Appendix E

Geotechnical Investigation Report, Fault Rupture Hazard Investigation Report

I-15 Logistics Project

Draft Environmental Impact Report

Appendix E.1

Geotechnical Investigation Report

I-15 Logistics Project

Draft Environmental Impact Report

CHJ Consultants
1355 E. Cooley Drive, Suite C, Colton, CA 92324 ◆ Phone (909) 824-7311 ◆ Fax (909) 503-1136
15345 Anacapa Road, Suite D, Victorville, CA 92392 ◆ Phone (760) 243-0506 ◆ Fax (760) 243-1225
77-564A Country Club Drive, Suite 122, Palm Desert, CA 92211 ◆ Phone (760) 772-8234 ◆ Fax (909) 503-1136

May 12, 2014

Caprock Partners
250 Main Street, Suite 240
Irvine, California 92614
Attention: Mr. Tom Donahue

Job No. 14176-3

Dear Mr. Donahue:

This letter transmits four copies of the Geotechnical Investigation report prepared for the proposed I-15 Logistics Center project on Lytle Creek Road in the Fontana area of San Bernardino County, California.

We are pleased to provide geotechnical services for this project. If you have questions or comments concerning this report, please contact us at your convenience.

Respectfully submitted,
CHJ CONSULTANTS

John S. McKeown

John S. McKeown, E.G.
Project Geologist

JMc/JFC:lb

Distribution: Caprock Partners (4)

GEOTCHNICAL INVESTIGATION
PROPOSED I-15 LOGISTICS CENTER
LYTLE CREEK ROAD
FONTANA AREA
SAN BERNARDINO COUNTY, CALIFORNIA
PREPARED FOR
CAPROCK PARTNERS
JOB NO. 14176-3

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1355 E. Cooley Drive, Suite C, Colton, CA 92324 ◆ Phone (909) 824-7311 ◆ Fax (909) 503-1136
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May 12, 2014

Caprock Partners
250 Main Street, Suite 240
Irvine, California 92614
Attention: Mr. Tom Donahue

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Dear Mr. Donahue:

Attached herewith is the Geotechnical Investigation report prepared for the proposed I-15 Logistics Center Project on Lytle Creek Road in the Fontana area of San Bernardino County, California.

This report is based upon a scope of services generally outlined in our proposal, dated March 14, 2014, and other written and verbal communications.

We are pleased to provide geotechnical services for this project. If you have questions or comments concerning this report, please contact this firm at your convenience.

Respectfully submitted,
CHJ CONSULTANTS

John S. McKeown

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INTRODUCTION

During April and May of 2014, a geotechnical investigation was performed by this firm for the proposed I-15 Logistics Center project, to be located northwest of Interstate 15 and southeast of Lytle Creek Road in the city of Fontana, California. The purposes of this investigation were to explore and evaluate the geotechnical conditions at the subject site and to provide appropriate geotechnical recommendations for design and construction of the proposed project.

To orient our investigation, an ALTA survey map, dated March 14, 2014, was furnished for our use. Also, a conceptual Site Plan dated January 14, 2014, was provided that indicates the building location, a planned water quality basin and graded slopes. The approximate location of the site is shown on the attached Index Map (Enclosure "A-1").

The results of our investigation, together with our conclusions and recommendations, are presented in this report.

SCOPE OF SERVICES

The scope of services provided during this geotechnical investigation included the following:

- Review of published and unpublished literature and maps
- Review and analysis of aerial photographs flown between 1938 and 2012
- Field reconnaissance of the site and surrounding area

- Site-specific geologic mapping of the site
- Marking of exploration locations at the site and notification of Underground Service Alert of Southern California
- Excavation of six exploratory test pits and collection of bulk samples
- Observation of geologic materials in six fault exploration trenches
- Laboratory testing on selected samples
- Evaluation of the geotechnical engineering data to develop site-specific recommendations for site grading, foundation design, storm water disposal and mitigation of potential geologic constraints

PROJECT CONSIDERATIONS

The project consists of construction of a logistics-scale warehouse with associated infrastructure and parking areas. The rectangular building footprint is approximately 1.2 million square feet. It is our understanding that the proposed structure will be of concrete tilt-up-type construction, utilizing conventional spread foundations for support. Associated infrastructure is to include buried utilities and parking/driveway areas. Parking and driveway areas are assumed to be of hot mix asphalt (HMA) and/or Portland cement concrete (PCC) pavement. A large storm water quality basin is planned to the southwest of the structure. Graded slopes are planned to the northeast and southwest of the building.

The project grading plan was not available at the time of our investigation. Based on our review of the topography of the site, it is anticipated that grading of this site will entail cuts on the northeast end and fills on the southwest portion. The final project grading plan should be reviewed by the geotechnical engineer.

SITE DESCRIPTION

The approximately 72-acre site consists of two contiguous parcels referred to herein as the Getchell parcel and Stutzke parcel. An approximately 9-acre parcel adjoining the site to the southwest is planned for a portion of the storm water quality basin. The 9-acre parcel was not included in this investigation. The site is bounded by Lytle Creek Road to the northwest, Caltrans right-of-way to the southeast, and private lands to the northeast and south. At the time of our investigation, the site was covered by a low growth of annual grasses and scrub-type plants. The majority of the site consists of undeveloped land associated with past agrarian activities. Portions of the site are developed with residential structures. More recent uses of the Stutzke parcel include storage of woodpiles, assorted vehicles and watercraft, and livestock farming. The Getchell parcel is occupied with a residence; however, no indications of farming or other land use are evident.

Overhead and buried utilities were observed or indicated by Underground Service Alert markings along Lytle Creek Road. Small-diameter steel water pipes were located and marked in several areas of the site. Some of these extend over 1/2 mile across the site area and convey spring flows to water tanks south of the site. Water lines were capped with permission of the owners where crossed by excavations and later restored to use. An assortment of rock walls, wire fences and boulder windrows were traversed during excavation work.

We reviewed aerial photographs of the site spanning the time period from 1938 to 2012. The residential and outbuilding structures and walls within the site, present at the time of our investigation, are visible as early as 1938. Light-toned sediments are visible emanating from Duncan Canyon and three small tributary canyons and are attributed to the flood of March 2, 1938. Electric tower pads and Lytle Creek Road are visible in present locations in 1938. Land clearing and rock removal from selected areas is visible as areas of light color tones on the photographs. In 1955, the Stutzke parcel includes mature trees as a windbreak at the toe of the escarpment along Lytle Creek Road. Orchard trees are also present within the site. Portions of the Getchell parcel appear cleared of vegetation in 1938 and 1955 with light toned areas corresponding to the geologic unit Qyf_4 (see

Enclosure "A-2" for an explanation of the geologic unit symbols). Indications of rock removal, vehicle tracking and clearing are visible as light toned tracks throughout both parcels. The most recent geomorphic edge of the Lytle Creek alluvial fan is visible as a tonal contrast and topographic inflection and corresponds approximately with the alignment of the Qw unit separating units Qyf_5 and the area of Qf/Qyf_4. The Duncan Canyon bench overlooks the site to the west-southwest as a relatively flat, uplifted geomorphic surface dissected by modern drainages including Duncan Canyon and three small tributaries. The bench surface, formed in Pleistocene-age sediments, represents a former valley floor adjacent to the San Gabriel range front much as the site exists in present time.

The site appears in imagery subsequent to 1960 in a similar state as that which existed during our investigation, with the amount of stored equipment, vehicles and livestock generally increasing through time. Aside from the Duncan Canyon bench and escarpment of the range front, evidence of active faulting such as lineaments, offset streams or scarps was not noted within the site on the imagery examined.

FIELD INVESTIGATION

Due to the volume of cobble to boulder-size material within the site soils, it was not feasible to collect undisturbed driven samples. Therefore, the soil conditions underlying the subject site were evaluated by means of observing the conditions in six fault exploration trenches ranging from approximately 50 feet to 500 feet in length and 13 to 15 feet deep. In addition, six exploratory test pits were excavated a maximum depth of 12 feet below the existing ground surface (bgs) with a track-mounted CAT 365 excavator equipped with a 50-inch-wide bucket. The approximate locations of our exploratory trenches and test pits are indicated on the attached Geologic Map and Site Plan (Enclosure "A-2").

Logs of the subsurface conditions, as encountered within the explorations, were recorded at the time of excavation by a geologist from this firm. Bulk samples of typical soil types obtained were returned to the laboratory in sealed containers for testing and evaluation.

Our exploratory trench logs are presented in Appendix "B". The stratification lines presented on the trench logs represent approximate boundaries between soil types, which may include gradual transitions.

LABORATORY INVESTIGATION

Included in the laboratory testing program were field moisture content tests on all samples returned to the laboratory. The results are included on the trench logs. Optimum moisture content - maximum dry density relationships were established for two typical soil types. Direct shear testing was performed on selected remolded samples in order to provide shear strength parameters for bearing capacity and earth pressure evaluations. Sieve analyses were performed on selected samples to aid in soil classification. Sieve analyses, sand equivalent and R-value tests were performed on probable pavement subgrade soils to develop criteria for on-site pavement design recommendations. Selected samples of material were delivered to HDR|Schiff for soil corrosivity tests.

Our laboratory test results are presented in Appendix "C". Soil classifications provided in our geotechnical investigation are as per the Unified Soil Classification System (USCS).

SITE GEOLOGY AND SUBSURFACE SOIL CONDITIONS

The site of the proposed logistics center is located at the eastern end of the San Gabriel Mountains of southern California. The San Gabriel Range, along with the Santa Monica and San Bernardino Mountains and other ranges, forms the Transverse Ranges Geomorphic Province. The Transverse Ranges province is characterized by east-west trending mountains within the generally northwest-trending fabric of adjacent provinces. Fault systems along the margins of the province accommodate uplift of ranges relative to adjoining lowlands. The Cucamonga fault zone (CFZ) is a zone of thrust faults that extends from San Antonio Canyon to Lytle Creek along the south flank of the eastern San Gabriel Mountains and occupies the western edge of the site. Based on mapping by Morton and Matti (2001), the site is underlain by alluvial-fan sediments of middle to early Holocene age

(Enclosure "A-3"). Based on site-specific mapping, localized areas of colluvium (gravity-deposited sediment) and limited areas of recent alluvial deposits occur along the escarpment bounding the western edge of the site and locally within tributary drainages sourced west of the site.

As encountered in our explorations, the site is underlain by native sediments that are locally disturbed by past agrarian uses, plant growth and disking to depths varying from approximately 1 to 2 feet bgs. A topsoil horizon consisting of dark brown or reddish brown silty sand with scattered gravel occurs locally and varies from approximately 1/2 foot to 5 feet in thickness. This horizon is generally associated with areas indicated as Qyf_4 and Qf on the geologic map (Enclosure "A-2"). The upper soils are underlain by coarse-grained alluvial-fan sediments to the maximum depths explored. These sediments are present to the ground surface in areas indicated as Qyf_5 on Enclosure "A-2". The alluvial-fan sediments consist of thickly bedded to massive gravel and cobble-size materials in a fine- to medium-grained, silty sand matrix. Bouldery horizons and scattered zones were also encountered. The site soils are characterized by abundant gravel and cobble content. Based upon observations and excavation characteristics, the upper 1 to 2 feet of native soils are in a loose state. Medium dense to dense soils were encountered at depths generally greater than 2 feet.

Localized fill and debris of limited volume was observed as scattered piles, rock windrows and dry-stacked walls within the site. All undocumented fill and loose disturbed soils encountered at the site are considered unsuitable for the support of structures or pavement.

With the exception of Trench T-3B, neither groundwater nor bedrock was encountered within the explorations to the maximum depths attained. Bedrock was encountered in T-3B, located outside of the building area, at a depth of approximately 20 feet bgs. Refusal to excavation was not experienced in the explorations.

The materials encountered during this investigation were generally granular and considered to be non-critically expansive.

Our explorations exhibited slight to moderate caving in uncemented gravelly zones during excavation.

More detailed descriptions of the subsurface soil conditions encountered within our exploratory borings are presented on the attached trench logs.

FAULTING

The western portion of the site lies within an Alquist-Priolo Earthquake Fault Zone designated by the State of California to include traces of suspected active faulting associated with the Cucamonga fault zone. A fault rupture hazard investigation was performed concurrently with this geotechnical investigation. The results are discussed under separate cover. Mitigation of potential for fault rupture is included for this project by establishment of a no-build setback zone along the western site boundary. The limits of the setback zone are shown on Enclosure "A-2".

The tectonics of the Southern California area are dominated by the interaction of the North American plate and the Pacific plate, which slide past each other in a translational manner. Although some of the motion may be accommodated by rotation of crustal blocks such as the western Transverse Ranges (Dickinson, 1996), the San Andreas fault zone is thought to represent the major surface expression of the tectonic boundary and to be accommodating most of the translational motion between the Pacific plate and the North American plate. However, some of the plate motion is apparently also accommodated by other northwest-trending strike-slip faults that are thought to be related to the San Andreas system. These related faults include the San Jacinto fault and the Elsinore fault. Local compressional or extensional strain resulting from the translational motion along this boundary is accommodated by left-lateral, reverse and normal faults such as the San Jose fault, the Cucamonga fault zone and the Crafton Hills fault zone (Matti and others, 1992; Morton and Matti, 1993).

The Cucamonga fault is part of a series of east-west trending, predominantly reverse and thrust faults coincident with the southern margin of the San Gabriel Mountains known as the Transverse Ranges frontal fault system. The Cucamonga fault is located within the western site boundary where an inferred trace at the range front of the San Gabriel Mountains has been observed in trenches to truncate Holocene alluvium. Evidence of recent activity on traces of the Cucamonga fault located west of the site includes well-defined fresh scarps, sag ponds and disrupted Holocene-age alluvium (Dutcher and Garrett, 1963; Yerkes, 1985; Morton and Yerkes, 1987). The San Fernando fault of this system, located in the western portion of the San Gabriel Mountains, ruptured during the 1971 moment magnitude (M) 6.6 San Fernando earthquake.

The San Jacinto fault zone is a system of northwest-trending, right-lateral strike-slip faults. In the northern San Bernardino Valley, the San Jacinto fault zone is characterized by multiple parallel strands that include the Lytle Creek, the Glen Helen and the Rialto-Colton faults (Burnett and Hart, 1994; Morton and Matti, 1993; Matti and others, 1985). The "Lytle Creek" trace of the San Jacinto fault is located approximately 1/4 mile east of the site (Morton and Miller, 2006). More large historic earthquakes have occurred on the San Jacinto fault than any other fault in Southern California (Working Group on California Earthquake Probabilities, 1988). Based on the data of Matti and others (1992), the San Bernardino Valley segment of the San Jacinto fault may accommodate much of the motion between the Pacific plate and the North American plate in this area. Matti and others (1992) suggest this motion is transferred to the San Andreas fault in the Cajon Pass region by "stepping over" to parallel fault strands, which include the Glen Helen fault. The Working Group on California Earthquake Probabilities (1995) tentatively assigned a 37 percent (±17 percent) probability of a major earthquake on the San Bernardino Valley segment of the San Jacinto fault for the 30-year interval from 1994 to 2024.

The San Andreas fault zone is located along the southwest margin of the San Bernardino Mountains approximately 4-1/2 miles northeast of the site (Morton and Miller, 2006). Two main splays of the northwest-trending San Andreas fault zone, commonly referred to as the Mill Creek fault, or the north branch and the south branch, are present in the San Bernardino Valley area. Several minor splays of uncertain activity are also identified. The two main splays of the San Andreas fault merge in the Devore area north of the site. The toe of the mountain front in the San Bernardino area roughly demarcates the known presently active south branch of the San Andreas fault, which is characterized by youthful fault scarps, vegetational lineaments, springs and dextrally offset drainages. The Working Group on California Earthquake Probabilities (1995) tentatively assigned a 28 percent (±13 percent) probability to a major earthquake occurring on the San Bernardino Mountains segment of the San Andreas fault between 1994 and 2024.

The Red Hill fault is shown as a queried buried fault trace approximately 3-1/2 miles southwest of the site by Morton (1974) and Jennings (1994). The Red Hill fault is a northeast-trending left-lateral fault that is, for the most part, thought to be Pleistocene in age except possibly the easternmost portion. This fault is thought to form a local groundwater barrier (California Department of Water Resources, 1970; Fife and others, 1976). However, due to a paucity of wells in the area, the location and orientation of this barrier is uncertain (Smith, 1977).

The Rialto-Colton groundwater barrier is shown on published geologic maps approximately 6 miles southeast of the site (Carson and Matti, 1985; Morton, 1974; Woolfenden and Kadhim, 1997). The Rialto-Colton groundwater barrier is known as a subsurface structure, has no discernable surface features and is considered to be an inactive fault (Carson and Matti, 1985; Dutcher and Garret, 1963; Morton, 1974; and Woolfenden and Kadhim, 1997). A second groundwater barrier (Barrier J) has been identified approximately 1-1/2 miles southeast of the site (Dutcher and Garret, 1963; Woolfenden and Kadhim, 1997; City of Fontana, 2003). This barrier is identified based on hydrologic data, apparently has no discernable surface features and is considered to be an inactive fault.

Regional faults with the potential to generate strong ground shaking at the site include the Sierra Madre, North Frontal, Chino-Elsinore and Helendale faults located approximately 14 miles northeast, 19 miles west-southwest, 21 miles southwest and 32 miles northeast, respectively.

HISTORICAL EARTHQUAKES

A map of recorded earthquake epicenters is included as Enclosure "A-5" (Epi Software, 2000). This map includes the California Institute of Technology database for earthquakes with magnitudes of 4.0 or greater from 1932 through March of 2012.

The Working Group on California Earthquake Probabilities (1988) lists seven M 6.0 or greater earthquakes that have occurred on the San Jacinto fault since 1899, although they acknowledge that several of these earlier episodes may have occurred on other nearby faults. Two of these earthquakes took place in the San Bernardino Valley. An M 6.5 event in 1899 near Lytle Creek and an M 6.2 event in 1923 near Loma Linda may have occurred on the San Jacinto fault. However, Fife and others (1976) and Matti and Carson (1991) suggest that the 1923 event took place on an unnamed fault parallel to and east of the San Jacinto fault.

The San Fernando fault of the Transverse Ranges frontal fault system ruptured during the 1971 magnitude (M) 6.6 San Fernando earthquake. No significant historic earthquakes have been specifically attributed to the Cucamonga fault.

No large earthquakes have occurred on the San Bernardino Mountains segment of the San Andreas fault within the regional historical time frame. Using dendrochronological evidence, Jacoby and others (1987) inferred that a great earthquake on December 8, 1812, ruptured the northern reaches of this segment. Recent trenching studies have revealed evidence of rupture on the San Andreas fault at Wrightwood that occurred within this time frame (Fumal and others, 1993). Comparison of rupture events at the Wrightwood site and Pallett Creek, and analysis of reported intensities at the coastal missions, led Fumal and others (1993) to conclude that the December 8, 1812, event ruptured the San Bernardino Mountains segment of the San Andreas fault largely to the southeast of Wrightwood, possibly extending into the San Bernardino Valley. The average recurrence interval for large earthquakes along the southern San Andreas fault at six paleoseismic sites is 182 years (Stone and others, 2005). Surface rupture occurred on the Mojave segment of the San Andreas fault in the great

1857 Fort Tejon earthquake. The Coachella Valley segment of the San Andreas fault was responsible for the 1948 M 6.5 earthquake in the Desert Hot Springs area and for the 1986 M 5.6 earthquake in the North Palm Springs area.

The following table summarizes the historic seismic events in the region.

Summary of Historic Seismicity

Event ID	Date	Magnitude	Distance from Site (miles)	Direction from Site
Whittier Narrows	10/1/1987	5.9	37	WSW
Upland	2/28/1990	5.4	14	WSW
Sierra Madre	6/28/1991	5.8	32	WNW
Landers	6/28/1992	7.3	58	E
Big Bear	6/28/1992	6.4	36	E
Northridge	1/17/1994	6.7	62	W
Hector Mine	10/16/1999	7.1	75	NE
Yucaipa (14155260*)	6/16/2005	4.9	21	ESE
14355252	3/8/2008	3.9	1-1/2	SW
Chino Hills	7/29/2008	5.4	23	SW
11006189*	9/14/2011	4.2	27	SE
15141521*	4/28/2012	3.8	4-1/2	NNE
11413954	1/15/2014	4.4	2	S

* SCSN earthquake catalog

SEISMIC DESIGN PARAMETERS

Based on the geologic setting and anticipated project foundation design, the soils underlying the site are classified as Site Class "D", according to the 2013 California Building Code (CBC). The seismic design parameters according to ASCE 7-10, Section 11.4 are provided in the following table.

2013 CBC - Seismic Parameters	
Mapped Spectral Acceleration Parameters	$S_s = 2.92$ and $S_1 = 1.09$
Site Coefficients	$F_a = 1.0$ and $F_v = 1.5$
Adjusted Maximum Considered Earthquake Spectral Response Parameters	$S_{MS} = 2.92$ and $S_{M1} = 1.64$
Design Spectral Acceleration Parameters	$S_{DS} = 1.95$ and $S_{D1} = 1.09$

The site-specific design peak ground acceleration (PGA) according to ASCE 7-10, Section 11.8.3 is 1.0g. This value is based on the lesser of the maximum considered earthquake, 2 percent in 50-year probabilistic PGA with the deterministic PGA for a magnitude 6.7 event on the Cucamonga fault located 0.1 kilometer from the site.

GROUNDWATER AND LIQUEFACTION

GROUNDWATER:

The site is located in Section 18 of Township 1 North, Range 5 West, in the Rialto-Colton groundwater basin. The following table summarizes this data published by Western Municipal Water District (2014) and State of California Department of Water Resources (2014) with regard to groundwater levels in the area of the site.

Well No./Data Source	Surface Elevation (feet)	Date	Depth to Water (feet)	Location	Reference
1N5W19A001S	1,796	1-10-1992	158	0.9 mile SE	DWR (2014)
1N5W17K003S	1,850	11-15-2005	53	1 Miles ESE	WMWD (2014)
		10-21-2008	75		
		11-15-2011	58		
		3-1-2014	70		
1N5W7H001S	2,066	4-29-1993	73	¾ mile NW	WMWD (2014)
		4-8-2011	56		
Groundwater Contour Map	1973-1979		30 (NE portion)	--	Carson & Matti (1985)

A spring box along with riparian-type vegetation is located west of Lytle Creek Road near the Getchell farm driveway. We interpret the Cucamonga fault zone as a groundwater barrier at this location, causing water to rise to the surface near or west of the spring box. Indications of shallow water were not observed in the trench exposures east of Lytle Creek Road. It appears that groundwater does not occur in the near surface east of the fault zone; therefore, shallow groundwater (less than 50 feet bgs) is not anticipated within the site. Based on this data, the minimum depth to groundwater beneath the site is expected to be greater than 50 feet bgs.

LIQUEFACTION AND SEISMIC SETTLEMENT:

The site is not located in an area identified by the City of Fontana (2003) or County of San Bernardino (2010) as having a potential for liquefaction.

Liquefaction is a process in which strong ground shaking causes saturated soils to lose their strength and behave as a fluid (Matti and Carson, 1991). Ground failure associated with liquefaction can result in severe damage to structures. The geologic conditions for increased susceptibility to liquefaction are: 1) shallow groundwater (less than 50 feet in depth), 2) the presence of unconsolidated sandy alluvium, typically Holocene in age, and 3) strong ground shaking. All three of these conditions must be present for liquefaction to occur.

Two of the three conditions (presence of unconsolidated sandy alluvium and strong ground shaking) are present at the site. The current depth to groundwater at the site is anticipated to be greater than 50 feet bgs and the subsurface materials have a large percentage of gravel to cobble clast sizes. Therefore, liquefaction and seismic settlement are not considered to be a potential hazard to the site.

HYDROCONSOLIDATION

Based upon the classification of the soils encountered and our experience with similar soils in the area of the proposed development, it is our opinion that soils with a significant hydroconsolidation potential are not present at the subject site.

SLOPE STABILITY

The building portion of site is not located in an area identified as having a potential for slope instability (County of San Bernardino, 2010). Road cut slopes along the western site boundary may be susceptible to seismically induced rockfalls, slumps or shallow surficial slides. Indications of small debris flows in these slopes were observed in aerial imagery dated 2005. The relatively flat-lying topography of the site precludes the potential for slope instability in the building area; therefore, landsliding is not a hazard to the proposed project.

FLOODING AND EROSION

Evidence of localized flooding/sediment deposition was observed in aerial imagery where small tributary canyons empty into culverts along the west-central portion of the site. It is anticipated that drainage improvements will be designed to mitigate potential for site flooding from these drainages. The site is not located within a flood hazard zone as identified by FEMA (2008).

The surface soils encountered within the site consist of silty sands and gravelly sands that are moderately susceptible to erosion by wind and water. Positive drainage should be provided, and water should not be allowed to pond on the developed site. Water should not be allowed to flow over graded or natural slope areas in such a way as to cause erosion. Slopes should be graded according to current building code standards.

CONCLUSIONS

On the basis of our field and laboratory investigations, it is the opinion of this firm that the proposed development is feasible from a geotechnical standpoint, provided the recommendations contained in this report are implemented during design, grading and construction.

The northwestern portion site is located within an Alquist-Priolo earthquake fault zone established by the State of California for mitigation of surface fault rupture.

Evidence of active faulting within the site was found during a concurrent fault investigation. A project-specific building setback zone is established for the site as presented on Enclosure "A-2".

Conditions for landsliding or potential landsliding are not present on the site.

Due to the depth to groundwater, liquefaction and other shallow groundwater-related hazards are not anticipated.

Based upon our field investigation and test data, it is our opinion that existing fills, ***including trench excavation fills for this investigation and the concurrent fault investigation,*** and surficial native soils will not, in their present condition, provide uniform or adequate support for the proposed structures. These conditions may cause unacceptable differential and/or overall settlement upon application of the anticipated foundation loads. Site clearing can be expected to further aggravate the settlement-prone conditions.

Based upon the site conditions, a minimum mandatory removal of at least the upper 24 inches of existing soils should be conducted in areas to be graded throughout the site. To provide adequate support for the proposed structures, it is our recommendation that building areas be further subexcavated as necessary and recompacted to provide a compacted fill mat beneath footings and slabs. A compacted fill mat will provide a dense, uniform, high-strength soil layer to distribute the foundation loads over the underlying soils. Conventional spread foundations, either individual spread footings and/or continuous wall footings, may be utilized in conjunction with a compacted fill mat.

The bottoms of the removal excavations should be observed and approved by the engineering geologist prior to processing and fill placement. Any existing fills, ***including trench excavation fills***

for this investigation and the concurrent fault investigation, or unsuitable native soils should be removed at that time.

The on-site soils are generally granular and are considered to be non-critically expansive.

Based upon our observations and the material encountered within our exploratory trenches, it is anticipated that a significant quantity of oversized material (boulders larger than 12 inches) requiring special handling for disposal will be generated during the grading operation. While site-specific recommendations may be developed during grading plan preparation or in the field during construction, within this report we are providing general methods for disposing of oversized rock on site for preliminary consideration.

No evidence of recent significant flooding of the site was observed during the geologic field reconnaissance or on the aerial photographs reviewed.

RECOMMENDATIONS

Based on the geologic setting and anticipated project foundation design, the soils underlying the site are classified as Site Class "D", according to the 2013 CBC. The seismic design parameters according to ASCE 7-10, Section 11.4 are provided in the following table.

2013 CBC - Seismic Parameters	
Mapped Spectral Acceleration Parameters	$S_s = 2.92$ and $S_1 = 1.09$
Site Coefficients	$F_a = 1.0$ and $F_v = 1.5$
Adjusted Maximum Considered Earthquake Spectral Response Parameters	$S_{MS} = 2.92$ and $S_{M1} = 1.64$
Design Spectral Acceleration Parameters	$S_{DS} = 1.95$ and $S_{D1} = 1.09$

The site-specific design PGA according to ASCE 7-10, Section 11.8.3 is 1.0g.

GENERAL SITE GRADING:

It is imperative that no clearing and/or grading operations be performed without the presence of a representative of the geotechnical engineer. An on-site, pre-job meeting with the developer, the contractor and the geotechnical engineer should occur prior to all grading-related operations. Operations undertaken at the site without the geotechnical engineer present may result in exclusions of affected areas from the final compaction report for the project.

Grading of the subject site should be performed, at a minimum, in accordance with these recommendations and with applicable portions of the CBC. The following recommendations are presented for your assistance in establishing proper grading criteria.

INITIAL SITE PREPARATION:

All areas to be graded should be stripped of significant vegetation and other deleterious materials. These materials should be removed from the site for disposal.

MINIMUM MANDATORY REMOVAL AND RECOMPACTION OF EXISTING SOILS:

All areas to be graded should have at least the upper 24 inches of existing materials removed. The open excavation bottoms thus created should be observed by our engineering geologist to verify and document that suitable, non-compressible native sediments are exposed prior to moisture conditioning, compaction and refilling with properly tested and documented compacted fill. Deeper removals may be necessary, depending on the conditions encountered, as well as proposed footing depths and pad elevations.

Cavities created by removal of subsurface obstructions, such as structures and tree root stocks, should be thoroughly cleaned of loose soil, organic matter and other deleterious materials, shaped to provide access for construction equipment and backfilled as recommended for site fill.

PREPARATION OF FILL AREAS:

Prior to placing fill and after the subexcavation bottom has been observed and approved by the project engineering geologist, the surfaces of all areas to receive fill should be moisture conditioned to a depth of approximately 12 inches. The moisture conditioned soils should be brought to near optimum moisture content, and compacted to a relative compaction of at least 90 percent in accordance with ASTM D1557. It is anticipated that scarification of the underlying soils may result in dislodging oversized material, requiring additional handling. As such, a suitable alternative to the scarification of the underlying soils would be to moisture condition the soils, allowing sufficient time for the moisture to penetrate to a depth of 12 inches or more prior to compaction. Verification of the moisture penetration depth will be required if this alternative method is utilized.

OVERSIZED MATERIAL:

It is anticipated that quantities of oversized material (boulders larger than 12 inches in greatest dimension) requiring special handling for disposal may be encountered during the grading operation. While site-specific recommendations may be developed during grading plan preparation or in the field during construction, we are providing general methods for disposing of oversized rock on site for preliminary consideration.

Rocks between approximately 12 and 24 inches in size may be placed in areas of fill at a depth greater than approximately 10 feet below finish grade with the approval of the building official.

The oversized rock should be placed in windrows and adequately spaced to prevent nesting. Then, sandy matrix material should be flooded in between the rock to fill any void spaces. Continuous observation of the rock placement and flooding operation should be conducted by the geotechnical engineer.

Additionally, if rock disposal areas are considered necessary, oversized rock can be disposed of within designated areas that should be indicated on the grading plans. Rock disposal areas should be evaluated by the geotechnical engineer for suitability.

Oversized rock can also be crushed and exported off site or used in landscaping. Use of the oversize rock and appropriate maximum size of the oversize rock should be referred to the landscape architect.

Again, these recommendations are preliminary. Additional recommendations can be provided once the proposed grading is known. In any case, it is crucial that the geotechnical engineer be present to observe these operations. Further recommendations may be made in the field depending on the actual conditions encountered.

PREPARATION OF FOOTING AREAS:

All footings should rest upon at least 24 inches of properly compacted fill material. In areas where the required thickness of compacted fill is not accomplished by the mandatory subexcavation operation and by site rough grading, the footing areas should be subexcavated to a depth of at least 24 inches below the proposed footing base grade. The subexcavation should extend horizontally beyond the footing lines a minimum distance of 5 feet where possible. The bottoms of these excavations should then be moisture conditioned to a depth of at least 12 inches, brought to near optimum moisture content and recompacted to at least 90 percent relative compaction in accordance with ASTM D 1557 prior to refilling the excavation to grade as properly compacted fill.

COMPACTED FILLS:

The on-site soil should provide adequate quality fill material, provided it is free from roots, other organic matter, deleterious and oversized materials. Unless approved by the geotechnical engineer, rock or similar irreducible material with a maximum dimension greater than 12 inches should not be buried or placed in fills except as noted in the section "Oversized Material".

Import fill should be inorganic, non-expansive granular soils free from rocks or lumps greater than 6 inches in maximum dimension. The contractor shall notify the geotechnical engineer of import sources sufficiently ahead of their use so that the sources can be observed and approved as to the physical characteristic of the import material. For all import material, the contractor shall also submit current verified reports from a recognized analytical laboratory indicating that the import has a "not applicable" (Class S0) potential for sulfate attack based upon current (ACI) criteria and is not corrosive to ferrous metal and copper. In addition, a report should be submitted addressing environmental aspects of any proposed import material. The reports should be accompanied by a written statement from the contractor that the laboratory test results are representative of all import material that will be brought to the job. If imported fill is to be utilized in structural areas, it should meet the same strength requirement that was utilized to design the structure.

Fill should be spread in near-horizontal layers, approximately 12 inches in thickness. Thicker lifts may be approved by the geotechnical engineer if testing indicates that the grading procedures are adequate to achieve the required compaction. Each lift should be spread evenly, thoroughly mixed during spreading to attain uniformity of the material and moisture in each layer, brought to near optimum moisture content and compacted to a minimum relative compaction of 90 percent in accordance with ASTM D 1557.

Based upon the estimated relative compaction of the native soils encountered during this investigation and the relative compaction anticipated for compacted fill soils, we estimate compaction shrinkage of approximately 0 to 5 percent. Therefore, 1.00 cubic yards to 1.05 cubic yards of in-place soil material would be necessary to yield 1 cubic yard of properly compacted fill material. In addition, we would anticipate subsidence of approximately 0.1 foot. These values are exclusive of losses due to stripping, tree removal or the removal of other subsurface obstructions, if encountered, and may vary due to differing conditions within the project boundaries and the limitations of this investigation. Shrinkage due to oversize material losses are estimated at 5 percent for material over 12 inches in diameter and less than 1 percent for material over 24 inches in diameter.

Values presented for shrinkage and subsidence are estimates only. Final grades should be adjusted, and/or contingency plans to import or export material should be made to accommodate possible variations in actual quantities during site grading.

EXPANSIVE SOILS:

Since all soil materials encountered during this investigation were granular and considered to be non-critically expansive, specialized construction procedures to specifically resist expansive soil forces are not anticipated at this time. Additional evaluation of soils for expansion potential should be conducted by the geotechnical engineer during the grading operation.

FOUNDATION DESIGN:

If the site is prepared as recommended, the proposed structures may be safely founded on conventional spread foundations, either individual spread footings and/or continuous wall footings with slabs-on-grade, bearing on a minimum of 24 inches of compacted fill. Footings should be a minimum of 12 inches wide and should be established at a minimum depth of 12 inches below lowest adjacent final subgrade level. For the minimum width and depth, footings may be designed for a maximum safe soil bearing pressure of 2,500 pounds per square foot (psf) for dead plus live loads. This allowable bearing pressure may be increased by 400 psf for each additional foot of width and by 1,000 psf for each additional foot of depth, to a maximum safe soil bearing pressure of 5,000 psf for dead plus live loads. These bearing values may be increased by one-third for wind or seismic loading.

For footings thus designed and constructed, we would anticipate a maximum settlement of less than 1 inch. Differential settlement between similarly loaded adjacent footings is expected to be approximately one-half the total settlement.

LATERAL LOADING:

Resistance to lateral loads will be provided by passive earth pressure and base friction. For footings bearing against compacted fill, passive earth pressure may be considered to be developed at a rate of 420 psf per foot of depth. Base friction may be computed at 0.39 times the normal load. Base friction and passive earth pressure may be combined without reduction.

For preliminary retaining wall or shoring design purposes, a lateral active earth pressure developed at a rate of 40 psf per foot of depth should be utilized for unrestrained conditions. For restrained conditions, an at-rest earth pressure of 65 psf per foot of depth should be utilized. The "at-rest" condition applies toward braced walls which are not free to tilt. The "active" condition applies toward unrestrained cantilevered walls where wall movement is anticipated. The structural designer should use judgment in determining the wall fixity and may utilize values interpolated between the "at-rest" and "active" conditions where appropriate. These values are applicable only to level, properly drained backfill with no additional surcharge loadings and **do not include a factor of safety** other than conservative modeling of the soil strength parameters. If inclined backfills are proposed, this firm should be contacted to develop appropriate active earth pressure parameters. If import material is to be utilized for backfill, an engineer from this firm should verify the backfill has equivalent or superior strength values.

These values should be verified prior to construction when the backfill materials and conditions have been determined and are applicable only to properly drained backfills with no additional surcharge loadings. Toe bearing pressure for walls on soils not bearing against compacted fill, as recommended earlier under "Preparation of Footing Areas", should not exceed CBC values.

Backfill behind retaining walls should consist of a soil of sufficient granularity that the backfill will properly drain. The granular soil should be classified per the USCS as SW, SP, SW-SM, SP-SM, GW or GP and should meet the requirements of section 300-3.5.1 of the "Greenbook". Surface drainage should be provided to prevent ponding of water behind walls. A drainage system should be installed behind all retaining walls consisting of either of the following:

1. A 4-inch-diameter perforated PVC (Schedule 40) pipe or equivalent at the base of the stem encased in 2 cubic feet of granular drain material per lineal foot of pipe; or
2. Synthetic drains such as Enkadrain, Miradrain, Hydraway 300 or equivalent.

Perforations in the PVC pipe should be 3/8 inch in diameter. Granular drain material should be wrapped with filter cloth to prevent clogging of the drains with fines. The wall should be waterproofed to prevent nuisance seepage. The water will need to outlet to an approved drain.

Suitable quantities of on-site soil should be available for retaining wall backfill after screening the material to remove cobbles and boulders greater than 4 inches in diameter. Foundation concrete should be placed in neat excavations with vertical sides, or the concrete should be formed and the excavations properly backfilled as recommended for site fill.

TRENCH EXCAVATION:

Native material encountered within our explorations are classified as a Type "C" soil in accordance with the CAL/OSHA (2013) excavation standards. All trench excavation should be performed in accordance with CAL/OSHA excavation standards. Temporary excavations in native material should not be inclined steeper than 1-1/2 (h):1(v) for a maximum trench depth of 20 feet. For trench excavations deeper than 20 feet, this firm should be contacted.

PIPE BEDDING AND BACKFILLS:

Pipe Bedding

Pipe bedding material should meet and be placed according to the "Greenbook" or other project specifications. Pipe bedding should be uniform, free-draining granular material with a sand equivalent (SE) of at least 30. Sand equivalent testing of on-site material indicates an SE value of less than 30 for near-surface soils. Suitable material from deeper soils may be available after screening.

Backfill

Backfill should be compacted following the recommendations in the "Compacted Fills" section of this report.

Soils required to be compacted to at least 95 percent relative compaction, such as street subgrade and finish grade, should be moisture treated to near optimum moisture content not exceeding 2 percent above optimum.

To avoid pumping, backfill material should be mixed and moisture treated outside of the excavation prior to lift placement in the trench.

A lean sand/cement slurry should be considered to fill any cavities, such as void areas created by caving or undermining of soils beneath existing improvements or pavement to remain, or any other areas that would be difficult to properly backfill, if encountered.

SLABS-ON-GRADE:

To provide adequate support, concrete slabs-on-grade should bear on a minimum of 24 inches of compacted soil. Concrete slabs-on-grade should be a minimum of 4 inches in thickness. The soil should be compacted to 90 percent relative compaction. The final pad surfaces should be rolled to provide smooth, dense surfaces.

Slabs to receive moisture-sensitive coverings should be provided with a moisture vapor retarder. We recommend that a vapor retarder be designed and constructed according to the American Concrete Institute (ACI) 302.1R, "Guide for Concrete Floor and Slab Construction", which addresses moisture vapor retarder construction. At a minimum, the vapor retarder should comply with ASTM E1745 and have a nominal thickness of at least 10 mils. The vapor retarder should be properly sealed per the manufacturer's recommendations and protected from punctures and other damage. One inch of sand under the vapor retarder may assist in reducing punctures.

Concrete building slabs subjected to heavy loads, such as materials storage and/or forklift traffic, should be designed by a registered civil engineer competent in concrete design. A modulus of vertical subgrade reaction of 250 pounds per cubic inch can be utilized in the design of slabs-on-grade for the proposed project.

PRELIMINARY FLEXIBLE PAVEMENT DESIGN:

The following recommended structural sections were calculated based on traffic indices (TIs) provided in the Caltrans "Highway Design Manual for Safety Roadside Rest Areas" (Caltrans, 2012). Based upon our preliminary sampling and testing, the structural sections tabulated below should provide satisfactory HMA pavement. The R-value of the most representative material was used in our analysis. As per the Caltrans Highway Design Manual, Section 614.3, a design subgrade maximum R-value of 50 for the soil was utilized in performing the pavement section calculations.

Usage	TI	R-Value	Recommended Structural Section
Auto Parking Areas	5.0	50	0.25' HMA/0.35' Class 2 AB
Auto Road	5.5	50	0.25' HMA/0.35' Class 2 AB
Truck Parking Areas	6.0	50	0.30' HMA/0.35' Class 2 AB
Truck Lanes and Roads	8.0	50	0.40' HMA/0.45' Class 2 AB

AB = Aggregate Base

The above structural sections are predicated upon proper compaction of the utility trench backfills and the subgrade soils, with the upper 12 inches of subgrade soils and all AB material brought to a minimum relative compaction of 95 percent in accordance with ASTM D1557 prior to paving. The AB should meet Caltrans requirements for Class 2 base.

The above pavement design recommendations are based upon the results of preliminary sampling and testing, and should be verified by additional sampling and testing during construction when the actual subgrade soils are exposed. CHJ Consultants does not practice traffic engineering. The T.I.s used to develop the recommended HMA pavement sections are typical for projects of this type. We recommend that the data used be reviewed by the project civil engineer or traffic engineer to verify that they are appropriate for this project.

PRELIMINARY RIGID PAVEMENT DESIGN:

Based upon an R-value of 65, a modulus of subgrade reaction of approximately 200 pounds per square inch per inch (k) was utilized. We recommend the following PCC pavement designs. These designs are based upon the American Concrete Institute (ACI) Guide for Design and Construction of Concrete Parking Lots (ACI 330R-08).

Design Area	Recommended Section
Car Parking and Access Lanes Average Daily Truck Traffic = 1 (Category A)	4.0" PCC/Compacted Soil
Truck Parking and Interior Lane Areas Average Daily Truck Traffic = 25 (Category B)	5.5" PCC/Compacted Soil
Truck Interior and Exterior Lanes Average Daily Truck Traffic = 300 (Category C)	6.5" PCC/Compacted Soil
Truck Interior and Exterior Lanes Average Daily Truck Traffic = 700 (Category D)	7.0" PCC/Compacted Soil

The above recommended concrete sections are based on a design life of 20 years, with integral curbs or thickened edges. In addition, the above structural sections are predicated upon proper compaction of the utility trench backfills and the subgrade soils, with the upper 12 inches of subgrade soils brought to a uniform relative compaction of 95 percent (ASTM D1557).

Slab edges that will be subject to vehicle loading should be thickened at least 2 inches at the outside edge and tapered to 36 inches back from the edge. Typical details are given in the ACI "Guide for Design and Construction of Concrete Parking Lots" (ACI 330R-08). Alternatively, slab edges subject to vehicle loading should be designed with dowels or other load transfer mechanism. Thickened edges or dowels are not necessary where new pavement will abut areas of curb and gutter, buildings, or other structures preventing through-vehicle traffic and associated traffic loads.

The concrete sections may be placed directly over a compacted subgrade prepared as described above. The concrete to be utilized for the concrete pavement should have a minimum modulus of rupture of 550 pounds per square inch. Contraction joints should be sawcut in the pavement at maximum spacing of 30 times the thickness of the slab, up to a maximum of 15 feet. Sawcutting in the pavement should be performed within 12 hours of concrete placement, or preferably sooner. Sawcut depths should be equal to approximately one-quarter of the slab thickness for conventional saws or 1 inch when early-entry saws are utilized on slabs 9 inches thick or less. The use of plastic strips for formation of jointing is not recommended. The use of expansion joints is not recommended, except where the pavement will adjoin structures. Construction joints should be constructed such that adjacent sections butt directly against each other and are keyed into each other or the joints are properly doweled with smooth dowels. It should be noted that distributed steel reinforcement (welded wire fabric) is not necessary, nor will any decrease in section thickness result from its inclusion.

The above pavement design recommendations are based upon the results of preliminary sampling and testing, and should be verified by additional sampling and testing during construction when the actual subgrade soils are exposed. CHJ Consultants does not practice traffic engineering. The average daily truck traffic categories used to develop the recommended PCC pavement sections are typical for projects of this type. We recommend that the data used be reviewed by the project civil engineer or traffic engineer to verify that they are appropriate for this project.

POTENTIAL EROSION:

The potential for erosion should be mitigated by proper drainage design. Water should not be allowed to flow over graded areas or natural areas so as to cause erosion. Graded areas should be planted or otherwise protected from erosion by wind or water.

CHEMICAL/CORROSIVITY TESTING:

Selected samples of materials were delivered to HDR|Schiff for soil corrosivity testing. Laboratory testing consisted of pH, resistivity and major soluble salts commonly found in soils. These tests have been performed to screen the site for potentially corrosive soil values. The results of the laboratory tests performed by HDR|Schiff appear in Appendix "C".

Values obtained from the soil tested are considered potentially "mildly corrosive" to ferrous metals under as-received conditions and saturated conditions. Specific corrosion control measures, such as coating of the pipe with non-corrosive material or alternative non-metallic pipe material, will not be required.

Ammonium and nitrate levels did not indicate a concern as to corrosion of buried copper.

Results of the soluble sulfate testing indicate a "not applicable" (Class S0) anticipated exposure to sulfate attack. Based upon the criteria from Table 4.2.1. of the American Concrete Institute Manual of Concrete Practice (2011), no special measures, such as specific cement types or water-cement ratios, will be needed for this "not applicable" exposure to sulfate attack.

The soluble chloride content of the soils tested was not at levels high enough to be of concern with respect to corrosion of reinforcing steel. The results should be considered in combination with the soluble chloride content of the hardened concrete in determining the effect of chloride on the corrosion of reinforcing steel.

CHJ Consultants does not practice corrosion engineering. If further information concerning the corrosion characteristics, or interpretation of the results submitted herein, are required, then a competent corrosion engineer could be consulted.

CONSTRUCTION OBSERVATION:

All grading operations, including site clearing and stripping, should be observed by a representative of the geotechnical engineer. The geotechnical engineer's field representative will be present to provide observation and field testing and will not supervise or direct the actual work of the contractor, his employees or agents. Neither the presence of the geotechnical engineer's field representative nor the observations and testing by the geotechnical engineer shall excuse the contractor in any way for defects discovered in his work. It is understood that the geotechnical engineer will not be responsible for job or site safety on this project, which will be the sole responsibility of the contractor.

LIMITATIONS

CHJ Consultants has striven to perform our services within the limits prescribed by our client, and in a manner consistent with the usual thoroughness and competence of reputable geotechnical engineers and engineering geologists practicing under similar circumstances. No other representation, express or implied, and no warranty or guarantee is included or intended by virtue of the services performed or reports, opinion, documents, or otherwise supplied.

This report reflects the testing conducted on the site as the site existed during the investigation, which is the subject of this report. However, changes in the conditions of a property can occur with the passage of time, due to natural processes or the works of man on this or adjacent properties. Changes in applicable or appropriate standards may also occur whether as a result of legislation, application, or the broadening of knowledge. Therefore, this report is indicative of only those conditions tested at the time of the subject investigation, and the findings of this report may be invalidated fully or partially by changes outside of the control of CHJ Consultants. This report is therefore subject to review and should not be relied upon after a period of one year.

The conclusions and recommendations in this report are based upon observations performed and data collected at separate locations, and interpolation between these locations, carried out for the project and the scope of services described. It is assumed and expected that the conditions between locations observed and/or sampled are similar to those encountered at the individual locations where observation and sampling was performed. However, conditions between these locations may vary significantly. Should conditions that appear different from those described herein be encountered in the field, by the client or any firm performing services for the client or the client's assign, this firm should be contacted immediately in order that we might evaluate their effect.

If this report or portions thereof are provided to contractors or included in specifications, it should be understood by all parties that they are provided for information only and should be used as such.

The report and its contents resulting from this investigation are not intended or represented to be suitable for reuse on extensions or modifications of the project, or for use on any other project.

CLOSURE

We appreciate this opportunity to be of service and trust this report provides the information desired at this time. Should questions arise, please contact this office at your convenience.

REGISTERED PROFESSIONAL ENGINEER
JAMES F. COOKE
No. 3012
Exp. 12-31-15
GEOTECHNICAL
STATE OF CALIFORNIA
5-16-2014

Respectfully submitted,
CHJ CONSULTANTS

James F. Cooke

James F. Cooke, G.E. 3012
Project Geologist

REGISTERED GEOLOGIST
JOHN S. McKEOWN
NO. 2396
CERTIFIED ENGINEERING GEOLOGIST
Exp. 06-30-15
STATE OF CALIFORNIA
5-16-2014

John S. McKeown

John S. McKeown, E.G. 2396
Project Geologist

Robert J. Johnson, P.E.
President

JFC/JSM/RJJ:tlw/lb

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LIST OF AERIAL IMAGERY

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San Bernardino County Flood Control District, August 9, 1965, black and white aerial photograph nos. 123 and 124.

San Bernardino County Flood Control District, January 28, 1966, black and white aerial photograph nos. 26, 27 and 28.

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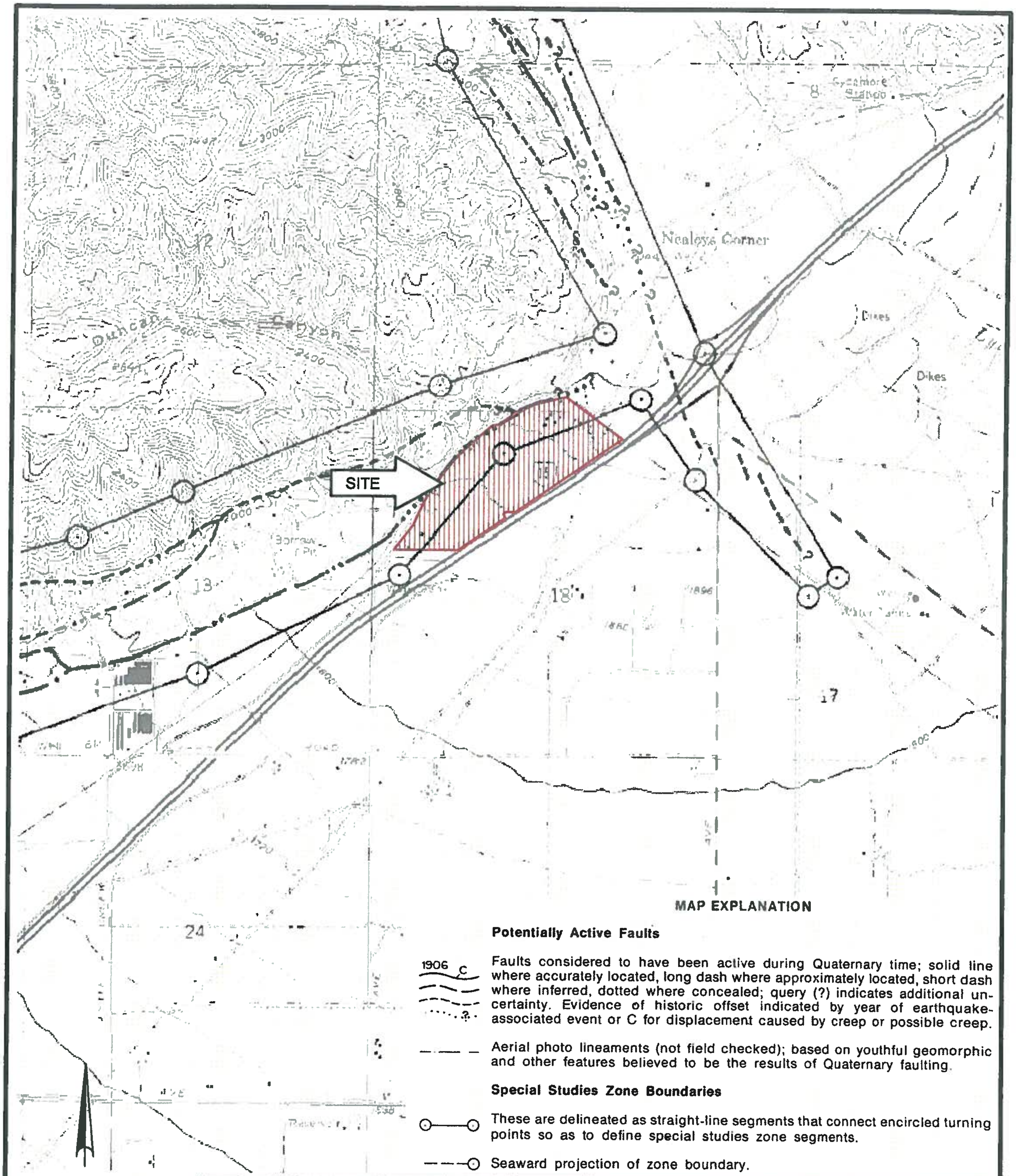
APPENDIX "A"

GEOTECHNICAL MAPS



MAP EXPLANATION

Potentially Active Faults

Faults considered to have been active during Quaternary time; solid line where accurately located, long dash where approximately located, short dash where inferred, dotted where concealed; query (?) indicates additional uncertainty. Evidence of historic offset indicated by year of earthquake-associated event or C for displacement caused by creep or possible creep.

Aerial photo lineaments (not field checked); based on youthful geomorphic and other features believed to be the results of Quaternary faulting.

Special Studies Zone Boundaries

These are delineated as straight-line segments that connect encircled turning points so as to define special studies zone segments.

Seaward projection of zone boundary.

SCALE: 1" = 2000'

INDEX MAP

FOR:
CAPROCK PARTNERS

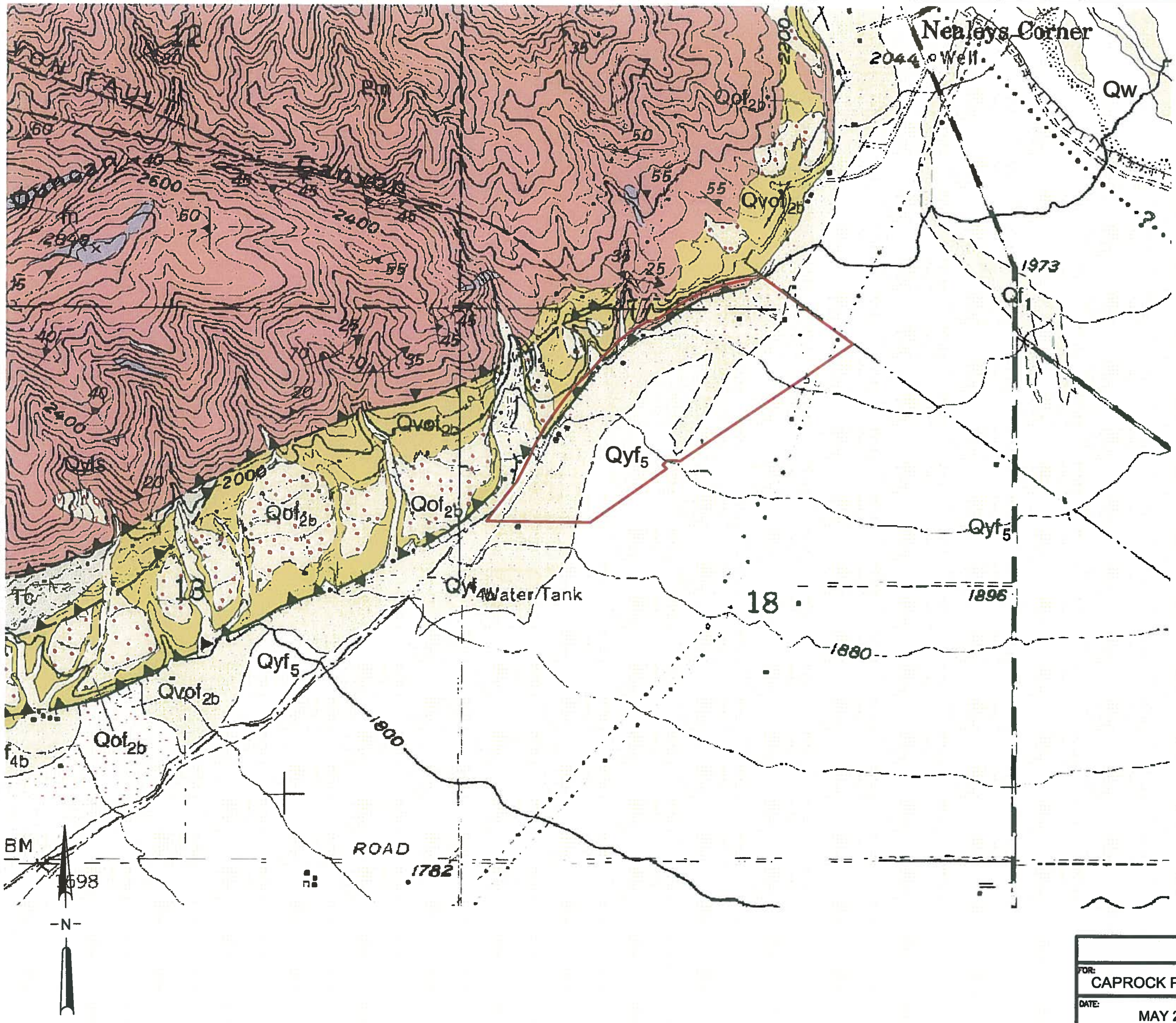
DATE:
MAY 2014

GEOTECHNICAL INVESTIGATION
PROPOSED I-15 LOGISTICS CENTER
LYTLE CREEK ROAD, FONTANA AREA
SAN BERNARDINO COUNTY, CALIFORNIA

ENCLOSURE
"A-1"

JOB NUMBER
14176-3

CHJ Consultants



SCALE: 1" = 1000'

GEOLOGIC UNITS:

Qw	Modern wash deposits (late Holocene)—Unconsolidated coarse-grained sand to bouldery alluvium of active channels and washes flooring drainage bottoms within mountains and on alluvial-fans along base of mountains. Most alluvium is, or recently was, subject to active stream flow. Includes some low-lying terrace deposits along alluviated canyon floors and areas underlain by colluvium along base of some slopes
Qf_1	Modern alluvial-fan deposits, Unit 1—Unconsolidated deposits of coarse grained sand to bouldery alluvium of modern fans having undissected surfaces; commonly distinguished by terrace level
Qyf_5	Young alluvial-fan deposits, Unit 5 (Holocene)—alluvial-fan deposits having slightly dissected surfaces and stage S7 soils. Slightly younger than Qyf4 based on geomorphic relations.
Qyf_4	Young alluvial-fan deposits, Unit 4 (Holocene)—alluvial-fan deposits having slightly dissected surfaces and stage S7 soils
Qya_4	Young alluvial-valley deposits, Unit 4 (Holocene)—Low terraces of gravelly sand
Qof_2	Old alluvial-fan deposits, Unit 2 (late Pleistocene)—alluvial-fan deposits having well-dissected surfaces and stage S4 to stage S3 soils
Qvof	Very old alluvial-fan deposits, unit 2—alluvial-fan deposits having extremely dissected surfaces and stage S2 soils
Tc	Conglomerate (Pliocene and Miocene)—Moderately indurated, gray, massive to moderately well bedded, non-marine boulder conglomerate.
Pm	Granulitic gneiss, mylonite, and cataclasite (Proterozoic?)—Prograde granulitic gneiss that is largely retrograded to amphibolite and greenschist grade mylonite and cataclasite. Granulitic gneiss includes quartz-feldspar gneiss, garnet quartz- feldspar gneiss, amphibolite, garnet-pyroxene rich rocks, and spinel pyroxene rich rocks.

——— – – – Geologic Contact - dashed where inferred

———— – – – …… High angle fault - Solid where accurately located; dashed where approximately located; dotted where concealed; queried where inferred.

▲▲▲ ▲ ▲?▲ Thrust fault - Solid where accurately located; dashed where approximately located; dotted where concealed; queried where inferred. Sawteeth on upper plate. Hachures indicate scarp; hachured on down-dropped block. Arrow and number indicates direction and dip of fault surface.

(Base Map: Morton, D.M. and Matti, J.C., 2001)

GEOLOGIC INDEX MAP

FOR: CAPROCK PARTNERS

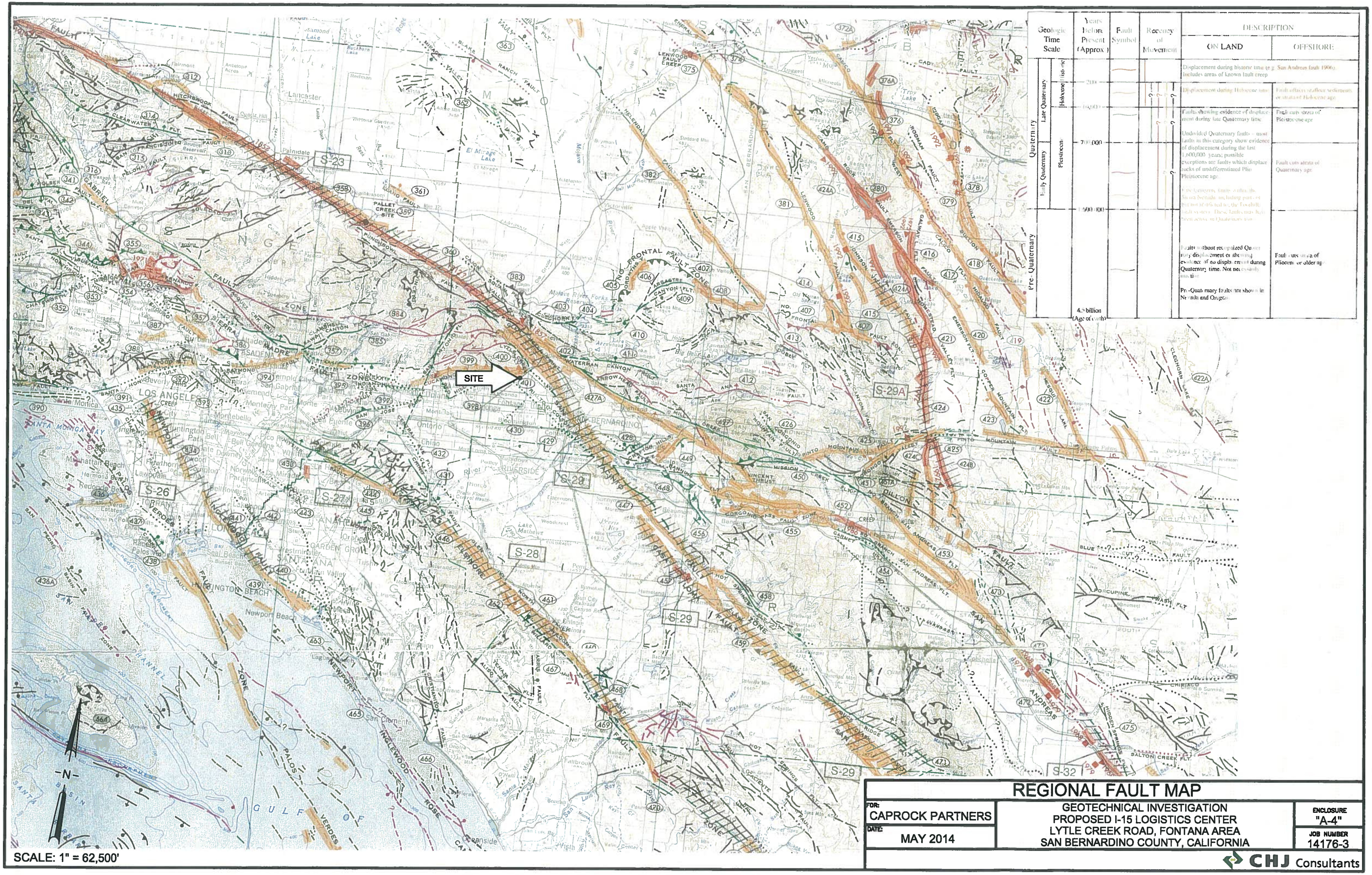
DATE: MAY 2014

GEOTECHNICAL INVESTIGATION
PROPOSED 1-15 LOGISTICS CENTER
LYTLE CREEK ROAD, FONTANA AREA
SAN BERNARDINO COUNTY, CALIFORNIA

ENCLOSURE "A-3"

JOB NUMBER 14176-3

CHJ Consultants



Geologic Time Scale			Years Before Present (Approx.)	Fault Symbol	Recency of Movement	DESCRIPTION ON LAND	DESCRIPTION OFFSHORE
Quaternary	Late Quaternary	Historic				Displacement during historic time (e.g. San Andreas fault 1906). Includes areas of known fault creep	
		Holocene	200		? ? ? ?	Displacement during Holocene time	Fault offsets seafloor sediments or strata of Holocene age
		Pleistocene	10,000		? ? ?	Faults showing evidence of displacement during late Quaternary time	Fault cuts strata of Pleistocene age
	Early Quaternary		700,000		?	Undivided Quaternary faults – most faults in this category show evidence of displacement during the last 1,600,000 years; possible exceptions are faults which displace rocks of undifferentiated Plio-Pleistocene age	Fault cuts strata of Quaternary age
						Pre-Cenozoic faults within the Sierra Nevada including part of but not restricted to the Foothills fault system. These faults may have been active in Quaternary time	
Pre-Quaternary			1,600,000			Faults without recognized Quaternary displacement or showing evidence of no displacement during Quaternary time. Not necessarily inactive Pre-Quaternary faults not shown in Nevada and Oregon	Fault cuts strata of Pliocene or older age
			4.5 billion (Age of earth)				

REGIONAL FAULT MAP

FOR: CAPROCK PARTNERS

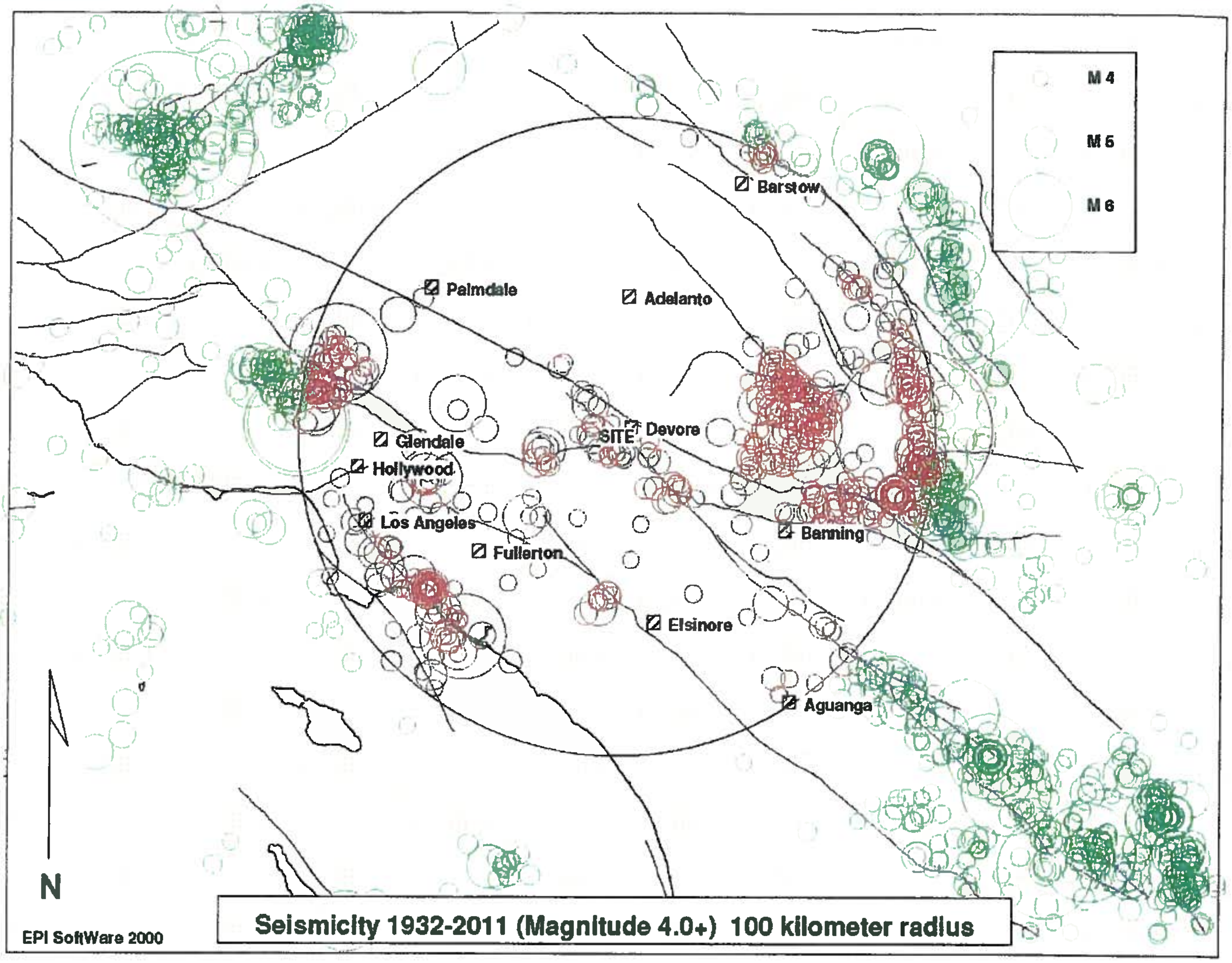
DATE: MAY 2014

GEOTECHNICAL INVESTIGATION
PROPOSED I-15 LOGISTICS CENTER
LYTLE CREEK ROAD, FONTANA AREA
SAN BERNARDINO COUNTY, CALIFORNIA

ENCLOSURE "A-4"

JOB NUMBER 14176-3

CHJ Consultants



Seismicity 1932-2011 (Magnitude 4.0+) 100 kilometer radius

SITE LOCATION: 34.1778 LAT. -117.4462 LONG.

MINIMUM LOCATION QUALITY: C

TOTAL # OF EVENTS ON PLOT: 1579

TOTAL # OF EVENTS WITHIN SEARCH RADIUS: 627

MAGNITUDE DISTRIBUTION OF SEARCH RADIUS EVENTS:

4.0- 4.9 : 573
5.0- 5.9 : 50
6.0- 6.9 : 3
7.0- 7.9 : 1
8.0- 8.9 : 0

CLOSEST EVENT: 4.0 ON SUNDAY, MARCH 09, 2008 LOCATED APPROX. 5 KILOMETERS SOUTHWEST OF THE SITE

LARGEST 5 EVENTS:

7.3 ON SUNDAY, JUNE 28, 1992 LOCATED APPROX. 92 KILOMETERS EAST OF THE SITE
6.6 ON TUESDAY, FEBRUARY 09, 1971 LOCATED APPROX. 91 KILOMETERS WEST OF THE SITE
6.4 ON SUNDAY, JUNE 28, 1992 LOCATED APPROX. 57 KILOMETERS EAST OF THE SITE
6.4 ON SATURDAY, MARCH 11, 1933 LOCATED APPROX. 78 KILOMETERS SOUTHWEST OF THE SITE
5.9 ON MONDAY, JANUARY 17, 1994 LOCATED APPROX. 96 KILOMETERS WEST OF THE SITE

EARTHQUAKE EPICENTER MAP

FOR:
CAPROCK PARTNERS

DATE:
MAY 2014

GEOTECHNICAL INVESTIGATION
PROPOSED I-15 LOGISTICS CENTER
LYTLE CREEK ROAD, FONTANA AREA
SAN BERNARDINO COUNTY, CALIFORNIA

ENCLOSURE
"A-5"

JOB NUMBER
14176-3

CHJ Consultants

APPENDIX "B"

EXPLORATORY LOGS

Enclosure "B" (1 of 2)
Job No. 14176-3

KEY TO LOGS

LEGEND OF LAB/FIELD TESTS:

Bulk	Indicates Disturbed or Bulk Sample
Cor.	Chemical/Corrosivity Tests (Caltrans 417, 422, & 643)
DS	Direct Shear Test (ASTM D 3080)
MDC	Maximum Density Optimum Moisture Determination (ASTM D 1557)
RV	R-value test (Caltrans 301)
SA	Sieve Analysis (ASTM C 117/136)
SE	Sand Equivalent Test (ASTM D 2419)

Enclosure "B" (2 of 2)
Job No. 14176-3

UNIFIED SOIL CLASSIFICATION SYSTEM

UNIFIED SOIL CLASSIFICATION AND SYMBOL CHART

COARSE-GRAINED SOILS (more than 50% of material is larger than No. 200 sieve size)		
		Clean Gravels (Less than 5% fines)
GRAVELS More than 50% of coarse fraction larger than No.4 sieve size	GW	Well-graded gravels, gravel-sand mixtures, little or no fines
	GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines
		Gravels with fines (More than 12% fines)
	GM	Silty gravels, gravel-sand-silt mixtures
	GC	Clayey gravels, gravel-sand-clay mixtures
		Clean Sands (Less than 5% fines)
SANDS 50% or more of coarse fraction smaller than No.4 sieve size	SW	Well-graded sands, gravelly sands, little or no fines
	SP	Poorly graded sands, gravelly sands, little or no fines
		Sands with fines (More than 12% fines)
	SM	Silty sands, sand-silt mixtures
	SC	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS (50% or more of material is smaller than No. 200 sieve size)		
SILTS AND CLAYS Liquid limit less than 50%	ML	Inorganic silts and very fine sands, rock flour, silty of clayey fine sands or clayey silts with slight plasticity
	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
	OL	Organic silts and organic silty clays of low plasticity
SILTS AND CLAYS Liquid limit 50% or greater	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
	CH	Inorganic clays of high plasticity, fat clays
	OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS	PT	Peat and other highly organic soils

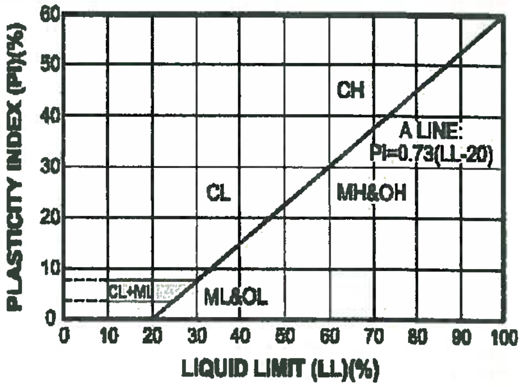
LABORATORY CLASSIFICATION CRITERIA

GW	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{D_{30}^2}{D_{10} \times D_{60}}$ between 1 and 3	
GP	Not meeting all gradation requirements for GW	
GM	Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols.
GC	Atterberg limits above "A" line with P.I. greater than 7	
SW	$C_u = \frac{D_{60}}{D_{10}}$ greater than 6; $C_c = \frac{D_{30}^2}{D_{10} \times D_{60}}$ between 1 and 3	
SP	Not meeting all gradation requirements for SW	
SM	Atterberg limits below "A" line or P.I. less than 4	Limits plotting in shaded zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols.
SC	Atterberg limits above "A" line with P.I. greater than 7	

Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size). Coarse-grained soils are classified as follows:

Less than 5 percent..GW, GP, SW, SP
More than 12 percent...GM, GC, SM, SC
5 to 12 percent................................Borderline cases requiring dual symbols

PLASTICITY CHART



EXPLORATORY TRENCH NO. 1

Date Excavated: 4/28/14 Client: Caprock

Equipment: CAT 365B Track-Mounted Excavator Bucket Size: 50"

Surface Elevation(ft): N/A Logged by: JMcK Station No.: N/A

DEPTH (ft)	GRAPHIC LOG	VISUAL CLASSIFICATION	REMARKS	SAMPLES DENSITY	SAMPLES BULK	RELATIVE COMP. (%)	FIELD MOISTURE (%)	DRY UNIT WT. (pcf)	LAB/FIELD TESTS
1 2		(SM) Silty Sand, fine to coarse, few gravel to 1", brown	Native		▩		5.8		SA, SE
3 4 5 6 7		(GP-GM) Cobbly Sand, fine to medium with coarse, with silt and few boulders to 26", brown to gray brown							
8 9		(GP-GM) Gravelly Sand, fine to medium with coarse, with silt, dark gray	Crudely bedded						
10 11		(GP-GM) Cobbly Sand, fine to medium, with silt, gray							
12 13 14		END OF TRENCH NO REFUSAL, NO BEDROCK NO GROUNDWATER, NO FILL CAVING OBSERVED							

EXPLORATORY TRENCH NO. 2

Date Excavated: 4/28/14
Client: Caprock
Equipment: CAT 365B Track-Mounted Excavator
Bucket Size: 50"
Surface Elevation(ft): N/A
Logged by: JMcK
Station No.: N/A

DEPTH (ft)	GRAPHIC LOG	VISUAL CLASSIFICATION	REMARKS	SAMPLES DENSITY	SAMPLES BULK	RELATIVE COMP. (%)	FIELD MOISTURE (%)	DRY UNIT WT. (pcf)	LAB/FIELD TESTS
		(GP-GM) Poorly graded gravel, with silt and sand, fine to medium, gray brown	Native		▩		2.4		Cor., DS, MDC, SA, SE
1									
2		(GP-GM) Cobbly Sand, fine to medium with coarse, with silt and boulders to 30", brown	Uncemented						
3									
4									
5									
		(GP-GM) Gravelly Sand, fine to medium with coarse, with cobbles to 8", gray brown							
6									
7									
8									
9									
10									
		END OF TRENCH NO REFUSAL, NO BEDROCK NO GROUNDWATER, NO FILL CAVING OBSERVED							
11									
12									
13									
14									

EXPLORATORY TRENCH NO. 3

Date Excavated: 4/28/14
Client: Caprock
Equipment: CAT 365B Track-Mounted Excavator
Bucket Size: 50"
Surface Elevation(ft): N/A
Logged by: JMcK
Station No.: N/A

DEPTH (ft)	GRAPHIC LOG	VISUAL CLASSIFICATION	REMARKS	SAMPLES		RELATIVE COMP. (%)	FIELD MOISTURE (%)	DRY UNIT WT. (pcf)	LAB/FIELD TESTS
				DENSITY	BULK				
 1 2		(SM) Silty Sand, fine to coarse, with gravel to 3", red brown	Native		▩		6.5		Cor., SA, SE
3 4 5 6 7 8 9 10		(GP-GM) Cobbly Sand, fine to medium with coarse, with silt and few boulders to 30", gray brown							
11 12 13 14		END OF TRENCH NO REFUSAL, NO BEDROCK NO GROUNDWATER, NO FILL CAVING OBSERVED							

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PROPOSED I-15 LOGISTICS CENTER
FONTANA AREA, SAN BERNARDINO COUNTY, CA

Job No. 14176-8

Enclosure B-3

EXPLORATORY TRENCH NO. 3B

Date Excavated: 4/28/14 | Client: Caprock

Equipment: CAT 365B Track-Mounted Excavator | Bucket Size: 50"

Surface Elevation(ft): N/A | Logged by: JMcK | Station No.: N/A

DEPTH (ft)	GRAPHIC LOG	VISUAL CLASSIFICATION	REMARKS	SAMPLES DENSITY	SAMPLES BULK	RELATIVE COMP. (%)	FIELD MOISTURE (%)	DRY UNIT WT. (pcf)	LAB/FIELD TESTS
	⁘	(SM) Silty Sand, fine to medium, few gravel to 2", brown gray	Native		▨		10.1		
1	⁘								
2	⁘								
3	⁘								
4	⁘								
5	⁘								
6		END OF TRENCH NO REFUSAL, NO BEDROCK NO GROUNDWATER, NO FILL CAVING OBSERVED							
7									
8									
9									
10									
11									
12									
13									
14									

EXPLORATORY TRENCH NO. 4

Date Excavated: 4/28/14
Client: Caprock
Equipment: CAT 365B Track-Mounted Excavator
Bucket Size: 50"
Surface Elevation(ft): N/A
Logged by: JMcK
Station No.: N/A

DEPTH (ft)	GRAPHIC LOG	VISUAL CLASSIFICATION	REMARKS	SAMPLES DENSITY	SAMPLES BULK	RELATIVE COMP. (%)	FIELD MOISTURE (%)	DRY UNIT WT. (pcf)	LAB/FIELD TESTS
0		(SM) Silty Sand, fine to coarse, few gravel to 3/4", brown	Native		▩		3.1		DS, MDC, SA, SE
1									
2									
3									
4									
5		(GP-GM) Gravelly Sand, fine to coarse, with silt, gray brown	Uncemented						
6		(GP-GM) Gravelly Sand, fine to coarse, with cobbles and few boulders to 16", gray	Medium Dense						
7									
8									
9									
10									
11		END OF TRENCH NO REFUSAL, NO BEDROCK NO GROUNDWATER, NO FILL CAVING OBSERVED IN GRAVEL UNITS							
12									
13									
14									

EXPLORATORY TRENCH NO. 5

Date Excavated: 4/28/14
Client: Caprock
Equipment: CAT 365B Track-Mounted Excavator
Bucket Size: 50"
Surface Elevation(ft): N/A
Logged by: JMcK
Station No.: N/A

DEPTH (ft)	GRAPHIC LOG	VISUAL CLASSIFICATION	REMARKS	SAMPLES DENSITY	SAMPLES BULK	RELATIVE COMP. (%)	FIELD MOISTURE (%)	DRY UNIT WT. (pcf)	LAB/FIELD TESTS
		(GW) Well Graded Gravel, with sand, fine to coarse, red brown	Native		▩		2.6		SA, SE
1 2		(GP-GM) Cobbly Gravel with sand, fine to medium with coarse, and silt, brown to gray							
3 4		(SM) Silty Sand, fine with medium, few gravel and cobbles to 8", brown							
5 6 7 8		(SM) Silty Sand, fine to medium, with gravel to 2", brown							
9		(GP-GM) Bouldery sand, fine to coarse, with cobbles and silt, gray							
10 11 12 13 14		END OF TRENCH NO REFUSAL, NO BEDROCK NO GROUNDWATER, NO FILL CAVING OBSERVED							

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PROPOSED I-15 LOGISTICS CENTER
FONTANA AREA, SAN BERNARDINO COUNTY, CA

Job No. 14176-8

Enclosure B-6

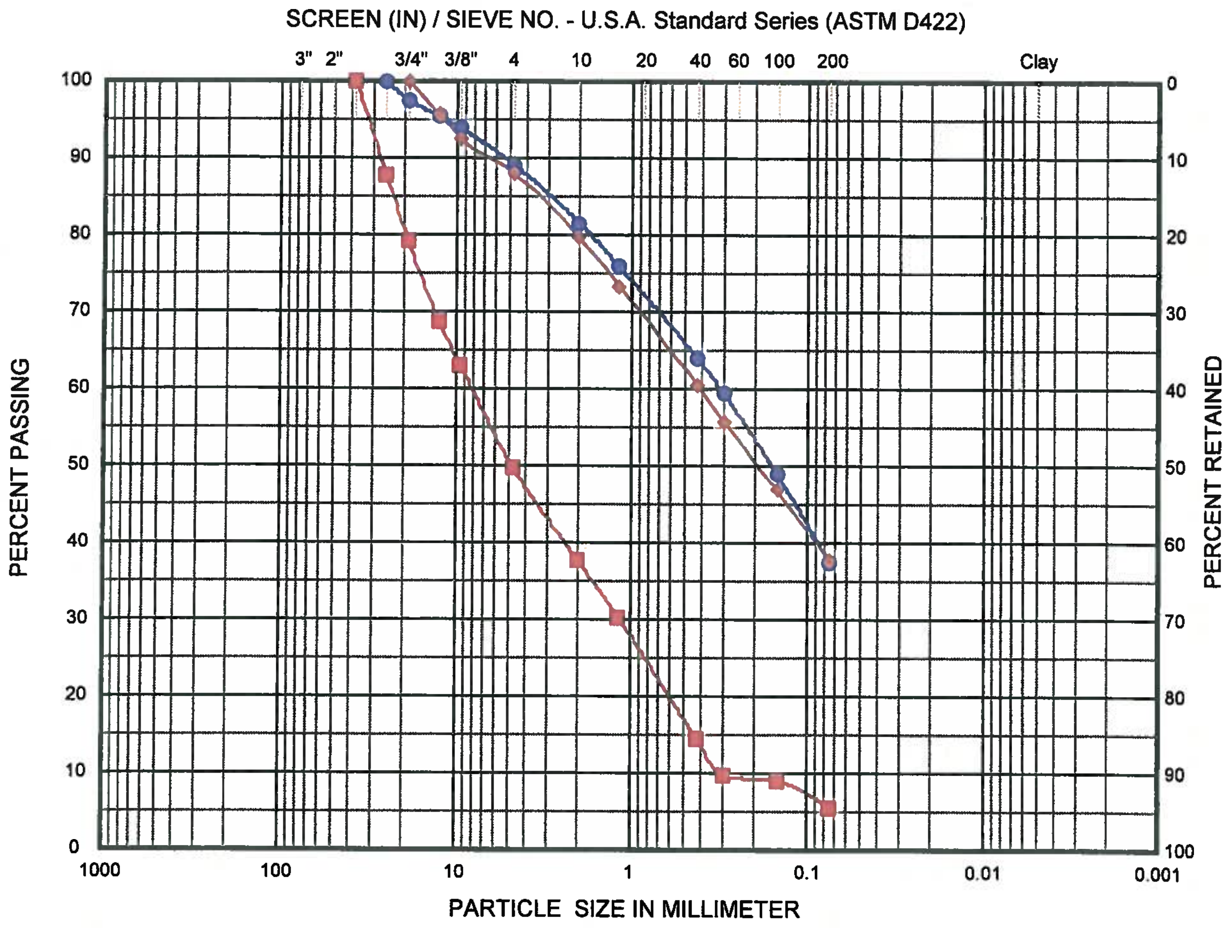
EXPLORATORY TRENCH NO. 6

Date Excavated: 4/28/14
Client: Caprock
Equipment: CAT 365B Track-Mounted Excavator
Bucket Size: 50"
Surface Elevation(ft): N/A
Logged by: JMcK
Station No.: N/A

DEPTH (ft)	GRAPHIC LOG	VISUAL CLASSIFICATION	REMARKS	SAMPLES DENSITY	SAMPLES BULK	RELATIVE COMP. (%)	FIELD MOISTURE (%)	DRY UNIT WT. (pcf)	LAB/FIELD TESTS
		(GP) Poorly Graded Gravel with sand, fine to medium, brownish gray	Native		▨		3.2		SA, SE
1			Loose to Medium Dense						
2		(GP-GM) Gravelly Sand, fine to medium, with cobbles and boulders to 18", brownish gray							
3			Uncemented						
4									
5									
6									
7									
8									
9									
10									
11		END OF TRENCH NO REFUSAL, NO BEDROCK NO GROUNDWATER, NO FILL CAVING 3' TO 5'							
12									
13									
14									

APPENDIX "C"

LABORATORY TESTING



Cobbles & Boulders	Gravel		Sand			Silt	Clay
	Coarse	Fine	Coarse	Medium	Fine		

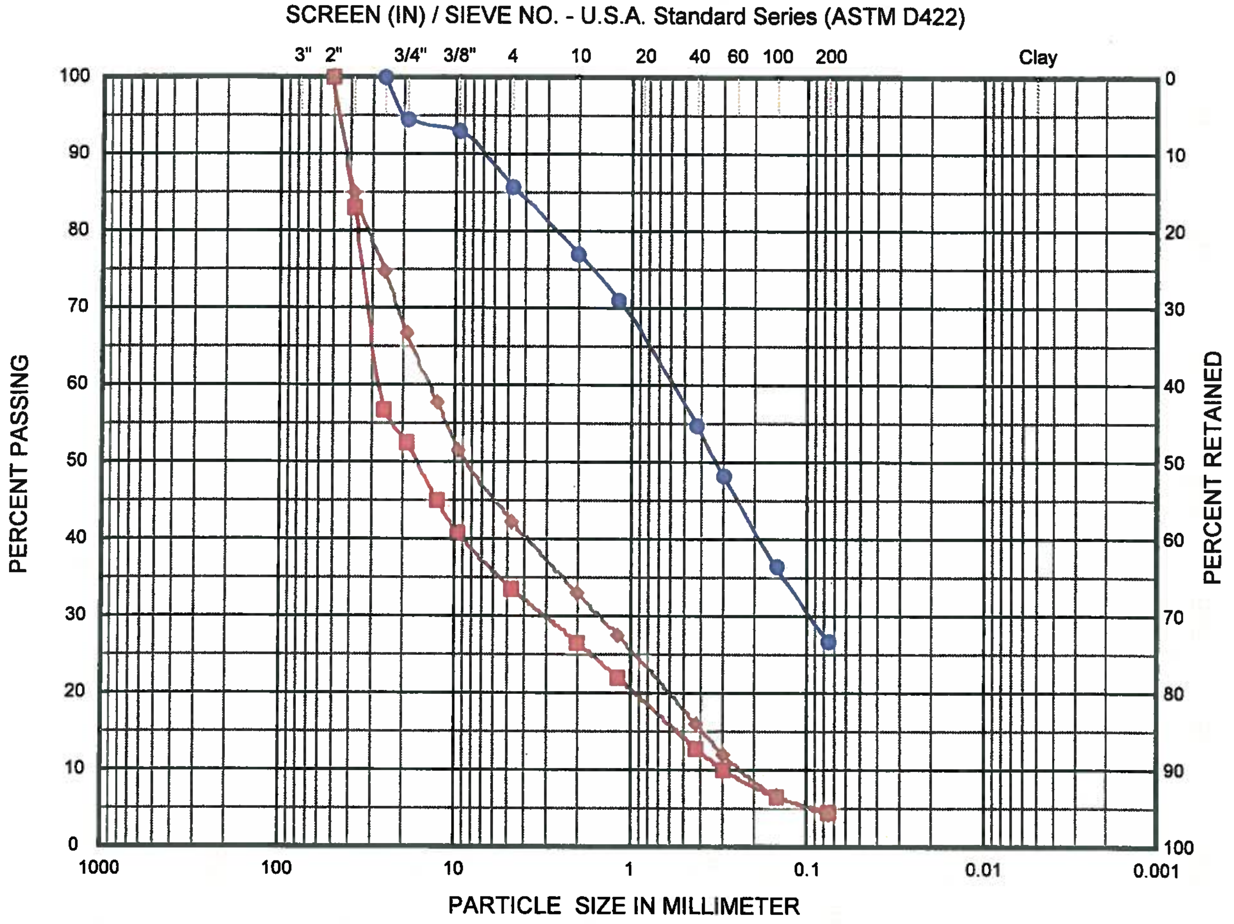
	Boring No.	Depth	Gravel	Sand	Fines	Clay	D_{10}	D_{30}	D_{50}	D_{60}	C_u	C_c
●	1A		10.9	51.6	37.6			0.048	0.159	0.314		
	(SM) Silty sand, fine to coarse											
■	2A		50.2	44.2	5.6		0.3130	1.154	4.819	8.162	26.1	0.5
	(GP-GM) Poorly-graded gravel with silt and sand											
◆	3A		11.9	50.3	37.8			0.042	0.191	0.410		
	(SM) Silty sand, fine to coarse											

N:\Projects\Geotechnical\2014\14176-3 Caprock, Getchell Parcel\Lab\LabSuite_14176-3.csv

PARTICLE SIZE DISTRIBUTION (ASTM D422)

Project:	Proposed I-15 Logistics Center				
Location:	Lytle Creek Road, Fontana Area, San Bernardino County, CA				
Job Number:	14176-3	Engineer:	JFC	Enclosure:	C-1

Prepared at 5/15/2014 9:07:23 AM



Cobbles & Boulders	Gravel		Sand			Silt	Clay
	Coarse	Fine	Coarse	Medium	Fine		

	Boring No.	Depth	Gravel	Sand	Fines	Clay	D_{10}	D_{30}	D_{50}	D_{60}	C_u	C_c
●	4A		14.2	59.2	26.6			0.096	0.331	0.577		
	(SM) Silty sand, fine to coarse											
■	5A		66.4	29.0	4.6		0.2977	3.074	16.510	27.413	92.1	1.2
	(GW) Well-graded gravel with sand											
◆	6A		57.6	38.1	4.3		0.2408	1.511	8.692	14.089	58.5	0.7
	(GP) Poorly-graded gravel with sand											

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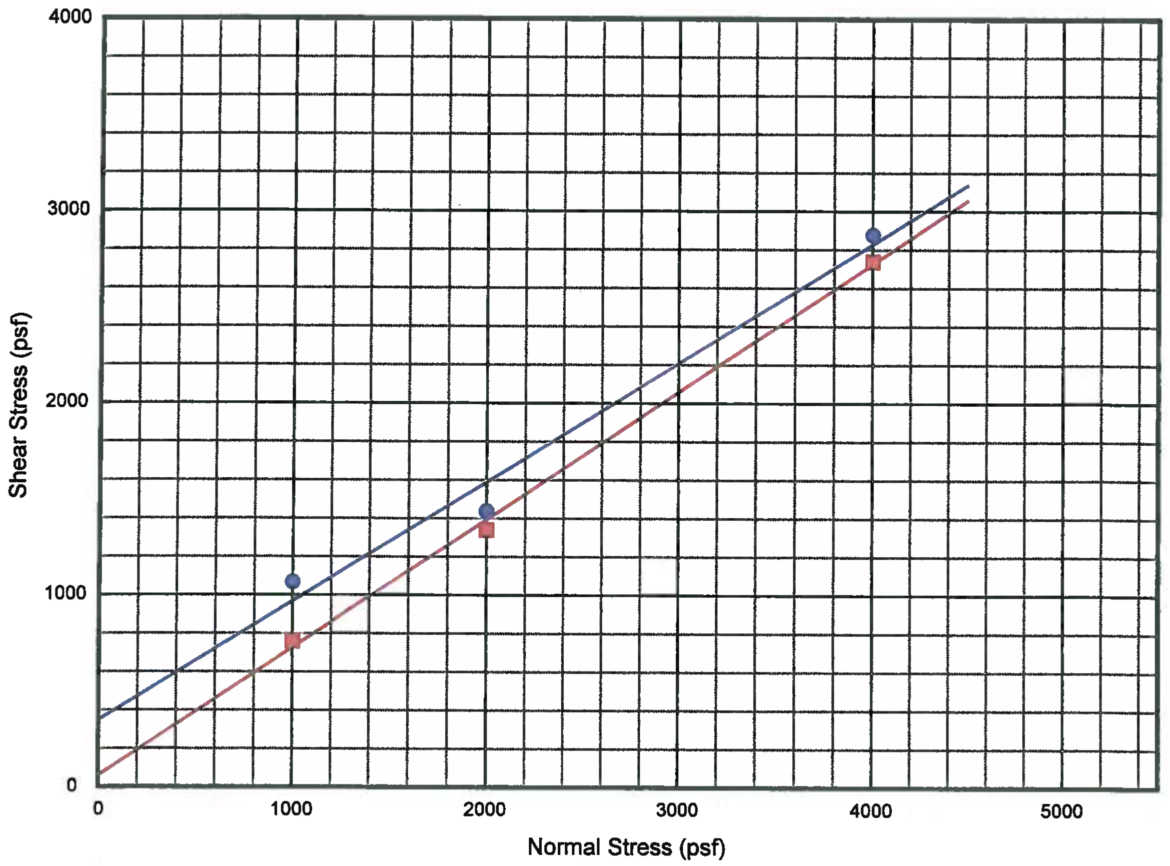
PARTICLE SIZE DISTRIBUTION (ASTM D422)

Project:	Proposed I-15 Logistics Center				
Location:	Lytle Creek Road, Fontana Area, San Bernardino County, CA				
Job Number:	14176-3	Engineer:	JFC	Enclosure:	C-2



	Boring No.	Depth (ft)	γ_d (pcf)	w (%)	C_{pk} (psf)	ϕ_{pk} (°)	C_{rs} (psf)	ϕ_{rs} (°)
●	2A	0	0.0	0.0	355.0	34.1	348.1	31.8
	(GP-GM) Poorly-graded gravel with silt and sand, gray brown / Undisturbed							
■	4A	0	0.0	0.0	59.9	33.8	57.9	33.7
	(SM) Silty Sand, fine to coarse / Undisturbed							

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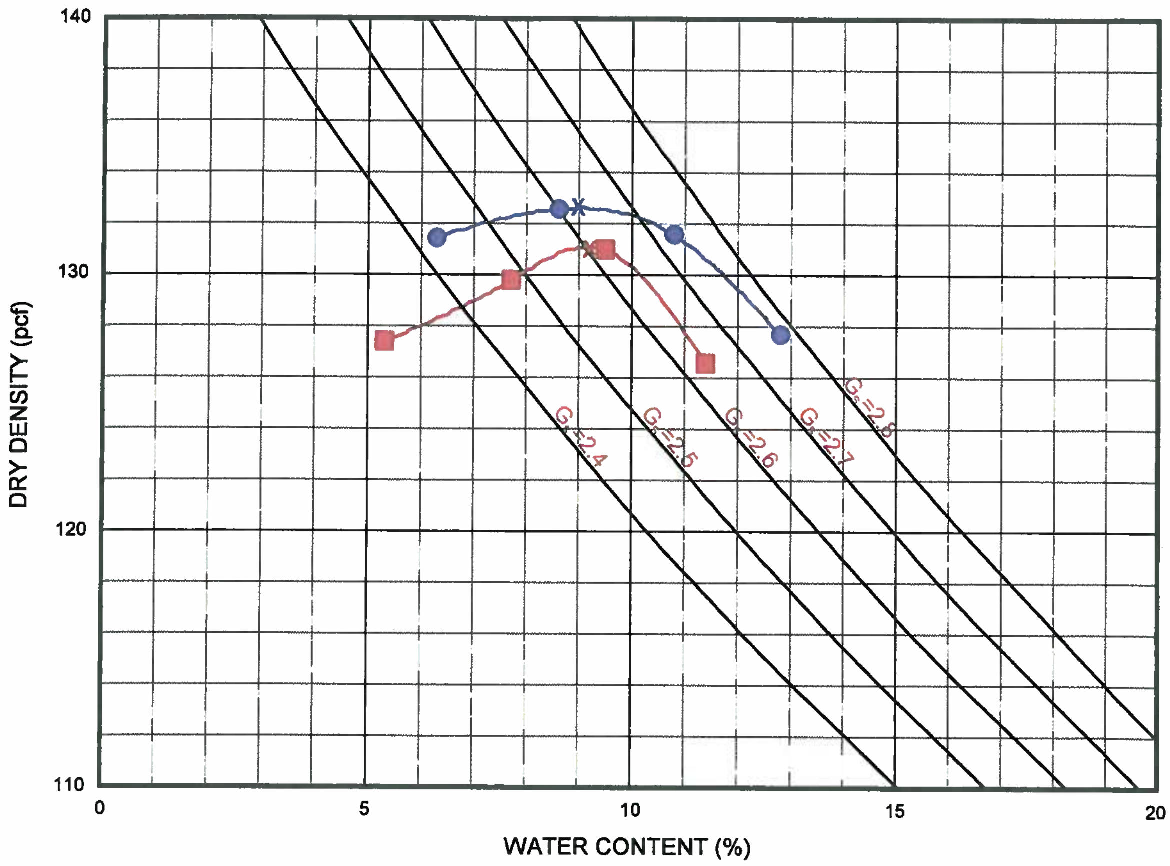
DIRECT SHEAR TESTS (ASTM D3080)

Project:	Proposed I-15 Logistics Center				
Location:	Lytle Creek Road, Fontana Area, San Bernardino County, CA				
Job Number:	14176-3	Engineer:	JFC	Enclosure:	C-3

Prepared at 5/15/2014 9:07:23 AM



	Boring No.	Depth (ft)	USCS Classification	γ_{dmax} (pcf)	w_o (%)
●	2A/6A	0	(GP-GM) Poorly Graded Gravel with Sand and Silt, mixture of 2A and 6A	132.6	9.0
■	4A	0	(SM) Silty Sand, fine to coarse	131.1	9.2

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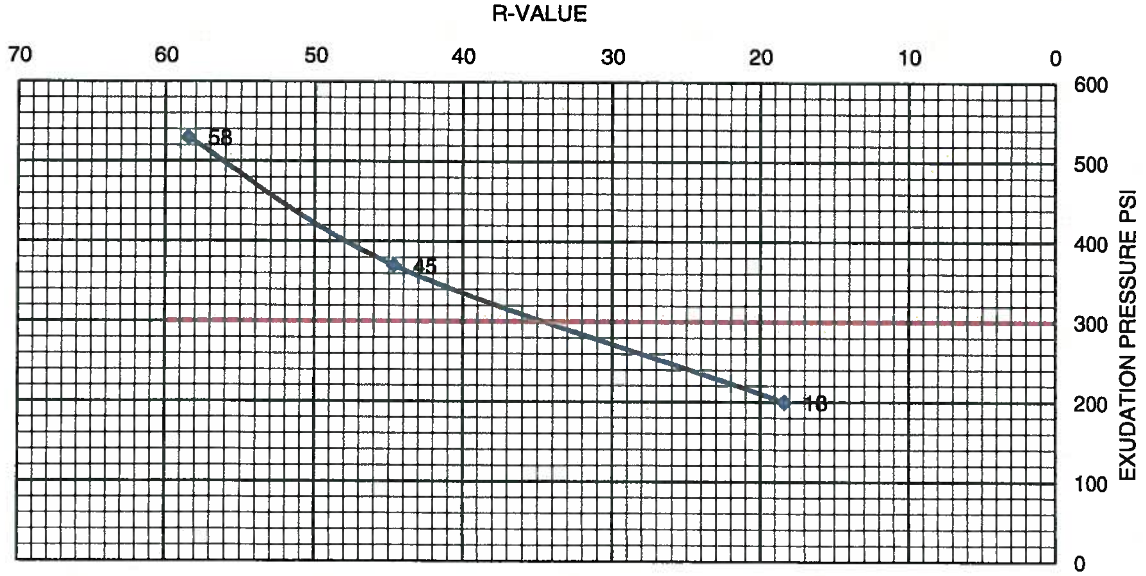
COMPACTION CURVES (ASTM D1557)

Project:	Proposed I-15 Logistics Center		
Location:	Lytle Creek Road, Fontana Area, San Bernardino County, CA		
Job Number:	14176-3	Engineer: JFC	Enclosure: C-4

Prepared at 5/15/2014 9:07:23 AM

Traffic Index (T.I.)	5.0	A	B	C	D
COMPACTOR AIR PRESSURE P.S.I.		250	350	350	
INITIAL MOISTURE %		6.9	6.9	6.9	
WATER ADDED, ML		55	45	35	
WATER ADDED %		5.2	4.3	3.3	
MOISTURE AT COMPACTION %		12.1	11.2	10.2	
HEIGHT OF BRIQUETTE		2.50	2.45	2.46	
WET WEIGHT OF BRIQUETTE		1139	1113	1143	
DENSITY LB. PER CU.FT.		123.2	123.8	127.8	
STABILOMETER PH AT 1000 LBS.		48	31	25	
2000 LBS.		107	62	46	
DISPLACEMENT		5.50	4.90	4.40	
R-VALUE		18	45	58	
EXUDATION PRESSURE		200	370	530	
THICK. INDICATED BY STAB.		1.31	0.89	0.66	
EXPANSION PRESSURE		0	11	19	
THICK. INDICATED BY E.P.		0.00	0.37	0.63	

EXUDATION CHART



R-Value: 35

Sample No.	Depth (ft)	Soil/Sample Type	SE	w_0(%)
3A	0	(SM) Silty sand, fine to coarse with gravel to 3", red brown	18	6.9

CHJ Consultants

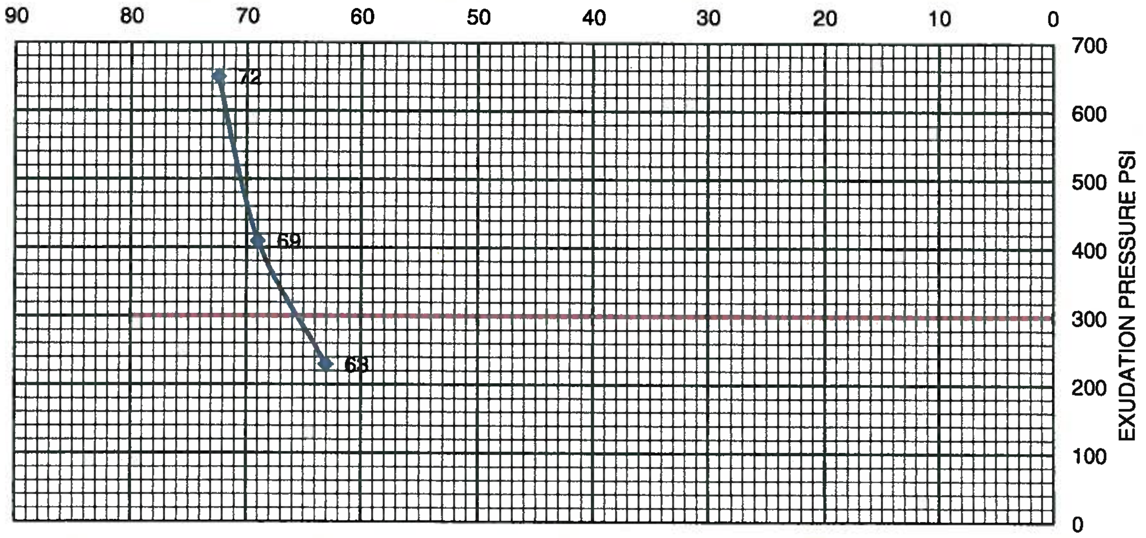
R-VALUE TEST

Project:	Proposed I-15 Logistics Center		
Location:	Lytle Creek Road, Fontana Area, San Bemardino County, CA		
Job No.:	14176-3	Enclosure:	C-5

Prepared at 5/13/2014

Traffic Index (T.I.) 4.0	A	B	C	D
COMPACTOR AIR PRESSURE P.S.I.	350	350	350	
INITIAL MOISTURE %	7.3	7.3	7.3	
WATER ADDED, ML	30	20	10	
WATER ADDED %	2.9	1.9	0.9	
MOISTURE AT COMPACTION %	10.2	9.2	8.2	
HEIGHT OF BRIQUETTE	2.46	2.48	2.51	
WET WEIGHT OF BRIQUETTE	1126	1135	1132	
DENSITY LB. PER CU.FT.	125.9	127.0	126.2	
STABILOMETER PH AT 1000 LBS.	20	18	16	
2000 LBS.	31	28	26	
DISPLACEMENT	6.10	5.30	4.90	
R-VALUE	63	69	72	
EXUDATION PRESSURE	230	410	650	
THICK. INDICATED BY STAB.	0.47	0.40	0.35	
EXPANSION PRESSURE	0	0	0	
THICK. INDICATED BY E.P.	0.00	0.00	0.00	

EXUDATION CHART
R-VALUE



R-Value: 65

Sample No.	Depth (ft)	Soil/Sample Type	SE	w_0(%)
2A/6A	0	Mixture of Poorly Graded Gravel with silt and sand	N/A	7.3

CHJ Consultants

R-VALUE TEST			
Project:	Proposed I-15 Logistics Center		
Location:	Lytle Creek Road, Fontana Area, San Bernardino County, CA		
Job No.:	14176-3	Enclosure:	C-6

Prepared at 5/13/2014

HDR | SCHIFF

Enclosure "C-7"

www.hdrinc.com
Corrosion Control and Condition Assessment (C3A) Department

Table 1 - Laboratory Tests on Soil Samples

C.H.J. Consultants
Caprock
Your #14176-3, HDR|Schiff #14-0293LAB
2-May-14

Sample ID

			2A
Resistivity		**Units**	
as-received		ohm-cm	1,240,000
saturated		ohm-cm	44,000
pH			7.6
Electrical Conductivity		mS/cm	0.03
Chemical Analyses			
Cations			
calcium	Ca^{2+}	mg/kg	37
magnesium	Mg^{2+}	mg/kg	3.0
sodium	Na^{1+}	mg/kg	4.9
potassium	K^{1+}	mg/kg	7.2
Anions			
carbonate	CO_3^{2-}	mg/kg	ND
bicarbonate	HCO_3^{1-}	mg/kg	70
fluoride	F^{1-}	mg/kg	ND
chloride	Cl^{1-}	mg/kg	1.2
sulfate	SO_4^{2-}	mg/kg	5.6
phosphate	PO_4^{3-}	mg/kg	ND
Other Tests			
ammonium	NH_4^{1+}	mg/kg	ND
nitrate	NO_3^{1-}	mg/kg	7.4
sulfide	S^{2-}	qual	na
Redox		mV	na

Electrical conductivity in millisiemens/cm and chemical analysis were made on a 1:5 soil-to-water extract.
mg/kg = milligrams per kilogram (parts per million) of dry soil.
Redox = oxidation-reduction potential in millivolts
ND = not detected
na = not analyzed

HDR | SCHIFF

Enclosure "C-8"

www.hdrinc.com
Corrosion Control and Condition Assessment (C3A) Department

Table 1 - Laboratory Tests on Soil Samples

C.H.J. Consultants
Caprock, Getchell Parcel
Your #14176-3, HDR|Schiff #14-0279LAB
29-Apr-14

Sample ID			3A
Resistivity		**Units**	
as-received		ohm-cm	212,000
saturated		ohm-cm	12,400
pH			6.3
Electrical Conductivity		mS/cm	0.03
Chemical Analyses			
Cations			
calcium	Ca^{2+}	mg/kg	27
magnesium	Mg^{2+}	mg/kg	5.0
sodium	Na^{1+}	mg/kg	8.5
potassium	K^{1+}	mg/kg	10
Anions			
carbonate	CO_3^{2-}	mg/kg	ND
bicarbonate	HCO_3^{1-}	mg/kg	58
fluoride	F^{1-}	mg/kg	ND
chloride	Cl^{1-}	mg/kg	1.8
sulfate	SO_4^{2-}	mg/kg	5.1
phosphate	PO_4^{3-}	mg/kg	ND
Other Tests			
ammonium	NH_4^{1+}	mg/kg	0.7
nitrate	NO_3^{1-}	mg/kg	14
sulfide	S^{2-}	qual	na
Redox		mV	na

Electrical conductivity in millisiemens/cm and chemical analysis were made on a 1:5 soil-to-water extract.
mg/kg = milligrams per kilogram (parts per million) of dry soil.
Redox = oxidation-reduction potential in millivolts
ND = not detected
na = not analyzed

Appendix E.2

Fault Rupture Hazard Investigation Report

I-15 Logistics Project

Draft Environmental Impact Report

CHJ Consultants
1355 E. Cooley Drive, Suite C, Colton, CA 92324 ◆ Phone (909) 824-7311 ◆ Fax (909) 503-1136
15345 Anacapa Road, Suite D, Victorville, CA 92392 ◆ Phone (760) 243-0506 ◆ Fax (760) 243-1225
77-564A Country Club Drive, Suite 122, Palm Desert, CA 92211 ◆ Phone (760) 772-8234 ◆ Fax (909) 503-1136

May 8, 2014

Caprock Partners
250 Main Street, Suite 240
Irvine, California 92614
Attention: Mr. Tom Donahue

Job No. 14176-8

Dear Mr. Donahue:

This letter transmits four copies of our Fault Rupture Hazard Investigation report prepared for the proposed I-15 Logistics Center Project on Lytle Creek Road in the Fontana area of San Bernardino County, California.

This report was based on the scope of services outlined in our proposal dated April 21, 2014.

We appreciate this opportunity to provide geotechnical services for this project. If you have questions or comments concerning this report, please contact this firm at your convenience.

Respectfully submitted,
CHJ CONSULTANTS

John S. McKeown

John S. McKeown, E.G.
Project Geologist

JSM:lb

Distribution: Caprock Partners (4)

FAULT RUPTURE HAZARD INVESTIGATION
PROPOSED I-15 LOGISTICS CENTER
LYTLE CREEK ROAD
FONTANA AREA
SAN BERNARDINO COUNTY, CALIFORNIA
PREPARED FOR
CAPROCK PARTNERS
JOB NO. 14176-8

CHJ Consultants
1355 E. Cooley Drive, Suite C, Colton, CA 92324 ◆ Phone (909) 824-7311 ◆ Fax (909) 503-1136
15345 Anacapa Road, Suite D, Victorville, CA 92392 ◆ Phone (760) 243-0506 ◆ Fax (760) 243-1225
77-564A Country Club Drive, Suite 122, Palm Desert, CA 92211 ◆ Phone (760) 772-8234 ◆ Fax (909) 503-1136

May 8, 2014

Caprock Partners
250 Main Street, Suite 240
Irvine, California 92614
Attention: Mr. Tom Donahue

Job No. 14176-8

Dear Mr. Donahue:

Attached herewith is the Fault Rupture Hazard Investigation report prepared for the proposed I-15 Logistics Center Project on Lytle Creek Road in the Fontana area of San Bernardino County, California.

This report is based upon a scope of services generally outlined in our proposal, dated March 14, 2014, and other written and verbal communications.

We appreciate this opportunity to provide engineering geologic services for this project. If you have questions or comments concerning this report, please contact this firm at your convenience.

Respectfully submitted,
CHJ CONSULTANTS

John S. McKeown

John S. McKeown, E.G.
Project Geologist

JSM/JJM:lb

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ENCLOSURE

FAULT RUPTURE HAZARD INVESTIGATION
PROPOSED I-15 LOGISTICS CENTER PROJECT
LYTLE CREEK ROAD
FONTANA AREA
SAN BERNARDINO COUNTY, CALIFORNIA
PREPARED FOR
CAPROCK PARTNERS
JOB NO. 14176-8

INTRODUCTION

During March and April 2014, a fault rupture hazard investigation was performed by this firm for the site of the proposed logistics center located between Lytle Creek Road and Interstate 15 in the Fontana area of San Bernardino County, California. The purposes of this investigation were to explore and evaluate the potential hazard of ground rupture due to surface faulting associated with the Cucamonga fault zone (CFZ) at the subject site. The location of the site is shown on Enclosure "A-1". A concurrent geotechnical investigation, presented under separate cover, includes geotechnical and engineering geologic discussion of other geologic hazards.

A portion of the site is located within a State of California-designated Alquist-Priolo Earthquake Fault Zone (APZ) and County of San Bernardino-designated hazard zone to evaluate areas of suspected faulting. The site location and boundaries of the site relative to the APZ are shown on Enclosure "A-2". Our investigation was tailored for a specific building footprint provided by you as a map exhibit. Our investigation focused on an area extending from approximately 50 feet west of the proposed building envelope to the edge of the mapped APZ zone. Explorations were also located outside the building area near mapped faulting and along the prominent escarpment forming the western property boundary that is interpreted to be formed by the Cucamonga fault. The building envelope and APZ were professionally surveyed and marked in the field to provide close control of explorations relative to pertinent features.

Our investigation included trenching across the mapped fault zone and within the building envelope to evaluate the presence/absence of faulting.

A Geologic Index Map (Enclosure "A-1") is included that shows mapped faults by Morton and Matti (2001). Thrust faults of the CFZ are depicted within older geologic units (Qof and Qvof) and separating crystalline basement rocks from sedimentary units. The southeastern most fault strand borders the site and forms a prominent escarpment along the base of the eastern San Gabriel Mountain range.

To orient our investigation, we utilized ALTA plans dated March 14, 2014, showing the location of the proposed building, site boundaries, existing structures and topography.

The results of our investigation, together with our conclusions and recommendations, are presented in this report.

SCOPE OF SERVICES

The scope of services provided during this investigation included the following:

- Reviewing published and unpublished literature and maps, including geologic reports on file with California Geological Survey
- Examining aerial imagery dated from 1938 to 2012
- Performing a geologic field reconnaissance and mapping of the site and surrounding area
- Coordinating with the excavation subcontractor for mobilization of equipment to the trenching site
- Marking excavations and notification of Underground Service Alert
- Coordinating with our geophysics subcontractor to locate and mark existing on-site water lines using radio detection equipment
- Performing geologic trenching and logging to evaluate the proposed building area with respect to mapped or suspected fault traces

- Coordinating with County of San Bernardino, California Geological Survey and U.S. Geological Survey personnel for field review of the trench exposures

- Performing a seismic-refraction survey to evaluate the bedrock surface at one location

- Evaluating the site-specific geologic data with regard to the potential age and location of fault displacement

- Establishing a building setback zone to mitigate fault rupture hazard

- Preparing this report

PROJECT CONSIDERATIONS

The project consists of construction of a large concrete, tilt-up-type warehouse/logistics structure and associated office and parking areas. The rectangular building footprint is approximately 1.2 million square feet.

The location of the proposed footprint is shown on the Geologic Map and Site Plan (Enclosure "A-4"). A modified footprint based on the setback established by this investigation is also shown.

SITE DESCRIPTION

The site consists of two contiguous parcels referred to herein as the Getchell parcel and Stutzke parcel. The site is bounded by Lytle Creek Road to the northwest, Caltrans right-of-way to the southeast, and private lands to the northeast and south. At the time of our investigation, the site was covered by a low growth of annual grasses and scrub-type plants. The majority of the site consists of undeveloped land associated with past agrarian activities. Portions of the site are developed with residential structures. More recent uses of the Stutzke parcel include storage of woodpiles, assorted vehicles and watercraft, and livestock farming. The Getchell parcel is occupied with a residence and outbuildings; however, no indications of farming or other land use are evident.

Overhead and buried utilities were observed or indicated by Underground Service Alert markings along Lytle Creek Road. Small-diameter steel water pipes were located and marked in several areas of the site. Some of these extend over 1/2 mile across the site area and convey spring flows to water tanks south of the site. Water lines were capped with permission of the owners where crossed by excavations and later restored to use. An assortment of rock walls, wire fences and boulder windrows were traversed during excavation work.

We reviewed aerial photographs of the site spanning the time period from 1938 to 2012. The residential and outbuilding structures and walls within the site at the time of our investigation are visible as early as 1938. Light-toned sediments are visible emanating from Duncan Canyon and three small tributary canyons and are attributed to the flood of March 2, 1938. Electric tower pads and Lytle Creek Road are visible in present locations in 1938. Land clearing and rock removal from selected areas is visible as areas of light color tones on the photographs. In 1955, the Stutzke parcel includes mature trees as a windbreak at the toe of the escarpment along Lytle Creek Road. Orchard trees are also present within the site. Portions of the Getchell parcel appear cleared of vegetation in 1938 and 1955 with light toned areas corresponding to the geologic unit Qyf_4. Indications of rock removal, vehicle tracking and clearing are visible as light toned tracks throughout both parcels. The most recent geomorphic edge of the Lytle Creek alluvial fan is visible as a tonal contrast and topographic inflection and corresponds approximately with the alignment of the Qw unit separating units Qyf_5 and the area of Qf/Qyf_4. The Duncan Canyon bench overlooks the site to the west-southwest as a relatively flat, uplifted geomorphic surface dissected by modern drainages including Duncan Canyon and three small tributaries. The bench surface, formed in Pleistocene age sediments, represents a former valley bottom adjacent to the San Gabriel range front much as the site exists in present time.

The site appears in imagery subsequent to 1960 in a similar state as that which existed during our investigation with the amount of stored equipment, vehicles and livestock generally increasing through time. Aside from the Duncan Canyon bench and escarpment of the range front, evidence of active faulting such as lineaments, offset streams or scarps were not noted within the site on the imagery examined.

GEOLOGIC AND STRUCTURAL SETTING

The site of the proposed logistics center is located at the eastern end of the San Gabriel Mountains of southern California. The San Gabriel Range, along with the Santa Monica and San Bernardino Mountains and other ranges, forms the Transverse Ranges geomorphic province. The Transverse Ranges province is characterized by east-west trending mountains within the generally northwest-trending fabric of adjacent provinces. Fault systems along the margins of the province accommodate uplift of ranges relative to adjoining lowlands. The CFZ is a zone of thrust faults that extends from San Antonio Canyon to Lytle Creek along the south flank of the eastern San Gabriel Mountains and occupies the western edge of the site. Based on mapping by Morton and Matti (2001), the site is underlain by alluvial-fan sediments of middle to early Holocene age. Based on site-specific mapping, localized areas of colluvium (gravity-deposited sediment) and limited areas of recent alluvial deposits occur along the escarpment bounding the western edge of the site and locally within tributary drainages sourced west of the site. The San Jacinto and San Andreas fault zones are located approximately 1,000 feet east and 4-1/2 miles northeast of the site, respectively.

CUCAMONGA FAULT ZONE:

The Cucamonga Fault Zone was recognized in the early 20th century by Eckis (1928), who described it as an important influence on alluvial fans of the eastern San Gabriel Range front between San Antonio Canyon and Lytle Creek. Subsequent studies indicated the CFZ to be part of a system of range front faults that extends along the south flank of the Transverse Ranges known as the Transverse Ranges Frontal Fault System. The San Fernando fault of this system ruptured during the 1971 preferred magnitude (M) 6.7 San Fernando earthquake. Along the eastern San Gabriel Range, the CFZ consists, at the surface, of a system of sinuous/anastomosing thrust faults that disrupt alluvial-fan surfaces or juxtapose crystalline basement rocks over younger sediments. Enclosure "A-3" provides an overview of the site relative to the various strands of the CFZ along the eastern margin of the San Gabriel Mountains. The CFZ was included in early editions of Alquist-Priolo Special Studies Zone Maps (nka Alquist-Priolo Earthquake Fault Zone Maps) by the State of California to mitigate potential for fault rupture hazard.

Morton and Matti (1987) designated three main strands of the fault zone based on interpreted age and degree of scarp degradation. Combined strands "B/C" are mapped along the western edge of the site and form conspicuous individual scarps across alluvial fans west of the site. These scarps are somewhat obscured by development but are well preserved at Etiwanda Canyon. Strand B is interpreted to be relatively older than Strand C where they occur separately. Strand C only ruptures the younger faulted sediments and forms fresher scarps than Strand B. Near-surface exposures of the CFZ indicate a north-dipping fault plane oriented from 80 degrees to horizontal (Morton and Matti, 1987). Cramer and Harrington (1987) cite northward fault dips from 50 to 60 degrees at depth based on seismic profile data. Nearly consistent down-dip plunge of slickensides on fault surfaces indicates that latest movements are down-dip (Morton and Matti, 1987).

The most recent event attributed to the CFZ using soil ages estimated by soils chronosequence studies by McFadden et al. (1982) and geomorphic relations is estimated as occurring prior to deposition of 200- to 700-year-old alluvium and after deposition of 1,000-year-old alluvium, placing latest activity between 700 and 1,000 years. Vertical displacement typically ranges from 2 meters to 20 meters for individual scarps, with some scarps exhibiting up to 40 meters of vertical throw. The CFZ is assigned an estimated slip rate of 5 millimeters per year and characteristic magnitude of 6.7 (Petersen et al., 2008). Lindvall and Rubin (2008) estimate a slip rate of 1.9 millimeters per year at Day Canyon using cosmogenic dating and geomorphic relations. The CFZ interacts in an unknown way with the right-lateral faults of the San Jacinto fault zone at Lytle Creek.

The fault location near the site is variously depicted on geologic maps to extend along the base of the topographic escarpment and terminate at Duncan Canyon (Morton, 1976) or continue eastward to Lytle Creek (Morton and Matti, 1987; 2001). The location plotted by Treiman (2000) in Google Earth maps is based on the general location of Morton and Matti (1987). Near the site, the CFZ is expressed as a southeast-facing escarpment approximately 90 to 100 feet high. The escarpment is modified by the alignment of Lytle Creek Road that is cut into older alluvium and bedrock materials near the base of the scarp. The road forms a series of slope cuts and shallow canyon fills near the west margin of the site. Several tributary drainages emerge from the San Gabriel Range across the scarp and are carried beneath the roadway in culvert pipes; thus, the relation between the scarp and incising drainages is obscured.

PREVIOUS INVESTIGATIONS

Mr. Edward Bortugno of the California Division of Mines and Geology (CDMG, 1977) reviewed data pertaining to location and activity of the CFZ for the purpose of zoning faults within the Devore 7.5-minute quadrangle for State-designated Alquist-Priolo Earthquake fault zones. Plate 1C of Bortugno's report shows his interpretation of the fault zone annotated on the 1974 earthquake fault zone map. Mr. Drew Smith of CDMG reviewed data pertaining to the CFZ near the site in reports dated October 1977 and March 1978. Smith speculates about the origin of the high escarpment along Lytle Creek Road and concludes that it is fault-related based on lack of sinuosity of the contact with the Lytle Creek fan sediments and range front. Mr. William Bryant (1995) reviewed data including the work by Morton and Matti (1987) for the CFZ that resulted in revised State zoning of the fault zoning near the site (Enclosure "A-2").

Prior trenching studies on the CFZ are located west of the site. Enclosure "A-3" shows two trenching sites located approximately 1 mile and 2-1/4 miles west of the site along the Cucamonga fault system. The Altum Group site reportedly revealed faults associated with basement over alluvium strands of the fault zone.

A copy of a report by RMA, dated May 27, 2011, and a review letter from County of San Bernardino Land Use Services Department dated June 16, 2011, were provided to us by Mr. Jerome Treiman of California Geological Survey. The RMA trenches were excavated as a supplement to unpublished work by SID Geotechnical and revealed faulting associated with the B/C strand of the CFZ. RMA recommended mitigation by a building setback zone. A residential tract has recently been completed near the RMA study location.

The RMA investigation reported the following:

- RMA trenches exposed young alluvial fan sediments with grayish hues and high gravel and cobble content overlain by fine-grained soils with reddish brown hues of alluvial and colluvial origin. An old fan unit was also identified.
- The colluvium was estimated to be late Holocene; the alluvial fan sediments late Pleistocene and late to mid Holocene; and the old fan unit early Pleistocene.
- The regionally mapped Cucamonga fault zone coincides with a distinct photographic lineament [the geomorphic escarpment].
- A contact between colluvium and younger alluvium in RMA FT-2 dips 5 to 25 degrees to the north, consistent with reverse faulting.
- Very old alluvial deposits at the north end of RMA FT-3 dip approximately 27 degrees to the north, consistent with reverse faulting.
- North-dipping clasts were found within young alluvium at the north end of RMA FT-3, suggesting possible reverse faulting.
- Locally thickened colluvium was exposed above north-dipping rock clasts in RMA FT-3, suggesting possible reverse faulting.
- Very old alluvium was found to overlie young alluvium in RMA FT-4 along a contact dipping 43 degrees to the north, suggesting reverse faulting.
- The Cucamonga fault is active and should be mitigated by establishment of building setbacks for human habitation.

Mapping by USGS and CGS for the Google Earth application included in the Quaternary Fault and Fold Database for the United States (2006) includes the fault location along the western site limit as depicted by Morton and Matti (2001).

Based on our review of the available data from prior investigations, the closest documented strand of the CFZ that exhibits Holocene age activity is located approximately 0.8 mile west of the site. Our current investigation constitutes the eastern-most known trench exposures of the Cucamonga Fault Zone to date.

As related by Mr. John Hockaday, who has occupied a parcel (APN 0239-071-05) just south of the site since the 1960s, marble or limestone bedrock was encountered at a depth of 183 feet during drilling of a water well on his land.

SUBSURFACE AND FIELD INVESTIGATION

Our field investigation program included excavation of four northwest-southeast oriented trenches and two additional short trenches to investigate the proposed building footprint within the APZ on the site. A total of approximately 1,785 lineal feet of trench was excavated using a team of track-mounted excavators. The first trench (Trench 1) reached a maximum depth of approximately 15 feet and was determined to reveal geologic materials deposited by a young alluvial fan sourced in Duncan Canyon. It was determined that these materials did not allow a sufficient "look back in time" for purposes of determining recent fault activity so further trenching south and west of existing site structures was not performed. A short trench (T-2B) was excavated as close as possible to the southern-most portion of the proposed building within the APZ as limited by existing structures and buried utilities. Trenches 2A, 3A, 3B and 4 were excavated as planned. Trench sidewall stability considerations necessitated the inclusion of benches in the excavations. The trench walls were cleaned to expose relatively undisturbed soil substrate and examined for geologic features, including sedimentary, lithologic, structural and soil horizons as potential indicators of fault-related features. A reference datum and lateral stationing were established along the trench exposures using a digital manometer, hand level and 300-foot tape to aid in location of the logged features. Geologic logging was performed by a team of geologists at a scale of 1 inch equal to 5 feet. Soil colors were derived from Munsell Soil Color Charts (2000). The locations of the trenches are shown on the attached Geologic Map and Site Plan (Enclosure "A-4"). The trench logs are included in Appendix "B".

Dr. Katherine Kendrick of U.S. Geological Survey and Ms. Janis Hernandez, Mr. Jerome Trieman, Mr. Brian Olson and Mr. Brian Swanson of California Geologic Survey visited the site on April 3, 2014, to observe the trench exposures with representatives of this firm. Mr. Wes Reeder, geologist for the County of San Bernardino, also attended this meeting. Dr. Sally McGill of California State University at San Bernardino briefly observed the trench exposures on April 4, 2014. Dr. Kendrick returned to the site April 18 and 23, 2014, to evaluate soil profiles at several trench locations (indicated on the trench logs in Appendix B). According to Dr. Kendrick, unit 2 of T-2A is older than the underlying unit 1 alluvial-fan sediments. This relationship also occurs in T-2B and implies reverse faulting.

A seismic refraction survey was performed by our sub-consultant TerraGeosciences adjacent to Trench 3B to evaluate the bedrock profile exposed in Trench 3B. The survey extended eastward approximately 200 feet from the edge of Lytle Creek Road and down the escarpment surface. Results and interpretations of the survey presented as a tomographic model are shown in Appendix "C". TerraGeosciences also performed utility location surveys as needed to locate and manage existing steel water lines that crossed the trench alignments.

The trench margins and fault locations were surveyed by Site Tech Incorporated to facilitate accuracy of their location and recovery of the trench margins during future site work.

GEOLOGIC MATERIALS

As observed in our explorations, the geologic materials within the site include modern surficial soils, alluvial-fan sediments associated with the Lytle Creek fan and local tributary canyons, and colluvium derived from an escarpment bounding the western site margin. These materials form a sequence of interbedded sedimentary units that are locally in scour contact and include buried paleosols that exhibit weak soil pedogenic structure. The primary lithology of the sequence is overprinted in the upper approximately 1 to 4 feet by a soil profile that exhibits brown to gray soil hues. A grayish brown "A" horizon is present at the existing ground surface that includes the currently active plant rooting zone and plow zone. The surficial geologic units identified for this investigation are discussed below. Specific descriptions are provided for units identified in the trench exposures on the trench logs. The logged units represent the vertical and lateral distribution of geologic materials in the subsurface. The distribution of surface geologic materials is shown on Enclosures "A-1" and "A-3".

FILL (f):

Fill is present as boulder windrows, levee embankments, disturbed soils associated with plowing or disking, dirt roads, side-cast spoils of Lytle Creek Road and stockpiles. These materials consist of sand, silt, gravel and cobbles derived from local materials. Not all occurrences are demarcated on the geologic map due to limitations of scale.

COLLUVIUM (Qcol):

Colluvium (slope-mantling deposits) of estimated middle to late Holocene age (Qcol) is associated with an escarpment along the western margin of the site. These materials consist of gravity and slope wash-deposited angular sand, silt, gravel and cobbles derived from Pleistocene alluvial-fan deposits that form road cut and canyon exposures along the western site margin. Some colluvium has apparently been reworked by periodic flows associated with the Lytle Creek fan. Color varies from brown to reddish brown depending on source area. The colluvium is generally massive but includes internal thin beds and horizons. This unit is not demarcated on the geologic map due to limitations of scale.

RECENT WASH DEPOSITS (Qw):

Wash deposits sourced from tributary canyons form outwash zones along the western site margin and a thin mantle within an active channel trending through the site. The alignment of the "Qw" channel demarcates the surface contact between Lytle Creek fan sediments and local fan sediments. Light color tones on aerial imagery reveal several episodes of deposition of wash sediments within the site. These sediments are generally identified in trench exposures as near-surface angular sands and gravelly sand lenses that form scour contacts in the shallow soil horizon.

LOCAL FAN SEDIMENTS (Qf$_1$, Qf$_2$):

Alluvial-fan sediments associated with Duncan Canyon and tributary canyons emerging at the western site margin are delineated based on topographic expression and trench observations. These sediments include diagnostic weathered marble clasts and reworked clasts of older alluvium. Clast size varies with energy of the source canyon with Duncan Canyon fan sediments including a greater fraction of cobbles and boulders. The deposits include gravelly sand and silty sand lenses. Color varies from gray to yellowish brown. These may be considered subunits of Qyf$_4$. Local fan units interfinger with Lytle Creek fan sediments in the subsurface. The unit designation Qf/Qyf$_4$ is assigned to areas where these units interfinger.

YOUNG ALLUVIAL-FAN SEDIMENTS (Qyf$_5$, Qyf$_4$):

Young alluvial-fan sediments associated with Duncan Canyon and tributary canyons emerging at the western site margin are delineated based on topographic expression and trench observations. These sediments are Holocene age and include diagnostic weathered marble clasts and reworked clasts of older alluvium. Clast size varies with energy of the source canyon with Duncan Canyon fan sediments including a greater fraction of cobbles and boulders. The deposits include gravelly sand and silty sand lenses. Color varies from gray to yellowish brown. Local fan units interfinger with Lytle Creek fan sediments in the subsurface. Qyf$_5$ is considered slightly younger than Qyf$_4$ (Morton and Matti, 2001).

OLD AND VERY OLD ALLUVIAL FAN DEPOSITS (Qof, Qvof):

Old and very old alluvial fan deposits (nomenclature of Morton and Matti, 2001) of Pleistocene age are exposed in road cuts and dissected terrain of the San Gabriel Mountains along the western site boundary and form the Duncan Canyon Bench surface. This surface is described as Stage S2 Soil by Matti et al. (1982) corresponding with a Pleistocene age. These sediments were deposited as alluvial fans along a former flank of the range prior to being uplifted and dissected by streams. These cemented sediments exhibit reddish-brown color hues, include thick beds of cobbly sandy gravel, silty sand, and gravelly sand with significant secondary clay content, and are locally cut by steep faults. The distribution of these materials is shown on Enclosures "A-1" and "A-3".

GNEISSIC BEDROCK (Pm):

Crystalline metamorphic bedrock was encountered at the west end of Trench 3B at a depth of approximately 20 feet below ground surface. The rock consists of hard, gray to dark bluish gray, fine-grained, slightly weathered, foliated gneiss with oxide coatings along joints and rounding on undisturbed faces. The alluvial-fan gravel unit filled irregularities in and rested against the steep rock surface. As related by Mr. John Hockaday, who has occupied a parcel just south of the Stutzke parcel since the 1960s, marble or limestone bedrock was encountered at a depth of 183 feet on his land during drilling of a water well. This suggests that bedrock occurs beyond the geomorphic margin of the eastern San Gabriel Mountains beneath an alluvial cover approximately 200 feet thick, at least near the range front.

DISCUSSION OF OBSERVATIONS

THRUST FAULT MORPHOLOGY AND EXPRESSION:

Thrust faults exhibit complex interactions with fluvial systems of major outwash basins. Scarp morphology (shape) is influenced by four main processes as described by Carretier et al. (2002). These are: 1) gravitational collapse of a newly formed fault scarp, 2) progressive erosion of the fault scarp during an interseismic period, 3) folding associated with the frontal thrust and backthrusts, and 4) competing alluvial deposition on mountain piedmont slopes and abrasion of the scarp by wash processes. Thrust fault zones may include a shear plane or planes separating hanging wall materials (upper plate) from footwall materials (lower plate) or may be expressed by diffuse folding. Thrust faults are generally easy to locate in exposures unless they flatten to subhorizontal or become parallel to bedding in the footwall (Carver and McCalpin, 1996). Deposition of scarp-derived colluvium from collapse of the hanging wall and subsequent slope wash processes work to modify fault scarps from a steep original profile to a residual erosional scarp (Wallace, 1977). The general model of evolution for a thrust fault scarp associated with several ruptures of a 45-degree dipping fault includes formation of several generations of colluvial layers (wedges) that stack in an upward-younging sequence and form an angular contact with the original ground surface (footwall) (Carver and McCalpin, 1996). As related by Carver and McCalpin (1996), Weber and Cotton (1980) describe the thrust fault process to include

> "the hanging wall block slides out on the former ground surface so that soft sediments are "bulldozed" up in front of the lip of the overthrust block. The soft sediments of the footwall …are also deformed by drag underneath the overriding plate. Much of the deformation of sediments on the footwall block is the result of …a "rolling and mixing" action that apparently produces extensive sub-fault conglomerate masses…"

TRENCH 2A:

Trench 2A revealed alluvial-fan sand/gravel deposits truncated and overlain by relatively older materials and slight warping of beds overlying an inferred fault tip. A 27-degree west-dipping shear zone/fault and voids in the alluvial fan gravel unit below the fault suggest shearing/dilation of the gravels and thrust fault geometry. The fault projects to the surface at approximately trench station 20; however, no features consistent with extension of faulting to the surface were present in the overlying sediments. Rather, the fault is terminated/overlain by flat-lying to slightly east-dipping, reddish-brown "depositional" units at a depth of approximately 12 feet below ground surface. The overlying units are un-ruptured and laterally continuous in a zone extending from the topographic escarpment to T-2A station 55. At T-2A station 55, the reddish-brown units pinch out or are scoured by younger alluvial-fan sediments.

Based on soil profile evaluation, Dr. Kendrick postulates a relatively older age of the reddish-brown units versus the underlying alluvial-fan sediments. This inverted age relationship implies thrust fault geometry. This postulated age relation requires a flat-lying fault plane along the contact between T-2A units 1 and 2 extending to T-2A station 55. One might expect significant disruption of the reddish-brown units by jumbling, back thrust faults or localized shear zones if emplaced by faulting; however, no such features were observed. Boulders and cobbles derived from the underlying alluvial fan unit are present at/in the base of the overlying reddish-brown colluvial unit. The boulders and cobbles may be interpreted as clasts dragged from the underlying alluvial unit into a diffuse shear zone during fault movement or as surface clasts of unit 1 covered by deposition of unit 2. The sense of fault displacement is interpreted as up-on-the-west, east-directed thrusting. Therefore, the proposed building location is on the footwall side of the fault zone. Based on lack of faulting or disruption of units 2 and 3 as might be expected for hanging wall sediments above a flat-lying thrust, we do not concur with the interpretation that the fault zone extends to T-2A station 55 as a flat-lying thrust required by unit 2 being older than unit 1. An alternative interpretation is inherited reddish color by units 2 and 3 from the adjacent very old alluvial-fan unit in the hanging wall.

For purposes of building setback, we have utilized the more conservative interpretation of Dr. Kendrick and established a fault projection at T-2A station 55.

TRENCH 2B:

Trench 2B revealed a similar stratigraphy and older-over-younger contact as Trench 2A; however, a discrete west-dipping shear zone was not observed, probably because the western extent of the trench was limited by proximity to Lytle Creek Road. The reddish-brown units of Trench 2B include thin beds that lie above the interpreted fault contact and appear to have a fluvial origin. A boulder consistent with clast types in the alluvial-fan gravel unit was present in the base of the colluvial unit at the west end wall of the trench suggests dragging of clasts by diffuse shearing as interpreted for the Trench 2A exposure. We believe a west-dipping shear feature is concealed beyond the west end of Trench 2B.

TRENCH 3B AND SEISMIC PROFILE S-1:

Trench 3B revealed sandy, gravelly alluvial-fan sediments with abundant cobbles overlain by finer-grained colluvial units. The T-3B colluvial units exhibit yellowish-brown rather than reddish-brown hues and are interpreted to be younger than the colluvial units of Trenches 2A and 2B. The proximity of Tributary 3 likely prevents formation of older soils due to more frequent flows that disturb the surface sediments in its outwash area. Subtle indications of shearing/faulting, including back-tilted alluvial gravels, dilation and mismatched color units within the alluvial fan gravel unit, were noted at T-3B station 7; however a discreet shear zone was not exposed. A relatively flat-lying stratigraphic sequence extends across the entire T-3B exposure. This sequence includes a silty clay bed with charcoal fragments (unit 3) that overlies lower alluvial-fan gravels (unit 2) and is in turn on-lapped by alluvial-fan gravels (unit 9). Charcoal samples collected from unit 3 were submitted for carbon-14 isotopic age determination. The result indicates an age of 4,325 ypb +/- 30 years, placing the alluvial-fan unit 2 at mid-Holocene age (Appendix D). Gneissic bedrock was exposed in the west end of T-3B. This is consistent with an outcrop of similar material in a road cut approximately 60 feet west of the trench end. Angular cobbles of gneiss, consistent with the bedrock in the trench and road cut exposure, were present in the colluvial unit above the bedrock surface.

A seismic velocity profile was measured adjacent to Trench 3B to evaluate the concealed geometry of the bedrock surface exposed at the west end of T-3B. The velocity contour image (Enclosure "C-1") suggests the presence of a step in the bedrock surface. The cause of this step may be interpreted in different ways. Suggested end-member interpretations of the seismic velocity contours are as follows:

1) Tracing the 5,000 foot-per-second contour to represent slightly to moderately weathered rock yields a sloping bedrock surface that mimics existing surface topographic features that can be produced by depositional processes. This surface is mantled by lower velocity, unconsolidated alluvial sediments.

2) Tracing the 6,000- to 7,000-foot-per-second contour to represent un-weathered rock yields a surface with a strong inflection at station 145, a steep escarpment between stations 150 and 160, and a surface that mimics existing ground profile from 160 to the west end of the line. The >9,000-foot-per-second contours imply an inversion of high-velocity material over relatively lower-velocity material.

Based on typical seismic velocities for gneissic bedrock, the structural setting of T-3B and the seismic line within an escarpment shown to be fault-related by T-2A and T-2B, and fault exposures within the same escarpment 1 mile to the southwest, we favor the second model and interpret the high-velocity zone at station 180 as a hanging wall feature of rock thrust upward and eastward along a reverse fault. Further, we interpret thickening of unconsolidated (lower-velocity) sediments to the east. The suggested projection of a 30-degree west-dipping fault onto the seismic contour profile is presented in Enclosure "C-3". The juxtaposition of a higher-velocity versus lower-velocity zone at S-1 station 85 suggests a thrust fault relation. We project this postulated fault to daylight at S-1 station 30, which extends beyond the eastern reach of T-3B. This postulated fault projection is shown on the Geologic Map and Site Plan (Enclosure "A-2.1"), and a building setback is established 50 feet to the southeast.

TRENCH 3A AND T-4:

Fault-related features, offset horizons or geomorphic evidence of faulting were not found within T-3A or T-4. These trenches exposed alluvial-fan gravels with cobble beds, scattered boulders and localized debris flow units. Internal scour and unit contacts provided continuous horizons for evaluation of potential fault offset. The alluvial-fan sediments are overlain by massive silty sand units of variable thickness that extend to the ground surface.

CUCAMONGA FAULT ZONE AND BUILDING SETBACK ZONE:

Based on our observations and logging of the subsurface materials, the stratigraphy and age relations of sediments exposed in the current trench explorations, and information presented by RMA regarding the CFZ location 1 mile to the southwest, we conclude that a fault zone corresponding approximately to the fault location mapped by Morton and Matti et al. (2001) and adopted by Treiman (2000) is located along or near the base of the topographic escarpment forming the western boundary of the site. The fault location is interpreted from structure, contact and stratigraphic relations in Trenches 2A, 2B and 3B, seismic line S-1 and geomorphic expression as a scarp-forming structure along the range front.

The geomorphic escarpment interpreted as a thrust fault in prior mapping is confirmed to be a fault-related feature formed during reverse-fault movement along the Cucamonga fault zone. Periodic localized modification of the scarp by Lytle Creek fan deposition or activity of tributary streams crossing the scarp is ongoing.

Correlative beds or other reference horizons were not exposed to provide estimates of displacement/vertical throw within the depth of trenching accomplished for this investigation. An average vertical displacement per event is postulated as 2 meters (6.5 feet) based on scarp height relations for the central and western portion of the CFZ that strike east-west (Morton and Matti, 1987). Based on a south-vergent San Gabriel Mountains block versus Peninsular Ranges block convergence model, we postulate a lesser component of vertical thrusting along the northeast-southwest striking range front bordering the site. We also postulate an oblique component of slip or tapering down of slip magnitude for the eastern end of the CFZ as it nears the Lytle Creek strand of the San Jacinto fault zone northeast of the site.

We established a survey point in the field for the surface projection of the fault located in T-2A defined by the limit of older over younger sediments. Based on similarity of the setting of T-2B relative to the geomorphic scarp with that of T-2A, we established a survey point representing the fault location near the southern limit of the building envelope (approximately 300 feet southeast of T-2A). This fault point was established normal to the scarp and measured from the slope toe with a 300-foot tape. We projected a postulated fault in T-3B by cross section and marked the Geologic Map and Site Plan accordingly. A setback zone was established using the surveyed setback points and the north end of T-4 with straight line projections between. The setback control points are depicted on the Geologic Map and Site Plan (Enclosure "A-2.1") in graphic and tabular formats.

ESTIMATED AGE OF ACTIVITY:

Based on the measured radiocarbon age of charcoal in T3B, the alluvial-fan unit 2 in T-3B is mid-Holocene. Based on comparison of clast weathering and clast coating characteristics and color hues of the alluvial-fan units in T-2A, T-3A, T-3B and T-4, a mid-Holocene age has been postulated for the alluvial-fan units in the trench exposures (Dr. Katherine Kendrick, personal communication).

The age of latest activity for the Cucamonga fault estimated by soils chronosequence studies by McFadden et al. (1982) and geomorphic relations is postulated as occurring prior to deposition of 200 to 700 year-old alluvium and after deposition of 1,000-year old alluvium placing latest activity between 700 and 1,000 years. Therefore, the mid-Holocene alluvial-fan sediments exposed in our trenches should reveal indications of faulting, if present, from the latest event on the CFZ. We observed faults and fault-related features in our trenches that imply disruption of mid-Holocene age sediments near the geomorphic scarp along the west margin of the site. The Holocene alluvial-fan sediments are truncated by a fault in T-2A and a similar relation is implied in T-2B. Therefore, the youngest faulted material is Holocene. This is consistent with a Holocene active classification of the greater Cucamonga fault zone.

CONCLUSIONS AND RECOMMENDATIONS

The Cucamonga fault zone is expressed as a geomorphic and subsurface feature along the northwestern boundary of the site. The age of disrupted sediments revealed by trenching indicates a Holocene (active) fault classification. The surface projection of the CFZ was postulated based on fault-related features exposed in trenches, soil age/stratigraphic relations and interpretation of a seismic velocity profile image. This surface projection is considered a most conservative interpretation of the available site geologic data and provides a suitable reference on which to base mitigation of fault rupture hazard for the proposed project in accordance with the requirements of the Alquist-Priolo Earthquake Fault Zoning Act. Further investigation may preclude faulting within portions of the setback area.

A discussion of other geologic hazards including regional faults, ground shaking from regional seismic sources, landslides, flooding, liquefaction and seismic settlement is presented under separate cover for a concurrent geotechnical investigation.

This investigation was performed for a specific building area relative to the APZ for the Devore quadrangle. Other site uses should be evaluated on an individual basis with consideration of the findings of this investigation.

Trench backfill within the slope areas along Lytle Creek Road were placed as compacted fill. These areas include T-2B, the west end of T-2A and T-3B. The remainder of T-2A, T-1, T-3A and T-4 were backfilled with spoils without compaction; this backfill is considered non-engineered and should be replaced according the recommendations of the concurrent geotechnical report.

The site, like most areas in the southern California region, is subject to ground shaking hazard from earthquakes on regional fault systems capable of producing moderate to severe ground shaking. This investigation specifically addresses fault rupture hazard for the proposed project. The concurrent geotechnical investigation addresses the engineering characteristics of site geologic materials and other geologic hazards including ground shaking, landslide, liquefaction, flooding and regional faults.

LIMITATIONS

CHJ Consultants has striven to perform our services within the limits prescribed by our client, and in a manner consistent with the usual thoroughness and competence of reputable geotechnical engineers and engineering geologists practicing under similar circumstances. No other representation, express or implied, and no warranty or guarantee is included or intended by virtue of the services performed or reports, opinion, documents, or otherwise supplied.

This report reflects the testing conducted on the site as the site existed during the investigation, which is the subject of this report. However, changes in the conditions of a property can occur with the passage of time, due to natural processes or the works of man on this or adjacent properties. Changes in applicable or appropriate standards may also occur whether as a result of legislation, application or the broadening of knowledge. Therefore, this report is indicative of only those conditions tested at the time of the subject investigation, and the findings of this report may be invalidated fully or partially by changes outside of the control of CHJ Consultants. This report is therefore subject to review and should not be relied upon after a period of one year.

The conclusions and recommendations in this report are based upon observations performed and data collected at separate locations, and interpolation between these locations, carried out for the project and the scope of services described. It is assumed and expected that the conditions between locations observed and/or sampled are similar to those encountered at the individual locations where observation and sampling was performed. However, conditions between these locations may vary significantly. Should conditions that appear different from those described herein be encountered in the field, by the client or any firm performing services for the client or the client's assign, this firm should be contacted immediately in order that we might evaluate their effect.

If this report or portions thereof are provided to contractors or included in specifications, it should be understood by all parties that they are provided for information only and should be used as such.

The report and its contents resulting from this investigation are not intended or represented to be suitable for reuse on extensions or modifications of the project, or for use on any other project.

CLOSURE

We appreciate this opportunity to be of service and trust this report provides the information desired at this time. Should questions arise, please contact this firm at your convenience.

Respectfully submitted,
CHJ CONSULTANTS

John S. McKeown

John S. McKeown, E.G. 2396
Project Geologist

REGISTERED GEOLOGIST
JOHN S. McKEOWN
NO. 2396
CERTIFIED ENGINEERING GEOLOGIST
Exp. 08-30-15
STATE OF CALIFORNIA

Jay J. Martin, E.G. 1529
Vice President

PROFESSIONAL GEOLOGIST
JAY J. MARTIN
No. 1529
CERTIFIED ENGINEERING GEOLOGIST
Exp. 8-31-14
STATE OF CALIFORNIA

JSM/JJM:lb

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LIST OF AERIAL IMAGERY

San Bernardino County Flood Control District, November 10, 1955, black and white aerial photograph nos. 6-27, 7-25 and 7-26.

San Bernardino County Flood Control District, August 9, 1965, black and white aerial photograph nos. 123 and 124.

San Bernardino County Flood Control District, January 28, 1966, black and white aerial photograph nos. 26, 27 and 28.

San Bernardino County Flood Control District, January 14, 1967, black and white aerial photograph nos. 38 and 42.

San Bernardino County Flood Control District, October 8, 1971, black and white aerial photograph nos. 10 and 11.

San Bernardino County Flood Control District, January 21, 1978, black and white aerial photograph nos. 172 and 173.

San Bernardino County Flood Control District, February 25, 1986, black and white aerial photograph nos. 172 and 173.

San Bernardino County Flood Control District, April 20, 1996, black and white aerial photograph nos. 217, 218 and 219.

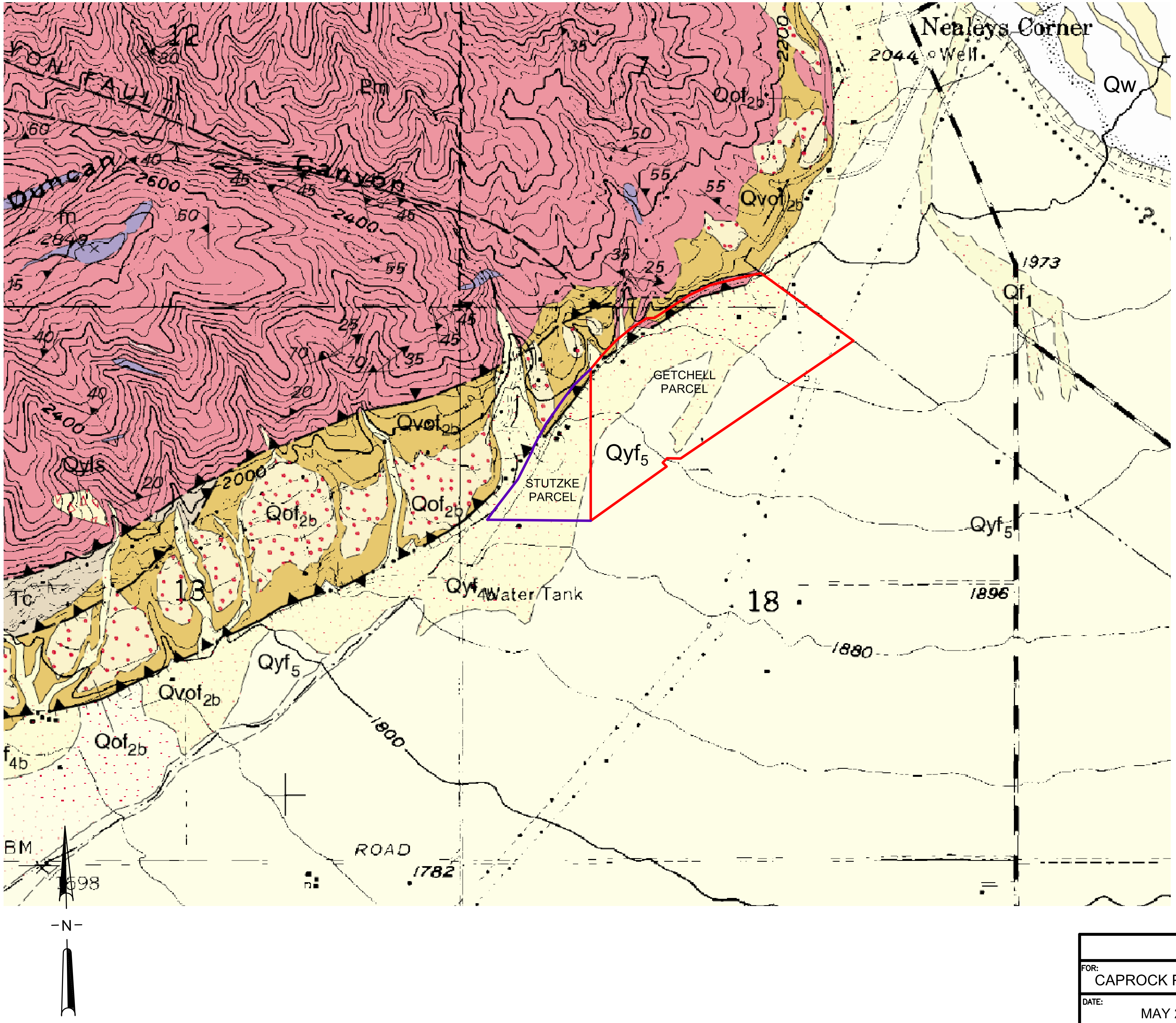
San Bernardino County Flood Control District, June 15, 2001, black and white aerial photograph nos. 230, 231 and 232.

San Bernardino County Flood Control District, January 19, 2005, color aerial photograph nos. 17-24, -25 and -26.

United States Department of Agriculture, July 9, 1938, black and white aerial photograph nos. AXL-63-72, -73, -74, -75 and -76.

APPENDIX "A"

GEOLOGIC MAPS



SCALE: 1" = 1000'

GEOLOGIC UNITS:

Qw	Modern wash deposits (late Holocene)—Unconsolidated coarse-grained sand to bouldery alluvium of active channels and washes flooring drainage bottoms within mountains and on alluvial-fans along base of mountains. Most alluvium is, or recently was, subject to active stream flow. Includes some low-lying terrace deposits along alluviated canyon floors and areas underlain by colluvium along base of some slopes
Qf$_1$	Modern alluvial-fan deposits, Unit 1—Unconsolidated deposits of coarse grained sand to bouldery alluvium of modern fans having undissected surfaces; commonly distinguished by terrace level
Qyf$_5$	Young alluvial-fan deposits, Unit 5 (Holocene)—alluvial-fan deposits having slightly dissected surfaces and stage S7 soils. Slightly younger than Qyf4 based on geomorphic relations.
Qyf$_4$	Young alluvial-fan deposits, Unit 4 (Holocene)—alluvial-fan deposits having slightly dissected surfaces and stage S7 soils
Qya$_4$	Young alluvial-valley deposits, Unit 4 (Holocene)—Low terraces of gravelly sand
Qof$_2$	Old alluvial-fan deposits, Unit 2 (late Pleistocene)—alluvial-fan deposits having well-dissected surfaces and stage S4 to stage S3 soils
Qvof	Very old alluvial-fan deposits, unit 2—alluvial-fan deposits having extremely dissected surfaces and stage S2 soils
Tc	Conglomerate (Pliocene and Miocene)—Moderately indurated, gray, massive to moderately well bedded, non-marine boulder conglomerate.
Pm	Granulitic gneiss, mylonite, and cataclasite (Proterozoic?)—Prograde granulitic gneiss that is largely retrograded to amphibolite and greenschist grade mylonite and cataclasite. Granulitic gneiss includes quartz-feldspar gneiss, garnet quartz- feldspar gneiss, amphibolite, garnet-pyroxene rich rocks, and spinel pyroxene rich rocks.

——— – – –	Geologic Contact - dashed where inferred
━━━ ━ ━ ━ ·····	High angle fault - Solid where accurately located; dashed where approximately located; dotted where concealed; queried where inferred.
▲▲▲ ▲ ▲?▲	Thrust fault - Solid where accurately located; dashed where approximately located; dotted where concealed; queried where inferred. Sawteeth on upper plate. Hachures indicate scarp; hachured on down-dropped block. Arrow and number indicates direction and dip of fault surface.

(Base Map: Morton, D.M. and Matti, J.C., 2001)

GEOLOGIC INDEX MAP

FOR:
CAPROCK PARTNERS

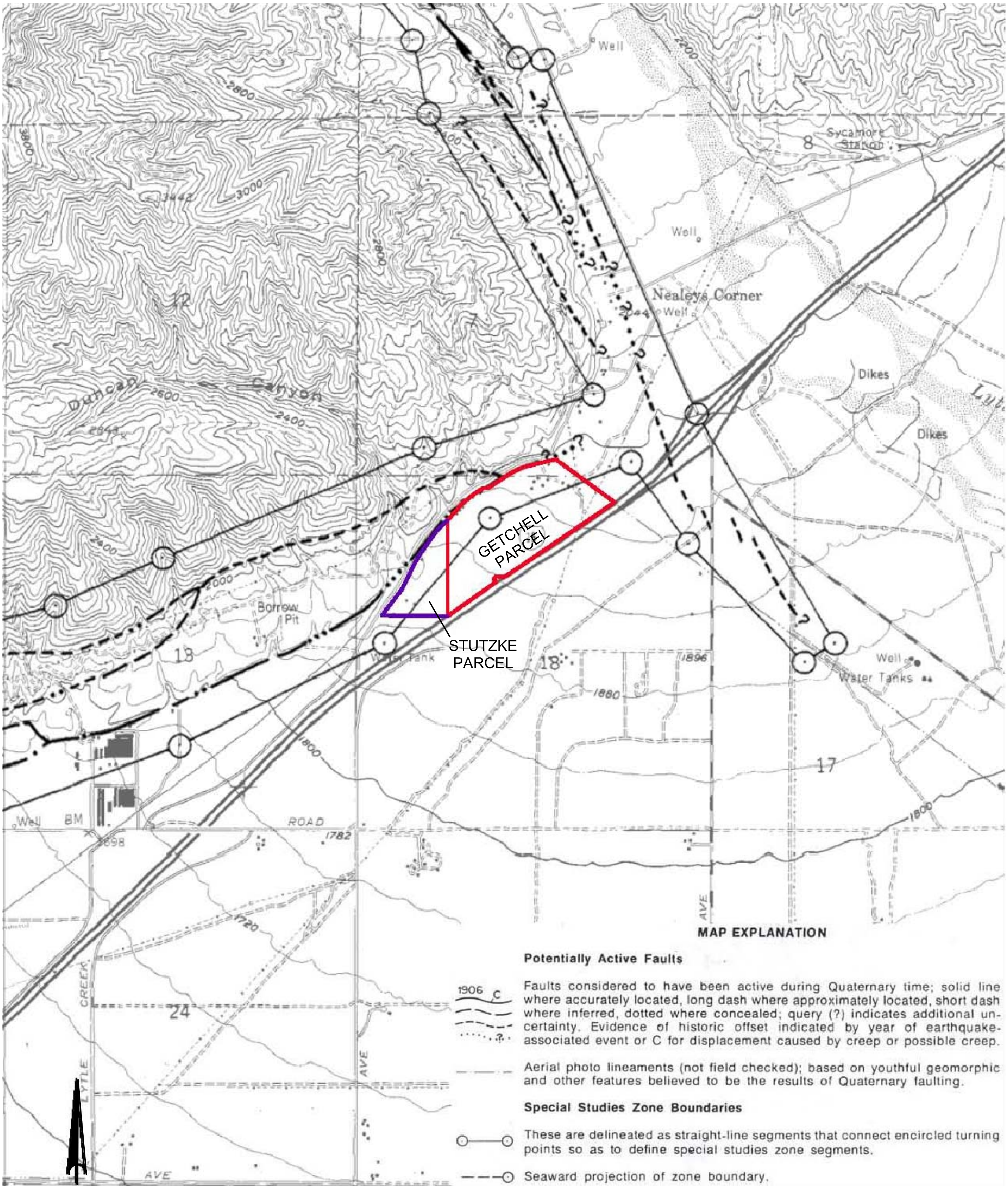
DATE:
MAY 2014

FAULT RUPTURE HAZARD INVESTIGATION
PROPOSED 1-15 LOGISTICS CENTER
LYTLE CREEK ROAD, FONTANA AREA
SAN BERNARDINO COUNTY, CALIFORNIA

ENCLOSURE
"A-1"

JOB NUMBER
14176-8

CHJ Consultants



MAP EXPLANATION

Potentially Active Faults

Faults considered to have been active during Quaternary time; solid line where accurately located, long dash where approximately located, short dash where inferred, dotted where concealed; query (?) indicates additional uncertainty. Evidence of historic offset indicated by year of earthquake-associated event or C for displacement caused by creep or possible creep.

Aerial photo lineaments (not field checked); based on youthful geomorphic and other features believed to be the results of Quaternary faulting.

Special Studies Zone Boundaries

These are delineated as straight-line segments that connect encircled turning points so as to define special studies zone segments.

Seaward projection of zone boundary.

–N–

SCALE: 1" = 2000'

FAULT RUPTURE HAZARD ZONES MAP

FOR:
CAPROCK PARTNERS

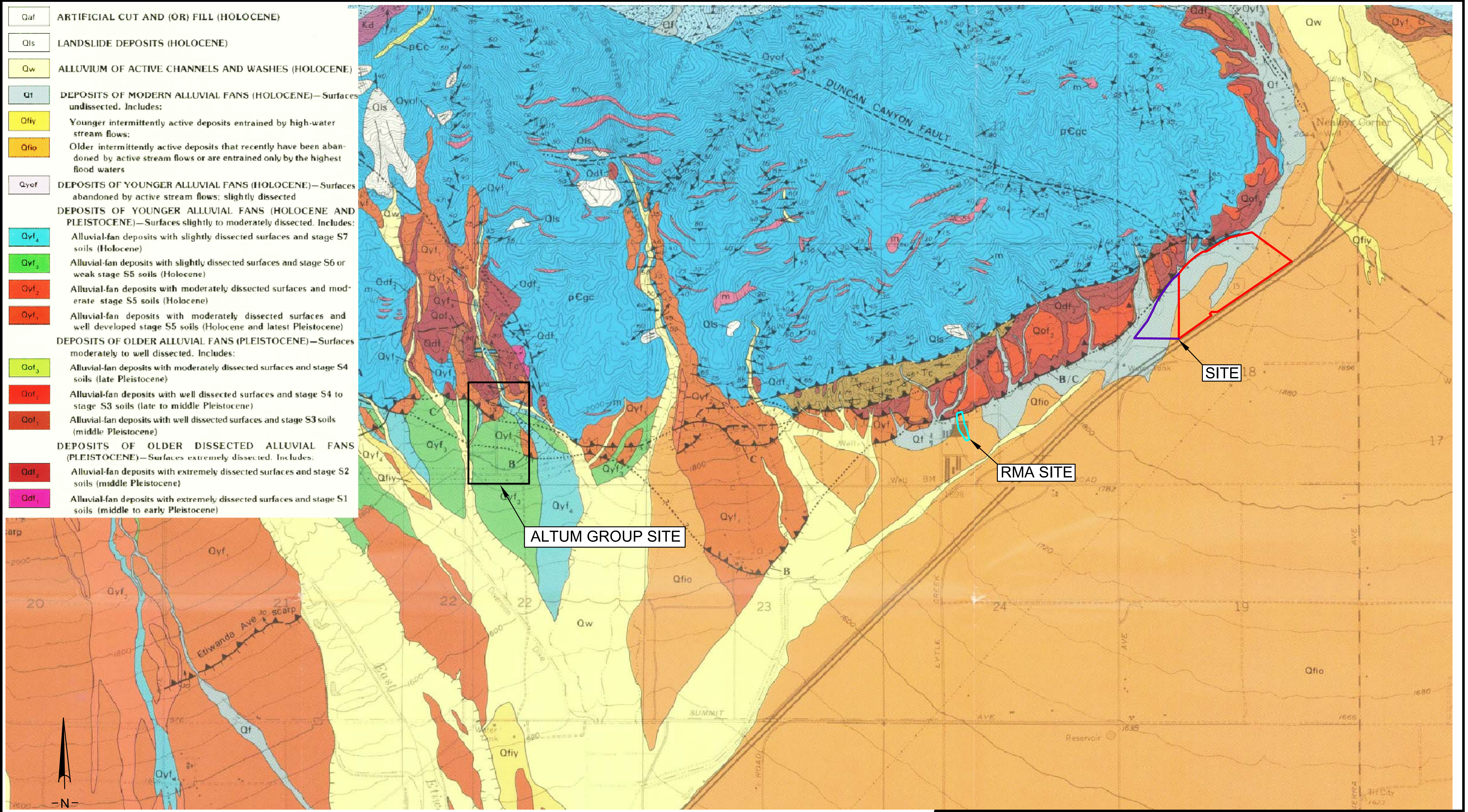
DATE:
MAY 2014

FAULT RUPTURE HAZARD INVESTIGATION
PROPOSED I-15 LOGISTICS CENTER
LYTLE CREEK ROAD, FONTANA AREA
SAN BERNARDINO COUNTY, CALIFORNIA

ENCLOSURE
"A-2"

JOB NUMBER
14176-8

CHJ Consultants



Qaf	ARTIFICIAL CUT AND (OR) FILL (HOLOCENE)
Qls	LANDSLIDE DEPOSITS (HOLOCENE)
Qw	ALLUVIUM OF ACTIVE CHANNELS AND WASHES (HOLOCENE)
Qf	DEPOSITS OF MODERN ALLUVIAL FANS (HOLOCENE)—Surfaces undissected. Includes:
$Qfiy$	Younger intermittently active deposits entrained by high-water stream flows;
$Qfio$	Older intermittently active deposits that recently have been abandoned by active stream flows or are entrained only by the highest flood waters
$Qyof$	DEPOSITS OF YOUNGER ALLUVIAL FANS (HOLOCENE)—Surfaces abandoned by active stream flows; slightly dissected
	DEPOSITS OF YOUNGER ALLUVIAL FANS (HOLOCENE AND PLEISTOCENE)—Surfaces slightly to moderately dissected. Includes:
Qyf_4	Alluvial-fan deposits with slightly dissected surfaces and stage S7 soils (Holocene)
Qyf_3	Alluvial-fan deposits with slightly dissected surfaces and stage S6 or weak stage S5 soils (Holocene)
Qyf_2	Alluvial-fan deposits with moderately dissected surfaces and moderate stage S5 soils (Holocene)
Qyf_1	Alluvial-fan deposits with moderately dissected surfaces and well developed stage S5 soils (Holocene and latest Pleistocene)
	DEPOSITS OF OLDER ALLUVIAL FANS (PLEISTOCENE)—Surfaces moderately to well dissected. Includes:
Qof_3	Alluvial-fan deposits with moderately dissected surfaces and stage S4 soils (late Pleistocene)
Qof_2	Alluvial-fan deposits with well dissected surfaces and stage S4 to stage S3 soils (late to middle Pleistocene)
Qof_1	Alluvial-fan deposits with well dissected surfaces and stage S3 soils (middle Pleistocene)
	DEPOSITS OF OLDER DISSECTED ALLUVIAL FANS (PLEISTOCENE)—Surfaces extremely dissected. Includes:
Qdf_2	Alluvial-fan deposits with extremely dissected surfaces and stage S2 soils (middle Pleistocene)
Qdf_1	Alluvial-fan deposits with extremely dissected surfaces and stage S1 soils (middle to early Pleistocene)

SCALE: 1" = 2000'

Morton, D.M. and Matti, J.C., 1987, The Cucamonga Fault Zone: Geologic Setting and Quaternary History *in* Recent Reverse Faulting in the Transverse Ranges, California, U.S. Geological Survey Professional Paper 1339.

PRIOR INVESTIGATIONS MAP

FOR:
CAPROCK PARTNERS

DATE:
MAY 2014

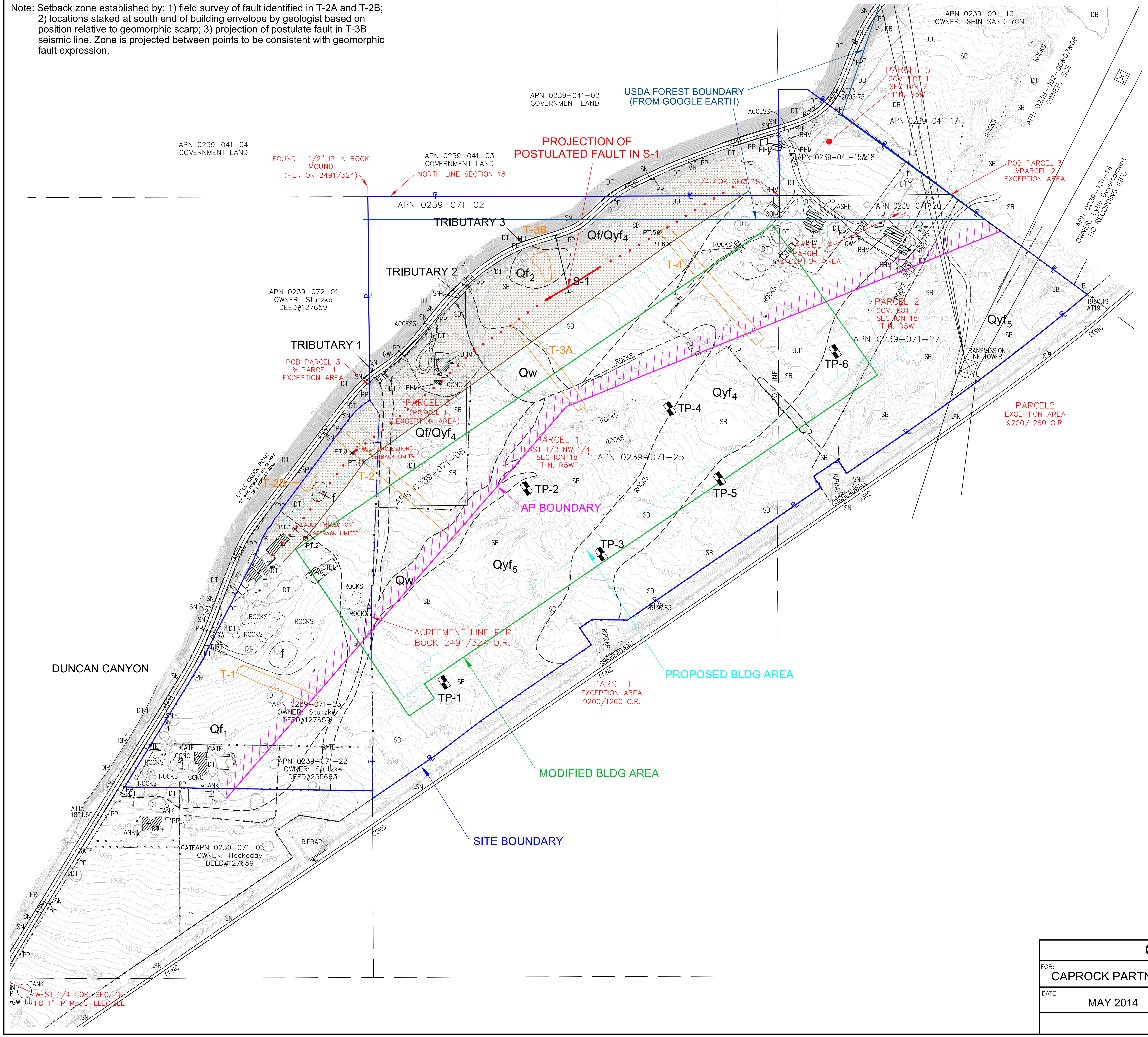
FAULT RUPTURE HAZARD INVESTIGATION
PROPOSED 1-15 LOGISTICS CENTER
LYTLE CREEK ROAD, FONTANA AREA
SAN BERNARDINO COUNTY, CALIFORNIA

ENCLOSURE
"A-3"

JOB NUMBER
14176-8

CHJ Consultants

Note: Setback zone established by: 1) field survey of fault identified in T-2A and T-2B; 2) locations staked at south end of building envelope by geologist based on position relative to geomorphic scarp; 3) projection of postulate fault in T-3B seismic line. Zone is projected between points to be consistent with geomorphic fault expression.



GEOLOGIC UNITS:

f - fill

Qw - recent wash deposits

Qf_1 - sediments of alluvial fan emanating from Duncan Canyon deposited prior to levee construction

Qf_2 - sediments of small alluvial fan sourced in unnamed canyon

Qyf_5 - young alluvial-fan sediments sourced from Lytle Creek. Slightly younger than Qyf_4.

Qyf_4 - young alluvial-fan sediments sourced from Lytle Creek. May include sediments sourced from small tributary canyons emerging along range front.

Geologic Contact

T-4 Exploratory Trench

TP-6 Test Pit Excavation

Postulated surface projection of Cucamonga fault, dotted where concealed or inferred

Building setback zone

SETBACK CONTROL POINTS:

Point	Northing	Easting	Elevation	Reference
1	4658.0530	1941.6942		Proj. fault S of T2B
2	4626.1626	1978.6979		setback – 50' from Pt. 1
3	4917.5792	2137.7482	1929.60	Proj. fault in T2A
4	4887.8846	2177.7016	1929.79	setback - 50' from Pt. 3
5	5670.4712	3185.1673	1964.97	trench T-4 end
6	50-feet SE of Pt. 5 on bearing 140 degrees			eastern setback point

NOTE: Points 2, 4 and 6 to be connected by straight line segments

Survey by SiteTech Inc., 38248 Potato Canyon Road, Oak Glen, California

N

SCALE: 1" = 150'

0 150 300

GEOLOGIC MAP AND SITE PLAN

FOR:
CAPROCK PARTNERS

DATE:
MAY 2014

FAULT RUPTURE HAZARD INVESTIGATION
PROPOSED I-15 LOGISTICS CENTER
LYTLE CREEK ROAD, FONTANA AREA
SAN BERNARDINO COUNTY, CALIFORNIA

ENCLOSURE
"A-4"

JOB NUMBER
14176-8

CHJ Consultants

APPENDIX "B"

TRENCH LOGS

LITHOLOGIC DESCRIPTION TRENCH 2A:

① **GRAVELLY SAND**: Brown to Yellowish Brown (10YR 5/3 to 5/4), fine- to coarse-grained with abundant cobbles and boulders, massive to crudely stratified, moist, non cohesive, loose, clasts are predominantly rounded to sub-angular (<5% of clasts show grussification), very light and discontinuous coatings along underside of clasts.

② **SILTY SAND**: Yellowish Brown (10YR 5/4), fine- to medium-grained, massive, slightly moist to dry, locally porous, few gravel, very weak pedogenic development.

③ **SILTY SAND**: Strong Brown (7.5Y 4/6 to 5/6), fine- to medium-grained with minor coarse and gravel, massive structure, moderately well indurated, slightly cohesive, clasts are angular to sub-angular, pinches out at Stn. 58 against units 5 and 6.

④ **SILTY SAND**: Brown to Dark Brown (10YR 4/3 to 3/3), fine- to coarse-grained, scattered gravel, loose, moist, slightly cohesive, generally massive structure, occasional rounded sand/gravel lenses, slightly porous, organics present, rooting zone in upper 8 to 12".

⑤ **SILTY SAND**: Yellowish Brown (10YR 5/4), fine- to medium-grained, massive, slight pedogenic appearance, scoured by unit 6 at top, pinch out at Stn. 60.

⑥ **GRAVELLY SILTY SAND**: Light Olive Brown (2.5YR 5/4), fine- to coarse-grained, angular gravel, massive to very poorly bedded, rare cobbles, grades upward into unit 4..

⑦ **GRAVELLY SILTY SAND**: Light Yellowish Brown (10YR 6/4) fine- to coarse-grained matrix with cobbles and gravel, massive to weakly bedded near top, [interpreted as debris flow sediments.

⑧ **GRAVELLY SILTY SAND**: Grayish Brown (10YR 5/2), fine- to coarse-grained, thinly stratified with planar bedding, forms relatively thin discontinuous lenses, dry, loose, non cohesive.

⑨ **COBBLY SILTY SAND**: Olive Brown (2.5Y 4/3), fine- to coarse-grained (with boulders to 15%), slightly moist, non cohesive, slightly stratified (discontinuous bedding), clasts are rounded to sub-angular and have very little to no coatings on underside of clasts.

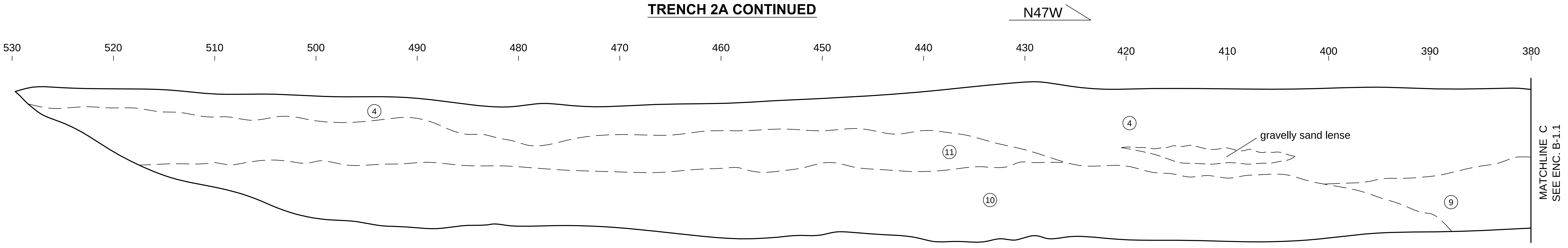
⑩ **COBBLY SILTY SAND**: Light Yellowish Brown to Light Olive Brown (2.5Y 6/4 to 5/4), fine- to coarse-grained, slightly moist, non cohesive, slightly stratified (discontinuous), clasts are sub-rounded to sub-angular, minor clast coatings (very thin and not complete), matrix is slightly cohesive.

⑪ **GRAVELLY SILTY SAND**: Light Olive Brown (2.5Y 5/3), fine- to coarse-grained with minor cobbles (<15%),slightly moist, non cohesive, massive structure, clasts are rounded to sub-rounded (no coatings).

SCALE: 1" = 5'

TRENCH 2A - SOUTH WALL		
FOR: CAPROCK PARTNERS	FAULT RUPTURE HAZARD INVESTIGATION PROPOSED I-15 LOGISTICS CENTER LYTLE CREEK ROAD, FONTANA AREA SAN BERNARDINO COUNTY, CALIFORNIA	ENCLOSURE "B-1.1"
DATE: MAY 2014		JOB NUMBER 14176-8
		CHJ Consultants

TRENCH 2A CONTINUED



LITHOLOGIC DESCRIPTION TRENCH 2A:

① **GRAVELLY SAND**: Brown to Yellowish Brown (10YR 5/3 to 5/4), fine- to coarse-grained with abundant cobbles and boulders, massive to crudely stratified, moist, non cohesive, loose, clasts are predominantly rounded to sub-angular (<5% of clasts show grussification), very light and discontinuous coatings along underside of clasts.

② **SILTY SAND**: Yellowish Brown (10YR 5/4), fine- to medium-grained, massive, slightly moist to dry, locally porous, few gravel, very weak pedogenic development.

③ **SILTY SAND**: Strong Brown (7.5Y 4/6 to 5/6), fine- to medium-grained with minor coarse and gravel, massive structure, moderately well indurated, slightly cohesive, clasts are angular to sub-angular, pinches out at Stn. 58 against units 5 and 6.

④ **SILTY SAND**: Brown to Dark Brown (10YR 4/3 to 3/3), fine- to coarse-grained, scattered gravel, loose, moist, slightly cohesive, generally massive structure, occasional rounded sand/gravel lenses, slightly porous, organics present, rooting zone in upper 8 to 12".

⑤ **SILTY SAND**: Yellowish Brown (10YR 5/4), fine- to medium-grained, massive, slight pedogenic appearance, scoured by unit 6 at top, pinch out at Stn. 60.

⑥ **GRAVELLY SILTY SAND**: Light Olive Brown (2.5YR 5/4), fine- to coarse-grained, angular gravel, massive to very poorly bedded, rare cobbles, grades upward into unit 4..

⑦ **GRAVELLY SILTY SAND**: Light Yellowish Brown (10YR 6/4) fine- to coarse-grained matrix with cobbles and gravel, massive to weakly bedded near top, [interpreted as debris flow sediments.

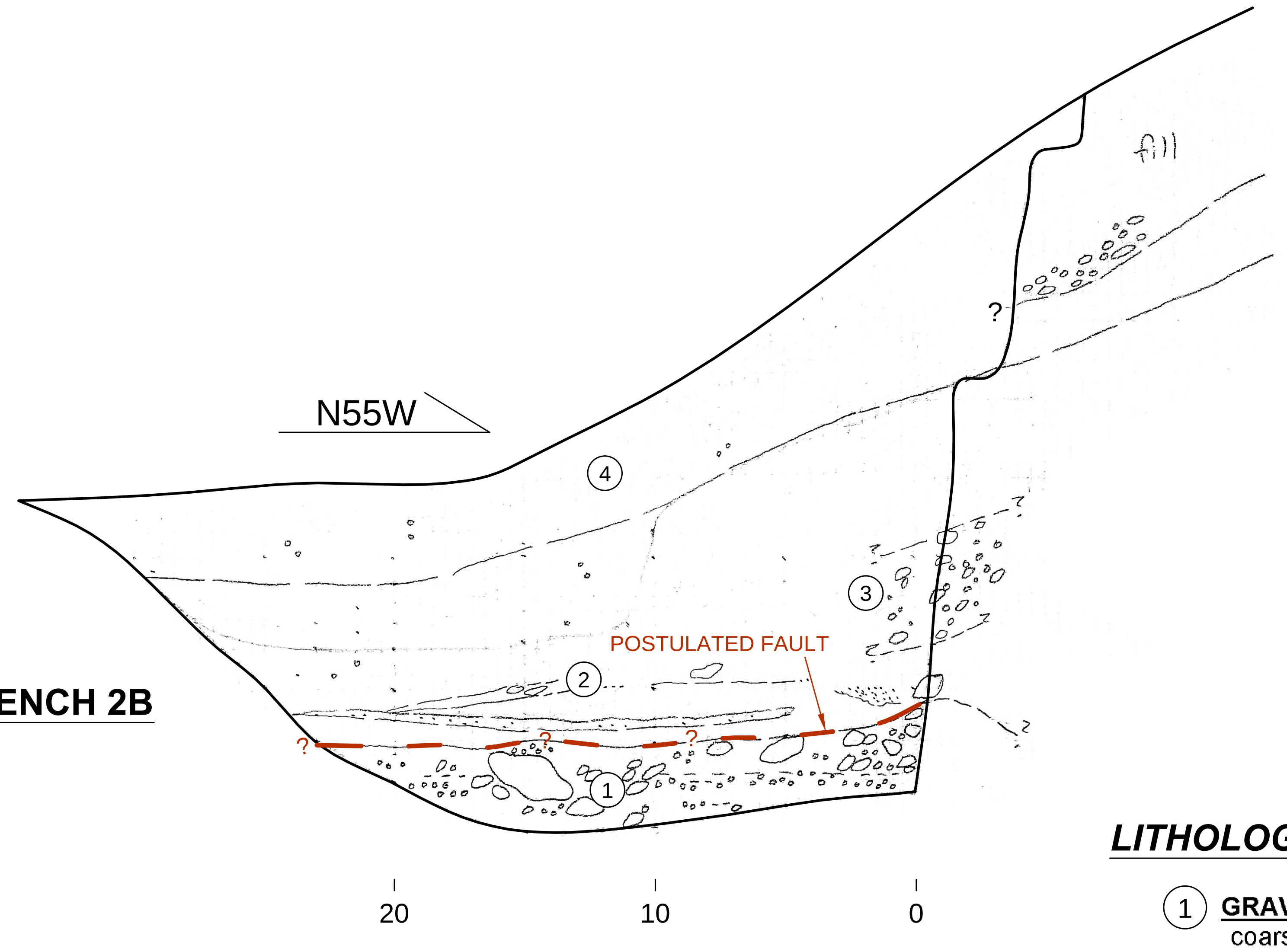
⑧ **GRAVELLY SILTY SAND**: Grayish Brown (10YR 5/2), fine- to coarse-grained, thinly stratified with planar bedding, forms relatively thin discontinuous lenses, dry, loose, non cohesive.

⑨ **COBBLY SILTY SAND**: Olive Brown (2.5Y 4/3), fine- to coarse-grained (with boulders to 15%), slightly moist, non cohesive, slightly stratified (discontinuous bedding), clasts are rounded to sub-angular and have very little to no coatings on underside of clasts.

⑩ **COBBLY SILTY SAND**: Light Yellowish Brown to Light Olive Brown (2.5Y 6/4 to 5/4), fine- to coarse-grained, slightly moist, non cohesive, slightly stratified (discontinuous), clasts are sub-rounded to sub-angular, minor clast coatings (very thin and not complete), matrix is slightly cohesive.

⑪ **GRAVELLY SILTY SAND**: Light Olive Brown (2.5Y 5/3), fine- to coarse-grained with minor cobbles (<15%),slightly moist, non cohesive, massive structure, clasts are rounded to sub-rounded (no coatings).

TRENCH 2B



LITHOLOGIC DESCRIPTION TRENCH 2B:

① **GRAVELLY SILTY SAND**: Grayish Brown to yellowish brown (10YR 5/2 to 5/4), fine- to coarse-grained, massive where clast-supported to stratified and bedded, cobbles forming crude bedding, few rounded boulders to 24" in size, non cohesive, clasts are rounded to sub-angular, some tablate, durable felsic lithologies dominate, mafic clasts slightly to moderately weathered, discontinuous clay films (alluvium of Lytle Creek fan). Truncated and mantled by Unit 2. Fourteen-inch boulder of Unit 1 type within base of Unit 2 suggests clast plucked from Unit 1 and dragged into Unit 2 above fault plane at Stn. 0.

② **SILTY SAND**: Dark Brown (7.5YR 3/3 to 3/2), moist, fine-grained, massive, dense/cohesive, locally porous, includes clasts of Unit 1 at base, includes internal beds of angular pebbly sand-small gravel and localized internal scour contacts.

③ **SILTY SAND**: Yellowish brown (10YR 5/4) fine- to medium-grained, with angular cobbles and gravel, dense to moderately dense, massive, expose in western portion of trench. Not observed east of Stn. 5 suggesting colluvial origin OR bed within older alluvial fan sediments.

④ **SILTY SAND**: Brown to Dark Brown (10YR 4/3) fine- to medium-grained, scattered gravel ½" to 2" in size, moist, loose to moderately dense, massive, discontinuous lenses of pebbly/gravelly sand scour; gritty films on clasts, upper portion is A horizon and rooting zone, lower contact is gradational with Unit 2.

SCALE: 1" = 5'

TRENCHES 2A AND 2B - SOUTH WALL

FOR:
CAPROCK PARTNERS

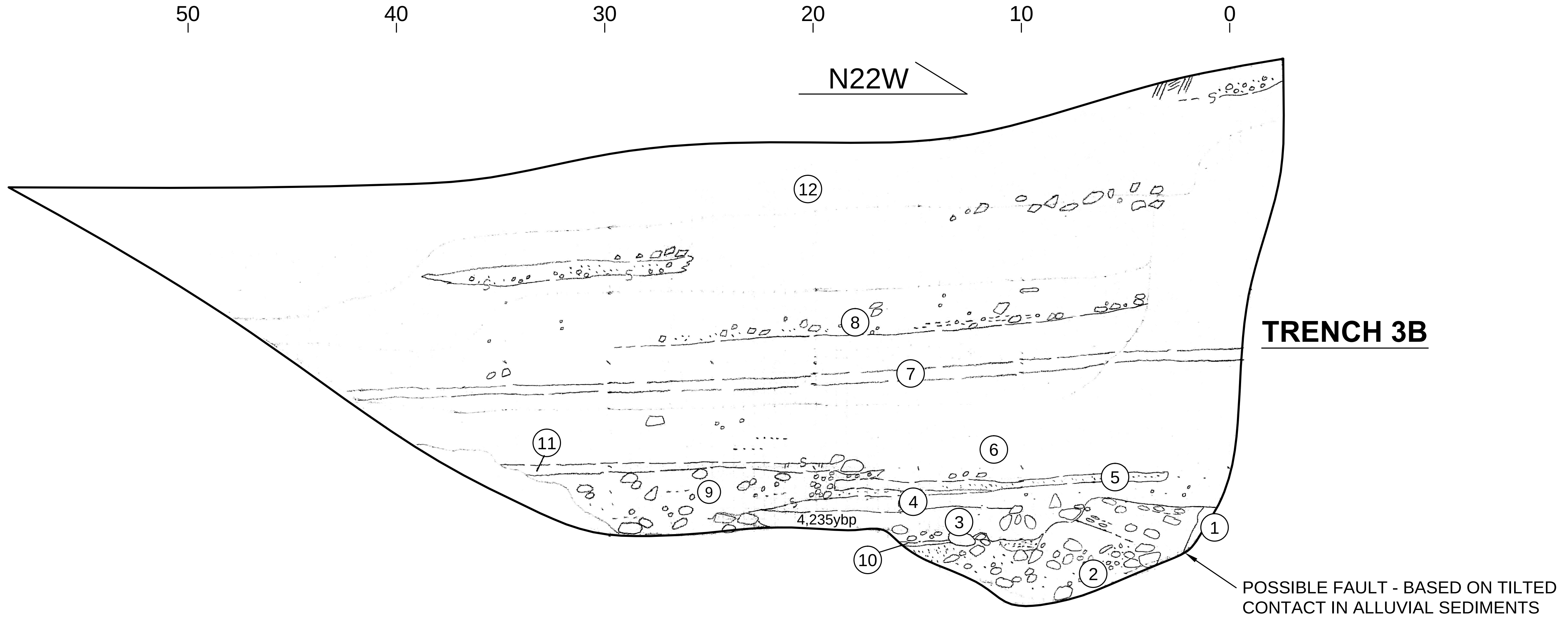
DATE:
MAY 2014

FAULT RUPTURE HAZARD INVESTIGATION
PROPOSED I-15 LOGISTICS CENTER
LYTLE CREEK ROAD, FONTANA AREA
SAN BERNARDINO COUNTY, CALIFORNIA

ENCLOSURE
"B-1.2"

JOB NUMBER
14176-8

CHJ Consultants



LITHOLOGIC DESCRIPTION TRENCH 3A:

① **GRAVELLY SILTY SAND**: Grayish Brown to yellowish brown (10YR 5/2 to 5/4), fine- to coarse-grained, massive where clast-supported to stratified and bedded, cobbles forming crude bedding, few rounded boulders to 20" in size, non cohesive, clasts are rounded to sub-angular, some tablate, durable felsic lithologies dominate, mafic clasts slightly to moderately weathered, discontinuous clay films (alluvium of Lytle Creek fan).

② **SILTY SAND**: Dark Brown (7.5YR 3/3 to 3/2), moist, fine-grained, massive, dense/cohesive, locally porous, includes clasts of Unit 1 at base, argillic horizon developed at top and locally scoured by Unit 3.

③ **SILTY SAND**: Dark grayish brown (10YR 4/2) fine- to medium-grained, scattered gravel ½" to 2" in size, moist, loose to moderately dense, massive, locally porous, discontinuous lenses of pebbly/gravelly sand; upper portion is A horizon and rooting zone, lower contact is gradational with Unit 2.

④ **CLAY BED:** ½" thick, very dark gray (2.5Y 3/2), plastic, occurs within fine-grained sand lense, overlies A horizon (interpreted as ash layer from 2005 burn event deposited with runoff from heavy precipitation during Dec. 2005/Jan. 2006.

⑤ **SILTY SAND**: Dark grayish brown (10YR 4/2) fine- to medium-grained, scattered gravel ½" to 2" in size forming stone lines, moist, loose to moderately dense, massive, discontinuous lenses of pebbly/gravelly sand scour; upper portion is A horizon and rooting zone, lower contact is gradational with Unit 2.

⑥ **GRAVELLY SILTY SAND**: Grayish Brown (2.5Y 5/2), fine- to coarse-grained, massive where clast-supported to stratified and bedded, cobbles forming crude bedding, few rounded boulders to 18" in size, non cohesive, clasts are rounded to sub-angular, some tablate, durable felsic lithologies dominate, mafic clasts slightly to moderately weathered, discontinuous clay films (alluvium of Lytle Creek fan).

LITHOLOGIC DESCRIPTION TRENCH 3B:

① **GNEISSIC BEDROCK**: Gray to Dark Bluish Gray, fine-grained, slightly weathered, foliated, oxide coatings along joints, rounding on undisturbed faces.

② **GRAVELLY SILTY SAND**: Grayish Brown (10YR 5/2), fine- to coarse-grained, slightly stratified and bedded, cobbles forming crude bedding, non cohesive, clasts are rounded to sub-angular, some tablate. (alluvium of Lytle Creek fan).

③ **SILTY SANDY CLAY**: Strong Brown (7.5Y 4/6), fine-grained, stratified, dense/cohesive, moist, contains charcoal, pores. Mantles Unit 2.

④ **SILTY SAND**: Brown to Dark Brown (10YR 4/3 to 3/3), fine- to medium-grained, dense, moist, slightly cemented, massive, locally porous.

⑤ **SILTY SAND:** fine- to coarse-grained, angular, pebble bed, strong brown (7.5Y 4/6).

⑥ **SILTY SAND:** fine- to coarse-grained, angular sand, rounded to angular gravel, dark yellowish brown (10YR 4/4), massive, slightly cemented.

⑦ **CLAYEY SAND:** Strong Brown (7.5YR 5/6) fine- to coarse-grained, angular sand and small gravel, sharp contact with Unit 6, forms 3" to 4" bed.

⑧ **SILTY SAND:** fine- to medium-grained, massive, scattered angular cobbles, brown (10YR 5/3), massive, slightly cemented. Upper contact grades into modern soil horizon.

⑨ **GRAVELLY SILTY SAND**: Grayish Brown (10YR 5/2), fine- to coarse-grained, slightly stratified and bedded, cobbles forming crude bedding, non cohesive, clasts are rounded to sub-angular, some tablate. (alluvium of Lytle Creek fan).

⑩ **SILTY SAND**: Dark Brown (7.5YR 4/4) fine-grained, 2" thick layer at top of SAND unit within Unit 1.

⑪ **SILTY SAND**: Light Olive Brown (2.5Y 5/4–5/6), fine-grained, massive, 3" thick layer with incipient columnar pedogenic fabric, scoured top at Stn. 20.

⑫ **SILTY SAND:** Dark grayish brown (10YR 4/2) fine- to medium-grained, scattered gravel ½" to 2" in size forming stone lines, moist, loose to moderately dense, massive, discontinuous lenses of pebbly/gravelly sand scour; upper portion is A horizon and rooting zone, lower contact is gradational with older soils.

SCALE: 1" = 5'

TRENCHES 3A AND 3B - SOUTH WALL

FOR:
CAPROCK PARTNERS

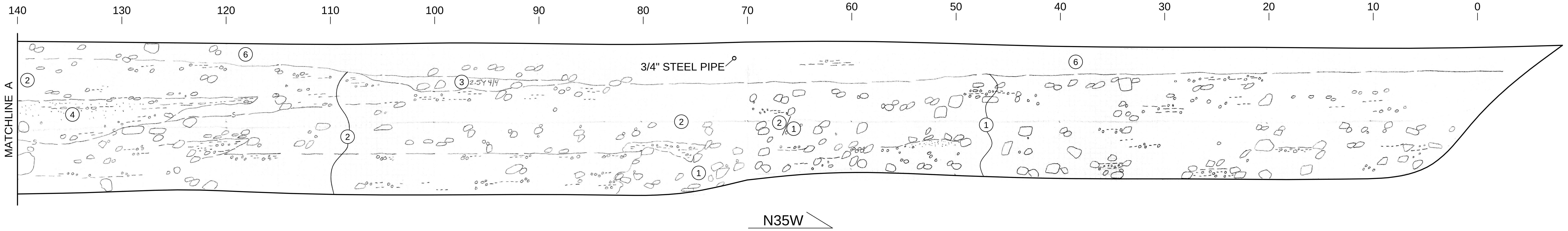
DATE:
MAY 2014

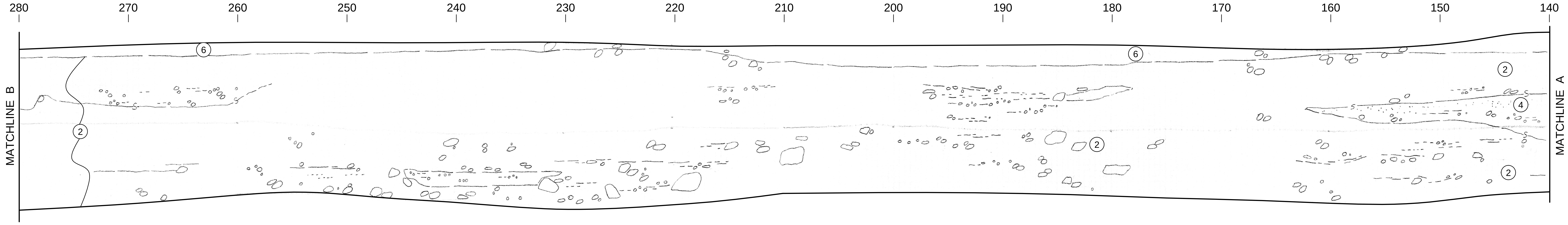
FAULT RUPTURE HAZARD INVESTIGATION
PROPOSED I-15 LOGISTICS CENTER
LYTLE CREEK ROAD, FONTANA AREA
SAN BERNARDINO COUNTY, CALIFORNIA

ENCLOSURE
"B-2"

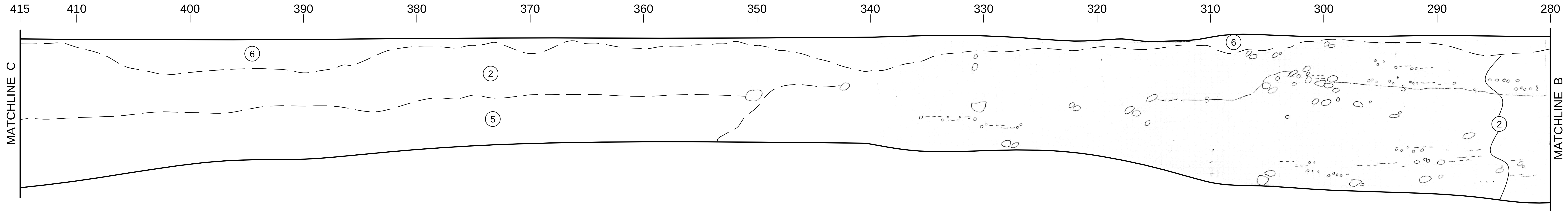
JOB NUMBER
14176-8

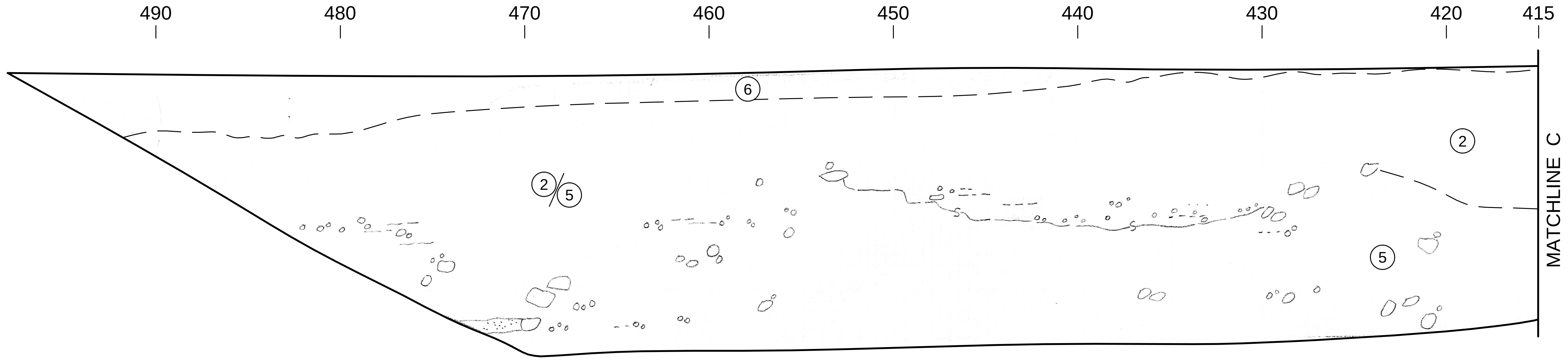
CHJ Consultants





TRENCH 4





LITHOLOGIC DESCRIPTION TRENCH 4:

① **GRAVELLY SILTY SAND**: dark yellowish brown (10YR 4/4), fine- to coarse-grained matrix, massive where clast-supported to stratified and bedded, cobbles forming crude bedding, slightly cohesive, clasts are rounded to sub-angular, durable felsic lithologies and mafic clasts moderately weathered, clay films (alluvium of local fan?).

② **GRAVELLY SILTY SAND**: Grayish Brown (10YR 5/2), fine- to coarse-grained, slightly stratified and bedded, cobbles forming crude bedding, non cohesive, clasts are rounded to sub-angular, some tablate. (alluvium of Lytle Creek fan).

③ **SILTY GRAVELLY SAND**: dark yellowish brown (10YR 4/4), fine- to medium-grained, moist, matrix-supported cobbles, random fabric, locally with open-stacked gravels at flow channel bases

④ **SAND**: yellowish brown (10YR 5/4),fine-grained, massive, moist, eolian deposit.

⑤ **SILTY GRAVELLY SAND**: dark yellowish brown (10YR 4/4), fine- to medium-grained, moist, matrix-supported cobbles, random fabric, locally with open-stacked gravels at flow channel bases

⑥ **SILTY SAND**: Dark grayish brown (2.5Y 5/2), moist, fine- to medium-grained, massive, forms 'A' horizon soil, overprints clasts of underlying units including cobbles and boulders of alluvial-fan sediments, thicker at west end of trench – onlaps alluvial-fan sediments near Station 120 where Lytle Creek fan deposits climb to surface.

SCALE: 1" = 5'

TRENCH 4

FOR:
CAPROCK PARTNERS

DATE:
MAY 2014

FAULT RUPTURE HAZARD INVESTIGATION
PROPOSED I-15 LOGISTICS CENTER
LYTLE CREEK ROAD, FONTANA AREA
SAN BERNARDINO COUNTY, CALIFORNIA

ENCLOSURE
"B-3"

JOB NUMBER
14176-8

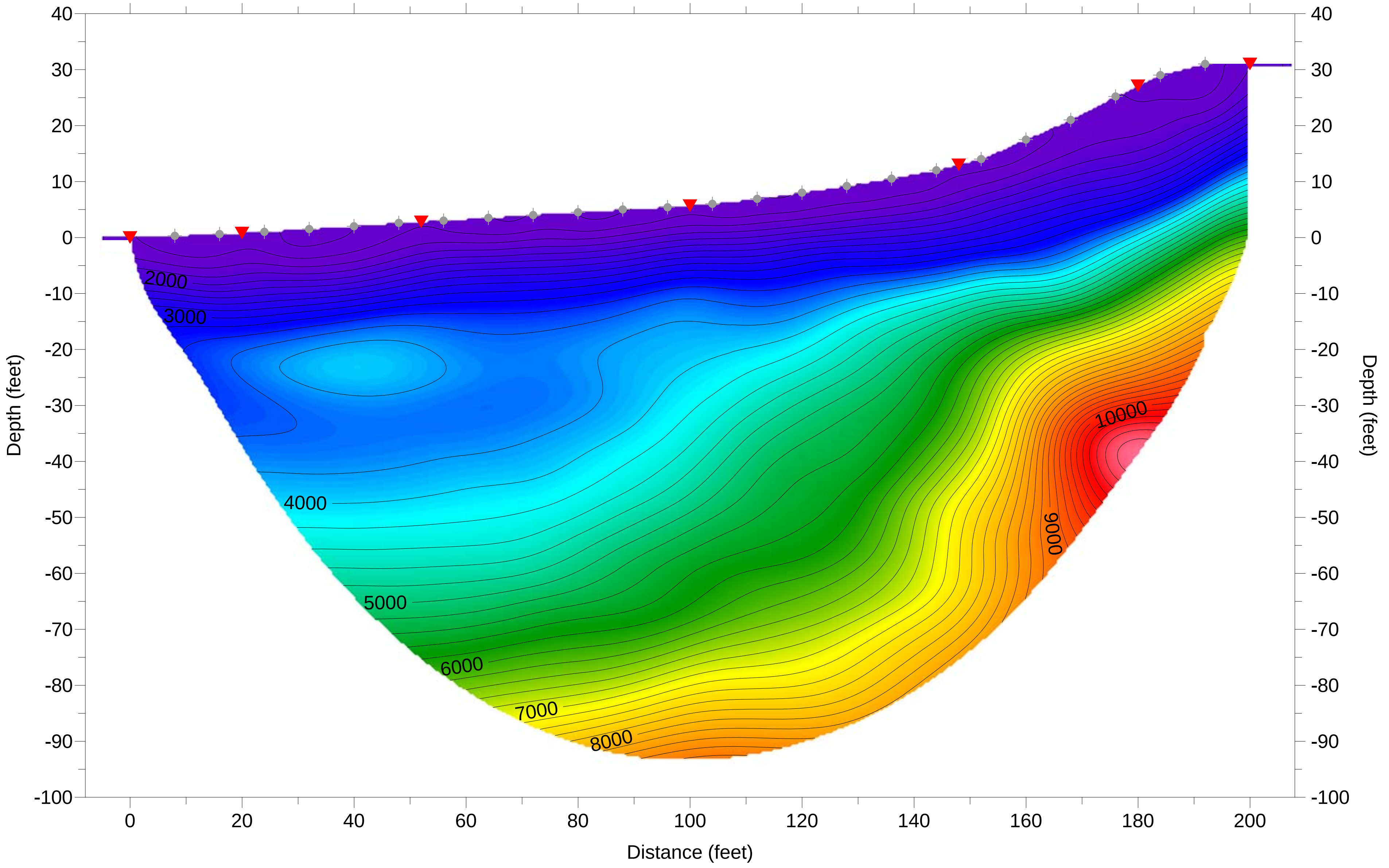
CHJ Consultants

APPENDIX "C"

SEISMIC REFRACTION DATA

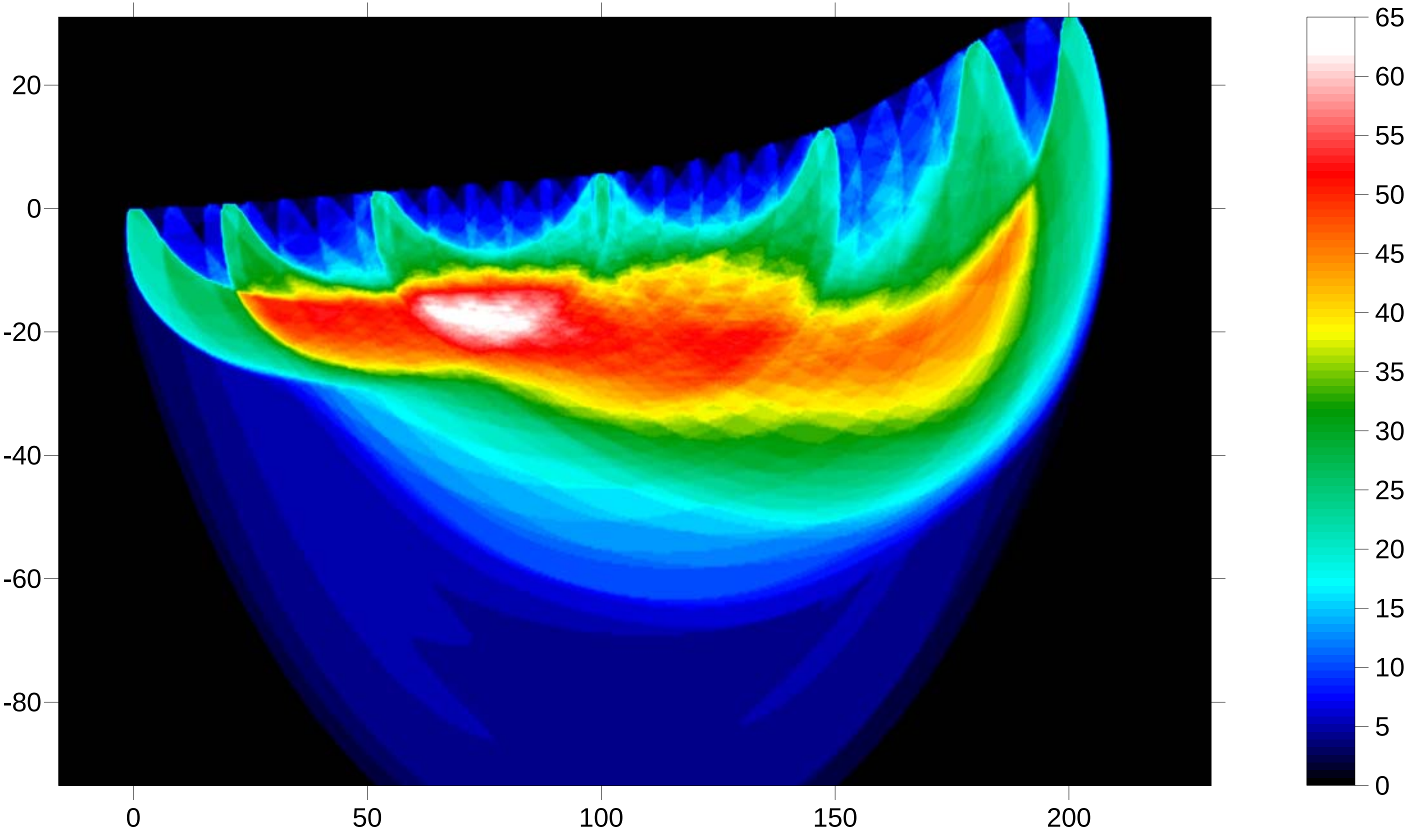
SEISMIC LINE S-1

North 20° West →



Enclosure C-1

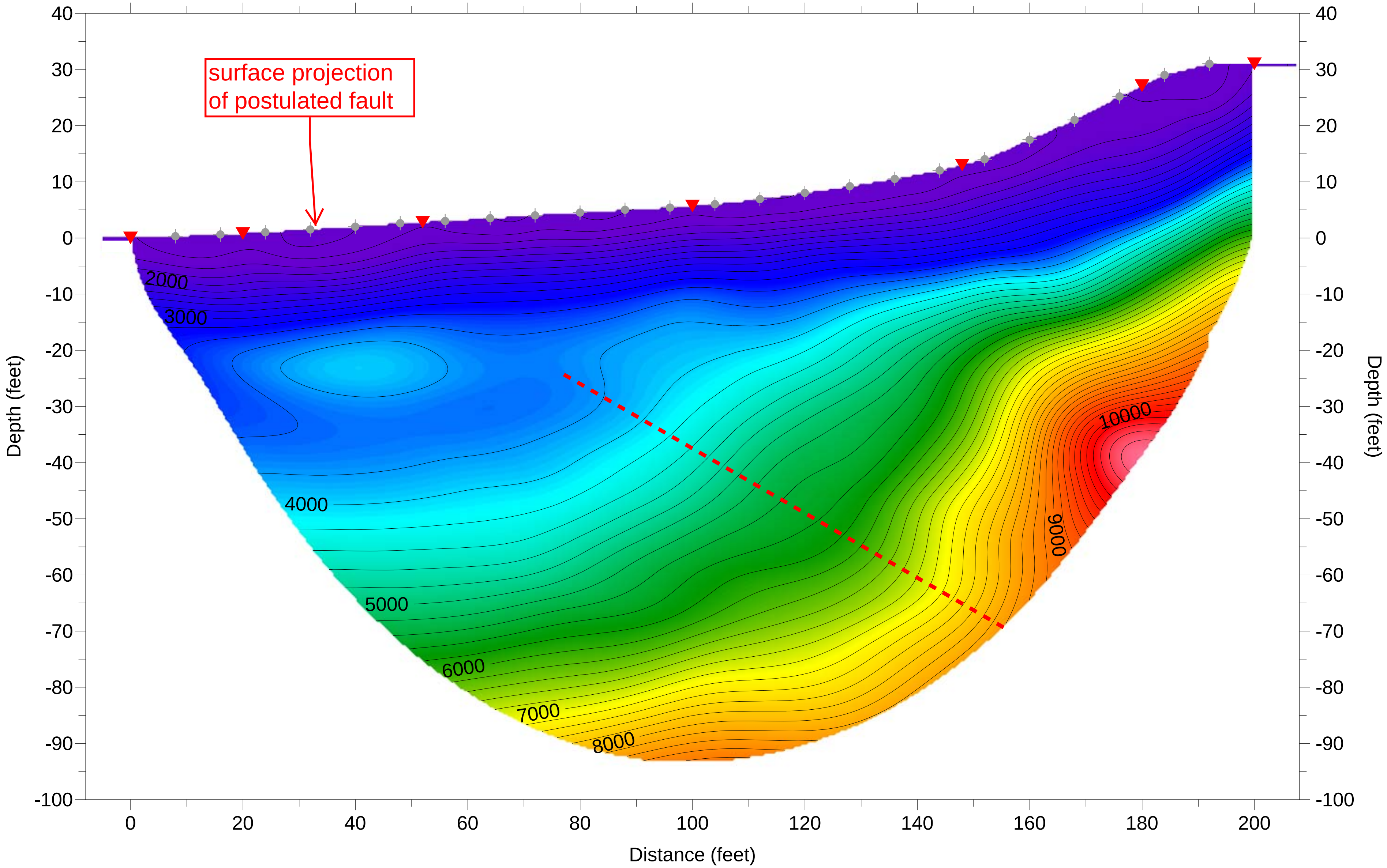
SEISMIC LINE S-1, 20 WET iterations, RMS error 1.0 %, DeltatV initial model artefacts !, Version 3.31



Enclosure C-2

SEISMIC LINE S-1

North 20° West →



Enclosure C-3

APPENDIX "D"

RADIOCARBON DATING REPORT

BETA
Consistent Accuracy . . .
. . . Delivered On-time

Beta Analytic Inc.
4985 SW 74 Court
Miami, Florida 33155 USA
Tel: 305 667 5167
Fax: 305 663 0964
Beta@radiocarbon.com
www.radiocarbon.com

Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

April 15, 2014

Mr. Jay J. Martin
CHJ Consultants, Inc.
1355 E. Cooley Drive, Suite C
Colton, CA 92324
United States

RE: Radiocarbon Dating Result For Sample T3B/001

Dear Mr. Martin:

Enclosed is the radiocarbon dating result for one sample recently sent to us. The report sheet contains the Conventional Radiocarbon Age (BP), the method used, material type, and applied pretreatments, any sample specific comments and, where applicable, the two-sigma calendar calibration range. The Conventional Radiocarbon age has been corrected for total isotopic fractionation effects (natural and laboratory induced).

All results (excluding some inappropriate material types) which fall within the range of available calibration data are calibrated to calendar years (cal BC/AD) and calibrated radiocarbon years (cal BP). Calibration was calculated using the one of the databases associated with the 2013 INTCAL program (cited in the references on the bottom of the calibration graph page provided for each sample.) Multiple probability ranges may appear in some cases, due to short-term variations in the atmospheric ^{14}C contents at certain time periods. Looking closely at the calibration graph provided and where the BP sigma limits intercept the calibration curve will help you understand this phenomenon.

Conventional Radiocarbon Ages and sigmas are rounded to the nearest 10 years per the conventions of the 1977 International Radiocarbon Conference and consistent with all past Beta Analytic radiocarbon dates. When counting statistics produce sigmas lower than +/- 30 years, a conservative +/- 30 BP is cited for the result.

All work on this sample was performed in our laboratories in Miami under strict chain of custody and quality control under ISO-17025 accreditation protocols. Sample, modern and blanks were all analyzed in the same chemistry lines by professional technicians using identical reagents and counting parameters within our own particle accelerators. A quality assurance report is posted to your directory for each result.

As always, your inquiries are most welcome. If you have any questions or would like further details of the analysis, please do not hesitate to contact us.

The cost of the analysis was charged to the American Express card provided. Thank you. As always, if you have any questions or would like to discuss the results, don’t hesitate to contact me.

Sincerely,

Darden Hood
Digital signature on file

BETA ANALYTIC INC.
DR. M.A. TAMERS and MR. D.G. HOOD

4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305-667-5167 FAX:305-663-0964
beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Mr. Jay J. Martin — Report Date: 4/15/2014

CHJ Consultants, Inc. — Material Received: 4/9/2014

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 377878	4320 +/- 30 BP	-23.1 o/oo	4350 +/- 30 BP

SAMPLE : T3B/001
ANALYSIS : AMS-PRIORITY delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 3080 to 3070 (Cal BP 5030 to 5020) and Cal BC 3025 to 2900 (Cal BP 4975 to 4850)

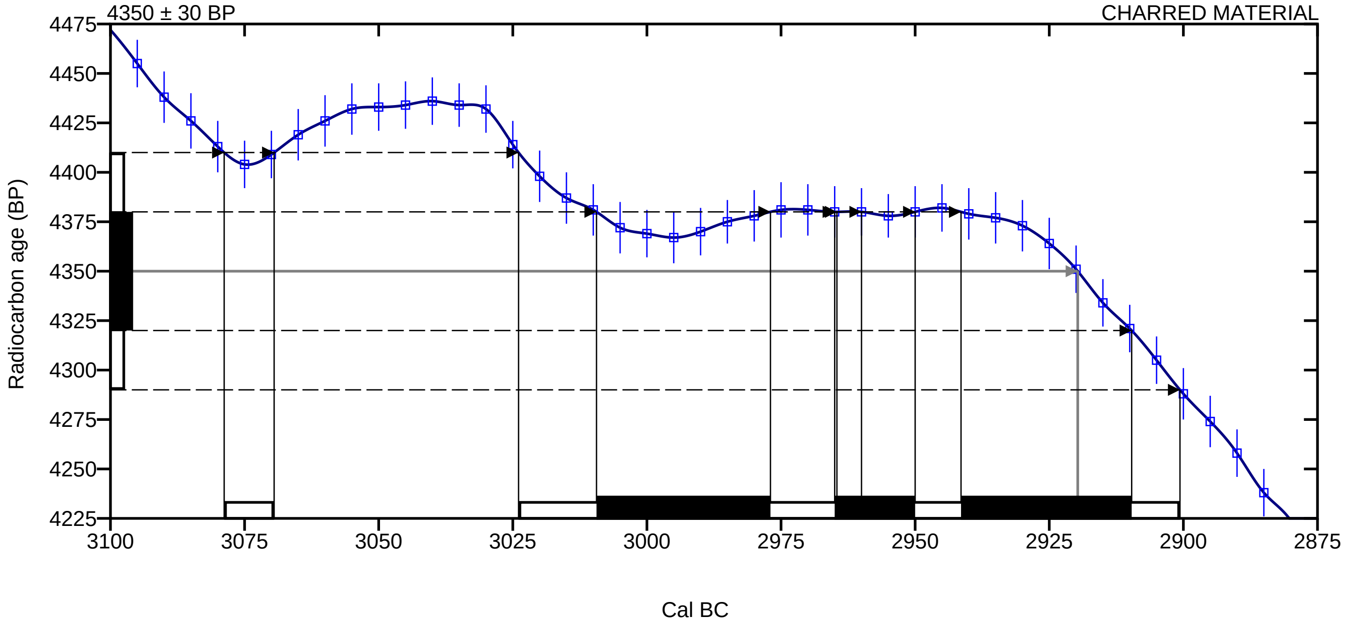
Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12 = -23.1 o/oo : lab. mult = 1)

Laboratory number	**Beta-377878**
Conventional radiocarbon age	**4350 ± 30 BP**
2 Sigma calibrated result **95% probability**	**Cal BC 3080 to 3070 (Cal BP 5030 to 5020)** **Cal BC 3025 to 2900 (Cal BP 4975 to 4850)**
Intercept of radiocarbon age with calibration curve	Cal BC 2920 (Cal BP 4870)
1 Sigma calibrated results 68% probability	Cal BC 3010 to 2975 (Cal BP 4960 to 4925) Cal BC 2965 to 2950 (Cal BP 4915 to 4900) Cal BC 2940 to 2910 (Cal BP 4890 to 4860)



Database used

INTCAL13

References

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates, Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

References to INTCAL13 database

Reimer PJ et al. IntCal13 and Marine13 radiocarbon age calibration curves 0– 50,000 years cal BP. Radiocarbon 55(4):1869– 1887.