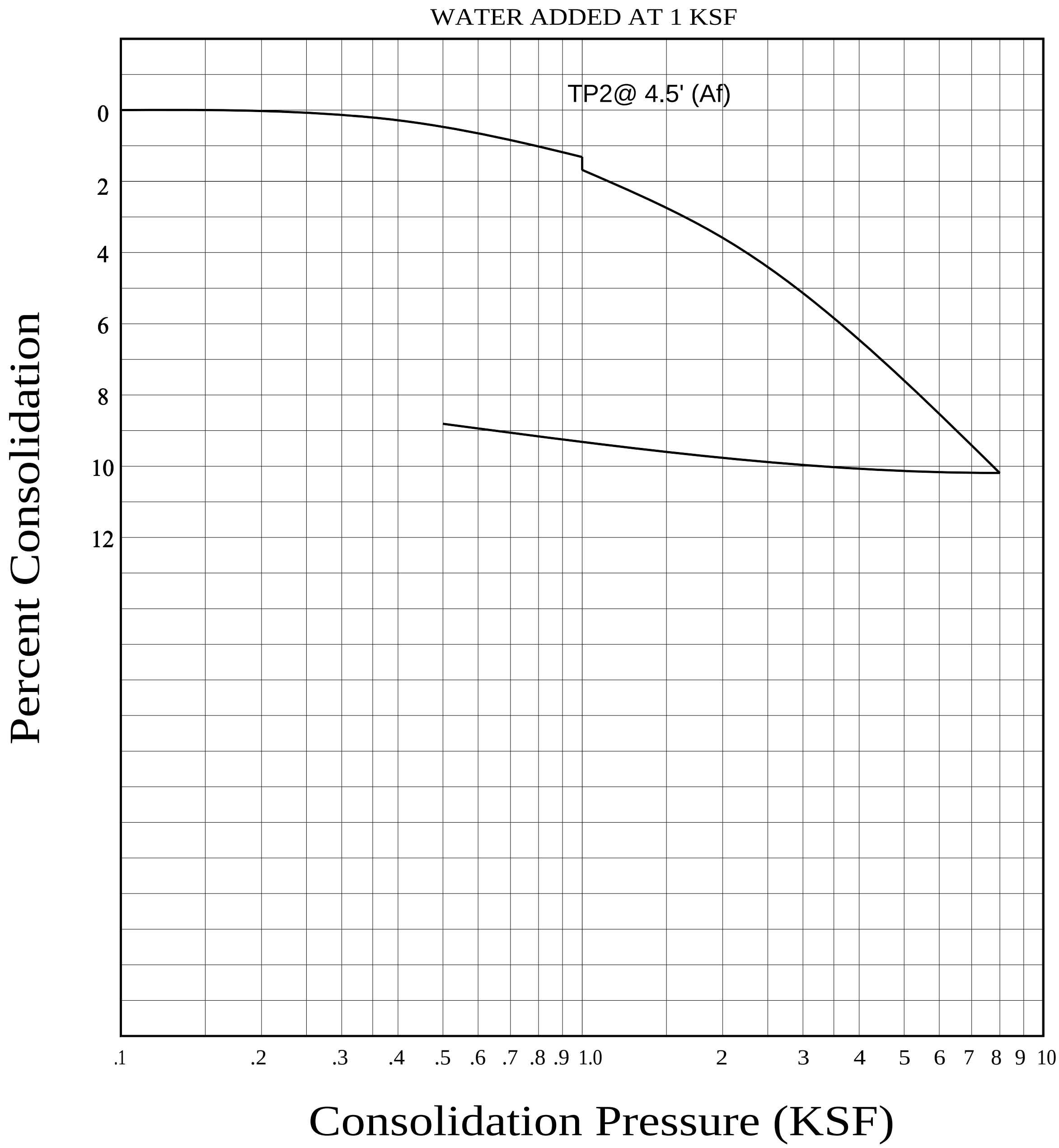
JMT		8000	JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. B17



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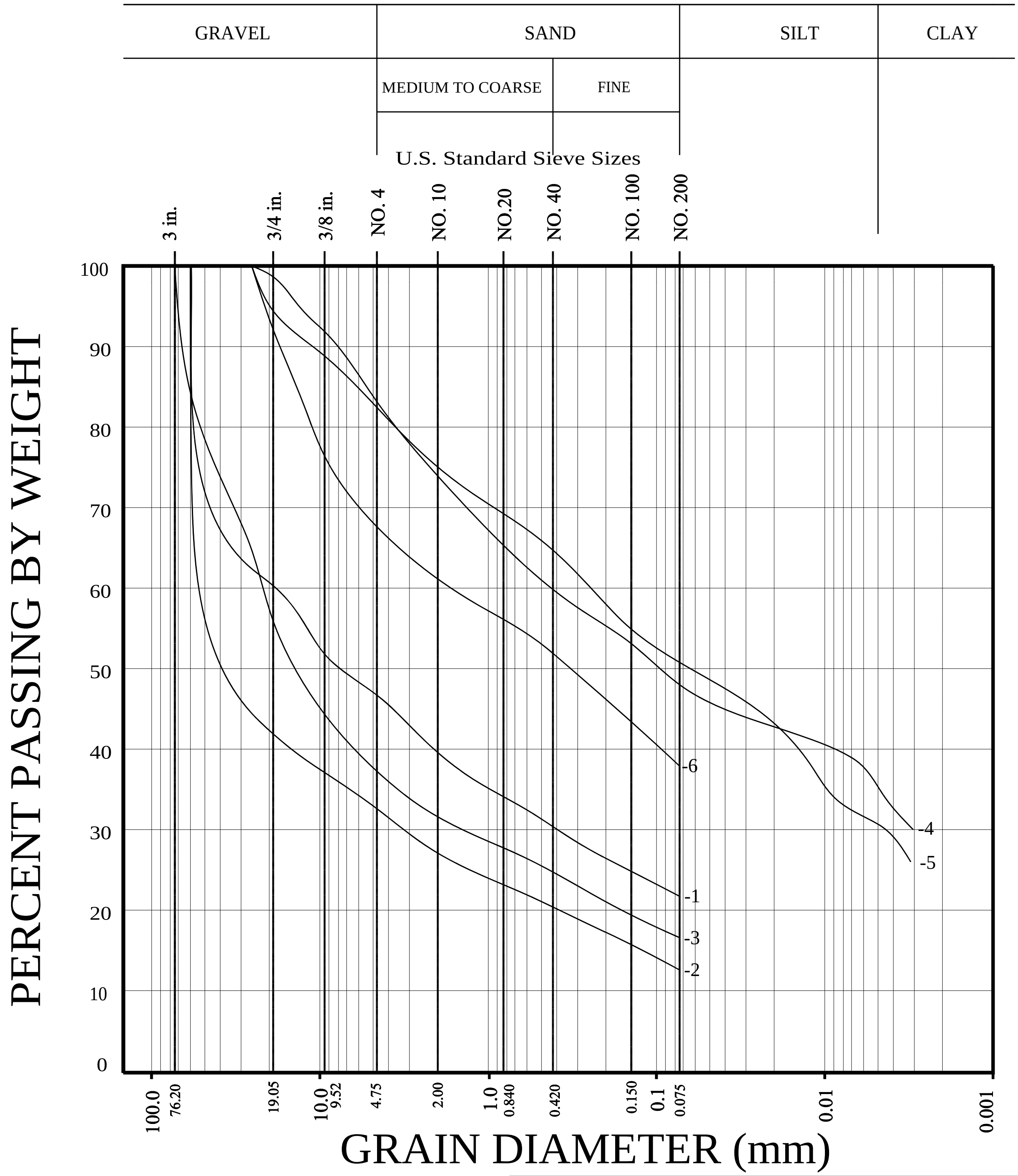
JMT		8000	JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. B18



SAMPLE	UNIFIED SOIL CLASSIFICATION
1- BA1 @ 21'	SC (Qpt)
2- BA1 @ 24'	SC (Qpt)
2- BA2 @ 16-18'	SM-SC (Qpt)

SAMPLE	UNIFIED SOIL CLASSIFICATION
4- B5 @ 0-5'	ML/CL
5- B6 @ 2-5'	ML/CL
6- B1 @ 10-15'	SP-SM (Qht)

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GRAIN SIZE DISTRIBUTION

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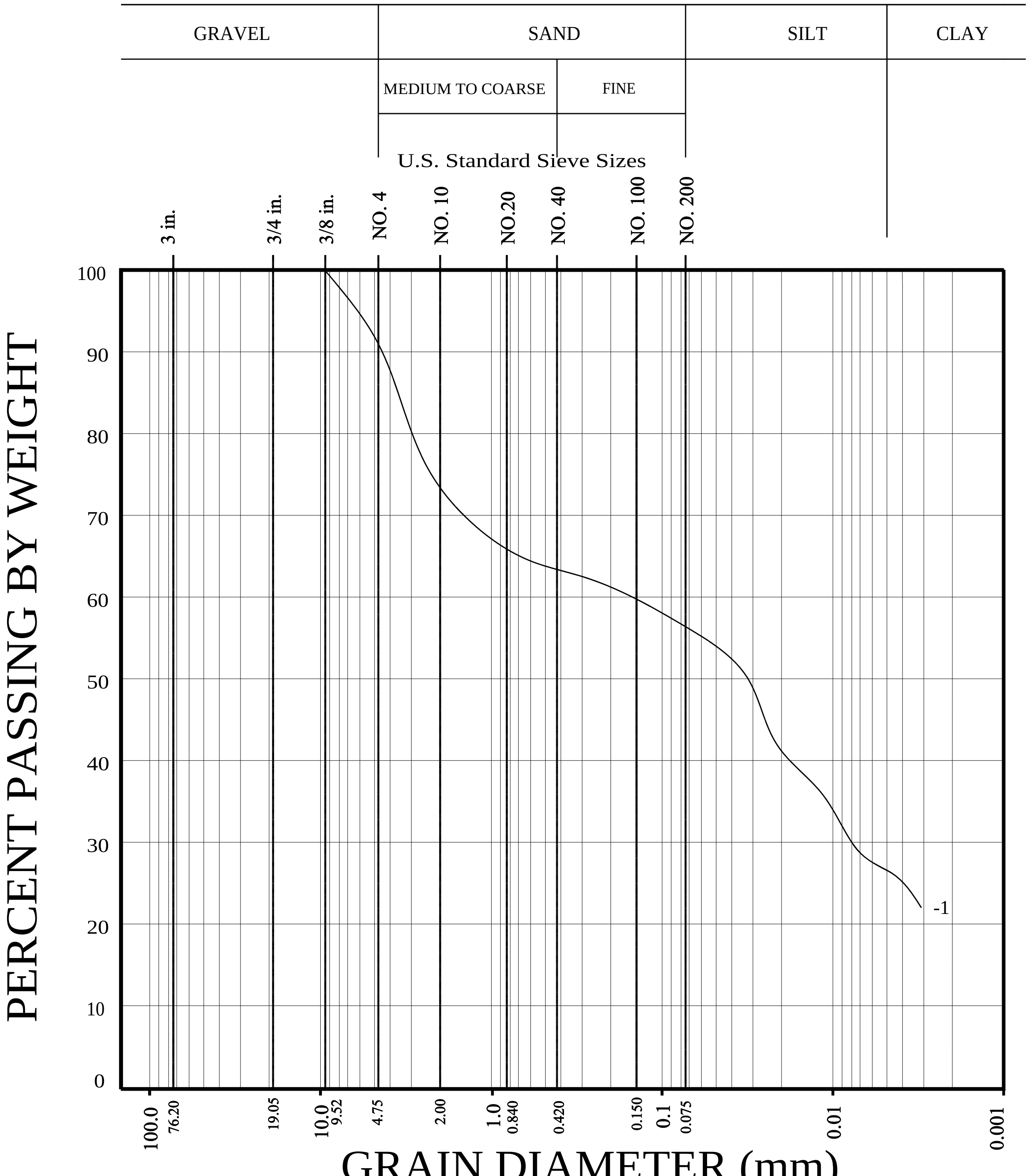
NDB		8000	JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. B19



SAMPLE	UNIFIED SOIL CLASSIFICATION
1- TP2 @ 2-4'	SC (Af)

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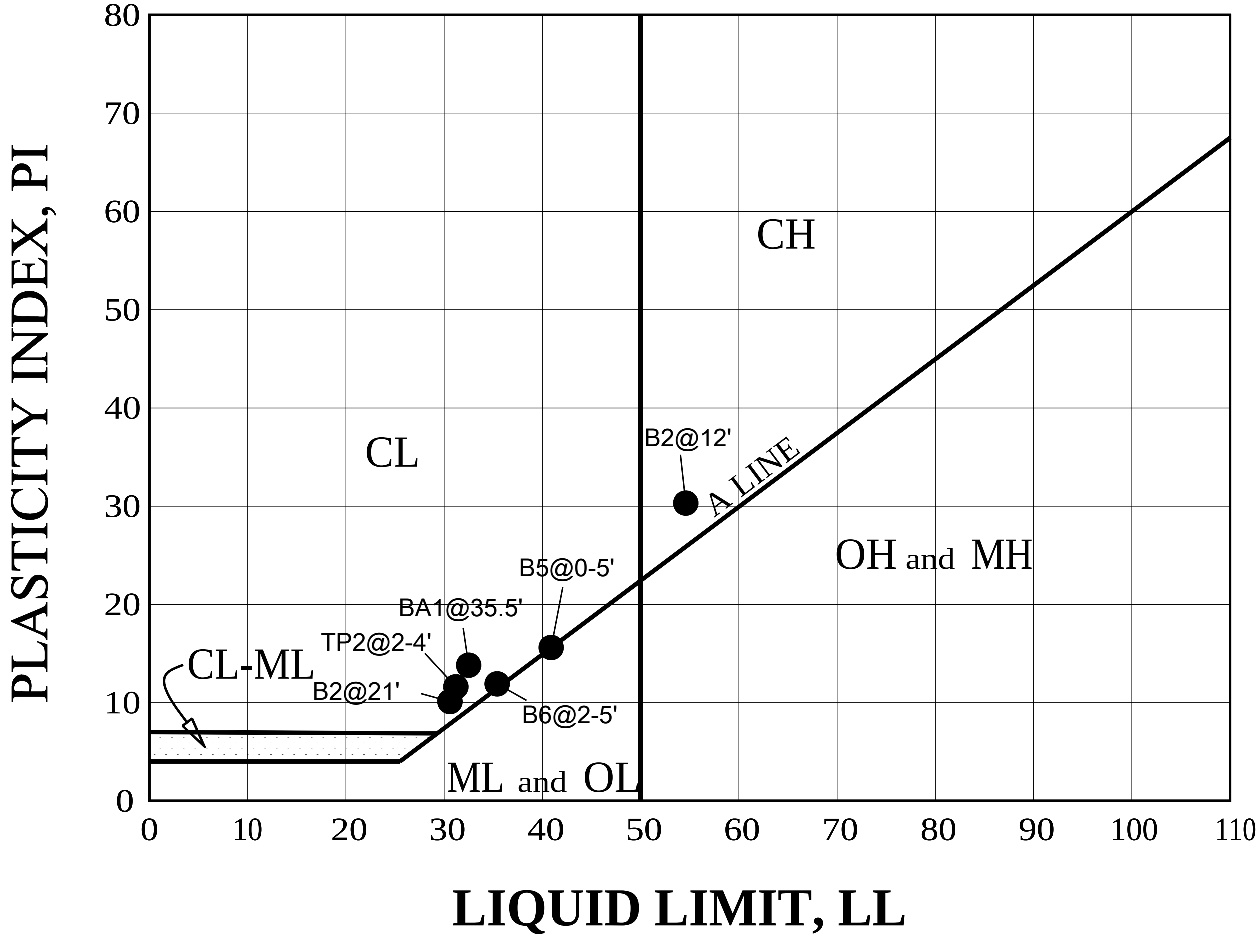
NDB		8000	JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. B20



BORING NUMBER	DEPTH (FEET)	LL	PL	PI	SOIL BEHAVIOR
B6	**2 - 5**	**35.4**	**23.5**	**11.9**	**ML / CL**
B5	**0 - 5**	**40.9**	**25.3**	**15.6**	**ML / CL**
BA1	**35.5**	**32.5**	**18.7**	**13.8**	**CL**
B3	**12**	**54.6**	**24.3**	**30.3**	**CL**
B2	**21**	**30.6**	**20.5**	**10.1**	**CL**
TP2	**2 - 4**	**31.2**	**19.6**	**11.6**	**CL**

*N/P indicates Non-Plastic

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ATTERBERG LIMITS

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JAN 17, 2013 | PROJECT NO. A8919-06-01 | FIG. B21

SUMMARY OF LABORATORY EXPANSION INDEX TEST RESULTS
ASTM D 4829-08A

Sample No.	Moisture Content (%)		Dry Density (pcf)	Expansion Index	*UBC Classification	**CBC Classification
	Before	After				
B6 @ 2-5'	11.5	27.8	98.7	42	Low	Expansive
B5 @ 0-5'	12.8	30.9	96.1	47	Low	Expansive
B3 @ 16' (Qcol)	21.3	24.2	105.5	92	High	Expansive
B2 @ 15.5' (Qht)	16.9	28.3	104.6	142	Very High	Expansive
B2 @ 18' (Tr)	13.0	25.6	103.4	69	Medium	Expansive

* Reference: 1997 Uniform Building Code, Table 18-I-B.

** Reference: 2010 California Building Code, Section 1803.5.3

SUMMARY OF LABORATORY MAXIMUM DENSITY AND
AND OPTIMUM MOISTURE CONTENT TEST RESULTS
ASTM D 1557-12

Sample No.	Soil Description	Maximum Dry Density (pcf)	Optimum Moisture (%)
B6 @ 2-5'	Brown Sandy Silt	109.5	16.5
B5 @ 0-5'	Olive Brown Silt & Clay with Sand	119.5	12.5
B4 @ 12-15'	Bedrock	117.0	13.0
B1 @ 0-5'	Brown Silty Sand	129.5	10.0
B1 @ 10-15'	Olive Brown Sand with Silt	118.0	13.0
TP3 @ 3-4'	Yellowish Brown Sand with Silt & Gravel	135.0*	6.0

* Rock Correction Performed

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LABORATORY TEST RESULTS

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VENTURA COUNTY, CALIFORNIA

JAN 17, 2013 | PROJECT NO. A8919-06-01 | FIG. B22

SUMMARY OF SAND EQUIVALENT TEST RESULTS
ASTM D 2419-09

Sample No.	Soil Type	SAND EQUIVALENT VALUE
BA2@16-18'	Qpt	14.8
B1@10-15'	Qht	7.1
TP3@3-4'	Af	18.1

SUMMARY OF FLEXIBLE WALL PERMEABILITY TEST RESULTS
ASTM D 5084-10

Sample No.	Soil Type	AVERAGE PERMEABILITY
B3@4'	Af	1.77E-6
B2@7'	Af	2.59E-7

ORGANIC CONTENT

Sample No.	ORGANICS CONTENT (%)
B4@4'	22.6
B4@2.5'	2.4

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LABORATORY TEST RESULTS

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VENTURA COUNTY, CALIFORNIA

JMT		8000	JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. B23

SUMMARY OF LABORATORY POTENTIAL OF HYDROGEN (pH) AND RESISTIVITY TEST RESULTS CALIFORNIA TEST NO. 643

Sample No.	Soil Type	pH	Resistivity (ohm centimeters)
B2 @ 21'	Tr	6.06	540 (Extremely Corrosive)
B1 @ 0-5'	Af	7.93	3300 (Corrosive)
TP2 @ 2-4'	Af	7.62	2300 (Highly Corrosive)

SUMMARY OF LABORATORY CHLORIDE CONTENT TEST RESULTS EPA NO. 325.3

Sample No.	Soil Type	Chloride Ion Content (%)
B2 @ 21'	Tr	0.005
B1 @ 0-5'	Af	0.008
TP2 @ 2-4'	Af	0.009

SUMMARY OF LABORATORY WATER SOLUBLE SULFATE TEST RESULTS CALIFORNIA TEST NO. 417

Sample No.	Soil Type	Water Soluble Sulfate (% SO_4)	Sulfate Exposure*
B6 @ 2-5'	- -	0.019	Negligible
B5 @ 0-5'	- -	0.040	Negligible
B4 @ 12-15'	Tr	0.204	Very Severe
B2 @ 15.5'	Qht	0.005	Negligible
B2 @ 21'	Tr	0.236	Very Severe
B1 @ 0-5'	Af	0.008	Negligible
TP2 @ 2-4'	Af	0.006	Negligible

* Reference: 2010 California Building Code, Section 1904.3 and ACI 381 Section 4.3.

GEOCON
WEST, INC.
ENVIRONMENTAL GEOTECHNICAL MATERIALS
3303 N. SAN FERNANDO BLVD. - SUITE 100 - BURBANK, CA 91504
PHONE (818) 841-8388 - FAX (818) 841-1704

CORROSIVITY TEST RESULTS

FRESNO CANYON FLOOD MITIGATION PROJECT
VENTURA COUNTY WATERSHED PROTECTION DISTRICT
VENTURA COUNTY, CALIFORNIA

JMT		8000	JAN 17, 2013	PROJECT NO. A8919-06-01	FIG. B24

APPENDIX C

Tunnelman's Ground Classification of Soils

(Terzaghi, 1950, Modified by Heuer, 1974)

<table>
<tr><th colspan="2">Classification</th><th>Behavior</th><th>Typical Soil Names</th><th>Site Soil Types</th></tr>
<tr><td colspan="2">Firm</td><td>Heading can be advanced without initial support, and final lining can be constructed before ground starts to move.</td><td>Loess above water table; hard clay, marl, cement sand and gravel when not highly stressed.</td><td>Stiff to hard clays</td></tr>
<tr><td rowspan="2">Raveling</td><td>Slow raveling</td><td rowspan="2">Chunks or flakes of material begin to drop out of the arch or walls sometime after the ground has been exposed, due to loosening or to overstress and "brittle" fracture (ground separates or breaks along distinct surfaces, opposed to squeezing ground). In fast raveling ground, the process starts within a few minutes; otherwise, the ground is slow raveling.</td><td>Residual soils or sand with small amounts of binder may be fast raveling below the water table, slow raveling above. Stiff fissured clays may be slow or fast raveling depending upon degree of overstress.</td><td rowspan="2">Medium dense to dense sands</td></tr>
<tr><td>Fast raveling</td><td></td></tr>
<tr><td colspan="2">Squeezing</td><td>Ground squeezes or extrudes plastically into tunnel, without visible fracturing or loss of continuity, and without perceptible increase in water content. Ductile, plastic yield and flow due to overstress.</td><td>Ground with low frictional strength. Rate of squeeze depends on degree of overstress. Occurs at shallow to medium depth in clay of very soft to medium consistency. Stiff to hard clay under high cover may move in combination of raveling at excavation surface and squeezing at depth behind surface.</td><td>Soft to medium stiff clays</td></tr>
<tr><td rowspan="2">Running</td><td>Cohesive, running</td><td rowspan="2">Granular materials without cohesion are unstable at a slope greater than their angle of repose ($\pm 30^{o}$-35^{o}). When exposed at steeper slopes they run like granulated sugar or dune sand until the slope flattens to the angle of repose.</td><td rowspan="2">Clean, dry granular materials. Apparent cohesion in moist sand, or weak cementation in any granular soil, may allow the material to stand for a brief period of raveling before it breaks down and runs. Such behavior is cohesive-running.</td><td>Medium dense to dense sands</td></tr>
<tr><td>Running</td><td></td></tr>
<tr><td colspan="2">Flowing</td><td>A mixture of soil and water flows into the tunnel like a viscous fluid. The material can enter the tunnel from the invert as well as from the face, crown, and walls, and can flow for great distances, completely filling the tunnel in some cases.</td><td>Below water table in silt, sand or gravel without enough clay content to give significant cohesion and plasticity. May also occur in sensitive clay when such material is disturbed.</td><td>Medium dense to dense sands</td></tr>
<tr><td colspan="2">Swelling</td><td>Ground absorbs water, increases in volume, and expands slowly into the tunnel.</td><td>Highly pre-consolidated clay with plasticity index in excess of about 30, generally containing significant percentages of montmorillonite.</td><td>Potentially swelling soils not observed in the borings</td></tr>
</table>

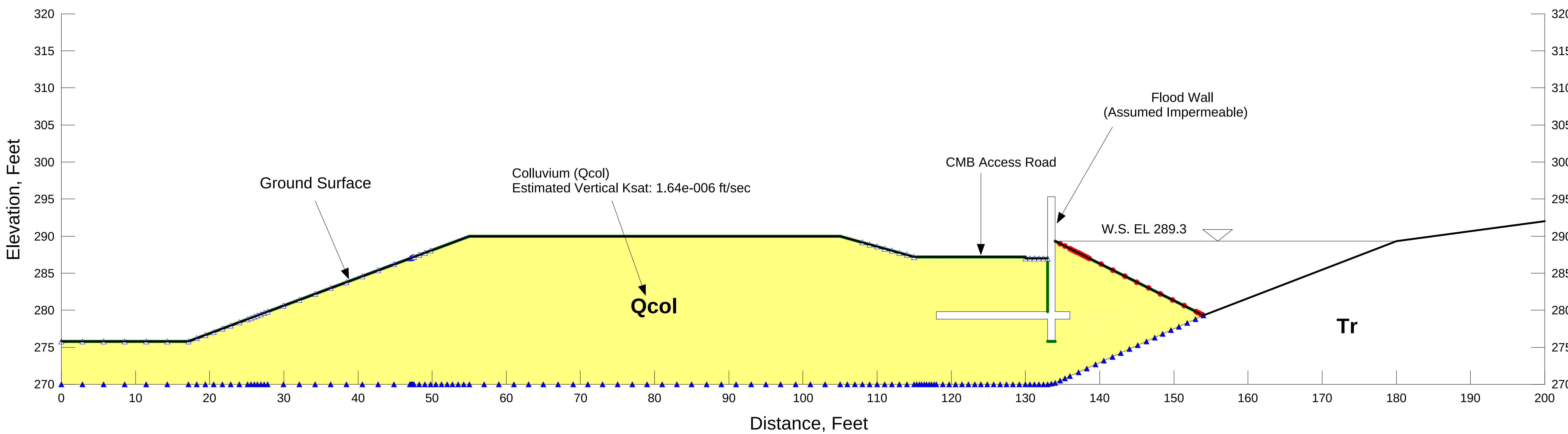
APPENDIX D

Seep/W Analysis

Project Name: Fresno Canyon Flood Mitigation Project
Project No.: A8919-06-01
Date: 12/20/2012
Time: 3:40:53 PM

Analysis Kind: SEEP
Method: SteadyState
Seepage Material Description & Parameters:
Description: Qcol: Hyd K Fn: 1 Vol WC Fn: 1 Ky/Kx Ratio: 1 Direction of Kx: 90
Description: Tr: Assumed Impermeable

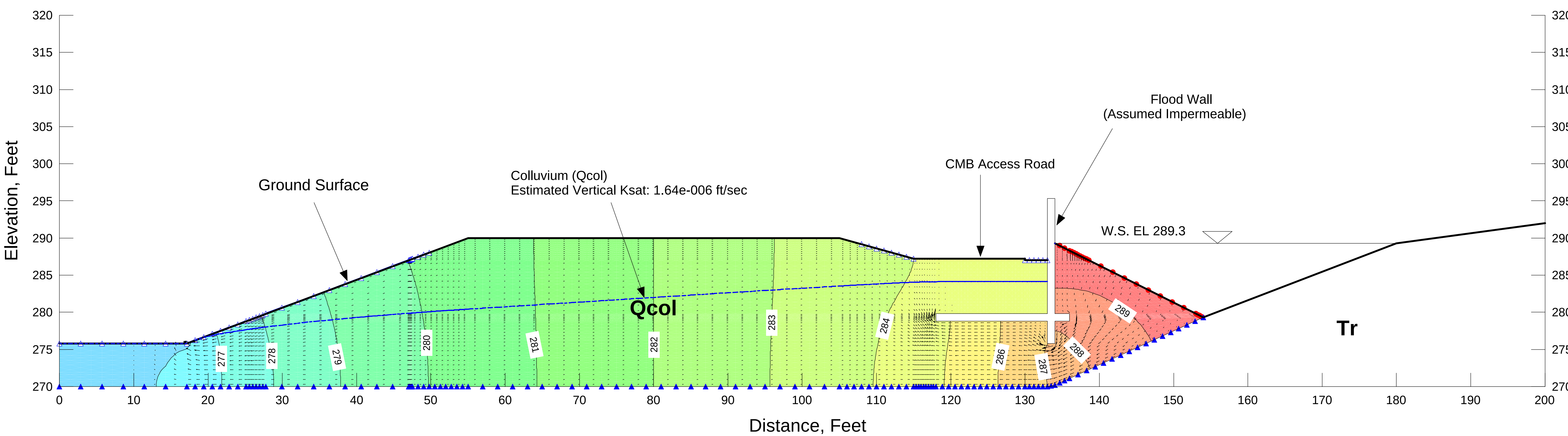
STEADY STATE ANALYSIS
Defined Cross-section



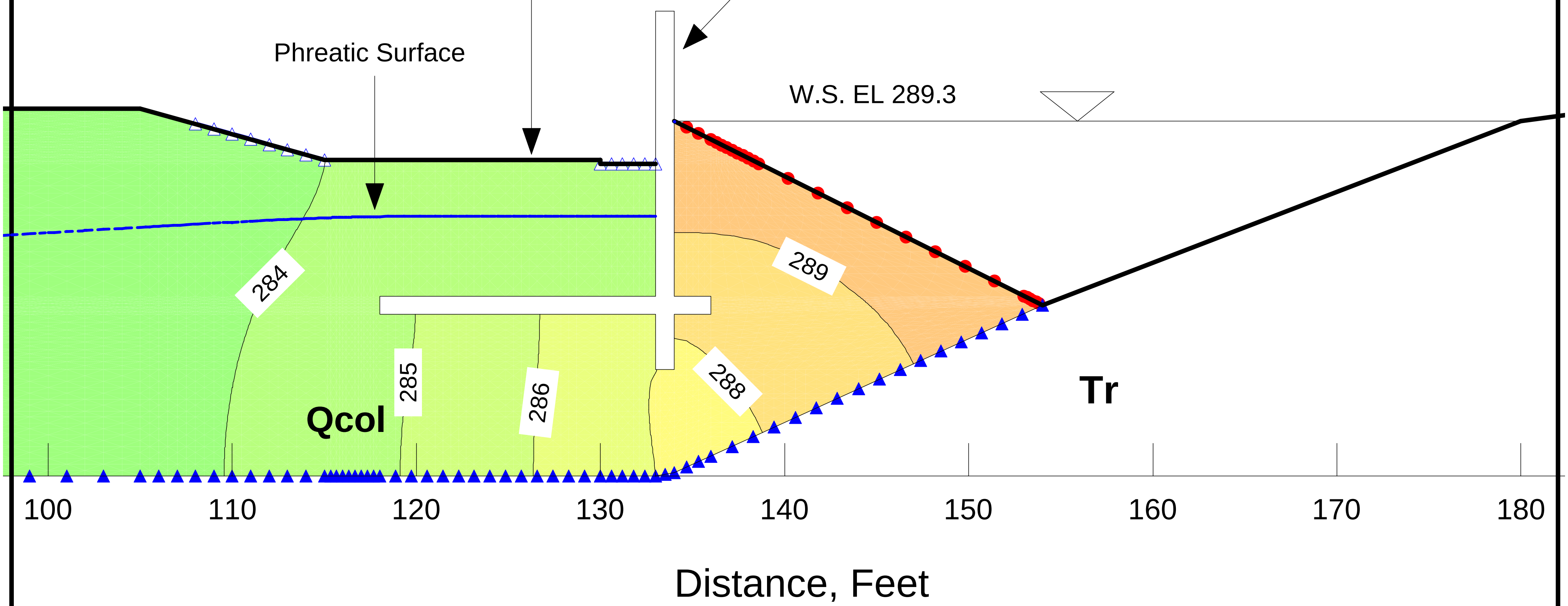
Project Name: Fresno Canyon Flood Mitigation Project
Project No.: A8919-06-01
Date: 12/20/2012
Time: 3:40:53 PM

Analysis Kind: SEEP
Method: SteadyState
Seepage Material Description & Parameters:
Description: Qcol: Hyd K Fn: 1 Vol WC Fn: 1 Ky/Kx Ratio: 1 Direction of Kx: 90
Description: Tr: Assumed Impermeable

STEADY STATE ANALYSIS
Total Head Contours (ft)



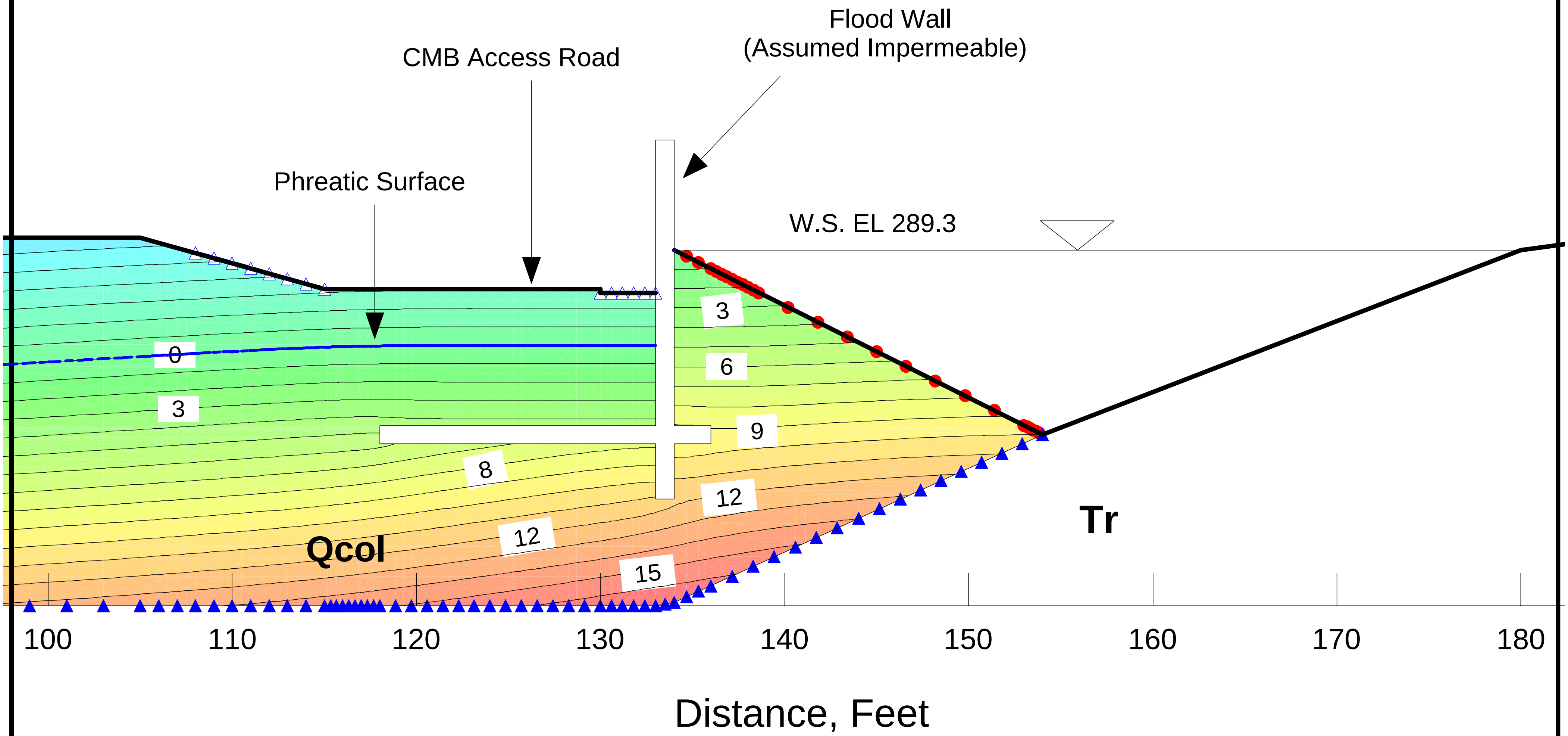
Total Head Contours (ft)



Project No. A8919-06-01

Figure D3

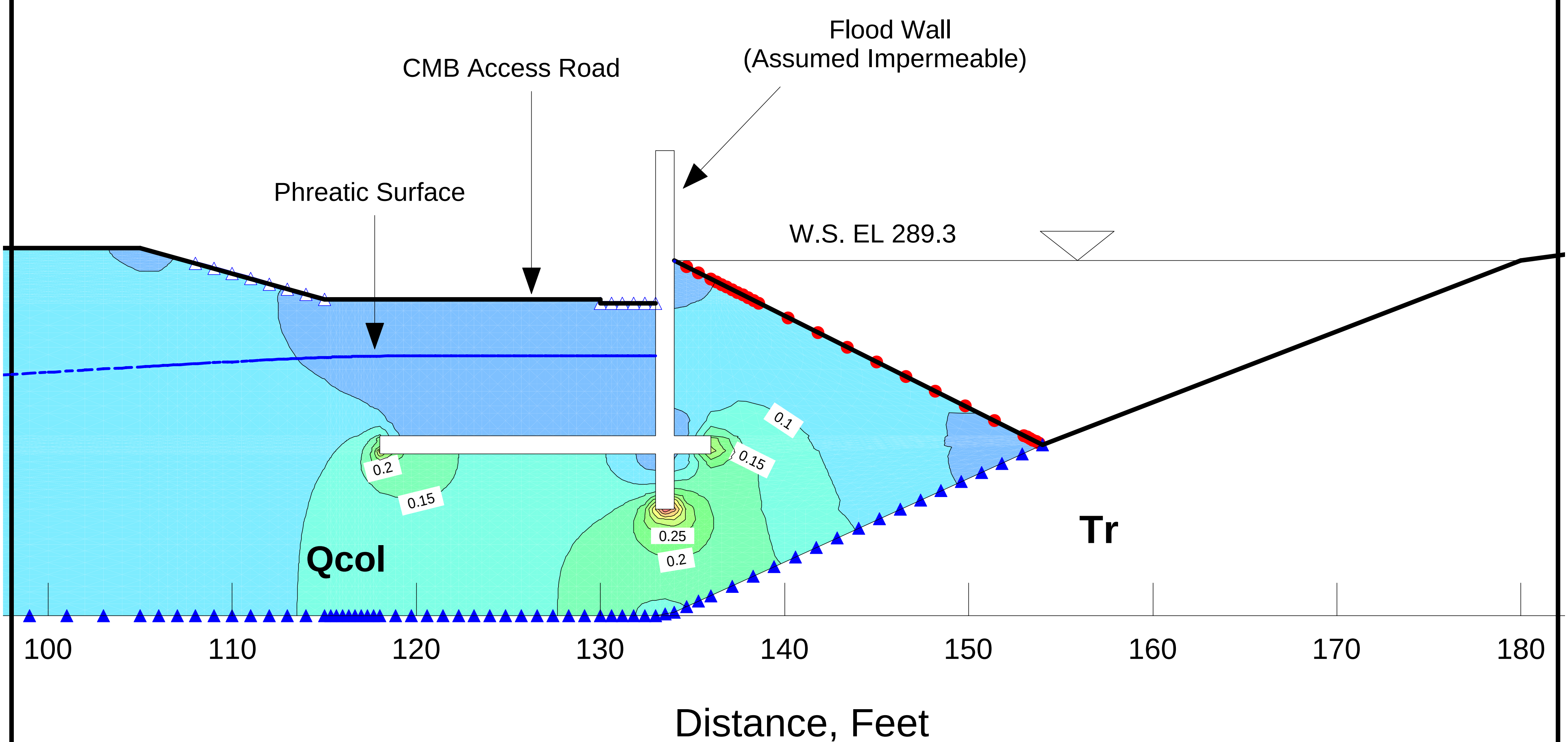
Pressure Head Contours (ft)



Project No. A8919-06-01

Figure D4

XY-Gradient Contours



Project No. A8919-06-01

Figure D5

United States Department of Agriculture

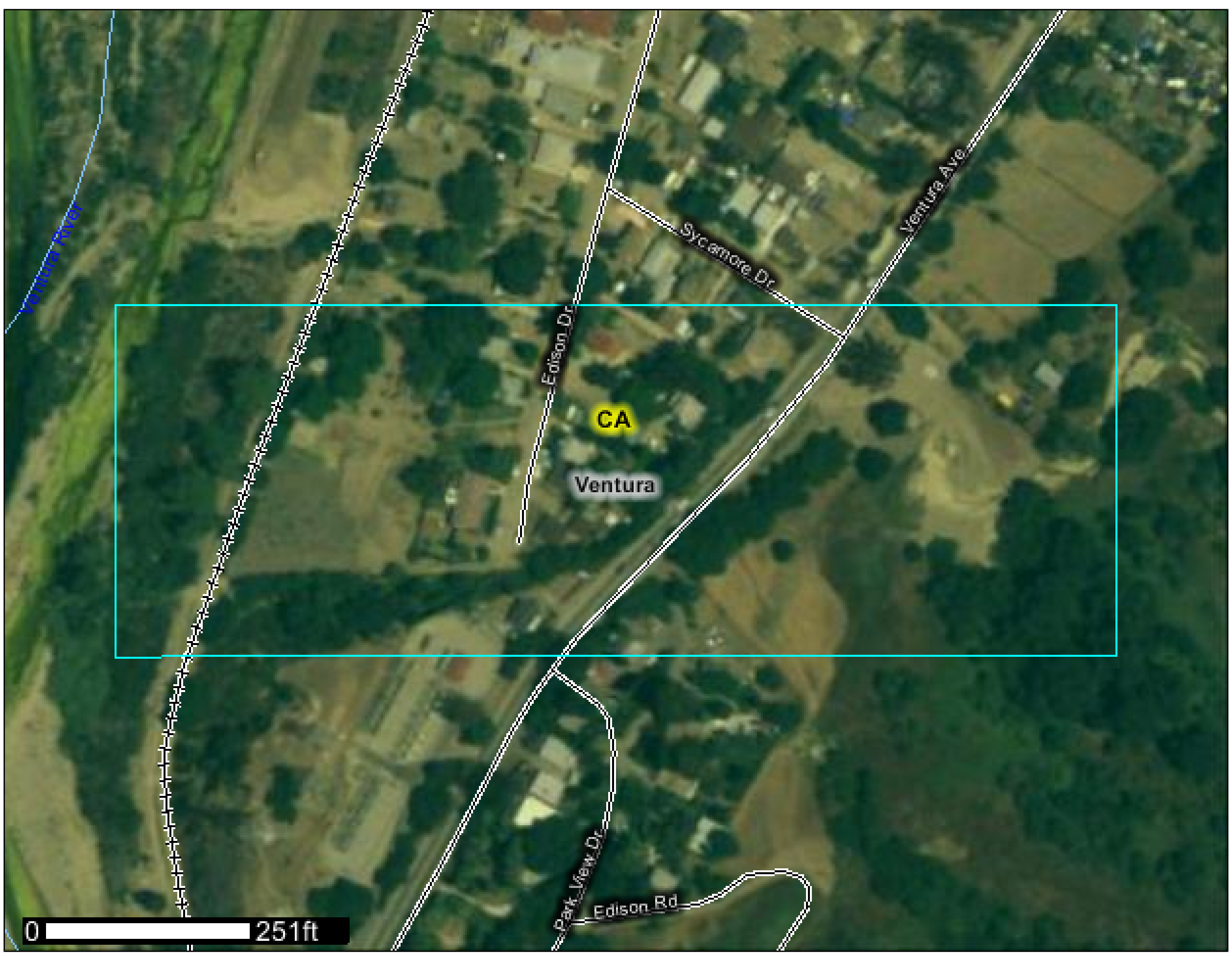
NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Ventura Area, California



January 18, 2013

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://soils.usda.gov/sqi/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://soils.usda.gov/contact/state_offices/).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Soil Data Mart Web site or the NRCS Web Soil Survey. The Soil Data Mart is the data storage site for the official soil survey information.

for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map

Map Scale: 1:2,040 if printed on A size (8.5" x 11") sheet.

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Units

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other

Special Line Features
- Gully
- Short Steep Slope
- Other

Political Features
- Cities

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:2,040 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 11N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Ventura Area, California
Survey Area Data: Version 6, Jan 3, 2008

Date(s) aerial images were photographed: 6/7/2005

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Ventura Area, California (CA674)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
DbF	Diablo clay, 30 to 50 percent slopes	4.4	37.0%
MoA	Mocho loam, 0 to 2 percent slopes	5.2	43.8%
Rw	Riverwash	2.3	19.2%
Totals for Area of Interest		**11.9**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Ventura Area, California

DbF—Diablo clay, 30 to 50 percent slopes

Map Unit Setting

Landscape: Uplands
Elevation: 30 to 3,000 feet
Mean annual precipitation: 12 to 35 inches
Mean annual air temperature: 57 to 61 degrees F
Frost-free period: 200 to 320 days

Map Unit Composition

Diablo and similar soils: 85 percent
Minor components: 15 percent

Description of Diablo

Setting

Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Residuum weathered from calcareous shale

Properties and qualities

Slope: 30 to 50 percent
Depth to restrictive feature: 40 to 60 inches to paralithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
Available water capacity: Moderate (about 6.0 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability (nonirrigated): 6e
Hydrologic Soil Group: D

Typical profile

0 to 28 inches: Clay
28 to 40 inches: Clay loam
40 to 44 inches: Weathered bedrock

Minor Components

San benito

Percent of map unit: 5 percent

Nacimiento

Percent of map unit: 5 percent

Gazos

Percent of map unit: 5 percent

MoA—Mocho loam, 0 to 2 percent slopes

Map Unit Setting

Landscape: Alluvial plains, valleys
Elevation: 0 to 3,500 feet
Mean annual precipitation: 12 to 30 inches
Mean annual air temperature: 59 degrees F
Frost-free period: 200 to 350 days

Map Unit Composition

Mocho and similar soils: 85 percent
Minor components: 11 percent

Description of Mocho

Setting

Landform: Alluvial fans
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from sedimentary rock

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: High (about 9.9 inches)

Interpretive groups

Farmland classification: Prime farmland if irrigated
Land capability classification (irrigated): 1
Land capability (nonirrigated): 3c
Hydrologic Soil Group: B

Typical profile

0 to 16 inches: Loam
16 to 60 inches: Loam

Minor Components

Anacapa

Percent of map unit: 4 percent

Sorrento

Percent of map unit: 4 percent

Hueneme

Percent of map unit: 3 percent

Rw—Riverwash

Map Unit Setting

Landscape: Valleys

Map Unit Composition

Riverwash: 90 percent
Minor components: 10 percent

Description of Riverwash

Setting

Landform: Drainageways
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Properties and qualities

Slope: 0 to 5 percent
Drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: About 0 to 60 inches
Frequency of flooding: Frequent
Available water capacity: Very low (about 2.9 inches)

Interpretive groups

Farmland classification: Not prime farmland
Land capability (nonirrigated): 8
Hydrologic Soil Group: D

Typical profile

0 to 6 inches: Sand
6 to 60 inches: Stratified coarse sand to sandy loam

Minor Components

Corralitos

Percent of map unit: 3 percent

Sandy alluvial land

Percent of map unit: 3 percent

Cortina

Percent of map unit: 2 percent

Metz

Percent of map unit: 2 percent

Soil Information for All Uses

Soil Properties and Qualities

The Soil Properties and Qualities section includes various soil properties and qualities displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each property or quality.

Soil Erosion Factors

Soil Erosion Factors are soil properties and interpretations used in evaluating the soil for potential erosion. Example soil erosion factors can include K factor for the whole soil or on a rock free basis, T factor, wind erodibility group and wind erodibility index.

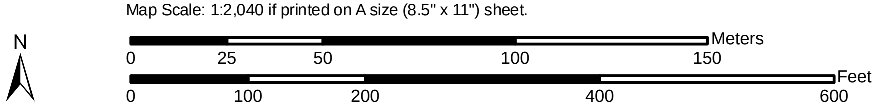
K Factor, Whole Soil

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

"Erosion factor Kw (whole soil)" indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Custom Soil Resource Report
Map—K Factor, Whole Soil

Map Scale: 1:2,040 if printed on A size (8.5" x 11") sheet.



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Units

Soil Ratings

.02

.05

.10

.15

.17

.20

.24

.28

.32

.37

.43

.49

.55

.64

Not rated or not available

Political Features

Cities

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

MAP INFORMATION

Map Scale: 1:2,040 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 11N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Ventura Area, California
Survey Area Data: Version 6, Jan 3, 2008

Date(s) aerial images were photographed: 6/7/2005

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—K Factor, Whole Soil

K Factor, Whole Soil— Summary by Map Unit — Ventura Area, California (CA674)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
DbF	Diablo clay, 30 to 50 percent slopes	.24	4.4	37.0%
MoA	Mocho loam, 0 to 2 percent slopes	.20	5.2	43.8%
Rw	Riverwash	.15	2.3	19.2%
Totals for Area of Interest			**11.9**	**100.0%**

Rating Options—K Factor, Whole Soil

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

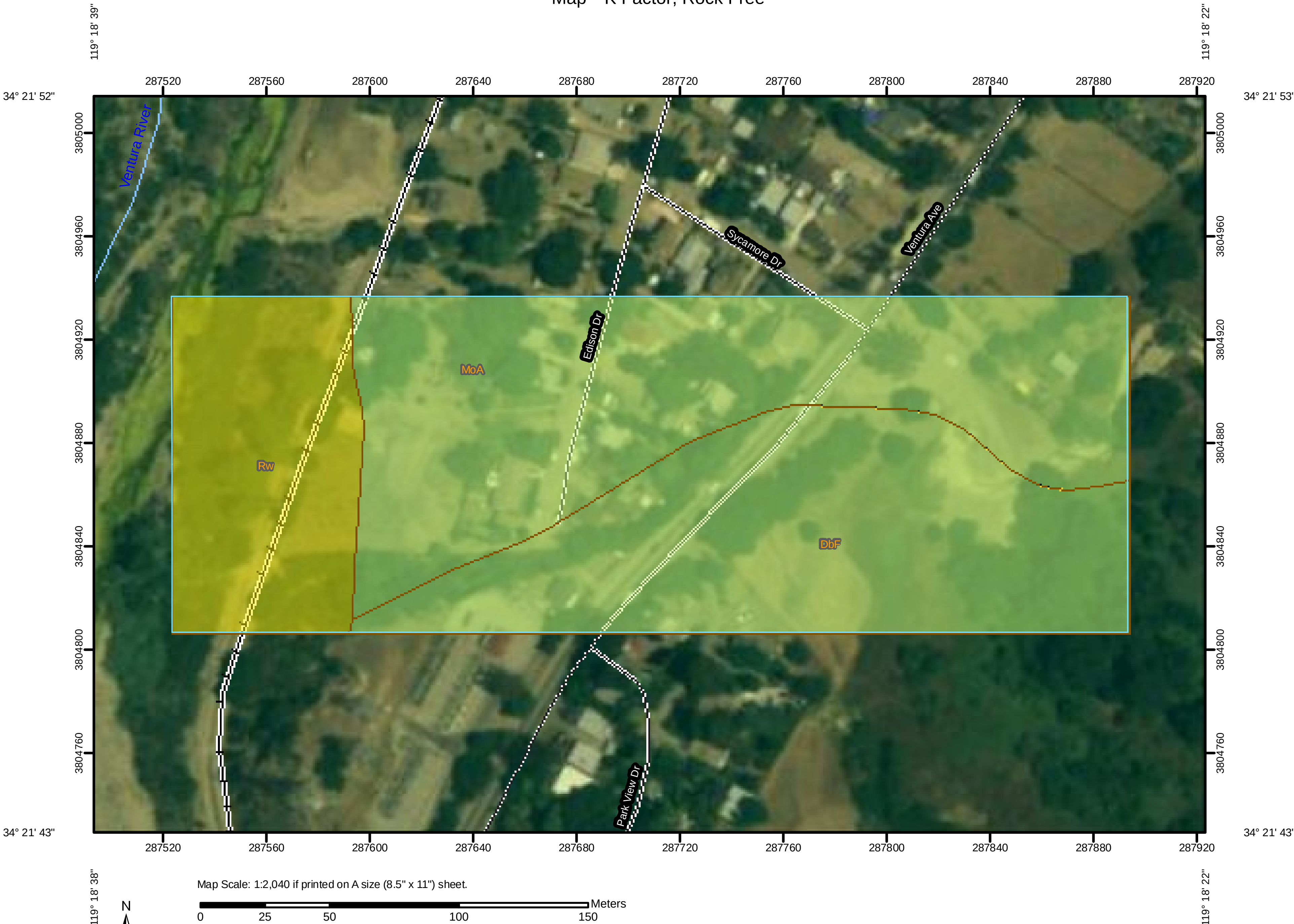
Layer Options: Surface Layer

K Factor, Rock Free

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

"Erosion factor Kf (rock free)" indicates the erodibility of the fine-earth fraction, or the material less than 2 millimeters in size.

Custom Soil Resource Report
Map—K Factor, Rock Free



Map Scale: 1:2,040 if printed on A size (8.5" x 11") sheet.

N

Meters: 0, 25, 50, 100, 150

Feet: 0, 100, 200, 400, 600

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Units

Soil Ratings

- .02
- .05
- .10
- .15
- .17
- .20
- .24
- .28
- .32
- .37
- .43
- .49
- .55
- .64
- Not rated or not available

Political Features

- Cities

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

MAP INFORMATION

Map Scale: 1:2,040 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 11N NAD83

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Table—K Factor, Rock Free

K Factor, Rock Free— Summary by Map Unit — Ventura Area, California (CA674)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
DbF	Diablo clay, 30 to 50 percent slopes	.24	4.4	37.0%
MoA	Mocho loam, 0 to 2 percent slopes	.24	5.2	43.8%
Rw	Riverwash	.17	2.3	19.2%
Totals for Area of Interest			**11.9**	**100.0%**

Rating Options—K Factor, Rock Free

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Layer Options: Surface Layer

Soil Qualities and Features

Soil qualities are behavior and performance attributes that are not directly measured, but are inferred from observations of dynamic conditions and from soil properties. Example soil qualities include natural drainage, and frost action. Soil features are attributes that are not directly part of the soil. Example soil features include slope and depth to restrictive layer. These features can greatly impact the use and management of the soil.

Hydrologic Soil Group

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

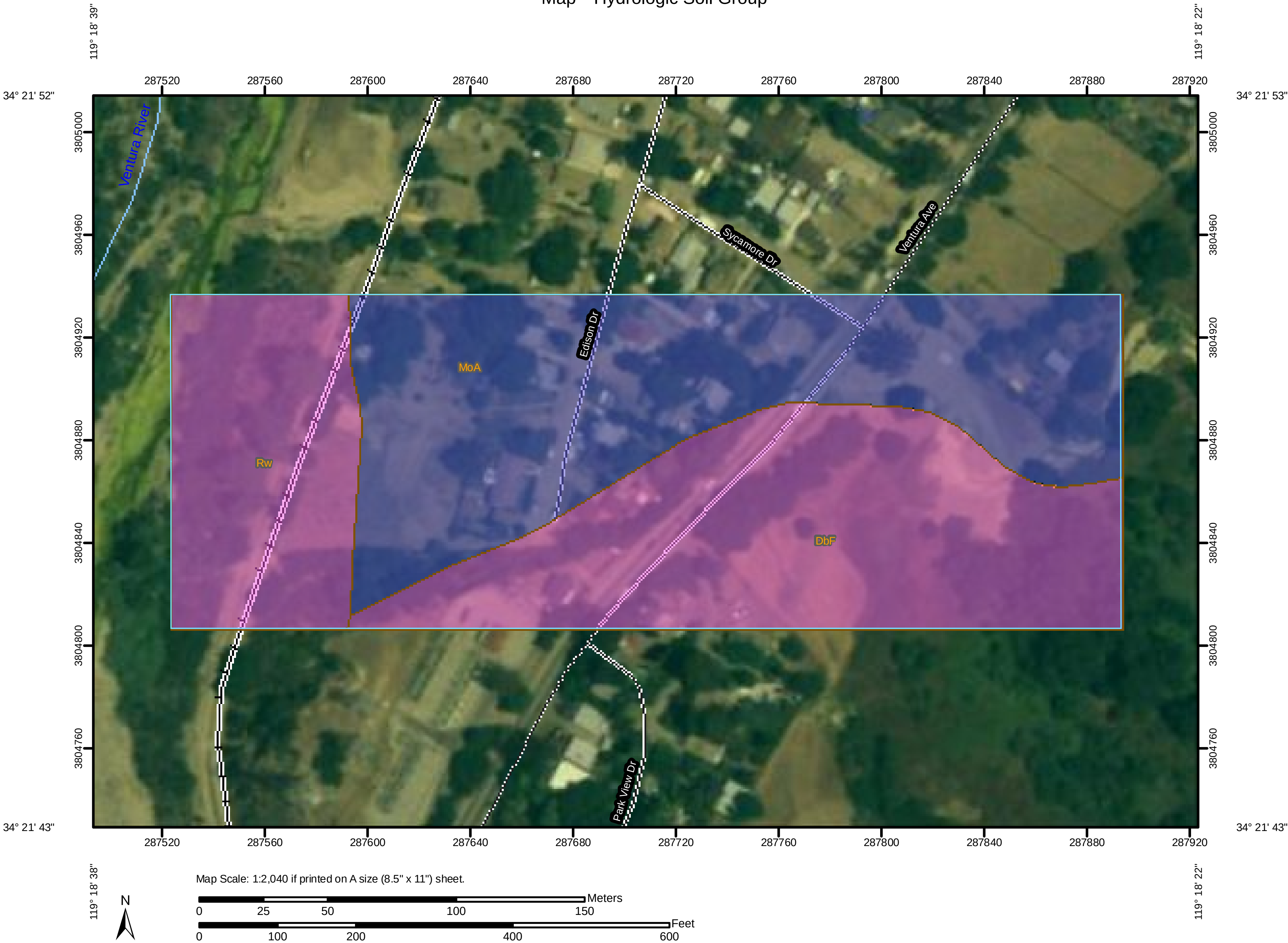
Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Map—Hydrologic Soil Group



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Units

Soil Ratings

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Political Features

Cities

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

MAP INFORMATION

Map Scale: 1:2,040 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

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Totals for Area of Interest			**11.9**	**100.0%**

Rating Options—Hydrologic Soil Group

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

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Glossary

Many of the terms relating to landforms, geology, and geomorphology are defined in more detail in the “National Soil Survey Handbook.”

ABC soil

A soil having an A, a B, and a C horizon.

Ablation till

Loose, relatively permeable earthy material deposited during the downwasting of nearly static glacial ice, either contained within or accumulated on the surface of the glacier.

AC soil

A soil having only an A and a C horizon. Commonly, such soil formed in recent alluvium or on steep, rocky slopes.

Aeration, soil

The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil

Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alkali (sodic) soil

A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

Alluvial cone

A semiconical type of alluvial fan having very steep slopes. It is higher, narrower, and steeper than a fan and is composed of coarser and thicker layers of material deposited by a combination of alluvial episodes and (to a much lesser degree) landslides (debris flow). The coarsest materials tend to be concentrated at the apex of the cone.

Alluvial fan

A low, outspread mass of loose materials and/or rock material, commonly with gentle slopes. It is shaped like an open fan or a segment of a cone. The material was deposited by a stream at the place where it issues from a narrow mountain valley or upland valley or where a tributary stream is near or at its junction with the main stream. The fan is steepest near its apex, which points upstream, and slopes gently and convexly outward (downstream) with a gradual decrease in gradient.

Alluvium

Unconsolidated material, such as gravel, sand, silt, clay, and various mixtures of these, deposited on land by running water.

Alpha,alpha-dipyridyl

A compound that when dissolved in ammonium acetate is used to detect the presence of reduced iron (Fe II) in the soil. A positive reaction implies reducing conditions and the likely presence of redoximorphic features.

Animal unit month (AUM)

The amount of forage required by one mature cow of approximately 1,000 pounds weight, with or without a calf, for 1 month.

Aquic conditions

Current soil wetness characterized by saturation, reduction, and redoximorphic features.

Argillic horizon

A subsoil horizon characterized by an accumulation of illuvial clay.

Arroyo

The flat-floored channel of an ephemeral stream, commonly with very steep to vertical banks cut in unconsolidated material. It is usually dry but can be transformed into a temporary watercourse or short-lived torrent after heavy rain within the watershed.

Aspect

The direction toward which a slope faces. Also called slope aspect.

Association, soil

A group of soils or miscellaneous areas geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

Available water capacity (available moisture capacity)

The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as:

Very low: 0 to 3
Low: 3 to 6
Moderate: 6 to 9
High: 9 to 12
Very high: More than 12

Backslope

The position that forms the steepest and generally linear, middle portion of a hillslope. In profile, backslopes are commonly bounded by a convex shoulder above and a concave footslope below.

Backswamp

A flood-plain landform. Extensive, marshy or swampy, depressed areas of flood plains between natural levees and valley sides or terraces.

Badland

A landscape that is intricately dissected and characterized by a very fine drainage network with high drainage densities and short, steep slopes and narrow interfluves. Badlands develop on surfaces that have little or no vegetative cover overlying unconsolidated or poorly cemented materials (clays, silts, or sandstones) with, in some cases, soluble minerals, such as gypsum or halite.

Bajada

A broad, gently inclined alluvial piedmont slope extending from the base of a mountain range out into a basin and formed by the lateral coalescence of a series of alluvial fans. Typically, it has a broadly undulating transverse profile, parallel to the mountain front, resulting from the convexities of component fans. The term is generally restricted to constructional slopes of intermontane basins.

Basal area

The area of a cross section of a tree, generally referring to the section at breast height and measured outside the bark. It is a measure of stand density, commonly expressed in square feet.

Base saturation

The degree to which material having cation-exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, and K), expressed as a percentage of the total cation-exchange capacity.

Base slope (geomorphology)

A geomorphic component of hills consisting of the concave to linear (perpendicular to the contour) slope that, regardless of the lateral shape, forms an apron or wedge at the bottom of a hillside dominated by colluvium and slope-wash sediments (for example, slope alluvium).

Bedding plane

A planar or nearly planar bedding surface that visibly separates each successive layer of stratified sediment or rock (of the same or different lithology) from the preceding or following layer; a plane of deposition. It commonly marks a change in the circumstances of deposition and may show a parting, a color difference, a change in particle size, or various combinations of these. The term is commonly applied to any bedding surface, even one that is conspicuously bent or deformed by folding.

Bedding system

A drainage system made by plowing, grading, or otherwise shaping the surface of a flat field. It consists of a series of low ridges separated by shallow, parallel dead furrows.

Bedrock

The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Bedrock-controlled topography

A landscape where the configuration and relief of the landforms are determined or strongly influenced by the underlying bedrock.

Bench terrace

A raised, level or nearly level strip of earth constructed on or nearly on a contour, supported by a barrier of rocks or similar material, and designed to make the soil suitable for tillage and to prevent accelerated erosion.

Bisequum

Two sequences of soil horizons, each of which consists of an illuvial horizon and the overlying eluvial horizons.

Blowout (map symbol)

A saucer-, cup-, or trough-shaped depression formed by wind erosion on a preexisting dune or other sand deposit, especially in an area of shifting sand or loose soil or where protective vegetation is disturbed or destroyed. The adjoining accumulation of sand derived from the depression, where recognizable, is commonly included. Blowouts are commonly small.

Borrow pit (map symbol)

An open excavation from which soil and underlying material have been removed, usually for construction purposes.

Bottom land

An informal term loosely applied to various portions of a flood plain.

Boulders

Rock fragments larger than 2 feet (60 centimeters) in diameter.

Breaks

A landscape or tract of steep, rough or broken land dissected by ravines and gullies and marking a sudden change in topography.

Breast height

An average height of 4.5 feet above the ground surface; the point on a tree where diameter measurements are ordinarily taken.

Brush management

Use of mechanical, chemical, or biological methods to make conditions favorable for reseeding or to reduce or eliminate competition from woody vegetation and thus allow understory grasses and forbs to recover. Brush management increases forage production and thus reduces the hazard of erosion. It can improve the habitat for some species of wildlife.

Butte

An isolated, generally flat-topped hill or mountain with relatively steep slopes and talus or precipitous cliffs and characterized by summit width that is less than the height of bounding escarpments; commonly topped by a caprock of resistant material and representing an erosion remnant carved from flat-lying rocks.

Cable yarding

A method of moving felled trees to a nearby central area for transport to a processing facility. Most cable yarding systems involve use of a drum, a pole, and wire cables in an arrangement similar to that of a rod and reel used for fishing. To reduce friction and soil disturbance, felled trees generally are reeled in while one end is lifted or the entire log is suspended.

Calcareous soil

A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Caliche

A general term for a prominent zone of secondary carbonate accumulation in surficial materials in warm, subhumid to arid areas. Caliche is formed by both geologic and pedologic processes. Finely crystalline calcium carbonate forms a nearly continuous surface-coating and void-filling medium in geologic (parent) materials. Cementation ranges from weak in nonindurated forms to very strong in indurated forms. Other minerals (e.g., carbonates, silicate, and sulfate) may occur as accessory cements. Most petrocalcic horizons and some calcic horizons are caliche.

California bearing ratio (CBR)

The load-supporting capacity of a soil as compared to that of standard crushed limestone, expressed as a ratio. First standardized in California. A soil having a CBR of 16 supports 16 percent of the load that would be supported by standard crushed limestone, per unit area, with the same degree of distortion.

Canopy

The leafy crown of trees or shrubs. (See Crown.)

Canyon

A long, deep, narrow valley with high, precipitous walls in an area of high local relief.

Capillary water

Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Catena

A sequence, or “chain,” of soils on a landscape that formed in similar kinds of parent material and under similar climatic conditions but that have different characteristics as a result of differences in relief and drainage.

Cation

An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity

The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity but is more precise in meaning.

Catsteps

See Terracettes.

Cement rock

Shaly limestone used in the manufacture of cement.

Channery soil material

Soil material that has, by volume, 15 to 35 percent thin, flat fragments of sandstone, shale, slate, limestone, or schist as much as 6 inches (15 centimeters) along the longest axis. A single piece is called a channer.

Chemical treatment

Control of unwanted vegetation through the use of chemicals.

Chiseling

Tillage with an implement having one or more soil-penetrating points that shatter or loosen hard, compacted layers to a depth below normal plow depth.

Cirque

A steep-walled, semicircular or crescent-shaped, half-bowl-like recess or hollow, commonly situated at the head of a glaciated mountain valley or high on the side of a mountain. It was produced by the erosive activity of a mountain glacier. It commonly contains a small round lake (tarn).

Clay

As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay depletions

See Redoximorphic features.

Clay film

A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Clay spot (map symbol)

A spot where the surface texture is silty clay or clay in areas where the surface layer of the soils in the surrounding map unit is sandy loam, loam, silt loam, or coarser.

Claypan

A dense, compact subsoil layer that contains much more clay than the overlying materials, from which it is separated by a sharply defined boundary. The layer restricts the downward movement of water through the soil. A claypan is commonly hard when dry and plastic and sticky when wet.

Climax plant community

The stabilized plant community on a particular site. The plant cover reproduces itself and does not change so long as the environment remains the same.

Coarse textured soil

Sand or loamy sand.

Cobble (or cobblestone)

A rounded or partly rounded fragment of rock 3 to 10 inches (7.6 to 25 centimeters) in diameter.

Cobbly soil material

Material that has 15 to 35 percent, by volume, rounded or partially rounded rock fragments 3 to 10 inches (7.6 to 25 centimeters) in diameter. Very cobbly soil material has 35 to 60 percent of these rock fragments, and extremely cobbly soil material has more than 60 percent.

COLE (coefficient of linear extensibility)

See Linear extensibility.

Colluvium

Unconsolidated, unsorted earth material being transported or deposited on side slopes and/or at the base of slopes by mass movement (e.g., direct gravitational action) and by local, unconcentrated runoff.

Complex slope

Irregular or variable slope. Planning or establishing terraces, diversions, and other water-control structures on a complex slope is difficult.

Complex, soil

A map unit of two or more kinds of soil or miscellaneous areas in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas.

Concretions

See Redoximorphic features.

Conglomerate

A coarse grained, clastic sedimentary rock composed of rounded or subangular rock fragments more than 2 millimeters in diameter. It commonly has a matrix of sand and finer textured material. Conglomerate is the consolidated equivalent of gravel.

Conservation cropping system

Growing crops in combination with needed cultural and management practices. In a good conservation cropping system, the soil-improving crops and practices more than offset the effects of the soil-depleting crops and practices. Cropping systems are needed on all tilled soils. Soil-improving practices in a conservation cropping system include the use of rotations that contain grasses and legumes and the return of crop residue to the soil. Other practices include the use of green manure crops of grasses and legumes, proper tillage, adequate fertilization, and weed and pest control.

Conservation tillage

A tillage system that does not invert the soil and that leaves a protective amount of crop residue on the surface throughout the year.

Consistence, soil

Refers to the degree of cohesion and adhesion of soil material and its resistance to deformation when ruptured. Consistence includes resistance of soil material to rupture and to penetration; plasticity, toughness, and stickiness of puddled soil material; and the manner in which the soil material behaves when subject to compression. Terms describing consistence are defined in the “Soil Survey Manual.”

Contour stripcropping

Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Control section

The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 10 inches and 40 or 80 inches.

Coprogenous earth (sedimentary peat)

A type of limnic layer composed predominantly of fecal material derived from aquatic animals.

Corrosion (geomorphology)

A process of erosion whereby rocks and soil are removed or worn away by natural chemical processes, especially by the solvent action of running water, but also by other reactions, such as hydrolysis, hydration, carbonation, and oxidation.

Corrosion (soil survey interpretations)

Soil-induced electrochemical or chemical action that dissolves or weakens concrete or uncoated steel.

Cover crop

A close-growing crop grown primarily to improve and protect the soil between periods of regular crop production, or a crop grown between trees and vines in orchards and vineyards.

Crop residue management

Returning crop residue to the soil, which helps to maintain soil structure, organic matter content, and fertility and helps to control erosion.

Cropping system

Growing crops according to a planned system of rotation and management practices.

Cross-slope farming

Deliberately conducting farming operations on sloping farmland in such a way that tillage is across the general slope.

Crown

The upper part of a tree or shrub, including the living branches and their foliage.

Cryoturbate

A mass of soil or other unconsolidated earthy material moved or disturbed by frost action. It is typically coarser than the underlying material.

Cuesta

An asymmetric ridge capped by resistant rock layers of slight or moderate dip (commonly less than 15 percent slopes); a type of homocline produced by differential erosion of interbedded resistant and weak rocks. A cuesta has a long, gentle slope on one side (dip slope) that roughly parallels the inclined beds; on the other side, it has a relatively short and steep or clifflike slope (scarp) that cuts through the tilted rocks.

Culmination of the mean annual increment (CMAI)

The average annual increase per acre in the volume of a stand. Computed by dividing the total volume of the stand by its age. As the stand increases in age, the mean annual increment continues to increase until mortality begins to reduce the rate of increase. The point where the stand reaches its maximum annual rate of growth is called the culmination of the mean annual increment.

Cutbanks cave

The walls of excavations tend to cave in or slough.

Decreasers

The most heavily grazed climax range plants. Because they are the most palatable, they are the first to be destroyed by overgrazing.

Deferred grazing

Postponing grazing or resting grazing land for a prescribed period.

Delta

A body of alluvium having a surface that is fan shaped and nearly flat; deposited at or near the mouth of a river or stream where it enters a body of relatively quiet water, generally a sea or lake.

Dense layer

A very firm, massive layer that has a bulk density of more than 1.8 grams per cubic centimeter. Such a layer affects the ease of digging and can affect filling and compacting.

Depression, closed (map symbol)

A shallow, saucer-shaped area that is slightly lower on the landscape than the surrounding area and that does not have a natural outlet for surface drainage.

Depth, soil

Generally, the thickness of the soil over bedrock. Very deep soils are more than 60 inches deep over bedrock; deep soils, 40 to 60 inches; moderately deep, 20 to 40 inches; shallow, 10 to 20 inches; and very shallow, less than 10 inches.

Desert pavement

A natural, residual concentration or layer of wind-polished, closely packed gravel, boulders, and other rock fragments mantling a desert surface. It forms where wind action and sheetwash have removed all smaller particles or where rock fragments have migrated upward through sediments to the surface. It typically protects the finer grained underlying material from further erosion.

Diatomaceous earth

A geologic deposit of fine, grayish siliceous material composed chiefly or entirely of the remains of diatoms.

Dip slope

A slope of the land surface, roughly determined by and approximately conforming to the dip of the underlying bedrock.

Diversion (or diversion terrace)

A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

Divided-slope farming

A form of field stripcropping in which crops are grown in a systematic arrangement of two strips, or bands, across the slope to reduce the hazard of water erosion. One strip is in a close-growing crop that provides protection from erosion, and the other strip is in a crop that provides less protection from erosion. This practice is used where slopes are not long enough to permit a full stripcropping pattern to be used.

Drainage class (natural)

Refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed. Alterations of the water regime by human activities, either through drainage or irrigation, are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized—*excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained,* and *very poorly drained*. These classes are defined in the “Soil Survey Manual.”

Drainage, surface

Runoff, or surface flow of water, from an area.

Drainageway

A general term for a course or channel along which water moves in draining an area. A term restricted to relatively small, linear depressions that at some time move concentrated water and either do not have a defined channel or have only a small defined channel.

Draw

A small stream valley that generally is shallower and more open than a ravine or gulch and that has a broader bottom. The present stream channel may appear inadequate to have cut the drainageway that it occupies.

Drift

A general term applied to all mineral material (clay, silt, sand, gravel, and boulders) transported by a glacier and deposited directly by or from the ice or transported by running water emanating from a glacier. Drift includes unstratified material (till) that forms moraines and stratified deposits that form outwash plains, eskers, kames, varves, and glaciofluvial sediments. The term is generally applied to Pleistocene glacial deposits in areas that no longer contain glaciers.

Drumlin

A low, smooth, elongated oval hill, mound, or ridge of compact till that has a core of bedrock or drift. It commonly has a blunt nose facing the direction from which the ice approached and a gentler slope tapering in the other direction. The longer axis is parallel to the general direction of glacier flow. Drumlins are products of streamline (laminar) flow of glaciers, which molded the subglacial floor through a combination of erosion and deposition.

Duff

A generally firm organic layer on the surface of mineral soils. It consists of fallen plant material that is in the process of decomposition and includes everything from the litter on the surface to underlying pure humus.

Dune

A low mound, ridge, bank, or hill of loose, windblown granular material (generally sand), either barren and capable of movement from place to place or covered and stabilized with vegetation but retaining its characteristic shape.

Earthy fill

See Mine spoil.

Ecological site

An area where climate, soil, and relief are sufficiently uniform to produce a distinct natural plant community. An ecological site is the product of all the environmental factors responsible for its development. It is typified by an association of species that differ from those on other ecological sites in kind and/or proportion of species or in total production.

Eluviation

The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

Endosaturation

A type of saturation of the soil in which all horizons between the upper boundary of saturation and a depth of 2 meters are saturated.

Eolian deposit

Sand-, silt-, or clay-sized clastic material transported and deposited primarily by wind, commonly in the form of a dune or a sheet of sand or loess.

Ephemeral stream

A stream, or reach of a stream, that flows only in direct response to precipitation. It receives no long-continued supply from melting snow or other source, and its channel is above the water table at all times.

Episaturation

A type of saturation indicating a perched water table in a soil in which saturated layers are underlain by one or more unsaturated layers within 2 meters of the surface.

Erosion

The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (accelerated)

Erosion much more rapid than geologic erosion, mainly as a result of human or animal activities or of a catastrophe in nature, such as a fire, that exposes the surface.

Erosion (geologic)

Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion pavement

A surficial lag concentration or layer of gravel and other rock fragments that remains on the soil surface after sheet or rill erosion or wind has removed the finer soil particles and that tends to protect the underlying soil from further erosion.

Erosion surface

A land surface shaped by the action of erosion, especially by running water.

Escarpment

A relatively continuous and steep slope or cliff breaking the general continuity of more gently sloping land surfaces and resulting from erosion or faulting. Most commonly applied to cliffs produced by differential erosion. Synonym: scarp.

Escarpment, bedrock (map symbol)

A relatively continuous and steep slope or cliff, produced by erosion or faulting, that breaks the general continuity of more gently sloping land surfaces. Exposed material is hard or soft bedrock.

Escarpment, nonbedrock (map symbol)

A relatively continuous and steep slope or cliff, generally produced by erosion but in some places produced by faulting, that breaks the continuity of more gently sloping land surfaces. Exposed earthy material is nonsoil or very shallow soil.

Esker

A long, narrow, sinuous, steep-sided ridge of stratified sand and gravel deposited as the bed of a stream flowing in an ice tunnel within or below the ice (subglacial) or between ice walls on top of the ice of a wasting glacier and left behind as high ground when the ice melted. Eskers range in length from less than a kilometer to more than 160 kilometers and in height from 3 to 30 meters.

Extrusive rock

Igneous rock derived from deep-seated molten matter (magma) deposited and cooled on the earth’s surface.

Fallow

Cropland left idle in order to restore productivity through accumulation of moisture. Summer fallow is common in regions of limited rainfall where cereal grain is grown.

The soil is tilled for at least one growing season for weed control and decomposition of plant residue.

Fan remnant

A general term for landforms that are the remaining parts of older fan landforms, such as alluvial fans, that have been either dissected or partially buried.

Fertility, soil

The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Fibric soil material (peat)

The least decomposed of all organic soil material. Peat contains a large amount of well preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

Field moisture capacity

The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity*.

Fill slope

A sloping surface consisting of excavated soil material from a road cut. It commonly is on the downhill side of the road.

Fine textured soil

Sandy clay, silty clay, or clay.

Firebreak

An area cleared of flammable material to stop or help control creeping or running fires. It also serves as a line from which to work and to facilitate the movement of firefighters and equipment. Designated roads also serve as firebreaks.

First bottom

An obsolete, informal term loosely applied to the lowest flood-plain steps that are subject to regular flooding.

Flaggy soil material

Material that has, by volume, 15 to 35 percent flagstones. Very flaggy soil material has 35 to 60 percent flagstones, and extremely flaggy soil material has more than 60 percent flagstones.

Flagstone

A thin fragment of sandstone, limestone, slate, shale, or (rarely) schist 6 to 15 inches (15 to 38 centimeters) long.

Flood plain

The nearly level plain that borders a stream and is subject to flooding unless protected artificially.

Flood-plain landforms

A variety of constructional and erosional features produced by stream channel migration and flooding. Examples include backswamps, flood-plain splays, meanders, meander belts, meander scrolls, oxbow lakes, and natural levees.

Flood-plain splay

A fan-shaped deposit or other outspread deposit formed where an overloaded stream breaks through a levee (natural or artificial) and deposits its material (commonly coarse grained) on the flood plain.

Flood-plain step

An essentially flat, terrace-like alluvial surface within a valley that is frequently covered by floodwater from the present stream; any approximately horizontal surface still actively modified by fluvial scour and/or deposition. May occur individually or as a series of steps.

Fluvial

Of or pertaining to rivers or streams; produced by stream or river action.

Foothills

A region of steeply sloping hills that fringes a mountain range or high-plateau escarpment. The hills have relief of as much as 1,000 feet (300 meters).

Footslope

The concave surface at the base of a hillslope. A footslope is a transition zone between upslope sites of erosion and transport (shoulders and backslopes) and downslope sites of deposition (toeslopes).

Forb

Any herbaceous plant not a grass or a sedge.

Forest cover

All trees and other woody plants (underbrush) covering the ground in a forest.

Forest type

A stand of trees similar in composition and development because of given physical and biological factors by which it may be differentiated from other stands.

Fragipan

A loamy, brittle subsurface horizon low in porosity and content of organic matter and low or moderate in clay but high in silt or very fine sand. A fragipan appears cemented and restricts roots. When dry, it is hard or very hard and has a higher bulk density than the horizon or horizons above. When moist, it tends to rupture suddenly under pressure rather than to deform slowly.

Genesis, soil

The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Gilgai

Commonly, a succession of microbasins and microknolls in nearly level areas or of microvalleys and microridges parallel with the slope. Typically, the microrelief of clayey soils that shrink and swell considerably with changes in moisture content.

Glaciofluvial deposits

Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and occur in the form of outwash plains, valley trains, deltas, kames, eskers, and kame terraces.

Glaciolacustrine deposits

Material ranging from fine clay to sand derived from glaciers and deposited in glacial lakes mainly by glacial meltwater. Many deposits are bedded or laminated.

Gleyed soil

Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors.

Graded stripcropping

Growing crops in strips that grade toward a protected waterway.

Grassed waterway

A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravel

Rounded or angular fragments of rock as much as 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

Gravel pit (map symbol)

An open excavation from which soil and underlying material have been removed and used, without crushing, as a source of sand or gravel.

Gravelly soil material

Material that has 15 to 35 percent, by volume, rounded or angular rock fragments, not prominently flattened, as much as 3 inches (7.6 centimeters) in diameter.

Gravelly spot (map symbol)

A spot where the surface layer has more than 35 percent, by volume, rock fragments that are mostly less than 3 inches in diameter in an area that has less than 15 percent rock fragments.

Green manure crop (agronomy)

A soil-improving crop grown to be plowed under in an early stage of maturity or soon after maturity.

Ground water

Water filling all the unblocked pores of the material below the water table.

Gully (map symbol)

A small, steep-sided channel caused by erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage whereas a rill is of lesser depth and can be smoothed over by ordinary tillage.

Hard bedrock

Bedrock that cannot be excavated except by blasting or by the use of special equipment that is not commonly used in construction.

Hard to reclaim

Reclamation is difficult after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Hardpan

A hardened or cemented soil horizon, or layer. The soil material is sandy, loamy, or clayey and is cemented by iron oxide, silica, calcium carbonate, or other substance.

Head slope (geomorphology)

A geomorphic component of hills consisting of a laterally concave area of a hillside, especially at the head of a drainageway. The overland waterflow is converging.

Hemic soil material (mucky peat)

Organic soil material intermediate in degree of decomposition between the less decomposed fibric material and the more decomposed sapric material.

High-residue crops

Such crops as small grain and corn used for grain. If properly managed, residue from these crops can be used to control erosion until the next crop in the rotation is established. These crops return large amounts of organic matter to the soil.

Hill

A generic term for an elevated area of the land surface, rising as much as 1,000 feet above surrounding lowlands, commonly of limited summit area and having a well defined outline. Slopes are generally more than 15 percent. The distinction between a hill and a mountain is arbitrary and may depend on local usage.

Hillslope

A generic term for the steeper part of a hill between its summit and the drainage line, valley flat, or depression floor at the base of a hill.

Horizon, soil

A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the “Soil Survey Manual.” The major horizons of mineral soil are as follows:

O horizon: An organic layer of fresh and decaying plant residue.

L horizon: A layer of organic and mineral limnic materials, including coprogenous earth (sedimentary peat), diatomaceous earth, and marl.

A horizon: The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of a B horizon.

E horizon: The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

B horizon: The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics, such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

C horizon: The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying soil material. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

Cr horizon: Soft, consolidated bedrock beneath the soil.

R layer: Consolidated bedrock beneath the soil. The bedrock commonly underlies a C horizon, but it can be directly below an A or a B horizon.

M layer: A root-limiting subsoil layer consisting of nearly continuous, horizontally oriented, human-manufactured materials.

W layer: A layer of water within or beneath the soil.

Humus

The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups

Refers to soils grouped according to their runoff potential. The soil properties that influence this potential are those that affect the minimum rate of water infiltration on a bare soil during periods after prolonged wetting when the soil is not frozen. These properties include depth to a seasonal high water table, the infiltration rate, and depth to a layer that significantly restricts the downward movement of water. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff.

Igneous rock

Rock that was formed by cooling and solidification of magma and that has not been changed appreciably by weathering since its formation. Major varieties include plutonic and volcanic rock (e.g., andesite, basalt, and granite).

Illuviation

The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

Impervious soil

A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

Increasers

Species in the climax vegetation that increase in amount as the more desirable plants are reduced by close grazing. Increasers commonly are the shorter plants and the less palatable to livestock.

Infiltration

The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration capacity

The maximum rate at which water can infiltrate into a soil under a given set of conditions.

Infiltration rate

The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Intake rate

The average rate of water entering the soil under irrigation. Most soils have a fast initial rate; the rate decreases with application time. Therefore, intake rate for design purposes is not a constant but is a variable depending on the net irrigation application. The rate of water intake, in inches per hour, is expressed as follows:

Very low: Less than 0.2
Low: 0.2 to 0.4
Moderately low: 0.4 to 0.75
Moderate: 0.75 to 1.25
Moderately high: 1.25 to 1.75
High: 1.75 to 2.5
Very high: More than 2.5

Interfluve

A landform composed of the relatively undissected upland or ridge between two adjacent valleys containing streams flowing in the same general direction. An elevated area between two drainageways that sheds water to those drainageways.

Interfluve (geomorphology)

A geomorphic component of hills consisting of the uppermost, comparatively level or gently sloping area of a hill; shoulders of backwearing hillslopes can narrow the upland or can merge, resulting in a strongly convex shape.

Intermittent stream

A stream, or reach of a stream, that does not flow year-round but that is commonly dry for 3 or more months out of 12 and whose channel is generally below the local water table. It flows only during wet periods or when it receives ground-water discharge or long, continued contributions from melting snow or other surface and shallow subsurface sources.

Invaders

On range, plants that encroach into an area and grow after the climax vegetation has been reduced by grazing. Generally, plants invade following disturbance of the surface.

Iron depletions

See Redoximorphic features.

Irrigation

Application of water to soils to assist in production of crops. Methods of irrigation are:

Basin: Water is applied rapidly to nearly level plains surrounded by levees or dikes.

Border: Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Controlled flooding: Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation: Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards so that it flows in only one direction.

Drip (or trickle): Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

Furrow: Water is applied in small ditches made by cultivation implements. Furrows are used for tree and row crops.

Sprinkler: Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

Subirrigation: Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Wild flooding: Water, released at high points, is allowed to flow onto an area without controlled distribution.

Kame

A low mound, knob, hummock, or short irregular ridge composed of stratified sand and gravel deposited by a subglacial stream as a fan or delta at the margin of a melting glacier; by a supraglacial stream in a low place or hole on the surface of the glacier; or as a ponded deposit on the surface or at the margin of stagnant ice.

Karst (topography)

A kind of topography that formed in limestone, gypsum, or other soluble rocks by dissolution and that is characterized by closed depressions, sinkholes, caves, and underground drainage.

Knoll

A small, low, rounded hill rising above adjacent landforms.

Ksat

See Saturated hydraulic conductivity.

Lacustrine deposit

Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Lake plain

A nearly level surface marking the floor of an extinct lake filled by well sorted, generally fine textured, stratified deposits, commonly containing varves.

Lake terrace

A narrow shelf, partly cut and partly built, produced along a lakeshore in front of a scarp line of low cliffs and later exposed when the water level falls.

Landfill (map symbol)

An area of accumulated waste products of human habitation, either above or below natural ground level.

Landslide

A general, encompassing term for most types of mass movement landforms and processes involving the downslope transport and outward deposition of soil and rock materials caused by gravitational forces; the movement may or may not involve saturated materials. The speed and distance of movement, as well as the amount of soil and rock material, vary greatly.

Large stones

Rock fragments 3 inches (7.6 centimeters) or more across. Large stones adversely affect the specified use of the soil.

Lava flow (map symbol)

A solidified, commonly lobate body of rock formed through lateral, surface outpouring of molten lava from a vent or fissure.

Leaching

The removal of soluble material from soil or other material by percolating water.

Levee (map symbol)

An embankment that confines or controls water, especially one built along the banks of a river to prevent overflow onto lowlands.

Linear extensibility

Refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. Linear extensibility is used to determine the shrink-swell potential of soils. It is an expression of the volume change between the water content of the clod at $^1/_3$- or $^1/_{10}$-bar tension (33kPa or 10kPa tension) and oven dryness. Volume change is influenced by the amount and type of clay minerals in the soil. The volume change is the percent change for the whole soil. If it is expressed as a fraction, the resulting value is COLE, coefficient of linear extensibility.

Liquid limit

The moisture content at which the soil passes from a plastic to a liquid state.

Loam

Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess

Material transported and deposited by wind and consisting dominantly of silt-sized particles.

Low strength

The soil is not strong enough to support loads.

Low-residue crops

Such crops as corn used for silage, peas, beans, and potatoes. Residue from these crops is not adequate to control erosion until the next crop in the rotation is established. These crops return little organic matter to the soil.

Marl

An earthy, unconsolidated deposit consisting chiefly of calcium carbonate mixed with clay in approximately equal proportions; formed primarily under freshwater lacustrine conditions but also formed in more saline environments.

Marsh or swamp (map symbol)

A water-saturated, very poorly drained area that is intermittently or permanently covered by water. Sedges, cattails, and rushes are the dominant vegetation in marshes, and trees or shrubs are the dominant vegetation in swamps. Not used in map units where the named soils are poorly drained or very poorly drained.

Mass movement

A generic term for the dislodgment and downslope transport of soil and rock material as a unit under direct gravitational stress.

Masses

See Redoximorphic features.

Meander belt

The zone within which migration of a meandering channel occurs; the flood-plain area included between two imaginary lines drawn tangential to the outer bends of active channel loops.

Meander scar

A crescent-shaped, concave or linear mark on the face of a bluff or valley wall, produced by the lateral erosion of a meandering stream that impinged upon and undercut the bluff.

Meander scroll

One of a series of long, parallel, close-fitting, crescent-shaped ridges and troughs formed along the inner bank of a stream meander as the channel migrated laterally down-valley and toward the outer bank.

Mechanical treatment

Use of mechanical equipment for seeding, brush management, and other management practices.

Medium textured soil

Very fine sandy loam, loam, silt loam, or silt.

Mesa

A broad, nearly flat topped and commonly isolated landmass bounded by steep slopes or precipitous cliffs and capped by layers of resistant, nearly horizontal rocky material. The summit width is characteristically greater than the height of the bounding escarpments.

Metamorphic rock

Rock of any origin altered in mineralogical composition, chemical composition, or structure by heat, pressure, and movement at depth in the earth's crust. Nearly all such rocks are crystalline.

Mine or quarry (map symbol)

An open excavation from which soil and underlying material have been removed and in which bedrock is exposed. Also denotes surface openings to underground mines.

Mine spoil

An accumulation of displaced earthy material, rock, or other waste material removed during mining or excavation. Also called earthy fill.

Mineral soil

Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Minimum tillage

Only the tillage essential to crop production and prevention of soil damage.

Miscellaneous area

A kind of map unit that has little or no natural soil and supports little or no vegetation.

Miscellaneous water (map symbol)

Small, constructed bodies of water that are used for industrial, sanitary, or mining applications and that contain water most of the year.

Moderately coarse textured soil

Coarse sandy loam, sandy loam, or fine sandy loam.

Moderately fine textured soil

Clay loam, sandy clay loam, or silty clay loam.

Mollic epipedon

A thick, dark, humus-rich surface horizon (or horizons) that has high base saturation and pedogenic soil structure. It may include the upper part of the subsoil.

Moraine

In terms of glacial geology, a mound, ridge, or other topographically distinct accumulation of unsorted, unstratified drift, predominantly till, deposited primarily by the direct action of glacial ice in a variety of landforms. Also, a general term for a landform composed mainly of till (except for kame moraines, which are composed mainly of stratified outwash) that has been deposited by a glacier. Some types of moraines are disintegration, end, ground, kame, lateral, recessional, and terminal.

Morphology, soil

The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil

Irregular spots of different colors that vary in number and size. Descriptive terms are as follows: abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent*. The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium,* from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse,* more than 15 millimeters (about 0.6 inch).

Mountain

A generic term for an elevated area of the land surface, rising more than 1,000 feet (300 meters) above surrounding lowlands, commonly of restricted summit area (relative to a plateau) and generally having steep sides. A mountain can occur as a single, isolated mass or in a group forming a chain or range. Mountains are formed primarily by tectonic activity and/or volcanic action but can also be formed by differential erosion.

Muck

Dark, finely divided, well decomposed organic soil material. (See Sapric soil material.)

Mucky peat

See Hemic soil material.

Mudstone

A blocky or massive, fine grained sedimentary rock in which the proportions of clay and silt are approximately equal. Also, a general term for such material as clay, silt, claystone, siltstone, shale, and argillite and that should be used only when the amounts of clay and silt are not known or cannot be precisely identified.

Munsell notation

A designation of color by degrees of three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with hue of 10YR, value of 6, and chroma of 4.

Natric horizon

A special kind of argillic horizon that contains enough exchangeable sodium to have an adverse effect on the physical condition of the subsoil.

Neutral soil

A soil having a pH value of 6.6 to 7.3. (See Reaction, soil.)

Nodules

See Redoximorphic features.

Nose slope (geomorphology)

A geomorphic component of hills consisting of the projecting end (laterally convex area) of a hillside. The overland waterflow is predominantly divergent. Nose slopes consist dominantly of colluvium and slope-wash sediments (for example, slope alluvium).

Nutrient, plant

Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter

Plant and animal residue in the soil in various stages of decomposition. The content of organic matter in the surface layer is described as follows:

Very low: Less than 0.5 percent
Low: 0.5 to 1.0 percent
Moderately low: 1.0 to 2.0 percent
Moderate: 2.0 to 4.0 percent
High: 4.0 to 8.0 percent
Very high: More than 8.0 percent

Outwash

Stratified and sorted sediments (chiefly sand and gravel) removed or “washed out” from a glacier by meltwater streams and deposited in front of or beyond the end moraine or the margin of a glacier. The coarser material is deposited nearer to the ice.

Outwash plain

An extensive lowland area of coarse textured glaciofluvial material. An outwash plain is commonly smooth; where pitted, it generally is low in relief.

Paleoterrace

An erosional remnant of a terrace that retains the surface form and alluvial deposits of its origin but was not emplaced by, and commonly does not grade to, a present-day stream or drainage network.

Pan

A compact, dense layer in a soil that impedes the movement of water and the growth of roots. For example, *hardpan, fragipan, claypan, plowpan,* and *traffic pan*.

Parent material

The unconsolidated organic and mineral material in which soil forms.

Peat

Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture. (See Fibric soil material.)

Ped

An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedisediment

A layer of sediment, eroded from the shoulder and backslope of an erosional slope, that lies on and is being (or was) transported across a gently sloping erosional surface at the foot of a receding hill or mountain slope.

Pedon

The smallest volume that can be called “a soil.” A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation

The movement of water through the soil.

Perennial water (map symbol)

Small, natural or constructed lakes, ponds, or pits that contain water most of the year.

Permafrost

Ground, soil, or rock that remains at or below 0 degrees C for at least 2 years. It is defined on the basis of temperature and is not necessarily frozen.

pH value

A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Phase, soil

A subdivision of a soil series based on features that affect its use and management, such as slope, stoniness, and flooding.

Piping

Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

Pitting

Pits caused by melting around ice. They form on the soil after plant cover is removed.

Plastic limit

The moisture content at which a soil changes from semisolid to plastic.

Plasticity index

The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plateau (geomorphology)

A comparatively flat area of great extent and elevation; specifically, an extensive land region that is considerably elevated (more than 100 meters) above the adjacent lower lying terrain, is commonly limited on at least one side by an abrupt descent, and has a flat or nearly level surface. A comparatively large part of a plateau surface is near summit level.

Playa

The generally dry and nearly level lake plain that occupies the lowest parts of closed depressions, such as those on intermontane basin floors. Temporary flooding occurs primarily in response to precipitation and runoff. Playa deposits are fine grained and may or may not have a high water table and saline conditions.

Plinthite

The sesquioxide-rich, humus-poor, highly weathered mixture of clay with quartz and other diluents. It commonly appears as red mottles, usually in platy, polygonal, or reticulate patterns. Plinthite changes irreversibly to an ironstone hardpan or to irregular aggregates on repeated wetting and drying, especially if it is exposed also to heat from the sun. In a moist soil, plinthite can be cut with a spade. It is a form of laterite.

Plowpan

A compacted layer formed in the soil directly below the plowed layer.

Ponding

Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

Poorly graded

Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Pore linings

See Redoximorphic features.

Potential native plant community

See Climax plant community.

Potential rooting depth (effective rooting depth)

Depth to which roots could penetrate if the content of moisture in the soil were adequate. The soil has no properties restricting the penetration of roots to this depth.

Prescribed burning

Deliberately burning an area for specific management purposes, under the appropriate conditions of weather and soil moisture and at the proper time of day.

Productivity, soil

The capability of a soil for producing a specified plant or sequence of plants under specific management.

Profile, soil

A vertical section of the soil extending through all its horizons and into the parent material.

Proper grazing use

Grazing at an intensity that maintains enough cover to protect the soil and maintain or improve the quantity and quality of the desirable vegetation. This practice increases the vigor and reproduction capacity of the key plants and promotes the accumulation of litter and mulch necessary to conserve soil and water.

Rangeland

Land on which the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundras, and areas that support certain forb and shrub communities.

Reaction, soil

A measure of acidity or alkalinity of a soil, expressed as pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degrees of acidity or alkalinity, expressed as pH values, are:

Ultra acid: Less than 3.5
Extremely acid: 3.5 to 4.4
Very strongly acid: 4.5 to 5.0
Strongly acid: 5.1 to 5.5
Moderately acid: 5.6 to 6.0
Slightly acid: 6.1 to 6.5
Neutral: 6.6 to 7.3
Slightly alkaline: 7.4 to 7.8
Moderately alkaline: 7.9 to 8.4
Strongly alkaline: 8.5 to 9.0
Very strongly alkaline: 9.1 and higher

Red beds

Sedimentary strata that are mainly red and are made up largely of sandstone and shale.

Redoximorphic concentrations

See Redoximorphic features.

Redoximorphic depletions

See Redoximorphic features.

Redoximorphic features

Redoximorphic features are associated with wetness and result from alternating periods of reduction and oxidation of iron and manganese compounds in the soil. Reduction occurs during saturation with water, and oxidation occurs when the soil is not saturated. Characteristic color patterns are created by these processes. The reduced iron and manganese ions may be removed from a soil if vertical or lateral fluxes of water occur, in which case there is no iron or manganese precipitation in that soil. Wherever the iron and manganese are oxidized and precipitated, they form either soft masses or hard concretions or nodules. Movement of iron and manganese as a result of redoximorphic processes in a soil may result in redoximorphic features that are defined as follows:

1. Redoximorphic concentrations.—These are zones of apparent accumulation of iron-manganese oxides, including:
   A. Nodules and concretions, which are cemented bodies that can be removed from the soil intact. Concretions are distinguished from nodules on the basis of internal organization. A concretion typically has concentric layers that are visible to the naked eye. Nodules do not have visible organized internal structure; *and*
   B. Masses, which are noncemented concentrations of substances within the soil matrix; *and*
   C. Pore linings, i.e., zones of accumulation along pores that may be either coatings on pore surfaces or impregnations from the matrix adjacent to the pores.
2. Redoximorphic depletions.—These are zones of low chroma (chromas less than those in the matrix) where either iron-manganese oxides alone or both iron-manganese oxides and clay have been stripped out, including:
   A. Iron depletions, i.e., zones that contain low amounts of iron and manganese oxides but have a clay content similar to that of the adjacent matrix; *and*
   B. Clay depletions, i.e., zones that contain low amounts of iron, manganese, and clay (often referred to as silt coatings or skeletans).
3. Reduced matrix.—This is a soil matrix that has low chroma *in situ* but undergoes a change in hue or chroma within 30 minutes after the soil material has been exposed to air.

Reduced matrix

See Redoximorphic features.

Regolith

All unconsolidated earth materials above the solid bedrock. It includes material weathered in place from all kinds of bedrock and alluvial, glacial, eolian, lacustrine, and pyroclastic deposits.

Relief

The relative difference in elevation between the upland summits and the lowlands or valleys of a given region.

Residuum (residual soil material)

Unconsolidated, weathered or partly weathered mineral material that accumulated as bedrock disintegrated in place.

Rill

A very small, steep-sided channel resulting from erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. A rill generally is not an obstacle to wheeled vehicles and is shallow enough to be smoothed over by ordinary tillage.

Riser

The vertical or steep side slope (e.g., escarpment) of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural, steplike landforms, such as successive stream terraces.

Road cut

A sloping surface produced by mechanical means during road construction. It is commonly on the uphill side of the road.

Rock fragments

Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Rock outcrop (map symbol)

An exposure of bedrock at the surface of the earth. Not used where the named soils of the surrounding map unit are shallow over bedrock or where “Rock outcrop” is a named component of the map unit.

Root zone

The part of the soil that can be penetrated by plant roots.

Runoff

The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Saline soil

A soil containing soluble salts in an amount that impairs growth of plants. A saline soil does not contain excess exchangeable sodium.

Saline spot (map symbol)

An area where the surface layer has an electrical conductivity of 8 mmhos/cm more than the surface layer of the named soils in the surrounding map unit. The surface layer of the surrounding soils has an electrical conductivity of 2 mmhos/cm or less.

Sand

As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Sandstone

Sedimentary rock containing dominantly sand-sized particles.

Sandy spot (map symbol)

A spot where the surface layer is loamy fine sand or coarser in areas where the surface layer of the named soils in the surrounding map unit is very fine sandy loam or finer.

Sapric soil material (muck)

The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

Saturated hydraulic conductivity (Ksat)

The ease with which pores of a saturated soil transmit water. Formally, the proportionality coefficient that expresses the relationship of the rate of water movement to hydraulic gradient in Darcy's Law, a law that describes the rate of water movement through porous media. Commonly abbreviated as "Ksat." Terms describing saturated hydraulic conductivity are:

Very high: 100 or more micrometers per second (14.17 or more inches per hour)

High: 10 to 100 micrometers per second (1.417 to 14.17 inches per hour)

Moderately high: 1 to 10 micrometers per second (0.1417 inch to 1.417 inches per hour)

Moderately low: 0.1 to 1 micrometer per second (0.01417 to 0.1417 inch per hour)

Low: 0.01 to 0.1 micrometer per second (0.001417 to 0.01417 inch per hour)

Very low: Less than 0.01 micrometer per second (less than 0.001417 inch per hour).

To convert inches per hour to micrometers per second, multiply inches per hour by 7.0572. To convert micrometers per second to inches per hour, multiply micrometers per second by 0.1417.

Saturation

Wetness characterized by zero or positive pressure of the soil water. Under conditions of saturation, the water will flow from the soil matrix into an unlined auger hole.

Scarification

The act of abrading, scratching, loosening, crushing, or modifying the surface to increase water absorption or to provide a more tillable soil.

Sedimentary rock

A consolidated deposit of clastic particles, chemical precipitates, or organic remains accumulated at or near the surface of the earth under normal low temperature and pressure conditions. Sedimentary rocks include consolidated equivalents of alluvium, colluvium, drift, and eolian, lacustrine, and marine deposits. Examples are sandstone, siltstone, mudstone, claystone, shale, conglomerate, limestone, dolomite, and coal.

Sequum

A sequence consisting of an illuvial horizon and the overlying eluvial horizon. (See Eluviation.)

Series, soil

A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Severely eroded spot (map symbol)

An area where, on the average, 75 percent or more of the original surface layer has been lost because of accelerated erosion. Not used in map units in which “severely eroded,”“very severely eroded,” or “gullied” is part of the map unit name.

Shale

Sedimentary rock that formed by the hardening of a deposit of clay, silty clay, or silty clay loam and that has a tendency to split into thin layers.

Sheet erosion

The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

Short, steep slope (map symbol)

A narrow area of soil having slopes that are at least two slope classes steeper than the slope class of the surrounding map unit.

Shoulder

The convex, erosional surface near the top of a hillslope. A shoulder is a transition from summit to backslope.

Shrink-swell

The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Shrub-coppice dune

A small, streamlined dune that forms around brush and clump vegetation.

Side slope (geomorphology)

A geomorphic component of hills consisting of a laterally planar area of a hillside. The overland waterflow is predominantly parallel. Side slopes are dominantly colluvium and slope-wash sediments.

Silica

A combination of silicon and oxygen. The mineral form is called quartz.

Silica-sesquioxide ratio

The ratio of the number of molecules of silica to the number of molecules of alumina and iron oxide. The more highly weathered soils or their clay fractions in warm-temperate, humid regions, and especially those in the tropics, generally have a low ratio.

Silt

As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Siltstone

An indurated silt having the texture and composition of shale but lacking its fine lamination or fissility; a massive mudstone in which silt predominates over clay.

Similar soils

Soils that share limits of diagnostic criteria, behave and perform in a similar manner, and have similar conservation needs or management requirements for the major land uses in the survey area.

Sinkhole (map symbol)

A closed, circular or elliptical depression, commonly funnel shaped, characterized by subsurface drainage and formed either by dissolution of the surface of underlying bedrock (e.g., limestone, gypsum, or salt) or by collapse of underlying caves within bedrock. Complexes of sinkholes in carbonate-rock terrain are the main components of karst topography.

Site index

A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75.

Slickensides (pedogenic)

Grooved, striated, and/or glossy (shiny) slip faces on structural peds, such as wedges; produced by shrink-swell processes, most commonly in soils that have a high content of expansive clays.

Slide or slip (map symbol)

A prominent landform scar or ridge caused by fairly recent mass movement or descent of earthy material resulting from failure of earth or rock under shear stress along one or several surfaces.

Slope

The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Slope alluvium

Sediment gradually transported down the slopes of mountains or hills primarily by nonchannel alluvial processes (i.e., slope-wash processes) and characterized by particle sorting. Lateral particle sorting is evident on long slopes. In a profile sequence, sediments may be distinguished by differences in size and/or specific gravity of rock fragments and may be separated by stone lines. Burnished peds and sorting of rounded or subrounded pebbles or cobbles distinguish these materials from unsorted colluvial deposits.

Slow refill

The slow filling of ponds, resulting from restricted water transmission in the soil.

Slow water movement

Restricted downward movement of water through the soil. See Saturated hydraulic conductivity.

Sodic (alkali) soil

A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

Sodic spot (map symbol)

An area where the surface layer has a sodium adsorption ratio that is at least 10 more than that of the surface layer of the named soils in the surrounding map unit. The surface layer of the surrounding soils has a sodium adsorption ratio of 5 or less.

Sodicity

The degree to which a soil is affected by exchangeable sodium. Sodicity is expressed as a sodium adsorption ratio (SAR) of a saturation extract, or the ratio of Na^{+} to Ca^{++} + Mg^{++}. The degrees of sodicity and their respective ratios are:

Slight: Less than 13:1

Moderate: 13-30:1

Strong: More than 30:1

Sodium adsorption ratio (SAR)

A measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration.

Soft bedrock

Bedrock that can be excavated with trenching machines, backhoes, small rippers, and other equipment commonly used in construction.

Soil

A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief and by the passage of time.

Soil separates

Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes, in millimeters, of separates recognized in the United States are as follows:

Very coarse sand: 2.0 to 1.0
Coarse sand: 1.0 to 0.5
Medium sand: 0.5 to 0.25
Fine sand: 0.25 to 0.10
Very fine sand: 0.10 to 0.05
Silt: 0.05 to 0.002
Clay: Less than 0.002

Solum

The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the material below the solum. The living roots and plant and animal activities are largely confined to the solum.

Spoil area (map symbol)

A pile of earthy materials, either smoothed or uneven, resulting from human activity.

Stone line

In a vertical cross section, a line formed by scattered fragments or a discrete layer of angular and subangular rock fragments (commonly a gravel- or cobble-sized lag concentration) that formerly was draped across a topographic surface and was later buried by additional sediments. A stone line generally caps material that was subject to weathering, soil formation, and erosion before burial. Many stone lines seem to be buried erosion pavements, originally formed by sheet and rill erosion across the land surface.

Stones

Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter if rounded or 15 to 24 inches (38 to 60 centimeters) in length if flat.

Stony

Refers to a soil containing stones in numbers that interfere with or prevent tillage.

Stony spot (map symbol)

A spot where 0.01 to 0.1 percent of the soil surface is covered by rock fragments that are more than 10 inches in diameter in areas where the surrounding soil has no surface stones.

Strath terrace

A type of stream terrace; formed as an erosional surface cut on bedrock and thinly mantled with stream deposits (alluvium).

Stream terrace

One of a series of platforms in a stream valley, flanking and more or less parallel to the stream channel, originally formed near the level of the stream; represents the remnants of an abandoned flood plain, stream bed, or valley floor produced during a former state of fluvial erosion or deposition.

Stripcropping

Growing crops in a systematic arrangement of strips or bands that provide vegetative barriers to wind erosion and water erosion.

Structure, soil

The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are:

Platy: Flat and laminated
Prismatic: Vertically elongated and having flat tops
Columnar: Vertically elongated and having rounded tops
Angular blocky: Having faces that intersect at sharp angles (planes)
Subangular blocky: Having subrounded and planar faces (no sharp angles)
Granular: Small structural units with curved or very irregular faces

Structureless soil horizons are defined as follows:

Single grained: Entirely noncoherent (each grain by itself), as in loose sand
Massive: Occurring as a coherent mass

Stubble mulch

Stubble or other crop residue left on the soil or partly worked into the soil. It protects the soil from wind erosion and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

Subsoil

Technically, the B horizon; roughly, the part of the solum below plow depth.

Subsoiling

Tilling a soil below normal plow depth, ordinarily to shatter a hardpan or claypan.

Substratum

The part of the soil below the solum.

Subsurface layer

Any surface soil horizon (A, E, AB, or EB) below the surface layer.

Summer fallow

The tillage of uncropped land during the summer to control weeds and allow storage of moisture in the soil for the growth of a later crop. A practice common in semiarid regions, where annual precipitation is not enough to produce a crop every year. Summer fallow is frequently practiced before planting winter grain.

Summit

The topographically highest position of a hillslope. It has a nearly level (planar or only slightly convex) surface.

Surface layer

The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Surface soil

The A, E, AB, and EB horizons, considered collectively. It includes all subdivisions of these horizons.

Talus

Rock fragments of any size or shape (commonly coarse and angular) derived from and lying at the base of a cliff or very steep rock slope. The accumulated mass of such loose broken rock formed chiefly by falling, rolling, or sliding.

Taxadjuncts

Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior. Soils are recognized as taxadjuncts only when one or more of their characteristics are slightly outside the range defined for the family of the series for which the soils are named.

Terminal moraine

An end moraine that marks the farthest advance of a glacier. It typically has the form of a massive arcuate or concentric ridge, or complex of ridges, and is underlain by till and other types of drift.

Terrace (conservation)

An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet. A terrace in a field generally is built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

Terrace (geomorphology)

A steplike surface, bordering a valley floor or shoreline, that represents the former position of a flood plain, lake, or seashore. The term is usually applied both to the relatively flat summit surface (tread) that was cut or built by stream or wave action and to the steeper descending slope (scarp or riser) that has graded to a lower base level of erosion.

Terracettes

Small, irregular steplike forms on steep hillslopes, especially in pasture, formed by creep or erosion of surficial materials that may be induced or enhanced by trampling of livestock, such as sheep or cattle.

Texture, soil

The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying “coarse,”“fine,” or “very fine.”

Thin layer

Otherwise suitable soil material that is too thin for the specified use.

Till

Dominantly unsorted and nonstratified drift, generally unconsolidated and deposited directly by a glacier without subsequent reworking by meltwater, and consisting of a heterogeneous mixture of clay, silt, sand, gravel, stones, and boulders; rock fragments of various lithologies are embedded within a finer matrix that can range from clay to sandy loam.

Till plain

An extensive area of level to gently undulating soils underlain predominantly by till and bounded at the distal end by subordinate recessional or end moraines.

Tilth, soil

The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Toeslope

The gently inclined surface at the base of a hillslope. Toeslopes in profile are commonly gentle and linear and are constructional surfaces forming the lower part of a hillslope continuum that grades to valley or closed-depression floors.

Topsoil

The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Trace elements

Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, in soils in extremely small amounts. They are essential to plant growth.

Tread

The flat to gently sloping, topmost, laterally extensive slope of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural steplike landforms, such as successive stream terraces.

Tuff

A generic term for any consolidated or cemented deposit that is 50 percent or more volcanic ash.

Upland

An informal, general term for the higher ground of a region, in contrast with a low-lying adjacent area, such as a valley or plain, or for land at a higher elevation than the flood plain or low stream terrace; land above the footslope zone of the hillslope continuum.

Valley fill

The unconsolidated sediment deposited by any agent (water, wind, ice, or mass wasting) so as to fill or partly fill a valley.

Variegation

Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

Varve

A sedimentary layer or a lamina or sequence of laminae deposited in a body of still water within a year. Specifically, a thin pair of graded glaciolacustrine layers seasonally deposited, usually by meltwater streams, in a glacial lake or other body of still water in front of a glacier.

Very stony spot (map symbol)

A spot where 0.1 to 3.0 percent of the soil surface is covered by rock fragments that are more than 10 inches in diameter in areas where the surface of the surrounding soil is covered by less than 0.01 percent stones.

Water bars

Smooth, shallow ditches or depressional areas that are excavated at an angle across a sloping road. They are used to reduce the downward velocity of water and divert it off and away from the road surface. Water bars can easily be driven over if constructed properly.

Weathering

All physical disintegration, chemical decomposition, and biologically induced changes in rocks or other deposits at or near the earth's surface by atmospheric or biologic agents or by circulating surface waters but involving essentially no transport of the altered material.

Well graded

Refers to soil material consisting of coarse grained particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

Wet spot (map symbol)

A somewhat poorly drained to very poorly drained area that is at least two drainage classes wetter than the named soils in the surrounding map unit.

Wilting point (or permanent wilting point)

The moisture content of soil, on an ovendry basis, at which a plant (specifically a sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

Windthrow

The uprooting and tipping over of trees by the wind.

APPENDIX F

Greenhouse Gas Emission Calculations

Fresno Canyon

Ventura County, Annual

1.0 Project Characteristics

1.1 Land Usage

Land Uses	Size	Metric	Lot Acreage	Floor Surface Area	Population
User Defined Industrial	1,000.00	User Defined Unit	1.00	45,000.00	0

1.2 Other Project Characteristics

Urbanization	Urban	**Wind Speed (m/s)**	2.6	**Precipitation Freq (Days)**	31
Climate Zone	9			**Operational Year**	2016
Utility Company	Southern California Edison				
CO2 Intensity (lb/MWhr)	630.89	**CH4 Intensity (lb/MWhr)**	0.029	**N2O Intensity (lb/MWhr)**	0.006

1.3 User Entered Comments & Non-Default Data

Project Characteristics -

Land Use - Pipe and open trench flood control project. Approximately 1,000 feet in length. Assume site approximately 1 acre.

Construction Phase - Schedule provided by contractor.

Off-road Equipment - Equipment list provided by developer.

Off-road Equipment - Equipment list provided by developer.

Off-road Equipment - Equipment list provided by developer.

Off-road Equipment - Equipment list provided by developer.

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Off-road Equipment - Equipment list provided by developer.

Off-road Equipment - Equipment list provided by developer.

Construction Off-road Equipment Mitigation - Assume watering of construction areas.

Table Name	Column Name	Default Value	New Value
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tblConstructionPhase	NumDays	10.00	5.00
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tblConstructionPhase	NumDays	100.00	20.00
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tblConstructionPhase	PhaseEndDate	9/25/2015	9/15/2015
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tblConstructionPhase	PhaseStartDate	8/29/2015	8/19/2015
tblConstructionPhase	PhaseStartDate	10/24/2015	10/26/2015
tblConstructionPhase	PhaseStartDate	10/31/2015	11/2/2015
tblLandUse	LandUseSquareFeet	0.00	45,000.00
tblLandUse	LotAcreage	0.00	1.00
tblOffRoadEquipment	HorsePower	8.00	16.00
tblOffRoadEquipment	LoadFactor	0.43	0.38
tblOffRoadEquipment	OffRoadEquipmentType		Excavators
tblOffRoadEquipment	OffRoadEquipmentType		Off-Highway Trucks

tblOffRoadEquipment	OffRoadEquipmentType		Tractors/Loaders/Backhoes
tblOffRoadEquipment	OffRoadEquipmentType		Cranes
tblOffRoadEquipment	OffRoadEquipmentType		Tractors/Loaders/Backhoes
tblOffRoadEquipment	OffRoadEquipmentType		Excavators
tblOffRoadEquipment	OffRoadEquipmentType		Off-Highway Trucks
tblOffRoadEquipment	OffRoadEquipmentType		Welders
tblOffRoadEquipment	OffRoadEquipmentType		Off-Highway Trucks
tblOffRoadEquipment	OffRoadEquipmentType		Tractors/Loaders/Backhoes
tblOffRoadEquipment	OffRoadEquipmentType		Tractors/Loaders/Backhoes
tblOffRoadEquipment	OffRoadEquipmentType		Excavators
tblOffRoadEquipment	OffRoadEquipmentType		Plate Compactors
tblOffRoadEquipment	OffRoadEquipmentType		Cranes
tblOffRoadEquipment	OffRoadEquipmentType		Tractors/Loaders/Backhoes
tblOffRoadEquipment	OffRoadEquipmentType		Excavators
tblOffRoadEquipment	OffRoadEquipmentType		Off-Highway Trucks
tblOffRoadEquipment	OffRoadEquipmentType		Welders
tblOffRoadEquipment	OffRoadEquipmentType		Off-Highway Trucks
tblOffRoadEquipment	OffRoadEquipmentType		Excavators
tblOffRoadEquipment	OffRoadEquipmentType		Plate Compactors
tblOffRoadEquipment	OffRoadEquipmentType		Excavators
tblOffRoadEquipment	OffRoadEquipmentType		Off-Highway Trucks
tblOffRoadEquipment	OffRoadEquipmentType		Tractors/Loaders/Backhoes
tblOffRoadEquipment	OffRoadEquipmentType		Plate Compactors
tblOffRoadEquipment	OffRoadEquipmentType		Bore/Drill Rigs
tblOffRoadEquipment	OffRoadEquipmentType		Cranes
tblOffRoadEquipment	OffRoadEquipmentType		Tractors/Loaders/Backhoes
tblOffRoadEquipment	OffRoadEquipmentType		Excavators
tblOffRoadEquipment	OffRoadEquipmentType		Off-Highway Trucks

tblOffRoadEquipment	OffRoadEquipmentType		Tractors/Loaders/Backhoes
tblOffRoadEquipment	OffRoadEquipmentType		Excavators
tblOffRoadEquipment	OffRoadEquipmentType		Cranes
tblOffRoadEquipment	OffRoadEquipmentType		Off-Highway Trucks
tblOffRoadEquipment	OffRoadEquipmentType		Tractors/Loaders/Backhoes
tblOffRoadEquipment	OffRoadEquipmentType		Excavators
tblOffRoadEquipment	OffRoadEquipmentType		Off-Highway Trucks
tblOffRoadEquipment	OffRoadEquipmentType		Forklifts
tblOffRoadEquipment	OffRoadEquipmentType		Excavators
tblOffRoadEquipment	OffRoadEquipmentType		Off-Highway Trucks
tblOffRoadEquipment	OffRoadEquipmentType		Tractors/Loaders/Backhoes
tblOffRoadEquipment	OffRoadEquipmentType		Excavators
tblOffRoadEquipment	OffRoadEquipmentType		Plate Compactors
tblOffRoadEquipment	OffRoadEquipmentType		Tractors/Loaders/Backhoes
tblOffRoadEquipment	OffRoadEquipmentType		Excavators
tblOffRoadEquipment	OffRoadEquipmentType		Off-Highway Trucks
tblOffRoadEquipment	OffRoadEquipmentType		Rollers
tblOffRoadEquipment	OffRoadEquipmentType		Graders
tblOffRoadEquipment	OffRoadEquipmentType		Tractors/Loaders/Backhoes
tblOffRoadEquipment	OffRoadEquipmentType		Excavators
tblOffRoadEquipment	OffRoadEquipmentType		Off-Highway Trucks
tblOffRoadEquipment	OffRoadEquipmentType		Tractors/Loaders/Backhoes
tblOffRoadEquipment	OffRoadEquipmentType		Excavators
tblOffRoadEquipment	OffRoadEquipmentType		Off-Highway Trucks
tblOffRoadEquipment	OffRoadEquipmentType		Rollers
tblOffRoadEquipment	OffRoadEquipmentType		Graders
tblOffRoadEquipment	OffRoadEquipmentType		Rollers
tblOffRoadEquipment	OffRoadEquipmentType		Graders

tblOffRoadEquipment	OffRoadEquipmentType		Off-Highway Trucks
tblOffRoadEquipment	OffRoadEquipmentUnitAmount	0.00	1.00
tblOffRoadEquipment	OffRoadEquipmentUnitAmount	0.00	1.00
tblOffRoadEquipment	OffRoadEquipmentUnitAmount	0.00	1.00
tblOffRoadEquipment	OffRoadEquipmentUnitAmount	0.00	1.00
tblOffRoadEquipment	PhaseName		Jacking and receiving pits
tblOffRoadEquipment	PhaseName		Jacking and receiving pits
tblOffRoadEquipment	PhaseName		Jacking and receiving pits
tblOffRoadEquipment	PhaseName		RC pipe installation
tblOffRoadEquipment	PhaseName		RC pipe installation
tblOffRoadEquipment	PhaseName		RC pipe installation
tblOffRoadEquipment	PhaseName		RC pipe installation
tblOffRoadEquipment	PhaseName		RC pipe installation
tblOffRoadEquipment	PhaseName		Removal of existing facilities
tblOffRoadEquipment	PhaseName		Removal of existing facilities
tblOffRoadEquipment	PhaseName		Sewer line relocation
tblOffRoadEquipment	PhaseName		Sewer line relocation
tblOffRoadEquipment	PhaseName		Sewer line relocation
tblOffRoadEquipment	PhaseName		RC pipe open trench
tblOffRoadEquipment	PhaseName		RC pipe open trench
tblOffRoadEquipment	PhaseName		RC pipe open trench
tblOffRoadEquipment	PhaseName		RC pipe open trench
tblOffRoadEquipment	PhaseName		RC pipe open trench
tblOffRoadEquipment	PhaseName		Inlet structure
tblOffRoadEquipment	PhaseName		Inlet structure
tblOffRoadEquipment	PhaseName		Inlet structure
tblOffRoadEquipment	PhaseName		Floodwall and foundation
tblOffRoadEquipment	PhaseName		Floodwall and foundation

tblOffRoadEquipment	PhaseName		Floodwall and foundation
tblOffRoadEquipment	PhaseName		Floodwall and foundation
tblOffRoadEquipment	PhaseName		Retaining wall north
tblOffRoadEquipment	PhaseName		Retaining wall north
tblOffRoadEquipment	PhaseName		Retaining wall north
tblOffRoadEquipment	PhaseName		Retaining wall north
tblOffRoadEquipment	PhaseName		Retaining wall north
tblOffRoadEquipment	PhaseName		Retaining wall at Edison
tblOffRoadEquipment	PhaseName		Retaining wall at Edison
tblOffRoadEquipment	PhaseName		Retaining wall at Edison
tblOffRoadEquipment	PhaseName		Retaining wall at Edison
tblOffRoadEquipment	PhaseName		Retaining wall at bike path
tblOffRoadEquipment	PhaseName		Retaining wall at bike path
tblOffRoadEquipment	PhaseName		Retaining wall at bike path
tblOffRoadEquipment	PhaseName		Retaining wall at bike path
tblOffRoadEquipment	PhaseName		Outlet structure rock
tblOffRoadEquipment	PhaseName		Outlet structure rock
tblOffRoadEquipment	PhaseName		RCP drain connections
tblOffRoadEquipment	PhaseName		RCP drain connections
tblOffRoadEquipment	PhaseName		RCP drain connections
tblOffRoadEquipment	PhaseName		Bike path
tblOffRoadEquipment	PhaseName		Bike path
tblOffRoadEquipment	PhaseName		Bike path
tblOffRoadEquipment	PhaseName		Bike path
tblOffRoadEquipment	PhaseName		Bike path
tblOffRoadEquipment	PhaseName		Access road
tblOffRoadEquipment	PhaseName		Access road
tblOffRoadEquipment	PhaseName		Access road

tblOffRoadEquipment	PhaseName		CMB access road
tblOffRoadEquipment	PhaseName		CMB access road
tblOffRoadEquipment	PhaseName		CMB access road
tblOffRoadEquipment	PhaseName		CMB access road
tblOffRoadEquipment	PhaseName		CMB access road
tblOffRoadEquipment	PhaseName		AC access road pavement
tblOffRoadEquipment	PhaseName		AC access road pavement
tblOffRoadEquipment	PhaseName		Fence and gate
tblProjectCharacteristics	OperationalYear	2014	2016

2.0 Emissions Summary

2.1 Overall Construction

Unmitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Year	tons/yr										MT/yr					
2015	0.2607	2.8360	1.4892	2.8800e-003		0.1353	0.1353		0.1247	0.1247	0.0000	272.4802	272.4802	0.0811	0.0000	274.1828
Total	**0.2607**	**2.8360**	**1.4892**	**2.8800e-003**		**0.1353**	**0.1353**		**0.1247**	**0.1247**	**0.0000**	**272.4802**	**272.4802**	**0.0811**	**0.0000**	**274.1828**

Mitigated Construction

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Year	tons/yr										MT/yr					
2015	0.2604	0.8309	1.4874	2.8800e-003		0.1351	0.1351		0.1246	0.1246	0.0000	272.1560	272.1560	0.0810	0.0000	273.8567
Total	**0.2604**	**0.8309**	**1.4874**	**2.8800e-003**		**0.1351**	**0.1351**		**0.1246**	**0.1246**	**0.0000**	**272.1560**	**272.1560**	**0.0810**	**0.0000**	**273.8567**

	ROG	**NOx**	**CO**	**SO2**	**Fugitive PM10**	**Exhaust PM10**	**PM10 Total**	**Fugitive PM2.5**	**Exhaust PM2.5**	**PM2.5 Total**	**Bio- CO2**	**NBio-CO2**	**Total CO2**	**CH4**	**N20**	**CO2e**
Percent Reduction	**0.1189**	**70.7030**	**0.1189**	**0.0000**	**0.0000**	**0.1183**	**0.1183**	**0.0000**	**0.1122**	**0.1122**	**0.0000**	**0.1190**	**0.1190**	**0.1233**	**0.0000**	**0.1190**

2.2 Overall Operational

Unmitigated Operational

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Area	0.2288	9.0000e-005	9.4300e-003	0.0000		3.0000e-005	3.0000e-005		3.0000e-005	3.0000e-005	0.0000	0.0179	0.0179	5.0000e-005	0.0000	0.0189
Energy	0.0000	0.0000	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Mobile	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Waste						0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Water						0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	**0.2288**	**9.0000e-005**	**9.4300e-003**	**0.0000**	**0.0000**	**3.0000e-005**	**3.0000e-005**	**0.0000**	**3.0000e-005**	**3.0000e-005**	**0.0000**	**0.0179**	**0.0179**	**5.0000e-005**	**0.0000**	**0.0189**

2.2 Overall Operational

Mitigated Operational

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Area	0.2288	9.0000e-005	9.4300e-003	0.0000		3.0000e-005	3.0000e-005		3.0000e-005	3.0000e-005	0.0000	0.0179	0.0179	5.0000e-005	0.0000	0.0189
Energy	0.0000	0.0000	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Mobile	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Waste						0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Water						0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	**0.2288**	**9.0000e-005**	**9.4300e-003**	**0.0000**	**0.0000**	**3.0000e-005**	**3.0000e-005**	**0.0000**	**3.0000e-005**	**3.0000e-005**	**0.0000**	**0.0179**	**0.0179**	**5.0000e-005**	**0.0000**	**0.0189**

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio-CO2	Total CO2	CH4	N20	CO2e
Percent Reduction	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**

3.0 Construction Detail

Construction Phase

Phase Number	Phase Name	Phase Type	Start Date	End Date	Num Days Week	Num Days	Phase Description
1	Jacking and receiving pits	Grading	4/8/2015	4/14/2015	5	5	
2	RC pipe installation	Grading	4/15/2015	5/14/2015	5	22	
3	Removal of existing facilities	Demolition	4/22/2015	4/28/2015	5	5	
4	Sewer line relocation	Trenching	4/28/2015	6/1/2015	5	25	
5	RC pipe open trench	Trenching	5/29/2015	7/2/2015	5	25	
6	Inlet structure	Building Construction	7/3/2015	7/31/2015	5	21	
7	Floodwall and foundation	Building Construction	8/3/2015	8/28/2015	5	20	
8	Retaining wall north	Building Construction	8/19/2015	9/15/2015	5	20	
9	Retaining wall at Edison	Building Construction	9/16/2015	9/22/2015	5	5	
10	Retaining wall at bike path	Building Construction	9/23/2015	10/6/2015	5	10	
11	Outlet structure rock	Building Construction	10/7/2015	10/20/2015	5	10	
12	RCP drain connections	Building Construction	10/21/2015	10/23/2015	5	3	
13	Bike path	Building Construction	10/26/2015	10/28/2015	5	3	
14	Access road	Building Construction	10/29/2015	10/30/2015	5	2	
15	CMB access road	Building Construction	11/2/2015	11/4/2015	5	3	
16	AC access road pavement	Paving	11/5/2015	11/9/2015	5	3	
17	Fence and gate	Building Construction	11/10/2015	11/16/2015	5	5	

OffRoad Equipment

Phase Name	Offroad Equipment Type	Amount	Usage Hours	Horse Power	Load Factor
Jacking and receiving pits	Excavators	1	8.00	162	0.38
Jacking and receiving pits	Off-Highway Trucks	1	8.00	400	0.38
Jacking and receiving pits	Tractors/Loaders/Backhoes	1	8.00	97	0.37
RC pipe installation	Cranes	1	6.00	226	0.29
RC pipe installation	Tractors/Loaders/Backhoes	2	8.00	97	0.37
RC pipe installation	Excavators	1	8.00	162	0.38

RC pipe installation	Off-Highway Trucks	1	8.00	400	0.38
RC pipe installation	Welders	1	8.00	46	0.45
Removal of existing facilities	Off-Highway Trucks	1	8.00	400	0.38
Removal of existing facilities	Tractors/Loaders/Backhoes	1	8.00	97	0.37
Sewer line relocation	Tractors/Loaders/Backhoes	2	8.00	97	0.37
Sewer line relocation	Excavators	1	8.00	162	0.38
Sewer line relocation	Plate Compactors	1	8.00	8	0.43
RC pipe open trench	Cranes	1	6.00	226	0.29
RC pipe open trench	Tractors/Loaders/Backhoes	1	8.00	97	0.37
RC pipe open trench	Excavators	1	8.00	162	0.38
RC pipe open trench	Off-Highway Trucks	1	8.00	400	0.38
RC pipe open trench	Welders	1	8.00	46	0.45
Inlet structure	Off-Highway Trucks	3	8.00	400	0.38
Inlet structure	Excavators	1	8.00	162	0.38
Inlet structure	Plate Compactors	1	8.00	16	0.38
Floodwall and foundation	Excavators	1	8.00	162	0.38
Floodwall and foundation	Off-Highway Trucks	3	8.00	400	0.38
Floodwall and foundation	Tractors/Loaders/Backhoes	1	8.00	97	0.37
Floodwall and foundation	Plate Compactors	1	8.00	8	0.43
Retaining wall north	Bore/Drill Rigs	1	8.00	205	0.50
Retaining wall north	Cranes	2	6.00	226	0.29
Retaining wall north	Tractors/Loaders/Backhoes	2	8.00	97	0.37
Retaining wall north	Excavators	1	8.00	162	0.38
Retaining wall north	Off-Highway Trucks	1	8.00	400	0.38
Retaining wall at Edison	Tractors/Loaders/Backhoes	2	8.00	97	0.37
Retaining wall at Edison	Excavators	1	8.00	162	0.38
Retaining wall at Edison	Cranes	1	6.00	226	0.29
Retaining wall at Edison	Off-Highway Trucks	1	8.00	400	0.38

Retaining wall at bike path	Tractors/Loaders/Backhoes	2	8.00	97	0.37
Retaining wall at bike path	Excavators	1	8.00	162	0.38
Retaining wall at bike path	Off-Highway Trucks	2	8.00	400	0.38
Retaining wall at bike path	Forklifts	1	8.00	89	0.20
Outlet structure rock	Excavators	1	8.00	162	0.38
Outlet structure rock	Off-Highway Trucks	1	8.00	400	0.38
RCP drain connections	Tractors/Loaders/Backhoes	2	8.00	97	0.37
RCP drain connections	Excavators	1	8.00	162	0.38
RCP drain connections	Plate Compactors	1	8.00	8	0.43
Bike path	Tractors/Loaders/Backhoes	2	8.00	97	0.37
Bike path	Excavators	1	8.00	162	0.38
Bike path	Off-Highway Trucks	1	8.00	400	0.38
Bike path	Rollers	1	8.00	80	0.38
Bike path	Graders	1	8.00	174	0.41
Access road	Tractors/Loaders/Backhoes	2	8.00	97	0.37
Access road	Excavators	1	8.00	162	0.38
Access road	Off-Highway Trucks	1	8.00	400	0.38
CMB access road	Tractors/Loaders/Backhoes	2	8.00	97	0.37
CMB access road	Excavators	1	8.00	162	0.38
CMB access road	Off-Highway Trucks	1	8.00	400	0.38
CMB access road	Rollers	1	8.00	80	0.38
CMB access road	Graders	1	8.00	174	0.41
AC access road pavement	Rollers	1	8.00	80	0.38
AC access road pavement	Graders	1	8.00	174	0.41
Fence and gate	Off-Highway Trucks	1	8.00	400	0.38

Trips and VMT

Phase Name	Offroad Equipment Count	Worker Trip Number	Vendor Trip Number	Hauling Trip Number	Worker Trip Length	Vendor Trip Length	Hauling Trip Length	Worker Vehicle Class	Vendor Vehicle Class	Hauling Vehicle Class

3.1 Mitigation Measures Construction

Water Exposed Area

Clean Paved Roads

3.2 Jacking and receiving pits - 2015

Unmitigated Construction On-Site

Acres of Grading: 0

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	4.5200e-003	0.0511	0.0283	5.0000e-005		2.4300e-003	2.4300e-003		2.2400e-003	2.2400e-003	0.0000	5.1390	5.1390	1.5300e-003	0.0000	5.1712
Total	**4.5200e-003**	**0.0511**	**0.0283**	**5.0000e-005**		**2.4300e-003**	**2.4300e-003**		**2.2400e-003**	**2.2400e-003**	**0.0000**	**5.1390**	**5.1390**	**1.5300e-003**	**0.0000**	**5.1712**

3.2 Jacking and receiving pits - 2015

Mitigated Construction On-Site

Acres of Grading: 0

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	4.5100e-003	8.5700e-003	0.0283	5.0000e-005		2.4300e-003	2.4300e-003		2.2300e-003	2.2300e-003	0.0000	5.1329	5.1329	1.5300e-003	0.0000	5.1651
Total	**4.5100e-003**	**8.5700e-003**	**0.0283**	**5.0000e-005**		**2.4300e-003**	**2.4300e-003**		**2.2300e-003**	**2.2300e-003**	**0.0000**	**5.1329**	**5.1329**	**1.5300e-003**	**0.0000**	**5.1651**

3.3 RC pipe installation - 2015

Unmitigated Construction On-Site

Acres of Grading: 0

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.0369	0.3559	0.1990	3.5000e-004		0.0187	0.0187		0.0173	0.0173	0.0000	32.4247	32.4247	9.6200e-003	0.0000	32.6268
Total	**0.0369**	**0.3559**	**0.1990**	**3.5000e-004**		**0.0187**	**0.0187**		**0.0173**	**0.0173**	**0.0000**	**32.4247**	**32.4247**	**9.6200e-003**	**0.0000**	**32.6268**

3.3 RC pipe installation - 2015

Mitigated Construction On-Site

Acres of Grading: 0

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.0368	0.1677	0.1988	3.5000e-004		0.0187	0.0187		0.0173	0.0173	0.0000	32.3861	32.3861	9.6100e-003	0.0000	32.5879
Total	**0.0368**	**0.1677**	**0.1988**	**3.5000e-004**		**0.0187**	**0.0187**		**0.0173**	**0.0173**	**0.0000**	**32.3861**	**32.3861**	**9.6100e-003**	**0.0000**	**32.5879**

3.4 Removal of existing facilities - 2015

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	3.4900e-003	0.0390	0.0198	4.0000e-005		1.8300e-003	1.8300e-003		1.6900e-003	1.6900e-003	0.0000	3.8917	3.8917	1.1600e-003	0.0000	3.9161
Total	**3.4900e-003**	**0.0390**	**0.0198**	**4.0000e-005**		**1.8300e-003**	**1.8300e-003**		**1.6900e-003**	**1.6900e-003**	**0.0000**	**3.8917**	**3.8917**	**1.1600e-003**	**0.0000**	**3.9161**

3.4 Removal of existing facilities - 2015

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	3.4800e-003	8.5400e-003	0.0197	4.0000e-005		1.8300e-003	1.8300e-003		1.6900e-003	1.6900e-003	0.0000	3.8871	3.8871	1.1600e-003	0.0000	3.9115
Total	**3.4800e-003**	**8.5400e-003**	**0.0197**	**4.0000e-005**		**1.8300e-003**	**1.8300e-003**		**1.6900e-003**	**1.6900e-003**	**0.0000**	**3.8871**	**3.8871**	**1.1600e-003**	**0.0000**	**3.9115**

3.5 Sewer line relocation - 2015

Unmitigated Construction On-Site

Acres of Paving: 0

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.0147	0.1497	0.1062	1.5000e-004		9.8300e-003	9.8300e-003		9.0500e-003	9.0500e-003	0.0000	14.1196	14.1196	4.1400e-003	0.0000	14.2065
Total	**0.0147**	**0.1497**	**0.1062**	**1.5000e-004**		**9.8300e-003**	**9.8300e-003**		**9.0500e-003**	**9.0500e-003**	**0.0000**	**14.1196**	**14.1196**	**4.1400e-003**	**0.0000**	**14.2065**

3.5 Sewer line relocation - 2015

Mitigated Construction On-Site

Acres of Paving: 0

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.0147	0.0854	0.1061	1.5000e-004		9.8200e-003	9.8200e-003		9.0400e-003	9.0400e-003	0.0000	14.1028	14.1028	4.1300e-003	0.0000	14.1896
Total	**0.0147**	**0.0854**	**0.1061**	**1.5000e-004**		**9.8200e-003**	**9.8200e-003**		**9.0400e-003**	**9.0400e-003**	**0.0000**	**14.1028**	**14.1028**	**4.1300e-003**	**0.0000**	**14.1896**

3.6 RC pipe open trench - 2015

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.0374	0.3617	0.1959	3.6000e-004		0.0179	0.0179		0.0166	0.0166	0.0000	33.1476	33.1476	9.8300e-003	0.0000	33.3541
Total	**0.0374**	**0.3617**	**0.1959**	**3.6000e-004**		**0.0179**	**0.0179**		**0.0166**	**0.0166**	**0.0000**	**33.1476**	**33.1476**	**9.8300e-003**	**0.0000**	**33.3541**

3.6 RC pipe open trench - 2015

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.0374	0.1479	0.1957	3.5000e-004		0.0179	0.0179		0.0166	0.0166	0.0000	33.1082	33.1082	9.8200e-003	0.0000	33.3144
Total	**0.0374**	**0.1479**	**0.1957**	**3.5000e-004**		**0.0179**	**0.0179**		**0.0166**	**0.0166**	**0.0000**	**33.1082**	**33.1082**	**9.8200e-003**	**0.0000**	**33.3144**

3.7 Inlet structure - 2015

Unmitigated Construction On-Site

Residential Indoor: 0; Residential Outdoor: 0; Non-Residential Indoor: 0; Non-Residential Outdoor: 0

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.0370	0.4356	0.2091	4.7000e-004		0.0172	0.0172		0.0158	0.0158	0.0000	45.0336	45.0336	0.0134	0.0000	45.3159
Total	**0.0370**	**0.4356**	**0.2091**	**4.7000e-004**		**0.0172**	**0.0172**		**0.0158**	**0.0158**	**0.0000**	**45.0336**	**45.0336**	**0.0134**	**0.0000**	**45.3159**

3.7 Inlet structure - 2015

Mitigated Construction On-Site

Residential Indoor: 0; Residential Outdoor: 0; Non-Residential Indoor: 0; Non-Residential Outdoor: 0

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.0370		0.2089	4.7000e-004		0.0172	0.0172		0.0158	0.0158	0.0000	44.9800	44.9800	0.0134	0.0000	45.2620
Total	**0.0370**		**0.2089**	**4.7000e-004**		**0.0172**	**0.0172**		**0.0158**	**0.0158**	**0.0000**	**44.9800**	**44.9800**	**0.0134**	**0.0000**	**45.2620**

3.8 Floodwall and foundation - 2015

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.0393	0.4516	0.2255	4.9000e-004		0.0192	0.0192		0.0176	0.0176	0.0000	46.1608	46.1608	0.0137	0.0000	46.4489
Total	**0.0393**	**0.4516**	**0.2255**	**4.9000e-004**		**0.0192**	**0.0192**		**0.0176**	**0.0176**	**0.0000**	**46.1608**	**46.1608**	**0.0137**	**0.0000**	**46.4489**

3.8 Floodwall and foundation - 2015

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.0392	0.0341	0.2252	4.9000e-004		0.0191	0.0191		0.0176	0.0176	0.0000	46.1059	46.1059	0.0137	0.0000	46.3937
Total	**0.0392**	**0.0341**	**0.2252**	**4.9000e-004**		**0.0191**	**0.0191**		**0.0176**	**0.0176**	**0.0000**	**46.1059**	**46.1059**	**0.0137**	**0.0000**	**46.3937**

3.9 Retaining wall north - 2015

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.0367	0.4309	0.2049	4.2000e-004		0.0202	0.0202		0.0186	0.0186	0.0000	39.9469	39.9469	0.0119	0.0000	40.1973
Total	**0.0367**	**0.4309**	**0.2049**	**4.2000e-004**		**0.0202**	**0.0202**		**0.0186**	**0.0186**	**0.0000**	**39.9469**	**39.9469**	**0.0119**	**0.0000**	**40.1973**

3.9 Retaining wall north - 2015

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.0366	0.1994	0.2046	4.2000e-004		0.0202	0.0202		0.0186	0.0186	0.0000	39.8994	39.8994	0.0119	0.0000	40.1495
Total	**0.0366**	**0.1994**	**0.2046**	**4.2000e-004**		**0.0202**	**0.0202**		**0.0186**	**0.0186**	**0.0000**	**39.8994**	**39.8994**	**0.0119**	**0.0000**	**40.1495**

3.10 Retaining wall at Edison - 2015

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	6.8100e-003	0.0762	0.0402	7.0000e-005		3.8600e-003	3.8600e-003		3.5500e-003	3.5500e-003	0.0000	6.8987	6.8987	2.0600e-003	0.0000	6.9419
Total	**6.8100e-003**	**0.0762**	**0.0402**	**7.0000e-005**		**3.8600e-003**	**3.8600e-003**		**3.5500e-003**	**3.5500e-003**	**0.0000**	**6.8987**	**6.8987**	**2.0600e-003**	**0.0000**	**6.9419**

3.10 Retaining wall at Edison - 2015

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	6.8100e-003	0.0335	0.0401	7.0000e-005		3.8500e-003	3.8500e-003		3.5400e-003	3.5400e-003	0.0000	6.8905	6.8905	2.0600e-003	0.0000	6.9337
Total	**6.8100e-003**	**0.0335**	**0.0401**	**7.0000e-005**		**3.8500e-003**	**3.8500e-003**		**3.5400e-003**	**3.5400e-003**	**0.0000**	**6.8905**	**6.8905**	**2.0600e-003**	**0.0000**	**6.9337**

3.11 Retaining wall at bike path - 2015

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.0173	0.1910	0.1027	2.0000e-004		9.4200e-003	9.4200e-003		8.6600e-003	8.6600e-003	0.0000	18.8305	18.8305	5.6200e-003	0.0000	18.9485
Total	**0.0173**	**0.1910**	**0.1027**	**2.0000e-004**		**9.4200e-003**	**9.4200e-003**		**8.6600e-003**	**8.6600e-003**	**0.0000**	**18.8305**	**18.8305**	**5.6200e-003**	**0.0000**	**18.9485**

3.11 Retaining wall at bike path - 2015

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	0.0172	0.0445	0.1026	2.0000e-004		9.4100e-003	9.4100e-003		8.6500e-003	8.6500e-003	0.0000	18.8081	18.8081	5.6100e-003	0.0000	18.9260
Total	**0.0172**	**0.0445**	**0.1026**	**2.0000e-004**		**9.4100e-003**	**9.4100e-003**		**8.6500e-003**	**8.6500e-003**	**0.0000**	**18.8081**	**18.8081**	**5.6100e-003**	**0.0000**	**18.9260**

3.12 Outlet structure rock - 2015

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	7.2700e-003	0.0854	0.0447	9.0000e-005		3.5400e-003	3.5400e-003		3.2500e-003	3.2500e-003	0.0000	8.8366	8.8366	2.6400e-003	0.0000	8.8920
Total	**7.2700e-003**	**0.0854**	**0.0447**	**9.0000e-005**		**3.5400e-003**	**3.5400e-003**		**3.2500e-003**	**3.2500e-003**	**0.0000**	**8.8366**	**8.8366**	**2.6400e-003**	**0.0000**	**8.8920**

3.12 Outlet structure rock - 2015

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	7.2600e-003		0.0447	9.0000e-005		3.5300e-003	3.5300e-003		3.2500e-003	3.2500e-003	0.0000	8.8260	8.8260	2.6300e-003	0.0000	8.8814
Total	**7.2600e-003**		**0.0447**	**9.0000e-005**		**3.5300e-003**	**3.5300e-003**		**3.2500e-003**	**3.2500e-003**	**0.0000**	**8.8260**	**8.8260**	**2.6300e-003**	**0.0000**	**8.8814**

3.13 RCP drain connections - 2015

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	1.7600e-003	0.0180	0.0128	2.0000e-005		1.1800e-003	1.1800e-003		1.0900e-003	1.0900e-003	0.0000	1.6944	1.6944	5.0000e-004	0.0000	1.7048
Total	**1.7600e-003**	**0.0180**	**0.0128**	**2.0000e-005**		**1.1800e-003**	**1.1800e-003**		**1.0900e-003**	**1.0900e-003**	**0.0000**	**1.6944**	**1.6944**	**5.0000e-004**	**0.0000**	**1.7048**

3.13 RCP drain connections - 2015

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	1.7600e-003	0.0102	0.0127	2.0000e-005		1.1800e-003	1.1800e-003		1.0800e-003	1.0800e-003	0.0000	1.6923	1.6923	5.0000e-004	0.0000	1.7028
Total	**1.7600e-003**	**0.0102**	**0.0127**	**2.0000e-005**		**1.1800e-003**	**1.1800e-003**		**1.0800e-003**	**1.0800e-003**	**0.0000**	**1.6923**	**1.6923**	**5.0000e-004**	**0.0000**	**1.7028**

3.14 Bike path - 2015

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	5.3900e-003	0.0571	0.0311	5.0000e-005		3.1500e-003	3.1500e-003		2.9000e-003	2.9000e-003	0.0000	4.7998	4.7998	1.4300e-003	0.0000	4.8299
Total	**5.3900e-003**	**0.0571**	**0.0311**	**5.0000e-005**		**3.1500e-003**	**3.1500e-003**		**2.9000e-003**	**2.9000e-003**	**0.0000**	**4.7998**	**4.7998**	**1.4300e-003**	**0.0000**	**4.8299**

3.14 Bike path - 2015

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	5.3800e-003	0.0315	0.0311	5.0000e-005		3.1400e-003	3.1400e-003		2.8900e-003	2.8900e-003	0.0000	4.7941	4.7941	1.4300e-003	0.0000	4.8242
Total	**5.3800e-003**	**0.0315**	**0.0311**	**5.0000e-005**		**3.1400e-003**	**3.1400e-003**		**2.8900e-003**	**2.8900e-003**	**0.0000**	**4.7941**	**4.7941**	**1.4300e-003**	**0.0000**	**4.8242**

3.15 Access road - 2015

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	2.1700e-003	0.0239	0.0138	2.0000e-005		1.2400e-003	1.2400e-003		1.1400e-003	1.1400e-003	0.0000	2.3591	2.3591	7.0000e-004	0.0000	2.3739
Total	**2.1700e-003**	**0.0239**	**0.0138**	**2.0000e-005**		**1.2400e-003**	**1.2400e-003**		**1.1400e-003**	**1.1400e-003**	**0.0000**	**2.3591**	**2.3591**	**7.0000e-004**	**0.0000**	**2.3739**

3.15 Access road - 2015

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	2.1700e-003	6.8300e-003	0.0138	2.0000e-005		1.2400e-003	1.2400e-003		1.1400e-003	1.1400e-003	0.0000	2.3563	2.3563	7.0000e-004	0.0000	2.3711
Total	**2.1700e-003**	**6.8300e-003**	**0.0138**	**2.0000e-005**		**1.2400e-003**	**1.2400e-003**		**1.1400e-003**	**1.1400e-003**	**0.0000**	**2.3563**	**2.3563**	**7.0000e-004**	**0.0000**	**2.3711**

3.16 CMB access road - 2015

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	5.3900e-003	0.0571	0.0311	5.0000e-005		3.1500e-003	3.1500e-003		2.9000e-003	2.9000e-003	0.0000	4.7998	4.7998	1.4300e-003	0.0000	4.8299
Total	**5.3900e-003**	**0.0571**	**0.0311**	**5.0000e-005**		**3.1500e-003**	**3.1500e-003**		**2.9000e-003**	**2.9000e-003**	**0.0000**	**4.7998**	**4.7998**	**1.4300e-003**	**0.0000**	**4.8299**

3.16 CMB access road - 2015

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	5.3800e-003	0.0315	0.0311	5.0000e-005		3.1400e-003	3.1400e-003		2.8900e-003	2.8900e-003	0.0000	4.7941	4.7941	1.4300e-003	0.0000	4.8242
Total	**5.3800e-003**	**0.0315**	**0.0311**	**5.0000e-005**		**3.1400e-003**	**3.1400e-003**		**2.8900e-003**	**2.8900e-003**	**0.0000**	**4.7941**	**4.7941**	**1.4300e-003**	**0.0000**	**4.8242**

3.17 AC access road pavement - 2015

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	2.1300e-003	0.0212	0.0105	1.0000e-005		1.2800e-003	1.2800e-003		1.1800e-003	1.1800e-003	0.0000	1.2612	1.2612	3.8000e-004	0.0000	1.2691
Paving	0.0000					0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	**2.1300e-003**	**0.0212**	**0.0105**	**1.0000e-005**		**1.2800e-003**	**1.2800e-003**		**1.1800e-003**	**1.1800e-003**	**0.0000**	**1.2612**	**1.2612**	**3.8000e-004**	**0.0000**	**1.2691**

3.17 AC access road pavement - 2015

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	2.1300e-003	0.0212	0.0105	1.0000e-005		1.2800e-003	1.2800e-003		1.1800e-003	1.1800e-003	0.0000	1.2597	1.2597	3.8000e-004	0.0000	1.2676
Paving	0.0000					0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	**2.1300e-003**	**0.0212**	**0.0105**	**1.0000e-005**		**1.2800e-003**	**1.2800e-003**		**1.1800e-003**	**1.1800e-003**	**0.0000**	**1.2597**	**1.2597**	**3.8000e-004**	**0.0000**	**1.2676**

3.18 Fence and gate - 2015

Unmitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	2.5800e-003	0.0304	0.0137	3.0000e-005		1.1600e-003	1.1600e-003		1.0700e-003	1.0700e-003	0.0000	3.1363	3.1363	9.4000e-004	0.0000	3.1560
Total	**2.5800e-003**	**0.0304**	**0.0137**	**3.0000e-005**		**1.1600e-003**	**1.1600e-003**		**1.0700e-003**	**1.0700e-003**	**0.0000**	**3.1363**	**3.1363**	**9.4000e-004**	**0.0000**	**3.1560**

3.18 Fence and gate - 2015

Mitigated Construction On-Site

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Off-Road	2.5700e-003		0.0136	3.0000e-005		1.1600e-003	1.1600e-003		1.0700e-003	1.0700e-003	0.0000	3.1326	3.1326	9.4000e-004	0.0000	3.1522
Total	**2.5700e-003**		**0.0136**	**3.0000e-005**		**1.1600e-003**	**1.1600e-003**		**1.0700e-003**	**1.0700e-003**	**0.0000**	**3.1326**	**3.1326**	**9.4000e-004**	**0.0000**	**3.1522**

4.0 Operational Detail - Mobile

4.1 Mitigation Measures Mobile

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Mitigated	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Unmitigated	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

4.2 Trip Summary Information

	Average Daily Trip Rate			Unmitigated	Mitigated
Land Use	Weekday	Saturday	Sunday	Annual VMT	Annual VMT
User Defined Industrial	0.00	0.00	0.00		
Total	0.00	0.00	0.00		

4.3 Trip Type Information

	Miles			Trip %			Trip Purpose %		
Land Use	H-W or C-W	H-S or C-C	H-O or C-NW	H-W or C-W	H-S or C-C	H-O or C-NW	Primary	Diverted	Pass-by
User Defined Industrial	9.50	7.30	7.30	0.00	0.00	0.00	0	0	0

4.4 Fleet Mix

LDA	LDT1	LDT2	MDV	LHD1	LHD2	MHD	HHD	OBUS	UBUS	MCY	SBUS	MH
0.474028	0.063287	0.180321	0.158861	0.070757	0.010543	0.013219	0.016605	0.000784	0.000665	0.005582	0.000318	0.005029

5.0 Energy Detail

Historical Energy Use: N

5.1 Mitigation Measures Energy

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Electricity Mitigated						0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Electricity Unmitigated						0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NaturalGas Mitigated	0.0000	0.0000	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
NaturalGas Unmitigated	0.0000	0.0000	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

5.2 Energy by Land Use - NaturalGas

Unmitigated

	NaturalGas Use	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Land Use	kBTU/yr	tons/yr										MT/yr					
User Defined Industrial	0	0.0000	0.0000	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total		**0.0000**	**0.0000**	**0.0000**	**0.0000**		**0.0000**	**0.0000**		**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**

5.2 Energy by Land Use - NaturalGas

Mitigated

	NaturalGas Use	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Land Use	kBTU/yr	tons/yr										MT/yr					
User Defined Industrial	0	0.0000	0.0000	0.0000	0.0000		0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total		**0.0000**	**0.0000**	**0.0000**	**0.0000**		**0.0000**	**0.0000**		**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**

5.3 Energy by Land Use - Electricity

Unmitigated

	Electricity Use	Total CO2	CH4	N2O	CO2e
Land Use	kWh/yr	MT/yr			
User Defined Industrial	0	0.0000	0.0000	0.0000	0.0000
Total		**0.0000**	**0.0000**	**0.0000**	**0.0000**

5.3 Energy by Land Use - Electricity

Mitigated

	Electricity Use	Total CO2	CH4	N2O	CO2e
Land Use	kWh/yr	MT/yr			
User Defined Industrial	0	0.0000	0.0000	0.0000	0.0000
Total		**0.0000**	**0.0000**	**0.0000**	**0.0000**

6.0 Area Detail

6.1 Mitigation Measures Area

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category	tons/yr										MT/yr					
Mitigated	0.2288	9.0000e-005	9.4300e-003	0.0000		3.0000e-005	3.0000e-005		3.0000e-005	3.0000e-005	0.0000	0.0179	0.0179	5.0000e-005	0.0000	0.0189
Unmitigated	0.2288	9.0000e-005	9.4300e-003	0.0000		3.0000e-005	3.0000e-005		3.0000e-005	3.0000e-005	0.0000	0.0179	0.0179	5.0000e-005	0.0000	0.0189

6.2 Area by SubCategory

Unmitigated

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
SubCategory	tons/yr										MT/yr					
Architectural Coating	0.0521					0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Consumer Products	0.1758					0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Landscaping	9.2000e-004	9.0000e-005	9.4300e-003	0.0000		3.0000e-005	3.0000e-005		3.0000e-005	3.0000e-005	0.0000	0.0179	0.0179	5.0000e-005	0.0000	0.0189
Total	**0.2288**	**9.0000e-005**	**9.4300e-003**	**0.0000**		**3.0000e-005**	**3.0000e-005**		**3.0000e-005**	**3.0000e-005**	**0.0000**	**0.0179**	**0.0179**	**5.0000e-005**	**0.0000**	**0.0189**

Mitigated

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
SubCategory	tons/yr										MT/yr					
Architectural Coating	0.0521					0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Consumer Products	0.1758					0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Landscaping	9.2000e-004	9.0000e-005	9.4300e-003	0.0000		3.0000e-005	3.0000e-005		3.0000e-005	3.0000e-005	0.0000	0.0179	0.0179	5.0000e-005	0.0000	0.0189
Total	**0.2288**	**9.0000e-005**	**9.4300e-003**	**0.0000**		**3.0000e-005**	**3.0000e-005**		**3.0000e-005**	**3.0000e-005**	**0.0000**	**0.0179**	**0.0179**	**5.0000e-005**	**0.0000**	**0.0189**

7.0 Water Detail

7.1 Mitigation Measures Water

	Total CO2	CH4	N2O	CO2e
Category	MT/yr			
Mitigated	0.0000	0.0000	0.0000	0.0000
Unmitigated	0.0000	0.0000	0.0000	0.0000

7.2 Water by Land Use

Unmitigated

	Indoor/Outdoor Use	Total CO2	CH4	N2O	CO2e
Land Use	Mgal	MT/yr			
User Defined Industrial	0 / 0	0.0000	0.0000	0.0000	0.0000
Total		**0.0000**	**0.0000**	**0.0000**	**0.0000**

7.2 Water by Land Use

Mitigated

	Indoor/Outdoor Use	Total CO2	CH4	N2O	CO2e
Land Use	Mgal	MT/yr			
User Defined Industrial	0 / 0	0.0000	0.0000	0.0000	0.0000
Total		**0.0000**	**0.0000**	**0.0000**	**0.0000**

8.0 Waste Detail

8.1 Mitigation Measures Waste

Category/Year

	Total CO2	CH4	N2O	CO2e
	MT/yr			
Mitigated	0.0000	0.0000	0.0000	0.0000
Unmitigated	0.0000	0.0000	0.0000	0.0000

8.2 Waste by Land Use

Unmitigated

	Waste Disposed	Total CO2	CH4	N2O	CO2e
Land Use	tons	MT/yr			
User Defined Industrial	0	0.0000	0.0000	0.0000	0.0000
Total		**0.0000**	**0.0000**	**0.0000**	**0.0000**

Mitigated

	Waste Disposed	Total CO2	CH4	N2O	CO2e
Land Use	tons	MT/yr			
User Defined Industrial	0	0.0000	0.0000	0.0000	0.0000
Total		**0.0000**	**0.0000**	**0.0000**	**0.0000**

9.0 Operational Offroad

Equipment Type	Number	Hours/Day	Days/Year	Horse Power	Load Factor	Fuel Type

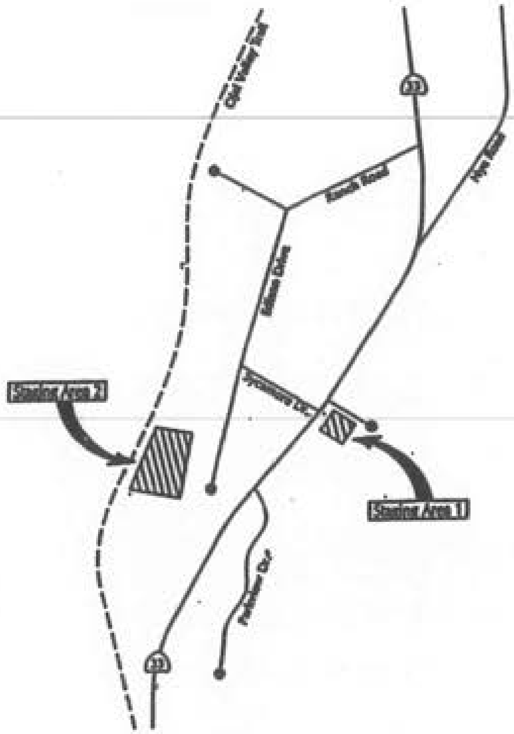
10.0 Vegetation

APPENDIX G

Traffic and Circulation Study (November 2013)

FRESNO CANYON FLOOD MITIGATION PROJECT

TRAFFIC AND CIRCULATION STUDY



November 19, 2013

ATE Project #12001

Prepared for:
Impact Sciences
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Camarillo, California 93012

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November 19, 2013

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TRAFFIC AND CIRCULATION STUDY
THE FRESNO CANYON FLOOD MITIGATION PROJECT

Associated Transportation Engineers (ATE) is pleased to submit the following traffic study for the Fresno Canyon Flood Mitigation Project. Specific to traffic, the project will require import/export of raw and finished material via trucks on State Route 33 in Casitas Springs and the local area street network. The traffic study addresses the short-term construction traffic impacts related to the construction of the Fresno Canyon Flood Mitigation Project.

It is understood that the traffic study will be included as part of the EIR being prepared for the project. We appreciate the opportunity to assist you with the project.

Associated Transportation Engineers

Richard L. Pool, P.E.
President

REGISTERED PROFESSIONAL ENGINEER
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STATE OF CALIFORNIA

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FIGURES

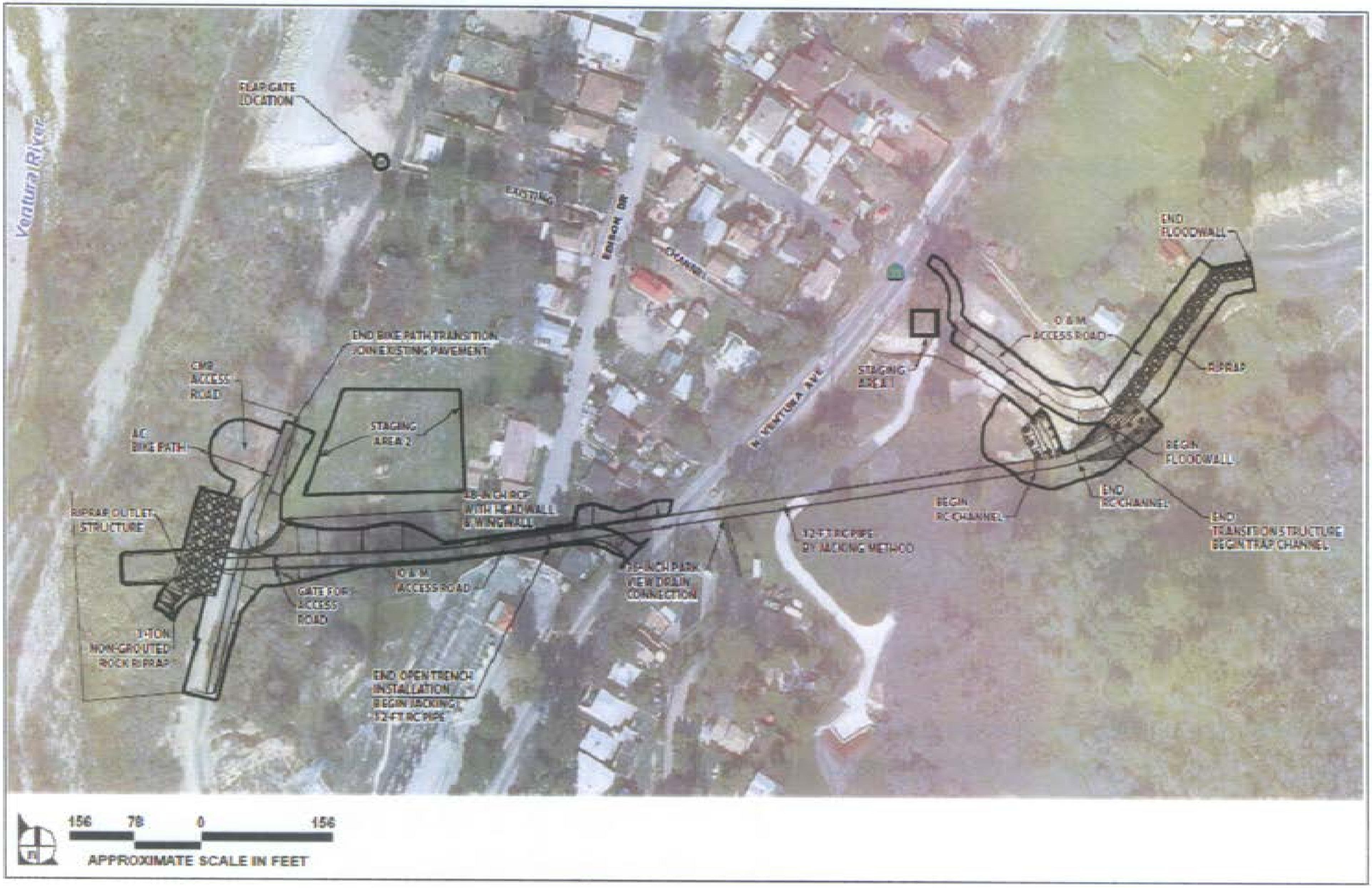
INTRODUCTION

This study contains an analysis of the potential traffic impacts associated with the Fresno Canyon Flood Mitigation Project. The project is located in the unincorporated area of Casitas Springs. The study analyzes the existing roadway system and evaluates potential short-term construction-related traffic impacts. The study also addresses potential site access issues. Mitigation measures are provided where necessary. The traffic study does not provide a long-term cumulative traffic analysis since the project proposes no operational or staffing increases that would increase traffic in the long-term.

PROJECT DESCRIPTION

The project site is located within the jurisdiction of the County of Ventura on property in the unincorporated area of Casitas Springs. The Ventura County Watershed Protection District (VCWPD), is proposing to construct a bypass storm drain facility to transport flood waters, sediment and debris from Fresno Canyon to the Ventura River to reduce the risk of flooding in the community of Casitas Springs. Figure 1 shows the general location of the project site. The facility will be designed to convey flows from the 100 year flood event by constructing a 12-foot diameter reinforced concrete pipe (RCP) installed via horizontal boring beneath State Route 33 and an open trench. The proposed project avoids the need to detour traffic on State Route 33 by using the horizontal boring method. The project includes two construction staging areas. One staging area on the eastern side of State Route 33 near the existing Fresno Canyon flood control channel inlet and the other staging area on undeveloped property north of the proposed pipeline alignment west of Edison Drive. The project also includes two maintenance roads. A 15-foot wide maintenance access road would extend west from State Route 33 to the outlet structure with turnaround area on uplands immediately west of the Ojai Valley Trail. A second maintenance access road would be constructed at the eastern end of the facility. It would connect to an existing access road at State Route 33 and extend north to the proposed flood wall.

The construction project would be short-term, estimated to be 8 months with 5 to 15 employees on site daily. Construction is planned to occur between the hours of 7:00 A.M. and 3:30 P.M., Monday through Friday, no Saturdays, Sundays or holidays. All of the construction would occur on VCWPD property. The traffic generated during the construction project would include truck and employee trips to/from the site. Trucks will import/export equipment, raw and finished material to the project site. The import of raw and finished material will be hauled to the site from sources to the south via U.S. Highway 101 and from sources north of Ojai via the 2-lane highway section of State Route 33. Truck and employee traffic will access to the project site via Ranch Road, Edison Drive, Sycamore Drive and an existing maintenance road from State Route 33.



ASSOCIATED TRANSPORTATION ENGINEERS

PROJECT LOCATION

FIGURE 1

MMF - #12001

EXISTING CONDITIONS

Street Network

Regional access to the project site is provided by U.S. Highway 101 to the south and the study-area roadway network comprising of State Route 33, as well as local streets Sycamore Drive and Edison Drive. ATE conducted a field review of the study-area roadway network. Figure 2 shows the area street network and the following text provides a brief discussion of the study-area roadways.

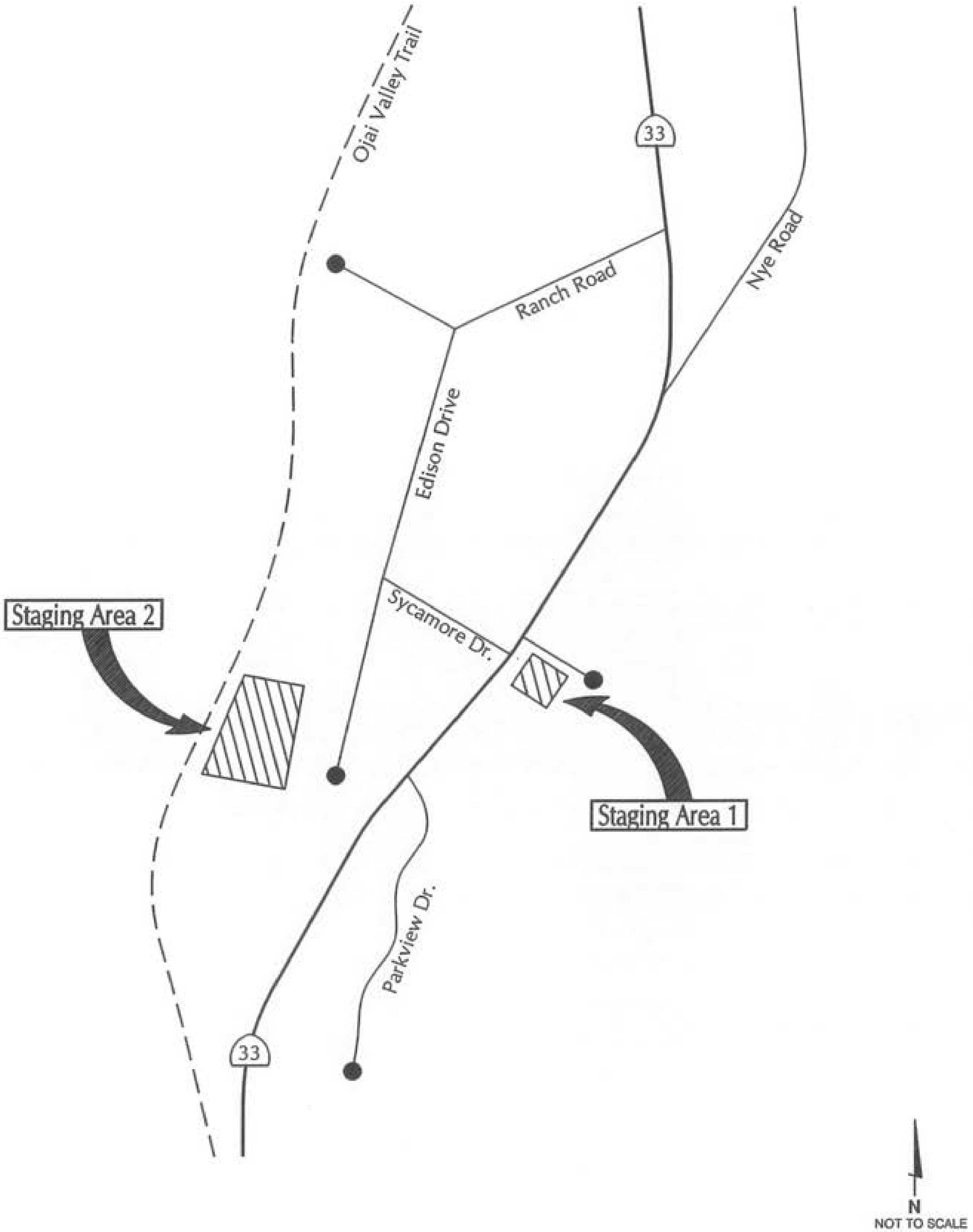
U.S. Highway 101 is the principal inter-city route along the Pacific Coast. Although U.S. Highway 101 runs mostly north-south in California, it runs east-west within the Ventura area. It is a 6-lane freeway within the Ventura area. U.S. Highway 101 connects to the study-area street network via an interchange at State Route 33.

State Route 33 located east of the project site, is the major north-south roadway within the study-area. State Route 33 extends as a 4-lane freeway from U.S. Highway 101 in the City of Ventura to Foster Park. Between the community of Casitas Springs and the City of Ojai the highway is primarily 2-lanes.

Sycamore Drive is a two-lane residential roadway extending west from State Route 33 to Edison Drive. The State Route 33/Edison Drive and Sycamore/Edison Drive intersections are controlled by STOP signs. Sycamore Drive would be utilized by construction traffic.

Edison Drive is a north-south residential roadway that extends south from Ranch Road to just south of Sycamore Drive. The Sycamore Drive/Edison Drive intersection is uncontrolled. Edison Drive would be utilized by construction traffic.

Ranch Road is an east-west residential roadway that extends west from State Route 33 to Edison Drive. Ranch Road transitions into Edison Drive. Ranch Road would be utilized by construction trucks and trucks with trailers.



ASSOCIATED TRANSPORTATION ENGINEERS

EXISTING STREET NETWORK/PROJECT STAGING AREAS

FIGURE 2

MMF - #12001

Roadway Operations

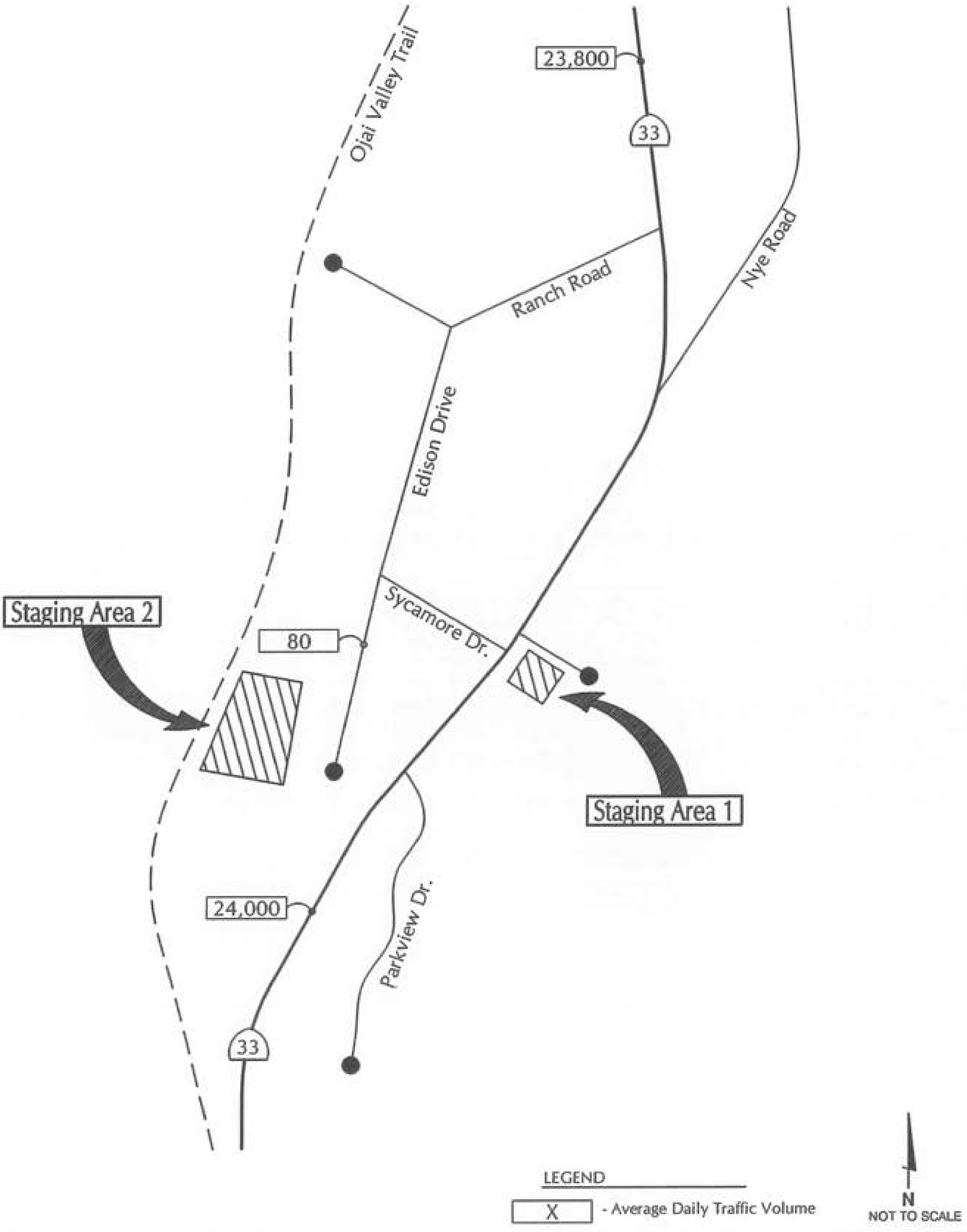
"Level of Service" (LOS) "A" through "F" are used to rate roadway operations, with LOS "A" indicating very good operating conditions and LOS "F" indicating poor conditions (more complete definitions of level of service are contained in the Technical Appendix for reference). LOS "A" through LOS "C" are generally considered acceptable, while LOS "D" through LOS F indicate poor conditions. Generally, Ventura consider LOS "C" or better as acceptable for roadway operations, however LOS "E" is acceptable for State Route 33.

Existing average daily traffic (ADT) volumes for the street network were obtained from count data on file at ATE and Caltrans[1]. Figure 3 shows the Existing ADT volumes on the key roadway segments of the study-area street network. The existing roadway operations are presented in Table 1. Levels of service are based on Ventura County engineering design capacities for roadways (a copy of roadway design capacities is contained in the Technical Appendix). The volumes indicate that the study-area roadways operate at LOS "A"-"E" based on Ventura County engineering design capacities. In the vicinity of the project site, State Route State 33 has been designated as an impacted location on the Ventura County regional roadway system. Per the Initial Study Assessment Guidelines, the addition of 1 peak hour trip to State Route 33 in the southbound direction in the A.M. commute period (6:30 A.M. - 9:00 A.M.) and northbound direction in the P.M. commute period (3:30 P.M. - 6:30 P.M.) would be considered a significant impact.

Table 1
Existing Roadway Operations

Roadway	Geometry	ADT	LOS
State Route 33	2-Lane	24,000	LOS E
Edison Drive	2-Lane	80	LOS A

1 Traffic Volumes on California State Highways, California Department of Transportation, 2012.



ASSOCIATED TRANSPORTATION ENGINEERS

EXISTING TRAFFIC VOLUMES

FIGURE 3

MMF - #12001

VENTURA COUNTY ADOPTED IMPACT THRESHOLDS

The thresholds from the Ventura County Initial Study Assessment Guidelines outlined below in Table 2 were used to assess the significance of the impacts associated with the traffic generated by the project.

Table 2
Minimum Acceptable Level of Service For Roadway Segments

County of Ventura - Minimum Acceptable Level of Service		
Case	**Minimum LOS**	**Description**
a.	LOS D	All County thoroughfares and state highways within the unincorporated area of the County, except as provided in case b.
b.	LOS E	State Route 33 between the end of the freeway and the City of Ojai.
c.	LOS C	All County maintained local roads.
d.	Varies	The LOS prescribed by the applicable city for all state highways, city thoroughfares, and city maintained local roads located within that city, if the city has formerly adopted General Plan policies, ordinances or a reciprocal agreement with the County, pertaining to development in the city that would individually or cumulatively affect the LOS of state highways, county thoroughfares and county-maintained local roads in the unincorporated are of the County.
e.		County LOS standards are applicable for any City that has not adopted its own standards.
At any intersection between two roads, each of which has a prescribed minimum acceptable LOS, the less stringent LOS of the two shall be the minimum acceptable LOS of that intersection.		

Project-Specific Impacts - A significant adverse project specific traffic impact is assumed to occur on any road segment if any one of the following results from the project:

a. If the project will add 10 or more PHT to a road segment that is currently operating at an acceptable LOS as defined in Table 2, but would cause the LOS to fall to an unacceptable level as defined in Table 2.

b. If the project will add one or more PHT to a roadway segment that is currently operating at less-than-acceptable LOS as defined in Table 2.

c. If the project will add 10 or more ADT or 1% or more of the total projected ADT, whichever is greater, to a roadway that is currently operating at less-than-acceptable LOS as defined in Table 2.

Table 3
Threshold of Significance For Changes in Level of Service at Intersections

Significant Changes in LOS	
Intersection Level of Service (Existing)	**Increase in V/C or Trips Greater Than**
LOS A	0.20
LOS B	0.15
LOS C	0.10
LOS D	10 Trips*
LOS E	5 Trips*
LOS F	1 Trip*
* To critical movements. These are the highest combination of left and opposing through/right-turn PHTM.	

Project Specific Impacts - A significant adverse project specific traffic impact is assumed to occur at any intersections if the project will change the V/C ratio or add PHT to impacted intersections that exceed the thresholds established in Table 3.

POTENTIAL IMPACTS

Trip Generation

Trip generation estimates were calculated for the Fresno Canyon project based on anticipated truck trips and construction employees. The trip generation calculations assume that construction will be limited to the hours of 7:00 A.M. to 3:30 P.M., Monday through Friday. The calculations were completed for weekday daily and peak hour activity levels. The 5 to 15 on-site employees would generate an estimated 9 to 28 daily trips over the entire construction period. The project will import 500 cubic yards of fill material, 360 cubic yards of concrete and 1,579 cubic yards of rock rip rap via trucks with a 10 cubic yard capacity. The import of raw material will require a total of 488 daily truck trips (244 truck loads) over the entire 8 month (166 days) construction schedule. This results in 4 average daily truck trips over the entire 166 days. This is in addition to general daily truck deliveries estimated to be 4 daily trips. Adding the employee and truck trips together would represent the project daily trip generation. The project workday would result in a total of 28 daily employee trips and 8 daily truck trips. Table 4 summarizes the trip generation calculations completed for the project.

Table 4
Trip Generation Estimates

Traffic Generator	Number/Day[a]	Daily Trips[b]	A.M. PHT[c]	P.M. PHT[c]
Peak Day				
Truck Loads (Fill, Concrete, Rock)	2/Day	4 Trips	0 Trips	0 Trips
Truck Loads (General Deliveries)	2/Day	4 Trips	0 Trips	0 Trips
Employees[d]	15/Day	28 Trips	14 Trips	14 Trips
Total		36 Trips	14 Trips	14 Trips

Notes: a. Truck loads averaged over the 166 day construction period for traffic analysis purposes.

b. 1 "round trip" to/from site is considered 2 trips for traffic analysis purposes.

c. Assumes 10% of daily truck trips during peak hour period.

d. Assumes 1.1 average vehicle occupancy for employees and all employees depart during P.M. peak commute period.

Truck Routing

A field review was completed to determine the existing conditions along these routes, constraints for trucks, and the most appropriate route for trucks transporting materials to/from the project site. Generally construction trucks will travel from the south via U.S. Highway 101 to import/export raw materials from Ventura/Oxnard. U.S. Highway 101 and State Route 33 are designated as truck routes in the County of Ventura. Construction trucks will also travel to/from the north via State Route 33 to import/export raw and finished materials from sources north of the project site in Casitas Springs and Ojai via the 2-lane highway section of State Route 33. The 2-lane section of State Route 33 through Casitas Springs is designated as an impacted roadway by the Ventura County General Plan. The 2-lane section of State Route 33 is lined with residential and small commercial units. The section of State Route 33 through Casitas Springs is somewhat narrow (±24 feet wide). Ventura County General Plan policy would restrict the time periods which construction traffic could use the route without impacting the 2-lane section of State Route 33. The project could specify that hauling from the north will only be done during non-peak hours outside the 6:30 A.M. to 9:00 A.M. southbound commute period and hauling from the south will only be done outside the 3:30 P.M. to 6:30 P.M. northbound commute period.

State Route 33 to Ranch Road or to the existing Maintenance Road is the truck route to the project site and project staging areas on both sides of State Route 33. Trucks destined to/from the south on U.S. Highway 101 use State Route 33 providing direct access to the project site. Inbound trucks from U.S. Highway 101 would exit at State Route 33, travel north to Ranch Road or the Maintenance Road, then on to the project site. The route would be the same in reverse for outbound trucks. The route provides the most direct access for trucks and trucks with trailers to the project site. The State Route 33/Ranch Road intersection is used by existing Ventura County Watershed Protection District vehicles. There is a northbound left-turn lane from State Route 33 to Ranch Road.

Potential Roadway Impacts

As illustrated on Figure 4 the project would result in a maximum of 36 daily trips using the roadway segments serving the project site. This additional traffic would not degrade roadway operations from a capacity standpoint, thus the project would not generate significant capacity impacts to the study-area roadways since the roadways would continue to operate in the LOS "A" - "E" range.

Table 5
Existing + Project Roadway Operations

Roadway	Geometry	ADT	LOS
State Route 33	2-Lane	24,036	LOS E
Edison Drive	2-Lane	116	LOS A

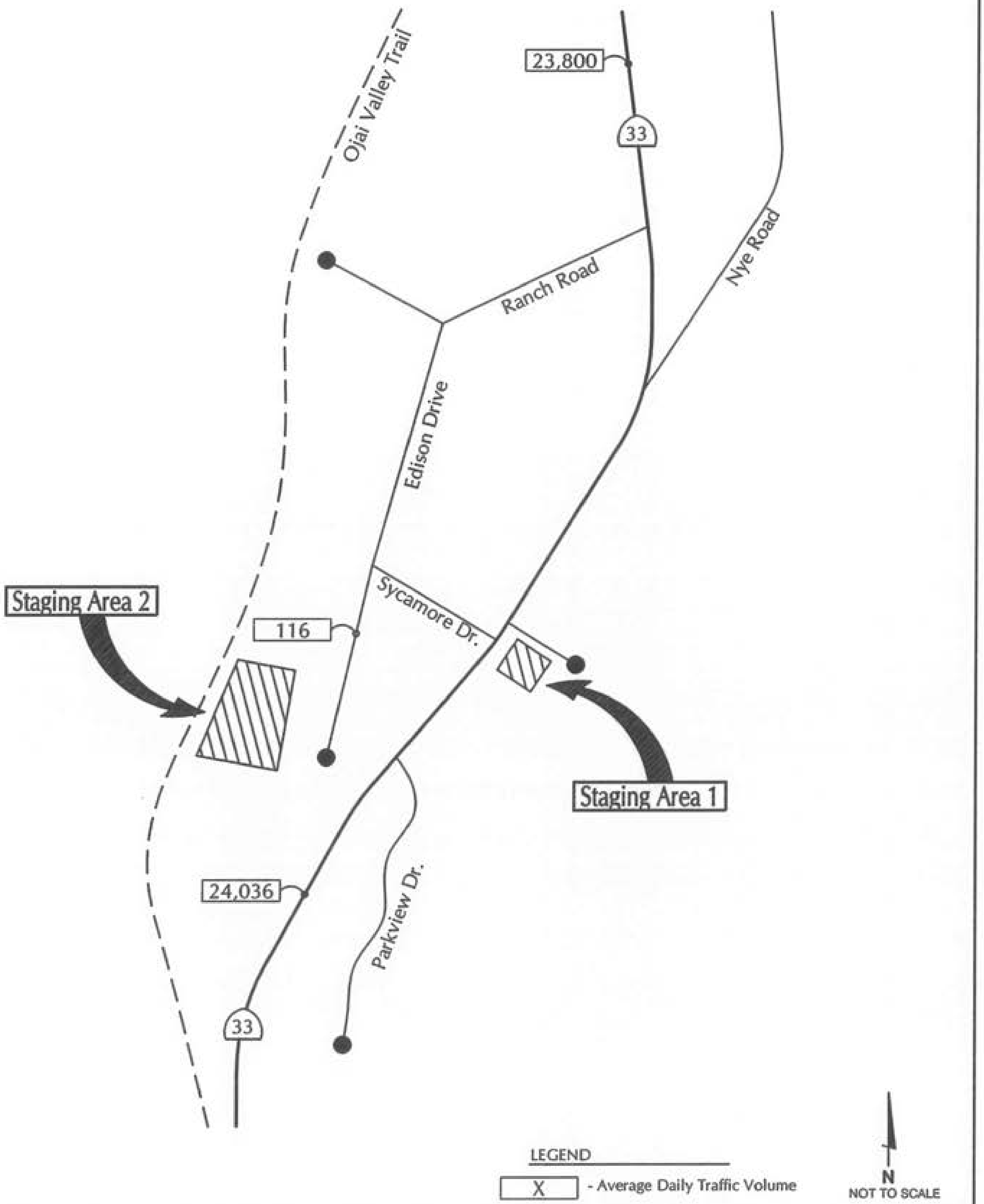
The information shown in the Table 5 does indicate that because of the project hours of construction, the project has the potential to generate a significant impact at the State Route 33 during the A.M. and P.M. peak hour periods. This roadway section operates at LOS "E" during the A.M. and P.M. peak hour period. Based on the project description, the project could add 1 or more southbound A.M. peak hour trip or 1 P.M. peak hour trip which exceeds the County's threshold for the 2-lane section of State Route 33 through Casitas Springs. Recommendations to mitigate this potential impact are provided in the Mitigation Measures section of the report.

The introduction of construction trucks and related traffic to the local roadways has the potential to impact the physical condition of the pavement section of Rancho Road and Edison Drive. Recommendations to mitigate this potential impacts to the pavement sections of the local roadways are provided in the Mitigation Measures section of the report.

CUMULATIVE IMPACTS

Traffic generated by the project is a result of construction only and is short-term in nature. No substantial increase in traffic would result from the project over the long-term because the proposed infrastructure would require only occasional maintenance and no additional employees would be hired for on-going operations. Therefore, the project would not add to cumulative traffic impacts.

Prior to the commencement of construction, a photo record and inventory of the condition of the study-area roadways and intersections along the truck route should be made. During construction, periodic inspections should be made to note any changes in the condition of the study-area roadways and intersections. After construction is completed, the study-area roadways should be inspected and repairs made to return the roadway to the condition prior to construction, if necessary.



ASSOCIATED TRANSPORTATION ENGINEERS

EXISTING + PROJECT TRAFFIC VOLUMES

FIGURE 4

MMF - #12001

MITIGATION MEASURES

Pre-Construction. Prior to the commencement of construction, a photo record and inventory of the condition of the study-area roadways and intersections along the truck route should be made. During construction, periodic inspections should be made to note any changes in the condition of the study-area roadways and intersections. After construction is completed, the study-area roadways should be inspected and repairs made to return the roadway to the condition prior to construction, if necessary.

Site Access. The access route for construction trucks and employees arriving to the site should be properly signed during periods of construction activity.

2-Lane Section of State Route 33. This section of State Route 33 operates at LOS "E" during the A.M. and P.M. peak hour periods and the project has the potential to add more than 1 employee trip southbound during the A.M. peak hour period and 1 trip northbound during the P.M. peak hour period exceeding the County's threshold. The temporary impact would be mitigated by the following measure:

> Project Scheduling. Construction is planned to occur between the hours of 7:00 A.M. and 3:30 P.M., Monday through Friday. The project could ensure that no new southbound employee trips arrive during the 6:30 A.M. - 9:00 A.M. peak hour period and no new northbound employee trips depart during the 3:30 P.M. - 6:30 P.M. peak hour period by hiring local Contractors with employees that live south of the project site or have employees which already travel south from Ojai to work which would mitigate the potential impact to the State Route 33. Since this is a temporary impact, employees that live in Ojai and already travel southbound on State Route 33 to work would not be considered new trips added to the impacted section.

Caltrans Encroachment Permits. The project would be required to apply and receive Caltrans encroachment permits for work done within the Caltrans Right-of-Way. The Caltrans encroachment permit may require a Traffic Control Plan (TCP) to mitigate any construction related impacts (i.e. temporary lane closures, lane or intersection modifications, etc.) to State Route 33 during the construction period.

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STUDY PARTICIPANTS AND REFERENCES

Associated Transportation Engineers

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TECHNICAL APPENDIX

CONTENTS:

LEVEL OF SERVICE DEFINITIONS

VENTURA COUNTY STANDARD ENGINEERING ROADWAY DESIGN CAPACITIES

LEVEL OF SERVICE DEFINITIONS

The ability of a roadway system to carry traffic is most often expressed in terms of "Levels of Service" (LOS). LOS A through F are used, with LOS A indicating very good operations and LOS F indicating poor operations. More complete level of service definitions are listed in the following table.

LOS	Definition
A	Conditions of free unobstructed flow, no delays and all signal phases sufficient in duration to clear all approaching vehicles.
B	Conditions of stable flow, very little delay, a few phases are unable to handle all approaching vehicles.
C	Conditions of stable flow, delays are low to moderate, full use of peak direction signal phases is experienced.
D	Conditions approaching unstable flow, delays are moderate to heavy, significant signal time deficiencies are experienced for short durations during the peak traffic period.
E	Conditions of unstable flow, delays are significant, signal phase timing is generally insufficient, congestion exists for extended duration throughout the peak period.
F	Conditions of forced flow, travel speeds are low and volumes are well above capacity. This condition is often caused when vehicles released by an upstream signal are unable to proceed because of back-ups from a downstream signal.

Source: Highway Capacity Manual, December 2000.

FIGURE 4.2.2

AVERAGE DAILY TRAFFIC (ADT) LEVEL OF SERVICE (LOS) THRESHOLDS COUNTY ROADS AND CONVENTIONAL STATE HIGHWAYS					
	CLASS I			CLASS II	CLASS III
LOS	2 LANES	4 LANES	6 LANES	2 LANES	2 LANES
A	2,400	19,000	29,000	1,500	350
B	5,600	28,000	42,000	3,900	2,000
C	10,000	38,000	57,000	7,000	3,300
D	16,000	47,000	70,000	11,000	5,900
E	27,000	58,000	87,000	21,000	16,000

ADT/LOS THRESHOLDS FREEWAYS				
LOS	4 LANES	6 LANES	8 LANES	10 LANES
A	31,000	46,000	62,000	77,000
B	48,000	71,000	95,000	119,000
C	68,000	102,000	136,000	169,000
D	82,000	123,000	164,000	205,000
E	88,000	132,000	176,000	220,000

SOURCE: VENTURA COUNTY PUBLIC WORKS AGENCY 9/94

R. 12/20/94