LGC Geotechnical, Inc.

March 27, 2020

Project No. 18117-01

Mr. Joe Martin
Trumark Homes
450 Newport Center Drive, Suite 300
Newport Beach, CA 92660

Subject: ***Fault Evaluation for the Proposed "Shady View" Residential Development, Tentative Tract 20317, City of Chino Hills, California***

In accordance with your request, LGC Geotechnical, Inc. has performed a comprehensive fault evaluation for the proposed "Shady View" residential development, Tentative Tract No. 20317, located in the City of Chino Hills, California. This report summarizes the results of our background review, subsurface fault exploration, and geotechnical analyses, and presents our findings, conclusions, and preliminary recommendations with regards to the impact of potential active faulting on the proposed development.

If you should have any questions regarding this report, please do not hesitate to contact our office. We appreciate this opportunity to be of service.

Respectfully,

LGC Geotechnical, Inc.

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KTM/DJB/amm

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1.0 INTRODUCTION

1.1 Purpose and Scope of Services

State of California Earthquake Fault Zones (formerly known as "AP Zones"), established under the Alquist-Priolo Earthquake Fault Zoning Act of 1972, have been delineated along observed traces of active faults within California. The purpose of the Alquist-Priolo Earthquake Fault Zoning Act is to prevent the construction on structures for human occupancy across active fault traces. A *Holocene-Active fault* is a fault that has had surface displacement within Holocene time, approximately the past 11,700 years (CGS, 2018). Where structures for human occupancy are proposed within the delineated Earthquake Fault Zones, the State requires detailed subsurface fault evaluations be performed so that engineering geologists can mitigate hazards associated with active faulting and ground rupture. If a *Holocene-Active fault* is identified within an area of proposed development, then structural setbacks, or other engineering mitigation measures, are recommended by the project geologist. The location and width of the structural setback zones are determined based on the geologic structure and type of active faulting encountered during the detailed fault evaluation and the proposed improvements.

The Earthquake Fault Zone for the Chino Fault overlies the western portion of the proposed residential development and a proposed aboveground bulk crude oil tank pad. The Site Location with Earthquake Fault Zone Map (Figure 1, Page 5), depicts the relative location of the proposed development and the State of California Earthquake Fault Zone, also presented on the Geologic Map (Sheets 1 & 2). The proposed development is generally within the northeast "triangle" of the subject site; this portion of the site is zoned for single-family residential use.

This report presents the results of our fault evaluation for the proposed "Shady View" residential development, located within the parcel locally known as Abacherli Ranch, in the City of Chino Hills, County of San Bernardino, California. The purpose of our work was to review previous fault studies and collect additional fault data in order to evaluate potential location of active faults and evaluate the potential for ground rupture on the proposed development. Our scope of services included:

- Review of pertinent readily available geologic background information including existing geologic reports, in-house regional geologic maps, aerial/satellite photographs, and published geologic literature. The review included a previous fault study conducted at the southern portion of the subject site by others.
- Perform subsurface fault exploration including excavation and logging of seven fault trenches totaling approximately 2,000 linear feet to depths ranging from 8 to 16 feet. The study was undertaken in two parts; four fault trenches were excavated in 2014 and an additional three fault trenches in 2020.
- Excavation, sampling, and downhole-logging of seven large diameter borings; four borings excavated in 2014 and an additional three borings in 2020.
- Surface geologic mapping of the site performed during the recent fault evaluation in 2020.
- Geologic analysis and evaluation of the previous fault studies and recent subsurface exploration in regards to potential active faults and their impact to the proposed development.

- Peer review provided by Tania Gonzalez of Earth Consultants, Inc. (ECI) which included field review of all seven fault trenches, and compilation of a soil analysis report for age-dating soils. Additionally, Eldon Gath of ECI provided peer review for fault trenches FT-1, FT-2, FT-3, and FT-4.
- Preparation of this comprehensive fault evaluation report presenting our findings, conclusions, and preliminary recommendations with respect to the proposed site development.

1.2 __Existing Conditions__

The approximately 130-acre property is located west of the 71 Freeway and south of the existing terminus of Shady View Drive and Via La Cresta streets, within the existing Butterfield Ranch residential development. Refer to the Site Location with Earthquake Fault Zone Map, Figure 1 (rear of text). The site is roughly rectangular shaped with a square-shaped cut-out that is not a part of the proposed development. The site is accessed by an unpaved road from Mystic Canyon Drive located to the west about a third of a mile from the site. The site currently consists of undeveloped land with areas of various land uses including oil extraction collection pipelines and a set of three bulk crude oil storage tanks near the center of the proposed development site. Other uses of the generally vacant land include localized areas of equipment storage, a beehive farm, split wood storage, and soil piles. The gated access road from Mystic Canyon Drive passes across the site and splits to provide both access to the square-shaped parcel encompassed by the subject site, and access to the upper reaches of the hills to the west of the site.

The subject site is surrounded by the existing Butterfield Ranch residential development to the north, and the square-shaped parcel (with a prominent water tank/ cell tower), a sliver of open space, and the 71 Freeway to the east. The site abuts open space to the south and west that also includes the oil extraction facilities at scattered locations throughout the nearby hills, and an evaporation pond. The hills to the west of the site are a part of the Mahala Oil Field; Chino Hills State Park is located further west.

Topographically the site consists of a large, slightly undulatory hillside at the southwest portion of the site and a series of low rolling canyons and ridges at the northeast portion of the site. A major active drainage runs west to east through the upper-middle portion of the site. Within the proposed southern portion of the development area, smaller canyons between low ridges trend west to east. Overall elevations range from approximately 560 feet above mean sea level (msl) to a maximum of 1,080 feet at the top of the large hillside that ascends above the proposed development area to the southwest. Vegetation onsite consists of moderate to thick low bushes (abundant mustard plants) and few scattered trees.

1.3 __Project Description__

Based on the rough grading plan (Hunsaker, 2020), the proposed residential development will consist of 159 single family lots for residential structures, a recreation center, interior streets, debris/detention basins, and other associated improvements. An aboveground bulk crude oil tank pad is proposed outside of the residential area at the northwest portion of the site, to be separated from the community by an ascending slope, an access road and a berm. Conventional retaining walls up to 10 feet are planned throughout the site, and Mechanically Stabilized Earth (MSE) retaining walls up to 30 feet in height at the eastern boundary. Open space forms the balance of the site with approximately 72 acres of natural open space located at the southwest portion of the roughly rectangular shaped site. The rough grading plan proposes design cuts of up to approximately 95 and fill slopes up to approximately 65 feet in height that include MSE retaining walls. Planned cuts and fills to reach design grade are anticipated to be on the order of approximately 45 feet and 60 feet, respectively, not considering remedial measures.

1.4 Previous Fault Evaluation

A previous fault evaluation was performed within the subject property at the southern portion of the site. Earth Consultants International (ECI) excavated a series of fault trenches across the trace of the Chino Hills Fault under grant from the United States Geological Survey (USGS). The referenced report (ECI, 2008) was reviewed and pertinent data included in herein.

The previous fault investigation included the following:

- Review of available regional geologic data pertinent to the subject site;
- Site specific geologic mapping;
- Interpretation of aerial photographs; and
- Excavation and logging of six fault trenches totaling approximately 600 linear feet within the small canyon at the southern portion of the site, also known as "McMasters Canyon". (ECI, 2008). Fault trenches were excavated to depths up to approximately 18 feet

The approximate locations of fault trenches by ECI are depicted on the Geologic Map (Sheets 1 & 2). Fault trench logs by ECI are presented in Appendix D. Representative fault attitudes from their evaluation are plotted and estimated traces of *Holocene-active faults* are incorporated into the study herein.

1.5 Field Evaluation by LGC Geotechnical

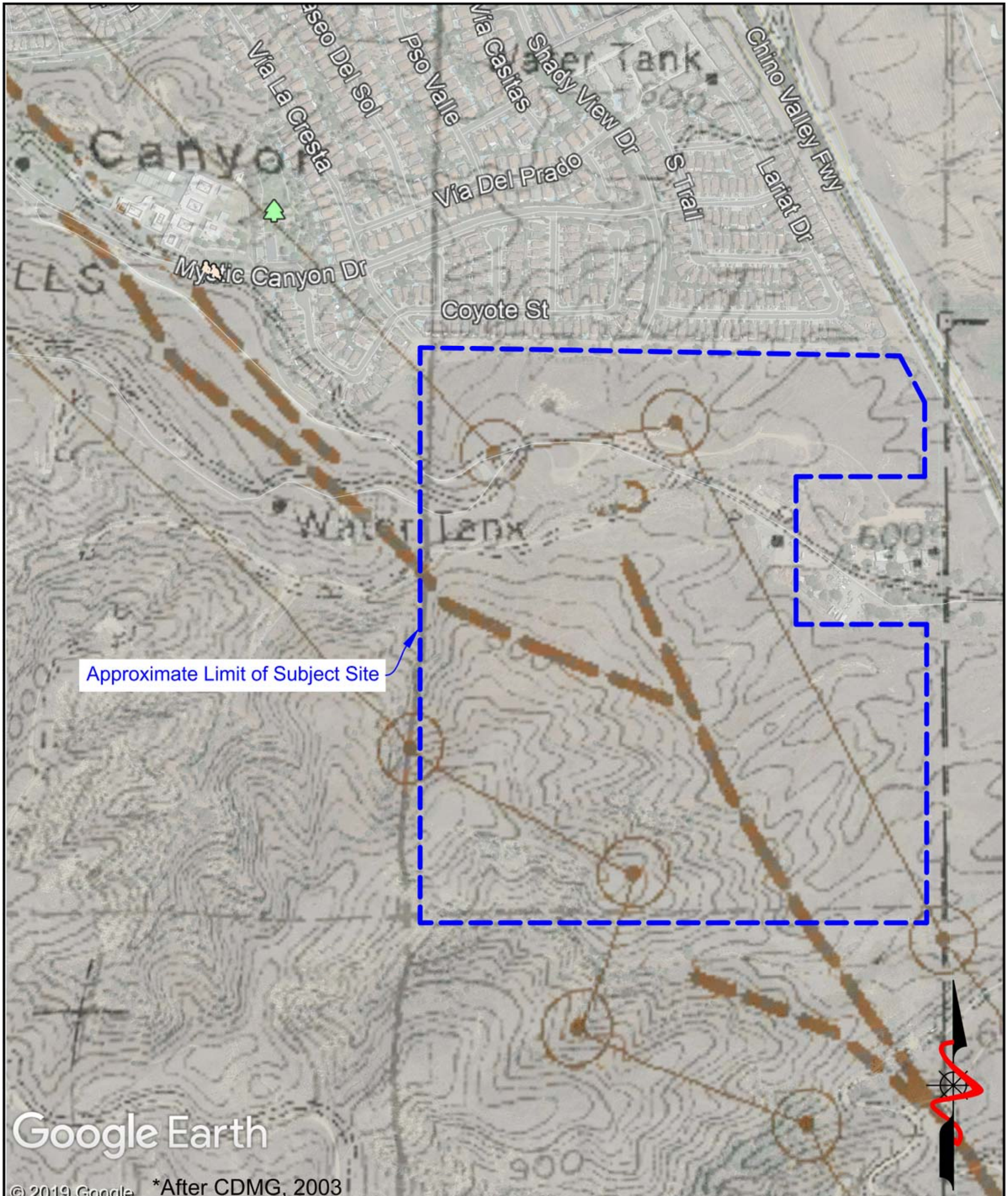
In order to gather information regarding potential faulting within the project site. LGC Geotechnical had previously excavated three fault trenches (FT-1 through FT-4) in 2014, and excavated an additional three fault trenches (FT-5 through FT-7) recently. Overall, more than 2,000 linear feet of fault trenching was performed for LGC Geotechnical at the locations depicted on the Geologic Map (Sheets 1 & 2). The trenches were excavated generally perpendicular to the orientation of the Chino Fault at intervals along the portion of the Earthquake Fault Zone that overlap the proposed residential development. The spacing of the trenches generally supports the maximum approximate 600-feet interval for fault-rupture hazard investigations required by the referenced County of San Bernardino standard (2007). Additionally, seven large-diameter bucket auger borings were excavated in the central hillside portion of the site. The borings were sampled and downhole-logged by an engineering geologist in order to supplement the fault trenching information and eventually to establish remedial measures for the proposed residential development.

Prior to the start of our subsurface exploration the Geotechnical Reviewer for the City of Chino Hills ("lead agency" in accordance with CGS, 2018) was notified in order to present the opportunity for field review of the excavations.

Earth Consultants International (ECI) was subcontracted by LGC Geotechnical to provide peer review and expertise with regards to age dating of soil horizons. Part of their work included sampling and analysis of soils within the fault trenches at strategic locations in order to perform age-dating of soil horizons. The purpose of soil age analysis is to constrain the age of the most recent fault activity; unbroken soil horizons observed in fault trenches can be age-dated in order to prove that a fault has not broken a soil horizon that is greater than 11,700 years old (aka "*pre-Holocene*"). This is an acceptable method of determination of whether a fault is *Holocene-active* and therefore requires a setback for habitable structures.

A soil analysis report was prepared by ECI and is included in Appendix B. The report was provided in accordance with CGS (2002), Note 42, Table 5-1 "Most applicable Age Dating Methods for Fault Activity Investigations". The Soil Profile Development Index (SDI) was utilized by ECI to date strategic soil horizons within the fault trenches. Application criteria notes that this method "requires quantitative dating of similar soil profiles in the area as calibration, [and] significant expertise is required for SDI age estimates." As noted above in the section titled "Previous Fault Evaluation," ECI performed the previous evaluation within the subject site and are considered by the geotechnical community to be soil age dating experts in this locality (ECI, 2008).

The large-diameter boring and fault trench locations are presented on the Geologic Map (Sheets 1 & 2). Logs for LGC Geotechnical fault trenches FT-1 through FT-7 are presented on Sheets 4 through 8, and ECI fault trenches ECI-FT-1 through ECI-FT-6 are presented on Sheets 9 through 10. Boring logs for large diameter borings are presented in Appendix B.



LGC Geotechnical, Inc.

FIGURE 1
Site Location with Earthquake Fault Zone Map

PROJECT NAME	Shady View
PROJECT NO.	18117-01
ENG. / GEOL.	DJB/KTM
SCALE	Not to Scale
DATE	March 2020

2.0 GEOLOGY

2.1 Regional Geology

Regionally the subject site is located northeast of the Santa Ana Mountains which are part of the Peninsular Ranges geomorphic province. The Chino Hills are considered to be a part of the Puente Hills which lie at the eastern margin of the Los Angeles Basin. Several regional faults have influenced formation and erosion of the mountains and hills over time including the Elsinore Fault Zone that splits into the Whittier Fault and the Chino Fault southeast of the subject site.

The Santa Ana River passes to the southwest of the site within an incised drainage that has abandoned a series of stream terraces (older alluvium) at various higher elevations that partially mantle the lower portion of the Chino Hills. The Prado Dam is sited several miles southeast of the site where it was constructed across the Santa Ana River.

More specifically, the site is predominately underlain by folded or overturned and locally faulted bedrock units with minor amounts of older alluvium along the slopes and ridges at various elevations, and young alluvium in the existing drainages.

2.2 Site-Specific Geology

Based on the Geologic Map of the 7.5-minute Prado Dam Quadrangle (Dibblee, 2001) and geologic field mapping, the subject site is underlain by Quaternary Alluvial Deposits, Quaternary Old Alluvial Fan Deposits, and Tertiary Puente Formation, Sycamore Canyon Member. Notably the Regional Geologic Map, Figure 2, presents the previously used nomenclature for the Puente Formation, ("Sycamore Canyon Formation"), updated with the current evaluation. The geologic units are summarized below from youngest to oldest and their approximate lateral limits are depicted on the Geologic Map (Sheets 1 & 2).

2.2.1 Quaternary Alluvial Deposits (Map Symbol – Qal)

The Quaternary Alluvial Deposits are located in the active drainages and valleys which occupy the lowest elevations at the subject site. Typically, these unconsolidated deposits vary in thickness from a few feet to greater than 50 feet. The material is generally light orangish brown to moderate brown, silty sand with gravel and cobbles, variable moisture and density.

2.2.2 Quaternary Older Alluvium(Map Symbol – Qoa)

Quaternary Older Alluvium was encountered in localized locations, elevated above the active drainages at the southwest portion of site, becoming deeper and more extant to the east and into the valley east of the 71 Freeway. The material is typically light reddish-brown clayey silt to silty sand with gravel and cobbles with interfingered zones of clayey sandy gravel and coarse sand, reddish yellow to strong brown, slightly moist, dense to very dense; indurated, faintly stratified, with some buried paleosol horizons. Alluvial deposits are interfingered with mudflow deposits consisting of clayey silt with fine sand, gravel, and cobbles, dark yellowish brown, slightly moist, stiff to very stiff, lacks structure, indurated.

Based on soil analysis by ECI (Appendix C), the Quaternary Older Alluvium observed in fault trenches is approximately 200,000 to 300,000 years old.

2.2.3 Tertiary Puente Formation, Sycamore Canyon Member (Map Symbol – Tpsc)

The Tertiary Puente Formation is a Late Miocene marine deposit that consists of four members that have a total thickness of up to about 5,400 feet. From oldest to youngest, the members are the La Vida Member, the Soquel Member, the Yorba Member, and the Sycamore Canyon Member. The youngest Sycamore Canyon Member is the bedrock unit at the subject site.

The Sycamore Canyon Member of the Puente Formation (Map Symbol – Tpsc) encountered onsite consists of thin to very thick interbedded conglomeratic sandstone, and sandstone, sandy siltstone and siltstone, light greenish gray to yellowish red to very pale brown, slightly moist, dense to very dense. Conglomerate beds were observed to be cemented, resistant to weathering, with sub-rounded to subangular, granitic and metamorphic gravel and cobble clasts.

2.3 Geologic Structure

The geologic structure of the bedrock unit at the site is generally controlled by the presence of the Chino Fault. As depicted in Cross Section 2-2', the Chino Fault is a right-lateral strike slip fault with a component of reverse dip-slip that is generally the reason for the escarpment/hillside at the southwest portion of the site. The Mahala Anticline that has been mapped within the Chino Hills to the west of the site is sub-parallel to the Chino Fault from approximately the subject site to the northwest adjacent to the locations where the trace of the fault has been identified at the base of the hills. The Mahala Anticline is the source of the oil being extracted in the hills west of the site, the Mahala Oil Field.

The bedding of the Puente Formation has been very consistent where observed at the site. Strike of bedding is generally northwest, similar to the trend of the Chino Fault, and dips range between 60 and 75 degrees southwest (overturned), in accordance with regional geologic mapping (Dibblee, 2001 & Morton, 2004) and observations on-site; the bedding likely mirrors the orientation of the fault itself. Refer to Figure 2, Regional Geologic Map (rear of text).

Proof in support of consistent, overturned bedding on site was observed during logging of fault trench FT-6 at approximate Station 1+60. At that location, a contact between sandy siltstone and coarse conglomerate depict a series of rip-up clasts of the finer materials caught within the coarser conglomeratic material. Using the rule of "original horizontal deposition" of bedding, the higher-energy depositional environment of the coarse-grained materials ripped up materials that were already deposited within the layer below; therefore, the sandy siltstone material was deposited first, the higher-energy conglomerate second. After lithification and during uplift, the beds became overturned by regional structural forces likely related to the presence of the Chino Fault.

The geomorphology of the site offers some clues to the geologic structure within the large hillside at the west/central portion of the site. The hillside represents the escarpment of the reverse dip-slip portion of fault movement (the upthrown "hanging wall"). Millennia of erosion from the hillside escarpment area during active faulting in the right-lateral strike slip sense of movement created a series of partially developed "beheaded" canyons, saddles, lineaments/breaks in slope, as discussed in detail as part of the photo-lineament studies presented in Treiman, 2002 & ECI, 2008.

Erosion of the bedrock surface on the footwall side of the fault and subsequent deposition of alluvial terrace deposits derived from the Santa Ana River watershed created the angular unconformity between bedrock and older alluvium (terrace deposits) observed at various elevations at the site.

Bedrock geologic structure is generally overturned, steeply into slope, thin to very thick bedding with few very thin clay beds. Sandy siltstone beds showed more jointing and shearing that the conglomerate beds that were observed to be more resistant to weathering and have some weak cementation. Joints and minor internal shears were more prominent within the fine-grained (siltstone) materials at the site than the cobbly conglomerate materials. Calcium carbonate deposits, manganese oxide, and iron oxide staining was common in bedrock materials.

More recent landslides have mantled the central hillside area of the site. Based on downhole-logging of the borings, the basal rupture surface is relatively shallow, clay-lined feature that overrides older alluvium that is perched on the hillside, as depicted in Cross Section 2-2' (In Pocket). Colluvium and slope wash of unknown thickness are typical in the hillside, especially around the edges of the identified landslide.

3.0 FAULTING

3.1 Regional Faulting

Overall faulting in Southern California tends to reflect the constant small movement of the Pacific to North American Plate boundary in that the majority of major active faults are right-lateral strike-slip with various oblique movements and features like the Transverse Ranges that are thought to act like a giant "ball-bearing" within the overall movement of the lithospheric plates. Many of the regional active faults trend northwest/southeast in reflection of the same orientation of the plate boundary.

Various faulting geometries include dip slip, strike slip and oblique slip, generally defined as the following. "Dip slip" faults are measured straight down the dip and in the plane of the fault and can include normal/extensional movement (pull-apart) or reverse/compressional movement (thrust faults are low-angle reverse faults). Nearly vertical "strike slip" faults are common in Southern California and right-lateral movement dominates the structural geologic regime of the region. "Oblique" faults are a combination of the two; slip along the Chino Fault is estimated to generally be right lateral strike-slip, with a component of reverse dip slip. Therefore, the Chino Fault is technically an oblique fault, however the strike-slip movement appears to dominate.

Regional faulting in the vicinity of the subject site is generally associated with the Whittier-Elsinore Fault Zone. In general, the Elsinore Fault trends northwest towards the Whittier Fault along the base of the eastern side of the Santa Ana Mountains. As the Elsinore Fault Zone trends northward, it diverges northward into the Chino Fault approximately within the City of Corona; the main branch of the Elsinore Fault becomes the Whittier Fault to the northwest but the Chino Fault also takes on some of the movement as discussed below.

3.2 Chino Fault

The trace of the *Holocene-active* Chino Fault has been identified to trend a combination of north and northwest across portions of the subject site, as approximately depicted on the Geologic Map (Sheets 1 & 2). The fault is located within a State of California Earthquake Fault Zone in accordance with the Alquist-Priolo Earthquake Fault Zoning Act. The overall geometry of the fault is estimated to strike about 40 degrees to the west, dipping 70 degrees west at depth based on petroleum drilling data, shallower near the surface (Treiman, 2002).

The geomorphic expression of the Chino Fault zone is visible in the aerial photographs reviewed for this study (Continental Aerial Photos, 2020) and as notated by others and documented in Trieman, 2002 and ECI, 2008. The trace of the fault at the base of the Chino Hills is indicated by beheaded and offset drainages, linear drainages, and aligned saddles and escarpments along its length within the portion of the fault called the "Chino Hills section". Treiman, 2002, estimated that as much as 1000 meters of late Quaternary offset has occurred. The right-lateral movement of the fault is hypothesized to have shifted the active drainages over time and created the differential erosion of the low ridges and valleys observed on the site today. The various small canyons at the southern portion of the residential development site were likely "beheaded" over the millennia as the active drainages from the Chino Hills continuously found new paths due to strike slip movement on the fault.

In plan view, the fault has two traces as depicted on the Geologic Map (Sheets 1 & 2). In the previous on-site fault study by performed by investigating geologists Madden and Yeats (ECI, 2008), they hypothesized that a left-bend or step in the Chino Fault within the site may have caused localized uplift and partitioning of slip across the bend/step. They considered a model that has a diffuse, high-angle fault that accommodates lateral/strike slip movement, and a low angle dip slip component would accommodate dip slip (reverse) movement. This hypothesis appears to be supported by the current study.

Excavation of fault trench FT-2 exposed the edge of a "flower structure" depicted on the log (Sheet 5) at Station 4+32. The petals of the flower structure are multiple closely spaced near surface faults that are oriented at a low angle between approximately 20 and 33 degrees of dip. The feature is likely very old, on the order of tens of thousands of years, as discussed in detail in the Soil Age Analysis Report by ECI (Appendix C). However, the soils horizon overlying the flower structure were not sufficiently continuous over the fault feature. Therefore, flower structure was determined to be *Holocene-active* due to lack of conclusive proof that it is pre-Holocene. The edge of this feature is where the Surveyed Fault Point is labeled on the fault trench log (FT-2 at Station 4+32), and in plan view on the Geologic Map (Sheets 1 & 2). This Surveyed Fault Point is the basis of the preliminary recommended setback for habitable structures herein. Refer to Cross Section 2-2' for a graphic presentation of the relationship between the fault and proposed design grades. Based on the inclination of the fault the recommended setback location will likely shift away from the proposed development once the project is graded. This will either maintain or increase the distance between the nearest proposed structure for human occupation and the surface location of the fault.

The side-step/eastern splay of the fault that was observed in fault trench FT-2, dies out going north, presumably at the base of the alluvial drainage before the low east-west ridgeline located north of the projected trace. No fault features were observed in the trenches FT-3, FT-4, FT-6 or FT-7. A fault was observed offsite during surface mapping of the area within an erosional drainage located northwest of the site, that generally aligns with the trend of the western fault depicted on the Geologic Map. The fault representing the western boundary of the fault zone is considered the main fault trace, and the eastern fault is a secondary feature that dies out within the active drainage, as it was not observed in the hillside to the north.

The Geologic Map depicts the approximate position of the trace of the Chino Fault on the subject site. This feature has been projected along geomorphic indicators such as breaks in slope and saddles combined with the information observed (including location, strike and dip, etc.) within fault trenches logged by both LGC Geotechnical, this study, and ECI, 2008.

Locations of soil sampling and analysis for soil age dating are noted on the fault trench logs at four locations. Analysis was performed within FT-1 at Station 3+25, within FT-2 at Station 3+98, and within FT-3 at Stations 0+25 and 0+90. Refer to the soils age analysis report by ECI, presented in Appendix C, for full discussion of methods and conclusions relative to the soil age dating.

4.0 CONCLUSIONS

Based on the results of our updated fault evaluation, it is our opinion that the proposed improvements are feasible from a geotechnical standpoint, provided that the structural setback recommendations contained in the following sections are incorporated during site planning and development. A summary of our conclusions are as follows:

- The *Holocene-active* Chino Fault transects the central and western portions of the subject site at the approximate locations depicted on the Geologic Map (Sheets 1 & 2). An Earthquake Fault Zone has been delineated by the State of California in accordance with the Alquist-Priolo Earthquake Fault Zoning Act (CGS, 2018). The fault is generally a right-lateral strike-slip with some component of reverse faulting that likely produced the escarpment of the Chino Hills.
- The recently completed fault trench study and a previous fault investigation (ECI, 2008) together indicate that the trace of the Chino Fault is located just outside of the proposed residential development at fault trench FT-2 and is increasingly distant from the proposed residential development at the south end of site. The Chino Fault has a left side-step within the limits of the site; the western fault trace appears to die out in the active drainage just north of fault trench FT-2. The eastern trace of the fault continues northwest outside of the area of the proposed development.
- The features observed at approximate Station 4+32 in fault trench FT-2 form the edge of a relatively low-angle "flower structure", not the main trace of the fault. The eastern edge of the flower structure is estimated to have a longer recurrence interval on the order of "tens of thousands of years", based on the age of soils the overlie the feature, as detailed in the Soil Stratigraphic analysis report provided in Appendix C. The probability of future movement on the main/western fault trace is high, however the probability of future movement on the eastern "flower structure" fault trace is low.
- The main trace of the Chino Fault is estimated to have a slip rate of less than half of the overall slip rate of the 5 to 6 mm/year of the Elsinore Fault. The Elsinore Fault is estimated to to split it's slip rate between the Whittier and Chino Faults, although some movement appears to be absorbed by folding. The slip rate of the Chino Fault is estimated to be up to approximately 2 mm/year.
- Two historic earthquake events have been recorded in the vicinity of the Chino Fault. A Magnitude 3.2 strike-slip earthquake occurred on February 16, 1989 at 4.3 kilometers in depth, and a Magnitude 3.9 strike -slip earthquake occurred on December 14, 2001 (Treiman, 2002). Based on the study by ECI, 2008, at the southern portion of the site, the fault last ruptured approximately mid-Holocene based on soil age dating evaluation.
- The proposed residential development is acceptable from a geotechnical standpoint, provided the recommendations for a setback of 50 feet from habitable structures are incorporated into the design. The current plan by Hunsaker (2020) indicates that all proposed habitable structures will be sufficiently setback (at least 50 feet) from the nearest trace of the Chino Fault. Therefore, no adjustments are required to the proposed residential layout. The location depicted as the "Surveyed Fault Point" on the Geologic Map and Cross Section 2-2', is located more than 50 feet from the nearest proposed structure at existing grades.
- Based on the inclination of the fault at the "Surveyed Fault Point", the design cut in that location will push the final position of the active fault trace further to the west and further away from proposed structures. Remedial measures consisting of construction of a keyway for the design cut slope will push the final location even further from proposed structures and cap the feature with artificial fill.

- The proposed location of three, above-ground crude oil storage tanks is acceptable from a geotechnical standpoint. Based on the findings of the fault study herein, it is our professional opion that no structural setback is required for the proposed location of oil tanks (Cross Section 1-1').
- Overall, the degree of confidence is high with regards to the findings and conclusions relative to active faulting for the proposed residential development and oil storage tank locations.

5.0 RECOMMENDATIONS

The following structural setback recommendations are to be considered preliminary and are based on our knowledge of the site geologic and proposed grading plan. The structural setback from the faults should be confirmed or adjusted during rough grading based on field observations and the actual mapped location of the fault.

In situations where a *Holocene-Active* fault is discovered, the project geologist is to consider all available data and provide recommendations regarding whether setbacks or other engineered solutions should be considered in the placement or design of a structure (for human occupancy) crossing the fault (CGS, 2018). Setback distances of proposed structures from *Holocene-Active* faults is dependent on the quality of the collected data, type and complexity of the fault, and extent/severity of fault related ground deformation (CGS, 2018). It is our opinion that the following structural setbacks provide an adequate distance from the fault trace in order to mitigate significant potential impacts of fault rupture and associated ground deformation on habitable structures. It should be understood that our setback recommendations are intended to maintain the structural integrity of the proposed structures and cannot preclude the potential for some distress to develop as a result of future seismic events.

5.1 Structural Fault Setback

An on-site fault has been determined to be *Holocene-active* as defined by the State of California; therefore, a structural/building setback from the active fault trace and/or other engineered solutions should be determined by the project geologist. We have recommended a setback of 50 feet to the nearest habitable structure from the surveyed location of the active fault trace. The final position of the 50 feet setback should be based on finished grade elevations. Based on our review of the rough grading plan presented as a base map for this study (Hunsaker, 2020), the fault projects through a design cut slope with cuts up to approximately 40 feet. A buttress keyway is anticipated to be constructed at the location that will further push the final fault position further west and away from habitable structures.

Going south of the Surveyed Fault Point, the location of the active fault lines up with the offsite trenches by ECI (2008) and the active fault location is increasingly further from the proposed development. However, this study is limited to the exploration performed, therefore, the 50 feet setback becomes a limit of habitable structures pending further investigations.

The proposed use of a portion of the subject site for bulk crude oil storage tanks on, Lot 161 (Geologic Map, Sheet 2) has been evaluated relative to the potential for active fault to underlie the proposed location. As shown on Cross Section 1-1’ (Sheet 3), no active fault was observed in fault trench FT-7, and no indication of active faulting was encountered to the approximate limits of the property where the fault trench was ended. The actual fault trace is estimated to be located approximately 350 feet or more from the western edge of the proposed oil tank location. Therefore, no specific geotechnical setback recommendations are anticipated to be required, and the proposed oil storage tank location is acceptable from a geotechnical standpoint.

The known and estimated fault locations and associated structural setback/study limitation lines are considered appropriate based on the information gathered during our subsurface exploration and our general understanding of the fault structure. However, it is extremely difficult to estimate/project the exact future location of a fault plane at finish grades prior to grading. The fault zone should be mapped by the project geologist and located with survey quality GPS equipment during grading to confirm or adjust the projected fault rupture zone and/or structural setback recommendations provided herein.

6.0 LIMITATIONS

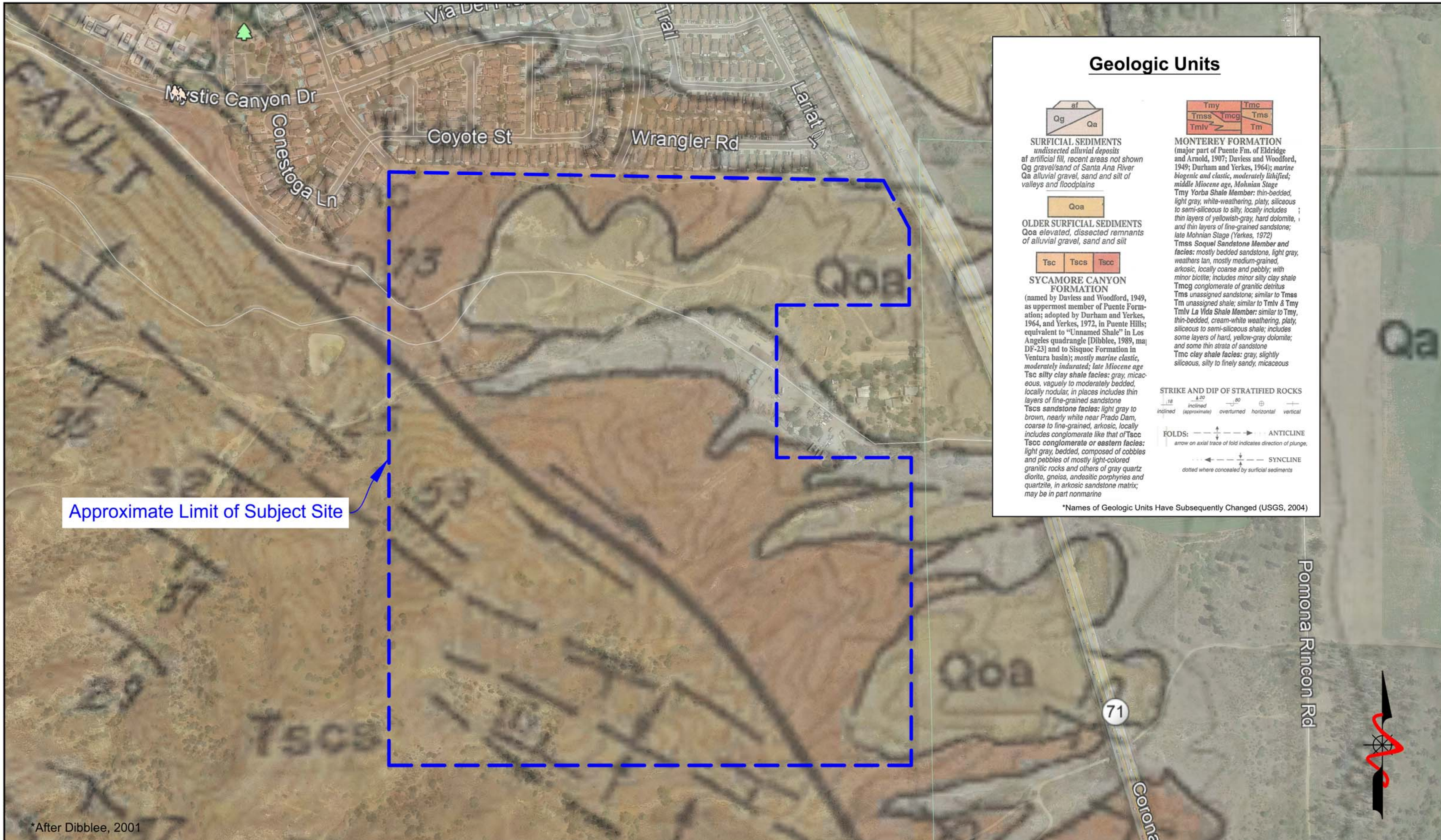
Our services were performed using the degree of care and skill ordinarily exercised, under similar circumstances, by reputable soils engineers and geologists practicing in this or similar localities. No other warranty, expressed or implied, is made as to the conclusions and professional advice included in this report.

This report is based on data obtained from limited observations of the site, which have been extrapolated to characterize the site. While the scope of services performed is considered suitable to adequately characterize the site geotechnical conditions relative to the proposed development, no practical evaluation can completely eliminate uncertainty regarding the anticipated geotechnical conditions in connection with a subject site. Variations may exist and conditions not observed or described in this report may be encountered during grading and construction.

This report is issued with the understanding that it is the responsibility of the owner, or of his/her representative, to ensure that the information and recommendations contained herein are brought to the attention of the other consultants (at a minimum the civil engineer, structural engineer, landscape architect) and incorporated into their plans. The contractor should properly implement the recommendations during construction and notify the owner if they consider any of the recommendations presented herein to be unsafe, or unsuitable.

The findings of this report are valid as of the present date. However, changes in the conditions of a site can and do occur with the passage of time, whether they be due to natural processes or the works of man on this or adjacent properties. The findings, conclusions, and recommendations presented in this report can be relied upon only if LGC Geotechnical has the opportunity to observe the subsurface conditions during grading and construction of the project, in order to confirm that our preliminary findings are representative for the site. This report is intended exclusively for use by the client, any use of or reliance on this report by a third party shall be at such party's sole risk.

In addition, changes in applicable or appropriate standards may occur, whether they result from legislation or the broadening of knowledge. Accordingly, the findings of this report may be invalidated wholly or partially by changes outside our control. Therefore, this report is subject to review and modification.



LGC Geotechnical, Inc.

LGC Geotechnical, Inc.
131 Calle Iglesia, Ste. 200
San Clemente, CA 92672
TEL (949) 369-6141 FAX (949) 369-6142

FIGURE 2
Regional Geologic Map

PROJECT NAME	Shady View
PROJECT NO.	18117-01
ENG. / GEOL.	DJB/KTM
SCALE	Not to Scale
DATE	March 2020

Appendix A
References

APPENDIX A

<u>References</u>

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Appendix B
Boring Logs

Geotechnical Boring Log B-1

Date : 8/1/2014 Page 1 of 2	**Drilling Company :** Alroy
Project Name : Abacherli Ranch	**Type of Rig :** Bucket Auger
Project Number : 14092-01	**Drop :** 12" **Hole Diameter :** 28"
Elevation of Top of Hole : ~ 678 ' MSL	**Drive Weight :** 0' to 23': 2400 lbs 24' to 43': 1550 lbs 44' to 62': 1300 lbs
Hole Location : See Geotechnical Map	

Logged by KTM

Sampled by CNJ

Elevation (ft)	Depth (ft)	Graphic Log	Attitudes	Sample Number	Blow Count	Dry Density(pcf)	Moisture (%)	USCS Symbol	DESCRIPTION	Type of Test
	0								**@ 0' to T.D. <u>Tertiary Puente Formation, Sycamore Canyon Member (Tpsc)</u>**	
									@ 0' Topsoil, undulatory contact, Silty fine SAND to Sandy SILT, dark brown, dry, stiff/dense, rootlets, krotovina to 4'	
675									@ 3' Silty fine SANDSTONE, light yellowish brown mottled, dry, very dense with loose zones, soft sediment deformation, extremely weathered, variable cementation, abundant calcium carbonate lined fractures, subplanar jointing/faulting, angular blocky zones	
	5									
670			B: N50W, 77SW						@ 7' Bedding, highly weathered and vague. Slightly undulatory, calcium carbonate lined, obscured by soft sediment deformation. Soil infill zones. SAND infill approximately 4" thick runs parallel. Becomes better defined with depth. Off white pods along bedding, to 5" in diameter	
	10			R-1	13/7"				@ 10' Sandy SILTSTONE, grayish orangish brown, dry to very slightly moist, dense, calcium carbonate (off-white pods)	
665			B: N45W, 73SW						@ 11' Bedding, grades to Silty fine SANDSTONE and fine Sandy SILTSTONE, mottled grayish brown and orangish brown, slightly moist, very stiff to hard, lenses of sand, very thin beds that are steeply dipping, scattered oxidation, trace fossils, moderately weathered but lacks open fractures	
	15									
660			B: N40W, 73S						@ 17' Bedding on sand lens	
	20			R-2	8/10"				@ 20' Sandy SILTSTONE, grayish orangish brown with white, slightly moist, dense, laminations, iron oxide staining	
655			B: N40W, 72S							
	25		SH: N25W, 7E						@ 25' Faint shear; cross-cutting clayey feature, almost continuous, oxidized	
650									@ 30' Bedding/Shear, top of 1/2" to 1" thick CLAY, gray, slightly moist, plastic, striations, tight, planar, continuous. Bottom at 43', possible flexural slip along bedding	

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THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF THE ACTUAL CONDITIONS ENCOUNTERED.

SAMPLE TYPES:

B	BULK SAMPLE
R	RING SAMPLE
G	GRAB SAMPLE

TEST TYPES:

DS	DIRECT SHEAR
MD	MAXIMUM DENSITY
SA	SIEVE ANALYSIS
S&H	SIEVE AND HYDROMETER
EI	EXPANSION INDEX
CN	CONSOLIDATION
CR	CORROSION
AL	ATTERBERG LIMITS
CO	COLLAPSE/SWELL
RV	R-VALUE

Last Edited: 9/3/2014

Geotechnical Boring Log B-1

Date :	8/1/2014 Page 2 of 2	**Drilling Company :**	Alroy
Project Name :	Abacherli Ranch	**Type of Rig :**	Bucket Auger
Project Number :	14092-01	**Drop :** 12"	**Hole Diameter :** 28"
Elevation of Top of Hole :	~ 678 ' MSL	**Drive Weight :**	0' to 23': 2400 lbs 24' to 43': 1550 lbs 44' to 62': 1300 lbs
Hole Location :	See Geotechnical Map		

Logged by KTM

Sampled by CNJ

Elevation (ft)	Depth (ft)	Graphic Log	Attitudes	Sample Number	Blow Count	Dry Density(pcf)	Moisture (%)	USCS Symbol	DESCRIPTION	Type of Test
	30		B/SH:N45W, 76S	R-3	30/10"				@ 30' - Sandy SILTSTONE: gray and orange brown mottled, slightly moist, very dense	
645										
	35									
640										
	40			R-4	20/4"				@ 40' Clayey SILTSTONE with Sand, light brownish gray with iron oxide mottling, slightly moist, very dense	
635			B/SH: N45W, 75S						@ 43' Bedding/Shear attitude. Bottom of feature described at 30'. Continuous, remains along bedding.	
	45									
630										
	50			R-5	50/10"				@ 50' Sandy SILTSTONE, orangish gray and light brown mottled, slightly moist, dense	
625										
	55									
									@ 57' End visual log	
620										

Total Depth = 60'
No Ground Water Encountered
Backfilled with Cuttings and Tamped on 8/4/2014

LGC Geotechnical, Inc.

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF THE ACTUAL CONDITIONS ENCOUNTERED.

SAMPLE TYPES:

B	BULK SAMPLE
R	RING SAMPLE
G	GRAB SAMPLE

TEST TYPES:

DS	DIRECT SHEAR
MD	MAXIMUM DENSITY
SA	SIEVE ANALYSIS
S&H	SIEVE AND HYDROMETER
EI	EXPANSION INDEX
CN	CONSOLIDATION
CR	CORROSION
AL	ATTERBERG LIMITS
CO	COLLAPSE/SWELL
RV	R-VALUE

Geotechnical Boring Log B-2

Date : 8/4/2014	Page 1 of 2	**Drilling Company :**	Alroy
Project Name :	Abacherli Ranch	**Type of Rig :**	Bucket Auger
Project Number :	14092-01	**Drop :** 12"	**Hole Diameter :** 28"
Elevation of Top of Hole :	~ 676 ' MSL	**Drive Weight :**	0' to 23': 2400 lbs 24' to 43': 1550 lbs 44' to 62': 1300 lbs
Hole Location :	See Geotechnical Map		

Logged by KTM

Sampled by KTM

Elevation (ft)	Depth (ft)	Attitudes	Sample Number	Blow Count	Dry Density(pcf)	Moisture (%)	USCS Symbol	DESCRIPTION	Type of Test
675	0							**0' to 19' Quaternary Older Alluvium (Qoa)** @ 0' Topsoil: dark brown, Silt with fine Sand, dry, loose	
		J: N77W, 65S						@ 2' SAND with Silt and Pebbles and Cobbles, reddish brown, dry, dense, subrounded rocks up to 4". Calcium carbonate, vague jointing	
670	5							@ 5' Becomes slightly moist, variable clasts include gravel lenses, "rotted" rock nested, subangular to subrounded. Matrix supported, Sand, silt, minor clay, very tight overall	
665	10		R-1	7				@ 10' Silty SAND with Pebbles, reddish brown, slightly moist, dense, moderately well indurated	
660	15								
								19' to T.D. Tertiary Puente Formation, Sycamore Canyon Member (Tpsc) @ 19' Undulatory contact, fine Sandy SILTSTONE with scattered very fine sand lenses, light yellowish brown, moist, very stiff, vague contact	
655	20		R-2	6				@ 20' Silty SANDSTONE light orangish brown, slightly moist, dense, lacks structure until 23'	
		B: N71W, 61S						@ 23' Bedding attitude, vague orange sand lens, soft sediment deformation	
650	25	Sh: NS, 64E B: N30W, 61SW						@ 25' Shear attitude, offset sand beds 2", tight, soft sediment deformation, vague	
		BN35W, 75SW	B-1					@ 28' Sand beds with manganese oxide, micro soft sediment deformation, trace fossils, continuous 1" thick SAND bed, light yellow, planar, some soft sediment deformation, to 37'	

Geotechnical, Inc.

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF THE ACTUAL CONDITIONS ENCOUNTERED.

SAMPLE TYPES:

B	BULK SAMPLE
R	RING SAMPLE
G	GRAB SAMPLE

TEST TYPES:

DS	DIRECT SHEAR
MD	MAXIMUM DENSITY
SA	SIEVE ANALYSIS
S&H	SIEVE AND HYDROMETER
EI	EXPANSION INDEX
CN	CONSOLIDATION
CR	CORROSION
AL	ATTERBERG LIMITS
CO	COLLAPSE/SWELL
RV	R-VALUE

Last Edited: 9/3/2014

Geotechnical Boring Log B-2

Date :	8/4/2014 Page 2 of 2	**Drilling Company :**	Alroy
Project Name :	Abacherli Ranch	**Type of Rig :**	Bucket Auger
Project Number :	14092-01	**Drop :** 12"	**Hole Diameter :** 28"
Elevation of Top of Hole :	~ 676 ' MSL	**Drive Weight :**	0' to 23': 2400 lbs 24' to 43': 1550 lbs 44' to 62': 1300 lbs
Hole Location :	See Geotechnical Map		

Logged by KTM

Sampled by KTM

Elevation (ft)	Depth (ft)	Graphic Log	Attitudes	Sample Number	Blow Count	Dry Density(pcf)	Moisture (%)	USCS Symbol	DESCRIPTION	Type of Test
645	30			R-3	30/10"				@ 30' Silty SANDSTONE, light gray, mottled with orangish brown, slightly moist to moist, very stiff to slightly hard, moderately weathered. Fossils and manganese oxidation, soft sediment deformation.	
640	35									
635	40		B: N35W, 72W	R-4	30				@ 40' SANDSTONE with Silt, light gray and light orangish brown mottled, slightly moist, very dense @ 41' Bedding attitude	
630	45								@ 47' End visual log	
625	50			R-5	50/7"				@ 50' Same as above at 40'	
620	55									

Total Depth = 51.5'
No Ground Water Encountered
Backfilled with Cuttings on 8/1/2014

Geotechnical, Inc.

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF THE ACTUAL CONDITIONS ENCOUNTERED.

SAMPLE TYPES:

B	BULK SAMPLE
R	RING SAMPLE
G	GRAB SAMPLE

TEST TYPES:

DS	DIRECT SHEAR
MD	MAXIMUM DENSITY
SA	SIEVE ANALYSIS
S&H	SIEVE AND HYDROMETER
EI	EXPANSION INDEX
CN	CONSOLIDATION
CR	CORROSION
AL	ATTERBERG LIMITS
CO	COLLAPSE/SWELL
RV	R-VALUE

Geotechnical Boring Log B-3

Date : 8/5/2014 Page 1 of 2	**Drilling Company :** Alroy
Project Name : Abacherli Ranch	**Type of Rig :** Bucket Auger
Project Number : 14092-01	**Drop :** 12" **Hole Diameter :** 28"
Elevation of Top of Hole : ~ 685 ' MSL	**Drive Weight :** 0' to 23': 2400 lbs 24' to 43': 1550 lbs 44' to 62': 1300 lbs
Hole Location : See Geotechnical Map	

Logged by KTM

Sampled by KTM

Elevation (ft)	Depth (ft)	Graphic Log	Attitudes	Sample Number	Blow Count	Dry Density(pcf)	Moisture (%)	USCS Symbol	DESCRIPTION	Type of Test
	0								**0' to 18' <u>Quaternary Older Alluvium (Qoa)</u>** @ 0' Topsoil, SILT, SAND, and PEBBLES, dark brown, dry, loose to dense, roots present, well indurated at contact with material below @ 1.5' Silty fine SAND with Gravel and Cobbles, reddish brown, dry to slightly moist, dense. Rock is subangular to highly variable, angular matrix supported. Rocks are "seated" in reddish/oxidation rinds. Some "rotted" appearance. Very well indurated. Few zones of silt and clayey silt.	
680	5									
									@ 9' Rocks up to 1' diameter, decomposed	
675	10									
									@ 11' Silty fine to coarse SAND with Pebbles, light reddish brown, moist, dense, iron and manganese oxide nodules	
									@ 13' Homogenous Clayey SILT with Sand, moist, stiff, abundant manganese oxide nodules	
670	15									
									18' to T.D. <u>Tertiary Puente Formation, Sycamore Canyon Member (Tpsc)</u> @ 18' Gravel Conglomerate. Gradual increase to rock supported zones with light yellow matrix, almost lithified.	
				B-1						
665	20			R-1	8				@ 20' Silty fine to coarse SANDSTONE with Pebbles, light reddish brown, slightly moist, dense, quartz rich pebbles to 3" in sample	
660	25									
			GB: N49W, 62S						@ 29' Vague contact with 5" yellow fine to coarse SANDSTONE bed	

Geotechnical, Inc.

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF THE ACTUAL CONDITIONS ENCOUNTERED.

SAMPLE TYPES:

B	BULK SAMPLE
R	RING SAMPLE
G	GRAB SAMPLE

TEST TYPES:

DS	DIRECT SHEAR
MD	MAXIMUM DENSITY
SA	SIEVE ANALYSIS
S&H	SIEVE AND HYDROMETER
EI	EXPANSION INDEX
CN	CONSOLIDATION
CR	CORROSION
AL	ATTERBERG LIMITS
CO	COLLAPSE/SWELL
RV	R-VALUE

Last Edited: 9/3/2014

Geotechnical Boring Log B-3

Date : 8/1/2014	Page 2 of 2	**Drilling Company :**	Alroy
Project Name :	Abacherli Ranch	**Type of Rig :**	Bucket Auger
Project Number :	14092-01	**Drop :** 12"	**Hole Diameter :** 28"
Elevation of Top of Hole :	~ 685 ' MSL	**Drive Weight :**	0' to 23': 2400 lbs 24' to 43': 1550 lbs 44' to 62': 1300 lbs
Hole Location :	See Geotechnical Map		

Logged by KTM

Sampled by KTM

Elevation (ft)	Depth (ft)	Graphic Log	Attitudes	Sample Number	Blow Count	Dry Density(pcf)	Moisture (%)	USCS Symbol	DESCRIPTION	Type of Test
	30			R-2	30/10"				@ 30' Silty Pebbly SANDSTONE with some Clay, light yellowish brown, moist, very dense. Conglomerate	
			J: N85W, 43N						@ 31' Joint attitude. Well defined, iron and manganese oxide lined, non-continuous and dies into conglomerate beds, cross cuts bedding.	
655	35									
			B: N30W, 67SW						@ 36' Bedding attitude on Faint laminations, non-continuous, dies into gravel conglomerate	
650	40			R-3	30/10"				@ 40' As above @ 30'	
			J: N25W, 16NE						@ 41' Joint attitude Faint oxidation and clayey zone, gravelly conglomerate	
			B/SH: N50E, 67SW						@ 43' Bedding attitude. Faint zone of gray, slightly clayey matrix, weathered zone, vaguely sheared along bedding	
645	45									
			B: N50W, 67SW						@ 46' SAND lenses, grey brown, manganese oxide defined, up to 4" thick	
640	50			R-4	50/7"				@ 50' Silty fine SANDSTONE with scattered pebbles, light gray, orange and dark brown mottled, moist, very dense, pebbles highly weathered quartz-rich, "rotted," manganese oxide.	
									Total Depth = 51.5' **No Ground Water Encountered** **Backfilled with Cuttings on 8/5/2014**	
635	55									

LGC Geotechnical, Inc.

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF THE ACTUAL CONDITIONS ENCOUNTERED.

SAMPLE TYPES:
- B BULK SAMPLE
- R RING SAMPLE
- G GRAB SAMPLE

TEST TYPES:
- DS DIRECT SHEAR
- MD MAXIMUM DENSITY
- SA SIEVE ANALYSIS
- S&H SIEVE AND HYDROMETER
- EI EXPANSION INDEX
- CN CONSOLIDATION
- CR CORROSION
- AL ATTERBERG LIMITS
- CO COLLAPSE/SWELL
- RV R-VALUE

Geotechnical Boring Log B-4

Date : 8/5/2014	Page 1 of 1	**Drilling Company :**	Alroy
Project Name :	Abacherli Ranch	**Type of Rig :**	Bucket Auger
Project Number :	14092-01	**Drop :** 12"	**Hole Diameter :** 28"
Elevation of Top of Hole :	~ 647 ' MSL	**Drive Weight :**	0' to 23': 2400 lbs 24' to 43': 1550 lbs 44' to 62': 1300 lbs
Hole Location :	See Geotechnical Map		

Surface Logged by KTM

Elevation (ft)	Depth (ft)	Graphic Log	Attitudes	Sample Number	Blow Count	Dry Density(pcf)	Moisture (%)	USCS Symbol	DESCRIPTION	Type of Test
	0								**0' to 24' <u>Quaternary Alluvium (Qal)</u>**	
645									@ 0' Silty fine to medium SAND with Gravel and Cobbles, light reddish brown, dry grading to slightly moist, loose to slightly dense, Belling of borehole, loose rocks, mostly rounded to subrounded cobbles, granite and metamorphics up to 8"	
	5									
640										
	10									
635										
	15									
630									@ 18' Silty SAND zone	
	20									
625									**@ 24' to T.D. <u>Tertiary Puente Formation, Sycamore Canyon Member (Tpsc)</u>**	
	25								@ 24' Silty fine SANDSTONE, light gray and orange mottled, moist, slightly dense to dense around 30', pervasive oxidation mottling	
620										

Total Depth = 30'
No Ground Water Encountered
Backfilled with Cuttings on 8/5/2014

LGC Geotechnical, Inc.

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF THE ACTUAL CONDITIONS ENCOUNTERED.

SAMPLE TYPES:
- B BULK SAMPLE
- R RING SAMPLE
- G GRAB SAMPLE

TEST TYPES:
- DS DIRECT SHEAR
- MD MAXIMUM DENSITY
- SA SIEVE ANALYSIS
- S&H SIEVE AND HYDROMETER
- EI EXPANSION INDEX
- CN CONSOLIDATION
- CR CORROSION
- AL ATTERBERG LIMITS
- CO COLLAPSE/SWELL
- RV R-VALUE

Last Edited: 9/3/2014

Geotechnical Boring Log B-5

Date :	1/20/2020 Page 1 of 3	**Drilling Company :**	Roy Brothers
Project Name :	Shady View	**Type of Rig :**	LoDril - Track Mounted Flight Auger
Project Number :	18117-01	**Drop :** 12"	**Hole Diameter :** 24"
Elevation of Top of Hole :	~ 732 ' MSL	**Drive Weight :**	0' - 15' = 1767 lbs 15' - 30' = 1182 lbs 30' - 45' = 757 lbs 45' - 60' = 489 lbs
Hole Location :	See Geotechnical Map		

Logged by MJG/KTM

Sampled by MJG/KTM

Elevation (ft)	Depth (ft)	Graphic Log	Attitudes	Sample Number	Blow Count	Dry Density(pcf)	Moisture (%)	USCS Symbol	DESCRIPTION	Type of Test
	0								**@ 0' - 29' <u>Quaternary Landslide (Qls)</u>**	
730									@ 0' to 6' - Colluvium; dark brown Sandy SILT, stiff, moist, rootlets	
	5			B1						
725									@ 6.3' - Layer of fine yellow silt 3" thick, over brecciated and rounded rock clasts of various types in zone of cobble conglomerate. Powdery white mineral deposits throughout slide.	
	10			R-1	15	114.9	5.4	SM	@ 10' - Silty SAND: tan to yellow, slightly moist, dense	
720										
	15								@ 15' - Decrease in rock fragments, blocks of sandstone (light gray and orange). Below is silt with gravels, moist, very stiff.	
715									@ 19' - oxidation banding, crushed rock clasts, white mineral	
	20			R-2	16	124.6	8.4	SM	@ 20' - Silty SAND with gravel: yellowish light brown, trace clay, moist, small clasts (<1"), iron oxide	
710										
			@24' - GB: N5E, 35E						@ 24' - Qls remnant bedding attitude, thin pinched clay	
	25		@25' - RS N15E, 27E						@ 25' - Rupture surface attitude - CLAY: very thin brown clay $\frac{1}{8}$" thick with slicken lines down dip, moist, soft, internal rupture surface	
			@26' - RS: N10E, 20E	Grab1					@ 26' - Rupture surface attitude, 1" thick moist soft brown clay. Grab sample taken	AL
705			@29' - RS: N65W, 3 to 5N						@ 29' - Basal rupture surface attitude, very thin gray clay, soft, moist, continuous, slightly undulatory	
									@ 29' - 48' <u>Quaternary Older Alluvium (Qoa)</u> Light brown to light yellowish brown Clay to Sand with gravels, moist, dense, varies	

LGC Geotechnical, Inc.

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF THE ACTUAL CONDITIONS ENCOUNTERED.

SAMPLE TYPES:

B	BULK SAMPLE
R	RING SAMPLE
G	GRAB SAMPLE

TEST TYPES:

DS	DIRECT SHEAR
MD	MAXIMUM DENSITY
SA	SIEVE ANALYSIS
S&H	SIEVE AND HYDROMETER
EI	EXPANSION INDEX
CN	CONSOLIDATION
CR	CORROSION
AL	ATTERBERG LIMITS
CO	COLLAPSE/SWELL
RV	R-VALUE

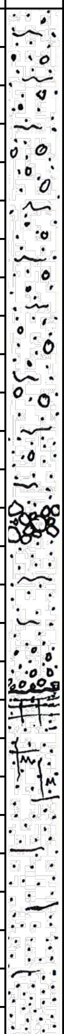
Last Edited: 2/27/2020

Geotechnical Boring Log B-5

Date : 1/20/2020	Page 2 of 3	**Drilling Company :**	Roy Brothers
Project Name :	Shady View	**Type of Rig :**	LoDril
Project Number :	18117-01	**Drop :** 12"	**Hole Diameter :** 24"
Elevation of Top of Hole :	~ 732 ' MSL	**Drive Weight :**	0' - 15' = 1767 lbs 15' - 30' = 1182 lbs 30' - 45' = 757 lbs 45' - 60' = 489 lbs
Hole Location :	See Geotechnical Map		

Logged by MJG/KTM

Sampled by MJG/KTM



Elevation (ft)	Depth (ft)	Graphic Log	Attitudes	Sample Number	Blow Count	Dry Density(pcf)	Moisture (%)	USCS Symbol	DESCRIPTION	Type of Test
	30			R-3	15	115.1	13.1	CL	@ 30' - CLAY with Gravels: light yellowish brown, slightly moist too moist, very stiff, rolls slightly, low to medium plasticity, well indurated	
700										
	35								@ 35' - Fine Sand with SILT and Gravels: light brown, moist	
695										
	40			R-4	18	105.9	7.3	SM	@ 40' - SAND to Silty SAND with gravels: yellowish brown to light brown, moist, moderately dense	
690									@ 43' - Rocky layer, concentration of gravel and cobbles ~1' thick	
	45									
685									**@ 48' to T.D. - <u>Possible Tertiary Puente Formation Sycamore Canyon Member (Tpsc)</u>** Paleosol, 4" thick ancient soil horizon, rectilinear weathering, sandy clay. Below is massive, lacks structure, weakly cemented (or well-indurated)	
	50			R-5	20	109.5	14.9		@ 50' - Silty SANDSTONE with trace clay: yellowish brown, moist, very dense, trace manganese oxide, root casts	
680										
	55								@ 55' - Increase in sand content	
675									@ 57' - End visual log	

LGC Geotechnical, Inc.

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF THE ACTUAL CONDITIONS ENCOUNTERED.

SAMPLE TYPES:

B	BULK SAMPLE
R	RING SAMPLE
G	GRAB SAMPLE

TEST TYPES:

DS	DIRECT SHEAR
MD	MAXIMUM DENSITY
SA	SIEVE ANALYSIS
S&H	SIEVE AND HYDROMETER
EI	EXPANSION INDEX
CN	CONSOLIDATION
CR	CORROSION
AL	ATTERBERG LIMITS
CO	COLLAPSE/SWELL
RV	R-VALUE

Geotechnical Boring Log B-5

Date : 1/20/2020	Page 3 of 3	**Drilling Company :**	Roy Brothers
Project Name : Shady View		**Type of Rig :**	LoDril
Project Number : 18117-01		**Drop :** 12"	**Hole Diameter :** 24"
Elevation of Top of Hole : ~ 732 ' MSL		**Drive Weight :**	0' - 15' = 1767 lbs 15' - 30' = 1182 lbs 30' - 45' = 757 lbs 45' - 60' = 489 lbs
Hole Location : See Geotechnical Map			

Logged by MJG/KTM

Sampled by MJG/KTM

Elevation (ft)	Depth (ft)	Graphic Log	Attitudes	Sample Number		Blow Count	Dry Density(pcf)	Moisture (%)	USCS Symbol	DESCRIPTION	Type of Test
	60			R-6		20	100.6	10.4	ML	@ 60' - Sandy SILTSTONE with Clay - Reddish brown red, oxidized, very stiff, moist, some clasts	
670											
	65									**Total Depth = 60'** **No Ground Water Encountered** **Backfilled with Cuttings on 1/20/2020**	
665											
	70										
660											
	75										
655											
	80										
650											
	85										
645											

Geotechnical, Inc.

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF THE ACTUAL CONDITIONS ENCOUNTERED.

SAMPLE TYPES:
B BULK SAMPLE
R RING SAMPLE
G GRAB SAMPLE

TEST TYPES:
DS DIRECT SHEAR
MD MAXIMUM DENSITY
SA SIEVE ANALYSIS
S&H SIEVE AND HYDROMETER
EI EXPANSION INDEX
CN CONSOLIDATION
CR CORROSION
AL ATTERBERG LIMITS
CO COLLAPSE/SWELL
RV R-VALUE

Geotechnical Boring Log B-6

Date : 1/21/2020	Page 1 of 3	**Drilling Company :**	Roy Brothers
Project Name :	Shady View	**Type of Rig :**	LoDril
Project Number :	18117-01	**Drop :** 12"	**Hole Diameter :** 24"
Elevation of Top of Hole :	~ 709 ' MSL	**Drive Weight :**	0' - 15' = 1767 lbs 15' - 30' = 1182 lbs 30' - 45' = 757 lbs 45' - 60' = 489 lbs
Hole Location :	See Geotechnical Map		

Logged by MJG/KTM

Sampled by MJG/KTM

Elevation (ft)	Depth (ft)	Attitudes	Sample Number	Blow Count	Dry Density(pcf)	Moisture (%)	USCS Symbol	DESCRIPTION	Type of Test
	0							**@ 0' to 24' - <u>Quaternary Landslide (Qls)</u>**	
								@ 0' - Vegetation, dark brown moist sandy clay, topsoil	
705								@ 3' - Transition to light yellowish brown sand with cobbles, slightly moist, dense, brecciated/angular clasts of granitic, meta, ash; iron oxide, white powdery mineralization	
	5	@6' - GB: N25W, 54 E						@ 6' - General Bedding attitude, possible remnant bedding within landslide block	
700								@ 8' - Intensely weathered clasts of white vitric sand, granitics, meta clasts, brecciated appearance. Dry, very dense intensely weathered	
	10		R-1	11	113.6	7.7	SM	@ 10' - Silty SAND: yellow to light brown, slightly moist, small rock fragments <1", some white mineralization, dense	
								@ 11' - Sandstone block, gray, 2' thick	
695									
	15							@ 17' - brown fine sand, dense	
690		@18' - RS: N35E, 42E						@ 18' - Rupture Surface attitude/internal shear, CLAY seam, gray, moist, soft. overlies brown fine sandstone, dense, manganese oxide	
	20	@20' - RS: 21W, 12 NE	R-2	10	99.1	26.1	CL	@ 20' - Sandy CLAY: slightly moist, stiff, light brown with gray mottle. Rupture surface, attitude, top of clayey zone, iron oxide, white mineralization. Internal rupture surface	
								@ 24' - Rupture surface attitude (basal), $\frac{1}{2}$" thick brown, moist, soft, planar	
685		@24' RS: N35W, 19NE						**@ 24' to 43' - <u>Quaternary Older Alluvium (Qoa)</u>**	
	25							Light reddish brown, clayey silt to sandy clay with scattered gravels, moist, very stiff, well indurated, extremely weathered	
680								@ 29' - Buried Paleosol: dark brown, rounded pebbles in clayey matrix, clasts of highly weathered granite	

LGC Geotechnical, Inc.

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B	BULK SAMPLE
R	RING SAMPLE
G	GRAB SAMPLE

TEST TYPES:

DS	DIRECT SHEAR
MD	MAXIMUM DENSITY
SA	SIEVE ANALYSIS
S&H	SIEVE AND HYDROMETER
EI	EXPANSION INDEX
CN	CONSOLIDATION
CR	CORROSION
AL	ATTERBERG LIMITS
CO	COLLAPSE/SWELL
RV	R-VALUE

Last Edited: 2/27/2020

Geotechnical Boring Log B-6

Date : 1/21/2020	Page 2 of 3	**Drilling Company :**	Roy Brothers
Project Name :	Shady View	**Type of Rig :**	LoDril
Project Number :	18117-01	**Drop :** 12"	**Hole Diameter :** 24"
Elevation of Top of Hole :	~ 709 ' MSL	**Drive Weight :**	0' - 15' = 1767 lbs 15' - 30' = 1182 lbs 30' - 45' = 757 lbs 45' - 60' = 489 lbs
Hole Location :	See Geotechnical Map		

Logged by MJG/KTM

Sampled by MJG/KTM

Elevation (ft)	Depth (ft)	Attitudes	Sample Number	Blow Count	Dry Density(pcf)	Moisture (%)	USCS Symbol	DESCRIPTION	Type of Test
	30		R-3	16	92.8	13.9	SC	@ 30' - Clayey SAND: dark brown to rusty orange, slightly moist to moist, very stiff, iron oxide	DS
675	35								
			B-1						
								@ 38' - Continuous layer of gravel, small clasts	
670									
	40		R-4	17	111.7	16.5	SC	@ 40' - Clayey SAND with pebbles: brown, moist, dense/very stiff small rock fragments (<1")	
								@ 43' to TD - <u>Tertiary Puente Formation Sycamore Canyon Member (Tpsc)</u> Light brown and white/gray mottled, sandy SILTSTONE to clayey SILTSTONE, very stiff, moist, iron oxide	
665	45								
								@ 48.5' - Attitude on possible general bedding, Weathered formational material, dense, very stiff, moist, orange brown mottled, iron oxide	
660		@48' - GB: N65E, 4NW							
	50		R-5	20	92.4	16.8	SC	@ 50' - Clayey SANDSTONE: light olive brown, moist, very stiff	DS
655								Increase hardness, decrease weathering	
	55							@ 55' - Gray siltstone, ~4" thick band of clayey siltstone, sub horizontal	
								@57' - End visual log	
650									

LGC Geotechnical, Inc.

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TEST TYPES:
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- SA SIEVE ANALYSIS
- S&H SIEVE AND HYDROMETER
- EI EXPANSION INDEX
- CN CONSOLIDATION
- CR CORROSION
- AL ATTERBERG LIMITS
- CO COLLAPSE/SWELL
- RV R-VALUE

Geotechnical Boring Log B-6

Date : 1/21/2020	Page 3 of 3	**Drilling Company :**	Roy Brothers
Project Name :	Shady View	**Type of Rig :**	LoDril
Project Number :	18117-01	**Drop :** 12"	**Hole Diameter :** 24"
Elevation of Top of Hole :	~ 709 ' MSL	**Drive Weight :**	0' - 15' = 1767 lbs 15' - 30' = 1182 lbs 30' - 45' = 757 lbs 45' - 60' = 489 lbs
Hole Location :	See Geotechnical Map		

Logged by MJG/KTM

Sampled by MJG/KTM

Elevation (ft)	Depth (ft)	Graphic Log	Attitudes	Sample Number		Blow Count	Dry Density(pcf)	Moisture (%)	USCS Symbol	DESCRIPTION	Type of Test
	60			R-6		21	94.2	18.9	SM	@ 60' - SANDSTONE with Clay, olive brown grades to gray, moist, dense	
										Total Depth = 60' **No Ground Water Encountered** **Backfilled with Cuttings on 1/21/2020**	
645	65										
640	70										
635	75										
630	80										
625	85										
620											

LGC Geotechnical, Inc.

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B	BULK SAMPLE
R	RING SAMPLE
G	GRAB SAMPLE

TEST TYPES:

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MD	MAXIMUM DENSITY
SA	SIEVE ANALYSIS
S&H	SIEVE AND HYDROMETER
EI	EXPANSION INDEX
CN	CONSOLIDATION
CR	CORROSION
AL	ATTERBERG LIMITS
CO	COLLAPSE/SWELL
RV	R-VALUE

Geotechnical Boring Log B-7

Date : 1/22/2020 Page 1 of 3	**Drilling Company :** Roy Brothers
Project Name : Shady View	**Type of Rig :** LoDril
Project Number : 18117-01	**Drop :** 12" **Hole Diameter :** 24"
Elevation of Top of Hole : ~ 702 ' MSL	**Drive Weight :** 0' - 15' = 1767 lbs 15' - 30' = 1182 lbs 30' - 45' = 757 lbs 45' - 60' = 489 lbs
Hole Location : See Geotechnical Map	

Logged by MJG/KTM

Sampled by MJG/KTM

Elevation (ft)	Depth (ft)	Graphic Log	Attitudes	Sample Number	Blow Count	Dry Density(pcf)	Moisture (%)	USCS Symbol	DESCRIPTION	Type of Test
	0								**@ 0' to 28' - <u>Quaternary Landslide (Qls)</u>**	
700									@ 0' - Topsoil: dark brown clayey silt with trace sand, scattered cobbles, gravels and rootlets, moist to very moist, soft to medium stiff	
									@ 2' - gradual contact with, Clayey SAND: yellowish brown, slightly moist, dense	
	5									
695										
									@ 8' - Gypsum, mottled light brown to yellow brown, abundant gravel and some cobbles	
	10			R-1	9	97.4	5.6	SM	@ 10' - Silty SAND: yellowish brown, slightly moist, moderately dense, gravel, ~1" clasts	
690										
									@ 13' - Rootlets and gypsum	
			@14' - C: N83E, 30S						@ 14' - Undulatory contact attitude, below is ~2" thick dark brown dry silty sand, slightly moist, dense, scattered gravel	
	15									
685			@17' - Sh: N10E, 18SE						@ 16.5' - CLAY: gypsum, manganese oxide, sheared, chaotic @ 17' - Shear attitude, lined with thin olive gray clay in vague but continuous zone, 6" wide with white mineral, partially cemented @ 17.5' - topsoil, dark brown sandy clay with gravel, moist, very stiff, grades to material below	
	20			R-2	12	113.5	10.6	SC	@ 20' - Clayey SAND with gravel: yellow with brown mottle, moist, dense	
680										
									@ 24' - Mangonese oxide stringers	
	25									
675									@ 28' - Rupture surface attitude, gray clay 1/2" thick (varies) slightly stiff, moist, rocks just above. Grab sample taken	TS AL
			@28' - RS: N45W, 15NE	Grab1					**@ 28' to T.D. - <u>Quaternary Older Alluvium (Qoa)</u>** Silty SAND with cobbles, yellowish brown to light brown, slightly moist, moderately dense to dense. cobbles are subrounded, white mineral	

Geotechnical, Inc.

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TEST TYPES:

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MD	MAXIMUM DENSITY
SA	SIEVE ANALYSIS
S&H	SIEVE AND HYDROMETER
EI	EXPANSION INDEX
CN	CONSOLIDATION
CR	CORROSION
AL	ATTERBERG LIMITS
CO	COLLAPSE/SWELL
TS	TORSIONAL SHEAR

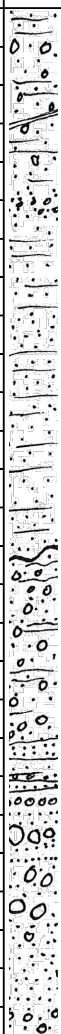
Last Edited: 2/27/2020

Geotechnical Boring Log B-7

Date :	1/22/2020	Page 2 of 3	**Drilling Company :** Roy Brothers
Project Name :	Shady View		**Type of Rig :** LoDril
Project Number :	18117-01		**Drop :** 12" **Hole Diameter :** 24"
Elevation of Top of Hole :	~ 702 ' MSL		**Drive Weight :** 0' - 15' = 1767 lbs 15' - 30' = 1182 lbs 30' - 45' = 757 lbs 45' - 60' = 489 lbs
Hole Location :	See Geotechnical Map		

Logged by MJG/KTM

Sampled by MJG/KTM



Elevation (ft)	Depth (ft)	Graphic Log	Attitudes	Sample Number	Blow Count	Dry Density(pcf)	Moisture (%)	USCS Symbol	DESCRIPTION	Type of Test
	30			R-3	15	119.1	9.6	SC	@ 30' - Clayey SAND with Gravel: light yellowish brown, slightly moist, dense	
670										
			@33' - Sh: N55E, 9NW						@ 33' - Faint internal shear attitude, <1" thick	
	35								@ 35' - Lens of sand, rounded to subrounded <1" clasts	
665										
	40			R-4	20	108.2	10.4	CL	@ 40' - Sandy CLAY: dark brown and yellow, moist, very stiff to slightly hard	
660										
									@ 43' - Brown, increase clay, increase in density	
	45								@ 45' - Undulatory contact between Clayey SAND and SAND with Clay and Gravels oxidized at contact, some angular clasts	
655										
	50			R-5	24	103.0	5.3	SM	@ 50' - Silty SAND: dark yellow, moist, dense. fine sand, slightly moist, dense, horizontal, 2" thick laminated deposit. Below is Sandy Gravel with faint sand lenses, friable, few cobbles, granitics, rounded	
650										
	55									
									@ 57' - End visual log	
645										

LGC Geotechnical, Inc.

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Geotechnical Boring Log B-7

Date : 1/22/2020	Page 3 of 3	**Drilling Company :**	Roy Brothers
Project Name :	Shady View	**Type of Rig :**	LoDril
Project Number :	18117-01	**Drop :** 12"	**Hole Diameter :** 24"
Elevation of Top of Hole :	~ 702 ' MSL	**Drive Weight :**	0' - 15' = 1767 lbs 15' - 30' = 1182 lbs 30' - 45' = 757 lbs 45' - 60' = 489 lbs
Hole Location :	See Geotechnical Map		

Logged by MJG/KTM

Sampled by MJG/KTM

Elevation (ft)	Depth (ft)	Graphic Log	Attitudes	Sample Number	Blow Count	Dry Density(pcf)	Moisture (%)	USCS Symbol	DESCRIPTION	Type of Test
	60			R-6	35	112.3	14.5	SM	@ 60' - Silty SAND with trace clay and rounded gravels, moist, dense, ~1" clasts	
640									**Total Depth = 60'** **No Ground Water Encountered** **Backfilled with Cuttings on 1/22/2020**	
	65									
635										
	70									
630										
	75									
625										
	80									
620										
	85									
615										

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- RV R-VALUE

Appendix C
Earth Consultants, Inc. (ECI) Report

ECI Project No. 3423.02
March 22, 2020

Earth Consultants International

To: **LGC GEOTECHNICAL, Inc.**
131 Calle Iglesia, Suite 200
San Clemente, California 92672

Attention: **Ms. Katie Maes,** Project Geologist

Subject: **Soil Stratigraphic Analyses as Part of a Fault Study Conducted in the Shady View Property off Mystic Canyon Road, in the City of Chino Hills**
LGC Geotechnical Project No. 18117-01 (for Trumark)

Dear Katie,

At your request, we conducted a soil-stratigraphic study to estimate the age of the soils exposed in seven trenches that your firm excavated and logged in the Shady View property referenced above. Soil age estimates were made for soil profiles described in the first three trenches you excavated onsite. These age estimates in turn provide information on the time of last displacement for the faults exposed therein. The area investigated is within the Alquist-Priolo Earthquake Fault Zone for the Chino fault (Treiman, 2002; CGS, 2003).

This letter report describes our methodology, findings and conclusions regarding the age of the deposits that we described, and our opinions regarding the recency of activity of the faults encountered.

Thank you for the opportunity to assist you with this project. Should you have any questions regarding our report, please do not hesitate to contact the undersigned.

Respectfully submitted for
Earth Consultants International, Inc.

Tania Gonzalez, CEG 1859
Vice-President/ Senior Project Consultant

ECI Project No. 3423.02
March 22, 2020

Soil Stratigraphic Analyses as Part of a Fault Study Conducted in the Shady View Property off Mystic Canyon Road, in the City of Chino Hills

INTRODUCTION

Per your request, we have completed a soil stratigraphic study to estimate the age soils developed in alluvial and colluvial deposits exposed in seven fault trenches that you excavated on the above-referenced property within the Alquist-Priolo Earthquake Fault Zone for the Chino fault (CGS, 2003).

The main objectives of our study were to:

1. Review the trench exposures to identify the geologic materials exposed therein and describe soil profiles representative of the degree of soil development characteristic of the various generations of alluvium and colluvium mantling the bedrock in the study area.
2. Use these soil descriptions to estimate the age of the various generations of sediments exposed in these trenches based on their degree of soil development.
3. Use the soil age estimates of the soils that extend unbroken across the faults observed in the trenches to evaluate the minimum age of last displacement for the faults. Based on these observations we provide input as to whether the faults observed are Holocene-active or not.

SCOPE OF WORK

Specific tasks that we completed for this study include:

- Conducted a total of four site visits to review seven trench exposures; measure, describe and collect soil samples; provide input on the environment of deposition for the various geological units observed; and opine on the activity or inactivity of the faults exposed therein.
- Described four soil profiles, one in trench LGC-FT-1 at about station 3+25; one in trench LGC-FT- 2 at station 3+99; and two in trench LGC-FT-3, one at station 0+25 and one at station 0+90. All soil profiles were made on the south walls of the trenches.
- Compared the soil descriptions made at the site with those of soils from other areas in southern California that developed in similar parent material. Specifically, we calculated soil development indices for the soil horizons we described, and compared them to those of other soils that have been dated using absolute dating methods. This allowed us to estimate the age of the soils, and therefore, the minimum age of the sediments exposed in the trenches, with emphasis on the alluvial and colluvial sediments overlying the bedrock and, in some areas, the faults exposed.
- Prepared this report and supporting appendix documenting the analyses completed as part of this study.

BACKGROUND and METHODOLOGY

The term soil as used herein refers to a natural body of mineral and/or organic material consisting of layers (or horizons) that are different from the underlying geologic material in their "morphological, physical, chemical and mineralogical properties and their biological characteristics" (Birkeland, 1984). These differences are the result of weathering and the effects of five main soil-forming factors: parent material, climate, slope or topography, organisms, and time (Jenny, 1941). Time is an important factor because the longer a geologic deposit is exposed to the effects of weathering and soil formation, the better developed the soil characteristics become. We take advantage of this factor when using soils to estimate the age of alluvial and colluvial deposits.

Soil development occurs primarily on stable geomorphic surfaces (a stable surface is one that is not being impacted by deposition or erosion). Soil development typically begins as soon as a surface stops being eroded or deposited on. Therefore, in some environments, such an alluvial plain or alluvial fan, it is common to find several weakly to moderately developed buried soils that rest one upon the other, sometimes separated by unaltered sediments (the parent material). The soils represent periods of subaerial weathering and soil formation that occurred in between periods of alluvial erosion and deposition. The age of the underlying primary deposits is estimated by summing the age of the individual overlying buried soils, recognizing that the soil age estimates will provide a minimum age for the parent material, as the estimated ages do not account for the length of time it took for the sediments to be deposited. Furthermore, if portions of the soil horizons, or even entire soil horizons, have been removed (truncated) by erosion, the age estimates will not capture that erosional period of time, further limiting the reliability of soils as indicators of the true age of the geological deposits that the soils formed into. Nevertheless, if these limitations are recognized and taken into account, soils developed in fluvial or alluvial fan environments can provide useful information. In areas where suitable datable materials such as charcoal are not available, or cannot be trusted due to intense bioturbation, mixing, or due to contamination from other sources, soil age estimations are particularly useful.

We described the soils reported herein according to the characteristics and nomenclature set forth by the Soil Survey Staff (1975, 1992), Birkeland (1984, 1999), and the National Soil Survey Center (2012). Characteristics that we recorded include: 1) texture or grain-size distribution, 2) structure (whether the soil mass breaks into distinctive peds, or is single-grained), 3) the amount, distribution and thickness of translocated clay forming films or stains on the soil ped faces and clasts, in pores, between sand grains (called bridges), around clasts, and in clast pockets, 4) the looseness or induration of the soil peds when dry and moist, and 5) the stickiness and plasticity of the wet soil. Colors of the soil matrix and clay films in both the dry and moist states were recorded using a Munsell Soil Color Chart. We also described the approximate percent of gravel, its composition, size, degree of roundness, and weathering stages using McFadden et al.’s (1982) criteria. Finally, we noted the presence of calcium carbonate, and manganese oxide or iron oxide staining. We used these characteristics to evaluate the minimum age of the alluvial and colluvial deposits that typically overlie bedrock of the Puente Formation. The complete soil profile descriptions are provided at the end of this report, in Appendix A.

Soil development index (SDI) values were calculated for the soils described based on their field characteristics using a modified version of the Harden (1982) method. We also calculated the soil's Maximum Horizon Index (MHI) using Ponti's (1985) methodology. Where appropriate, we normalized the soils to a constant depth of 200 cm for the SDI analyses. Both SDI and MHI values have been shown to be useful relative indicators of age when comparing soils developed in similar parent materials under similar climatic conditions (Harden, 1982; Rockwell et al., 1984; Rockwell et al., 1990; Bornyasz and Rockwell, 1997). Minimum, average and maximum age estimates for the deposits were made by comparing the SDI and MHI values obtained at the site with those of dated regional soils developed under similar conditions. The minimum and maximum values reported here represent the 95 percent confidence interval around the estimated mean of the data set used in Dolan et al. (1997).

FINDINGS

Combined, the seven trenches excavated onsite span the area between the eastern boundary of the Alquist-Priolo Earthquake Fault Zone (APEFZ) and the main trace of the Chino fault as shown on the APEFZ map (CGS, 2003), and provide coverage of the proposed buildable areas within the APEFZ across the site, from north to south. This study complements and extends the area of investigation eastward from the work previously conducted by Madden and Yeats (2008). Trenches LGC-FT-1 and LGC-FT-2 both consisted of east-northeast to northeast-trending excavations emplaced across the two main ridges in the central portion of the site. Slightly overlapping trenches LGC-FT-3 and LGC-FT-4 were emplaced just south of where the APEFZ makes a jog to the west near the northern end of the site. These were slightly overlapping excavations; the first was oriented northeasterly, and the second, to the west, trended northwesterly. LGC-FT-4 was excavated to intercept possible faults projecting northward from the western end of trench LGC-FT-2, where several shallow-dipping fault petals were observed, and to evaluate the western end of the zone where residential development is being considered. Trenches LGC-FT-6 and LGC-FT-7 extended the area of investigation farther west, across the area where an above-ground petroleum storage tank is proposed. Finally, trench LGC-FT-5 was excavated to confirm that no active faults extend through the lots proposed in the APEFZ near the project's southern boundary.

The trenches typically exposed bedrock assigned to the Sycamore Canyon member of the Puente Formation overlain by older alluvial deposits, colluvial/mudflow deposits, and soils developed in these units. Some sections of trench exposed only alluvial and colluvial deposits to the bottom, generally a depth of at least 10 feet (>3 meters). The colluvial/mudflow deposits are typically massive, whereas the alluvial deposits are poorly to well-bedded or laminated. Soils developed in both of these geologic units were described as part of our analysis. The bedrock consists of medium- to thick-bedded sandstone with siltstone and conglomerate interbeds. The conglomeratic beds contain distinctive rounded granitic clasts. Clasts eroded from the bedrock layers have been reworked and form a significant component of the older alluvial and colluvial deposits capping the bedrock, often forming stonelines at the boundary between depositional events. These clasts are also found at the surface, locally armoring the hillslopes. Representative soils developed in these geological deposits are described in the sub-sections below. Complete soil descriptions for the profiles are included as Appendix A.

In the area trenched, bedding in the Puente Formation is steeply dipping to vertical, and locally overturned. This was an unexpected finding, as cross-sections through the area, based on limited oil well data, show shallow-dipping to horizontal bedding east of the Chino fault (e.g. cross-section E-E' in Madden and Yeats, 2008). Interestingly, the trenches excavated by Madden farther upslope and across the presumed active fault zone exposed more shallowly dipping bedrock. These observations suggest that there is another structure, although not necessarily active, farther east, possibly near the boundary between the Chino Basin and the foothills of the Puente Hills, beyond the eastern limits of the subject site.

Soil Profile from LGC-FT-1 at Station 3+25
In the area where this first soil profile was described, the trench exposed stream channel sediments associated with an old, elevated alluvial terrace; the soils described developed in this unit. In this section of the trench the alluvial deposits extended to the bottom of the trench, for a minimum thickness of 3.25 meters (10.66 feet), and three separate soils (one at the current ground surface and two buried soils) were recognized therein.

At the surface is a thin A soil horizon that appears to be developing partly on a colluvial deposit (slopewash) and partly forming at the expense of the underlying, relict soil through bioturbation and accumulation of organic matter. The former is indicated by its loam texture which is unlike the clay of the underlying soil, whereas the latter is indicated by the red (2.5YR 4/6) fragments of soil mixed in with the darker, more organic-rich section. The soil peds also have remnant clay films on ped faces and in pores that are interpreted to be inherited from the argillic soil horizon that they are forming into (essentially the parent material for the actively forming A horizon).

The underlying argillic (and first buried) soil consists of clay with 5YR and 7.5YR hues, strong very coarse angular blocky to coarse prismatic structure, and many to continuous moderately thick clay films on ped faces, bridging grains and lining pores. The scattered cobbles observed within the unit displayed weathering stages II to III[1] of McFadden (1982).

The underlying, second buried soil is characterized by an argillic soil horizon that was modified by infiltrating water, removing some of the fine-grained clay, so that the horizon has characteristics of both an argillic (Bt) and elluvial (E) soil horizon. It is also possible that this is a buried A soil horizon equivalent to the one now at the surface, but with all organic matter oxidized so that it is no longer dark in color. Characteristics of this horizon include loam texture, 7.5YR hues with 5YR mottles, moderate angular blocky structure, continuous clay films bridging grains, common thin clay films on ped faces, and carbonate filaments along root casts.

The Bt/E horizon is underlain by an argillic (2Bt3) horizon at least 65 cm (25.6 inches) thick with 7.5YR to 5YR hues, sandy clay loam texture, common to continuous clay films, and grussified cobbles to weathering stages III of McFadden (1982). The underlying horizon has clay-rich lamellae (referred to as Bt lams or beta layers) that are thought to represent the effective depth of infiltrating water when this soil profile was at or near the surface, within the depth affected by soil-forming processes. The horizon has 7.5YR hues. The matrix consists of sandy loam with no soil structure

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[1] **Weathering Stages:**

Stage I: Unweathered bedrock, rings sharply to blow of hammer. Mafic rocks exhibiting stage I weathering characteristics are estimated to have been exposed to weathering agents for less than about 1,000 years. Leucocratic (light-colored igneous rocks) exhibiting stage I characteristics are thought to have been exposed to weathering agents for less than about 4,000 years.

Stage II: Slightly weathered bedrock, incipient to moderate surface pitting, fractured, with oxidation rinds greater than 1-2 mm in thickness, yields moderate ring to blow of hammer. Stage II mafic rocks have been exposed to weathering agents for about 4,000 years, whereas stage II leucocratic rocks could have been weathering for as much as about 10,000 years.

Stage III: Substantially weathered bedrock, surface highly pitted, strongly fractured, mafic minerals and feldspars may be strongly altered, clasts can be broken with difficulty by hand, dull sound to blow of hammer. Stage III mafic rocks are estimated to have been exposed to weathering agents for 10,000 to 75,000 years; stage III leucocratic rocks could have been weathering for as much as 400,000 years.

Stage IV: Very strongly weathered bedrock, easily disaggregated by hand into grus; very dull sound when struck with hammer. Stage IV mafic rocks have weathered for more than about 75,000 years; stage IV leucocratic rocks have weathered for more than 400,000 years.

(single-grained), and the lamellae consist of sandy loam to sandy clay loam with weak subangular·blocky structure, few to many clay films on ped faces, bridging grains, and lining pores, and manganese oxide stains. The base of the trench exposed oxidized alluvial sediments (referred to as a 3Cox horizon) that consist of sandy clay loam to sandy clay with 7.5YR hues, massive breaking to strong medium angular blocky soil structure, common to continuous thin clay films on ped faces, lining pores, and coating clast pockets, and manganese oxide stains.

Soil Profile LGC-FT-2 at Station 3+99

The soil profile described in trench FT-2 developed in a sequence of colluvial deposits that overlie bedrock of the Puente Formation. The overall section described is 362 cm (11.88 feet) thick, and includes one soil at the surface and two buried soils. The surface soil is defined by two A soil horizons (A1/A2), with the uppermost horizon consisting of silty clay loam locally armored by gravel and cobbles at the surface. The horizon has 10YR hues, and many roots, rootlets and abundant organics; the structure is weak fine subangular blocky breaking to moderate fine granular. The underlying A soil horizon is on its way to becoming a juvenile Bt (Btj) horizon, with slightly more clay than the unit above, as indicated by the few thin clay films on ped faces, stronger soil structure, and silty clay loam to silty clay texture. This horizon is extensively bioturbated.

The first buried soil in this profile, which was better exposed at station 3+75, consists of a 4.7-foot (143-cm-) thick sequence of argillic soil horizons. The uppermost of these (2Bt1) consists of silty clay to clay with strong medium prismatic breaking to strong fine to medium angular blocky soil structure, common to continuous clay films on ped faces, lining pores, bridging grains, and coating clast pockets. Although the soil matrix has 10YR colors, some of the mottles have 7.5YR hues. The second argillic (2Bt2) horizon consists of clay, 10YR hues in the matrix and clay films, moderate medium subangular blocky structure, and common to many thin to moderately thick clay films on ped faces, bridging grains, lining pores and coating clast pockets. The third argillic horizon (2Bt3) is texturally a silty clay loam to clay, with 10YR hues in the matrix and clay films, weak to moderate medium subangular blocky structure, and common to many thin to moderately thick clay films. The fourth argillic horizon (2Bt4) consists of silty clay loam, strong medium to coarse angular blocky structure, and many to continuous clay films on ped faces, bridging grains, and lining pores.

The third soil, and second buried soil observed at depth in this trench has a 3Bt5/4BC/4Cox sequence; the Bt horizon is an older mudflow deposit overlying pedogenically altered (BC) and oxidized (Cox) bedrock. Its overlying horizons were removed and truncated by erosion prior to burial by the overlying mudflow deposits. Given these constraints, the age estimates provided in the next section for this soil significantly underestimate the amount of time that this lower mudflow deposit and underlying bedrock were exposed to soil-forming processes and, as a result, the overall age estimate for the entire soil section is likely less than the true age of the lower mudflow unit. The 3Bt5 horizon is texturally a fine-grained silty clay with few scattered, angular to rounded gravel exhibiting weathering to McFadden's (1982) I to III stages. Its origin as a mudflow deposit is indicated by the many pinhole-sized and larger pores, and scattered angular to rounded gravel. The 4BC horizon consists of silty clay with 10YR hues in the matrix and mottles, moderate medium prismatic breaking to moderate to strong angular blocky soil structure, and few to common thin clay films on ped faces. Many rootlets, pinhole porosity, and manganese oxide stains attest to this section having been exposed to near-surface processes of soil formation, but the few marine worm casts still visible indicate that the section was at the fringe of the effective depth of soil formation, and as such, was not completely altered so as to obscure these primary sedimentary features.

Soil Profile LGC-FT-3 at Station 0+25

This soil profile developed in a thick sequence of colluvial and alluvial sediments. Several individual alluvial and colluvial packages can still be discerned based on grain-size differences; these are indicated by the prefix in the horizon designations. The uppermost soil at and near the ground surface consists of a relatively thin A sol horizon over two argillic soil horizons (A/Bt1/Bt2). The A soil horizon is a silty clay loam to silty clay with 10YR hues, and moderate subangular blocky breaking to moderate to strong granular structure. The first Bt horizon is a silty clay with 10YR hues and 7.5YR mottles, moderate medium subangular blocky breaking to fine subangular blocky structure, and few to many thin to moderately thick clay films. The second argillic horizon consists of silty clay to clay, 10YR hues with 7.5YR worm or root casts, moderate medium prismatic breaking to moderate to strong fine subangular blocky structure, common to continuous predominantly moderately thick clay films, and common pores pinhole-sized to 4 mm in diameter.

The first buried soil (2Bt3) is an argillic horizon only 20 cm (7.87 inches) thick that consists of sandy clay to clay, 7.5YR colors of the matrix with 5YR mottles and 10YR worm or root casts, strong medium prismatic structure breaking to strong fine angular blocky structure, and common to many thin to moderately thick clay films on ped faces. Aphanitic clasts are weathered to Stage II, whereas phaneritic clasts are weathered to Stage III of McFadden (1982). The bottom contact of this horizon is defined by a stoneline.

The second buried soil (3Bt4) is an argillic horizon consisting of gravelly to cobbly sandy clay with 7.5YR hues for the matrix and 5YR hues for the clay films, strong coarse prismatic breaking to strong medium to coarse angular blocky soil structure, common to many thin to moderately thick clay films, and subangular to rounded clasts weathered to Stage III. The horizon has an abrupt wavy contact with the underlying third buried soil.

The third buried soil (4Bt5) is an argillic horizon consisting of clay with 7.5YR to 5YR hues, strong medium to coarse prismatic breaking to strong medium angular blocky structure, common to continuous moderately thick to thick clay films, and gravel-sized clasts weathering to Stages II to III. The matrix in this horizon is finer-grained than that of the horizon above. These characteristics indicate a very strongly developed soil.

The fourth buried soil (5Bt6/5Bt_{lam}1/6Bt_{lam}2/7Bt_{lam}3/8Bt_{lam}4/9Bt_{lam}5) developed in a sequence of fluvial deposits with well-defined bedding; the bedding is no longer apparent in the upper argillic horizon, but can be observed in the underlying Bt_{lam} horizons, where the lamellae developed along bedding. The upper argillic horizon texturally consists of silty clay to clay. The color of the matrix has 10YR hues, whereas the worm and/or root casts are filled with material with 7.5YR hues, indicating translocation of redder material from above. This horizon has strong coarse angular blocky structure, common to many thin to moderately thick clay films on ped faces, lining pores and bridging grains, and calcium carbonate lining the root casts on ped faces. The matrix of this horizon is coarser-grained than that of the horizon above. The bottom contact of this horizon was not observed, as it occurred along a bench in the trench. The matrix of the underlying Bt_{lam}1 horizon consists of gravelly medium to coarse sand; the Bt lamellae are sandy loam. The matrix has 7.5YR hues, moderate fine subangular blocky structure breaking to single-grained, and no clay films. The lamellae have 7.5YR hues with 5YR to 2.5YR (significantly redder) mottles, moderate to strong medium angular blocky structure, few thin clay films on ped faces and many moderately thick clay films bridging grains.

The parent material of the lower Bt_{lam} horizon ($6Bt_{lam}2$) is interpreted as fine-grained overbank or mudflow deposits. Some degree of soil development is indicated by the presence of clay-rich lamellae. The matrix is a very fine sandy loam with 10YR to 7.5YR hues, massive breaking to single-grained structure, with many moderately thick clay films lining pores. The lamellae are sandy clay loam to sandy clay in texture, with 7.5YR, 5YR and 2.5YR hues, strong coarse to very coarse angular blocky structure, and many to continuous thin clay films on ped faces, bridging grains, and lining pores. The underlying $7Bt_{lam}3$ horizon is a coarse-grained alluvial package with distinct bedding that varies from mostly clast-supported layers consisting predominantly of cobbles and gravel, to sandier, matrix-supported-sections. The Bt lamellae and zones are irregular in width, location and spacing. The bottom contact of this unit is defined in places by a stoneline; the contact is clear and irregular in topography, with the underlying unit locally carved out before this high-energy deposit was laid down. The matrix has 7.5YR colors, is single-grained, and has no clay films. The lamellae consist of silty clay and loamy sand layers with 10YR to 7.5YR hues and 5YR clay films, weak fine subangular blocky breaking to single-grained structure, and few to many thin clay films on ped faces, lining pores and bridging grains.

The horizon below, labeled $8Bt_{lam}4$, is a matrix-supported mudflow deposit with many scattered gravels and cobbles. The pedogenically altered zones and lamellae are typically 4 to 8 cm (1.5 to 3 inches) thick. The matrix is a loamy sand with 10YR hues, massive structure, and common to many thin 7.5YR clay films lining pores. The clay-enriched zones and lamellae consist of 7.5YR sandy clay loam, massive structure, with common to many thin to moderately thick 5YR clay films lining pores and bridging grains.

The deepest horizon ($9Bt_{lam}5$) exposed in the trench is a fluvial deposit consisting mostly of sand and fine gravel with clay-enriched lamellae 2 to 6 cm (0.7 to 2.3 inches) thick. The matrix is a gravelly fine to coarse sand, 10YR to 7.5YR in color, single-grained, and with no clay films. The lamellae consist of loamy sand with 7.5YR and 5YR colors, weak fine to medium subangular blocky structure breaking to single-grained, and common thin clay films bridging grains and lining pores.

It is possible, and most likely, that all of the Bt_{lam} horizons in the bottom part of the trench developed as part of the same soil profile, before the fourth buried soil defined by the 5Bt6 horizon developed fully. The thickness of the entire section containing lamellae (essentially 2 meters, or 6 feet), if it indeed formed at the same time, indicates that this now-buried soil formed during a geologic period considerably wetter than the Holocene, as the depth of the lamellae reflect the depth of the wetting front. Essentially, the pedogenic layers referred to as lamellae or Bt_{lam} layers are interpreted to have formed where the clay from upper horizons translocated by water infiltrating through the various distinct sedimentary packages came out of solution, typically along grain-size boundaries.

Soil Profile LGC-FT-3 at Station 0+90

The last soil profile described for this study developed in older alluvium overlying slightly weathered and pedogenically altered bedrock of the Puente Formation. Four distinct soils developed in alluvium were recognized, as described further next. The first soil is characterized by an A1/A2/Bt1/Bt2 sequence. The uppermost, thin A soil horizon consists of silty clay loam to silty clay with 10YR colors, moderate medium subangular blocky breaking to moderate fine granular structure, and abundant organics, roots and pinhole-sized pores. The A horizon underneath has a silty clay texture, 10YR colors, moderate to medium to coarse subangular blocky breaking to strong fine granular structure, and common thin clay films on ped faces. This horizon also had many roots, and was extensively bioturbated, with many earthworm casts and roots. Small bone fragments, most likely associated with a krotovina, were observed in the area where we collected the soil samples. The silty clay texture and thin clay films on ped faces indicate that this layer, although labeled A2, has B horizon characteristics, suggesting that illuviation of clay from the upper A is slowly transforming this second layer into an argillic horizon.

The upper argillic soil horizon (Bt1) consists of clay with 10YR colors in the matrix and clay films, 7.5YR mottles, strong medium angular blocky structure, and common to continuous moderately thick to thin clay films on ped faces, bridging grains, and lining pores. Scattered angular to subrounded gravels and cobbles are weathered to Stages II to III of McFadden (1982). The lower argillic horizon (Bt2) also consists of clay, with 10YR colors, moderate coarse prismatic breaking to moderate medium to coarse angular blocky structure, many to continuous moderately thick to thick clay films on ped faces, bridging grains, and lining pores. This horizon has more gravel and cobbles than the horizon above; the angular to rounded clasts vary in their degree of weathering, with McFadden's (1982) stages I, II and III represented.

The underlying buried soils consist of three distinct truncated argillic soil horizons with calcium carbonate filaments and coatings. The first argillic horizon with pedogenic carbonate accumulation (labeled 2Btk1) consists of clay with 7.5YR colors in the matrix, and 10YR-colored clay films, suggesting translocation of clay from the overlying soil that is overprinting the redder color of this horizon. Other characteristics of this remnant soil include strong coarse angular blocky structure, many to continuous moderately thick to thick clay films on ped faces, lining pores and bridging grains, and few to common thin calcium carbonate filaments on the ped faces. The second buried argillic soil (3Btk2), which developed in a deposit originally significantly coarser-grained than the horizon above, is now also a clay, indicating a substantial amount of exposure to soil-forming processes. Colors of this horizon have a 10YR hue, and its structure is strong coarse angular blocky. This soil has many to continuously thick to moderately thick clay films on ped faces, lining pores, and bridging grains, and the scattered rounded cobbles in it have thick calcium carbonate coatings on them. Moderately thick calcium carbonate coatings were also observed on the ped faces.

The deepest truncated soil developed in older alluvial sediments (horizon 4Btk3) consists of clay with 10YR hues, strong very coarse angular blocky breaking to strong medium angular blocky structure, and many to continuous moderately thick to thick calcium carbonate coatings on the ped faces and lining pores, obscuring any clay films that may have been present. This horizon is sitting on slightly weathered fine-grained sandstone assigned to the Puente Formation (horizon 5C). The sandstone has been tilted to near-vertical as expressed by the bedding; its soil structure is massive. Colors of this unit are in the 7.5YR range with 10YR mottles. No clay films were observed.

DISCUSSION

Soil Age Estimates and Age of Faulting

In accordance with the methodology described by Harden (1983) and Harden and Taylor (1983), the characteristics of the soils are assigned numerical values that are then used to calculate the soils' degree of development. The characteristics of the parent material for each soil, either as observed in the trenches or assumed based on the characteristics of the developed soils, are also assigned numerical values. The characteristics of the parent material are then “subtracted” from the characteristics of the soil to develop an empirical estimate of the length of time that each geologic deposit was subjected to the effects of weathering and soil formation. For the profile in FT-1, we used the characteristics of the matrix in the Bt_{lam} horizon for the parent material (sandy loam with

7.5YR colors, single-grained, loose when dry and moist, non-sticky to slightly sticky and non-plastic when wet, no clay films). For the profile in FT-2, where many of the horizons had silty clay loam to silty clay textures, we used as the parent material a silt with 2.5Y to 10YR colors, massive soil structure, soft when dry, friable when moist, slightly sticky and slightly plastic when wet, and no clay films. We used the characteristics of the 3Cox and 5C horizons for the parent materials in trench FT-3 at stations 0+25 and 0+90, respectively. These are sands with 10YR colors, either single-grained or massive, and with no clay films. The sand in the 3Cox horizon was loose when dry and moist, and non-sticky and non-plastic when wet. The sand we used for the parent material at station 0+90 was hard when dry, very friable when moist, and non-sticky and non-plastic when wet.

As mentioned before, to obtain minimum age estimates for the soils described in the trenches we compared their Soil Development Index (SDI) and Mean Horizon Index (MHIs) values with the chronofunctions presented in Dolan et al. (1997). These chronofunctions are in turn based on the chronosequences of the Ventura Basin by Rockwell (1983) and Rockwell et al. (1985), the Merced Valley by Harden (1982), and the Cajon Pass by McFadden and Weldon (1987). The SDIs and MHIs that we used to estimate the age of each soil are listed on Table 1, together with the minimum, median and maximum age estimates provided by the chronofunctions. Each of the soil profiles analyzed are discussed further below in regards to their age and implications on the age of the faults observed nearby.

Soils in Trench LGC-FT-1 at Station 3+25

The soil profile described was developed in a thick sequence of older alluvium that incised into and stratigraphically capped, with an angular unconformity, tilted mudflow deposits and bedrock of the Puente Formation. Thus, the age of the older alluvium gives us a minimum age for the mudflow deposits and a minimum age for the faults exposed in the bedrock, as the alluvial sediments extend unbroken across these faults.

The profile is capped by an organic-rich, thin (5.1 inches; 13 cm) A soil horizon that we chose to separate (and analyze independently) from the underlying section because its lower contact is abrupt, suggesting an unconformity, and its texture is coarser than that of the underlying horizons. These observations suggest that this uppermost horizon is in part forming on a younger geologic deposit, possibly slopewash material, although some of its characteristics also suggest that it is developing at the expense of the underlying older soil. The regression curves indicate a median age for this soil, based on its characteristics, of about 21,000 years (average of the age estimates indicated by the MHI and SDI values; see Table 1). However, since many of these characteristics may be inherited, we prefer to use the minimum age estimate of 6,000 to 8,000 years. This is consistent with the interpretation that A soil horizons are modern to Holocene in age, as they are dynamic, constantly being reworked by bioturbation, and accumulating organic material in the form of plant matter that over time decomposes into humus. The dark color of this horizon indicates significant concentration of organic material in the form of humus, which in turn suggests that this soil is in a steady state condition (Birkeland, 1984, 1999).

The underlying relict (and truncated) argillic soil horizon (2Bt1) is strongly developed as indicated by its red colors (5YR and 7.5YR hues using the Munsell soil color notation), strong coarse prismatic to angular blocky structure, many to continuous clay films, and grussified state of its clasts. These properties are characteristic of a soil that has been exposed to soil-forming processes at the surface for many tens (to hundreds of) thousands of years. Although truncated (only a 1-foot-thick section of this horizon remains), the soil appears to have been originally thin, which suggests that it formed during a time period drier and hotter than our present-day climate. The SDI and MHI values calculated for this soil return median estimates of soil formation of between about 48,000 and 59,000 years, and maximum estimates of between about 143,000 and 165,000 years. Given the properties described before, the maximum values are preferred. Thus, this relict soil is estimated to be about 149,000 to 173,000 years old (this number is derived from adding the length of time of soil formation for the overlying A soil horizon to the estimates of the length of time this second soil was exposed to soil-forming processes at the surface prior to burial).

The underlying second buried soil has a 3Bt2/E/3Bt3/3Bt_{lam}/4Cox profile and is more than 9.1 feet (280 cm) thick. This paleosol has 7.5YR to 5YR colors, a sandy clay loam argillic soil horizon with common to continuous thin to moderately thick clay films on ped faces, and clasts weathered to stage III. The Bt_{lam} horizon alone is 70 cm (2.3 feet) thick. Unlike the first buried soil, the characteristics of the Bt and Bt_{lam} horizons suggest that this paleosol formed during a time period wetter than today that allowed clay to be translocated down the sedimentary profile to a significant depth rather than collecting in the overlying argillic horizon. As a result, the properties of this soil return relatively low SDI and MHI values, suggesting a less-well developed soil than the soil above, and shorter period of exposure to soil-forming processes. Specifically, the soil-age regressions yield an estimated length of formation at the surface for this soil of about 24,000 years (median) and 72,000 years (maximum). Given the red colors and clay films, we prefer the maximum estimate of 72,000 years. Adding this estimate to the estimated age for the overlying soils yields a total preferred age for the older alluvial deposits of between about 220,000 and 247,000 years.

The field observations of the older alluvium locally deeply incising into the underlying mudflow and bedrock deposits strongly suggest that these sediments were deposited during a period following significant channel incision, such as at the onset of an interglacial, when sea levels drop. The age estimates derived for this study are consistent with the deeper paleosol having formed during the interglacial correlative with marine isotope stage (MIS) 7 (MIS 7), dated to between 250,000 and 200,000 years ago. This age estimate correlates well with the ages for these older alluvial deposits previously proposed by other researchers. Specifically, Swan (1980, as referenced by Heath et al. 1982) suggested an age of 125,000 years, whereas Weber (1977) suggested an age between 50,000 and 500,000 years.

Given that soil-stratigraphic age estimates are typically minimum values because entire soil sections may be missing as a result of erosion, it is possible that these older alluvial deposits are in fact older. We check this possibility by correlating our observations of the depth and degree of soil development as likely indicators of the climate typical of when the soils formed to studies of Quaternary climate variability (Wendt et al., 2018). These investigators looked at water table fluctuations in a cave in southwestern Nevada, as recorded by variations in the type of calcite deposited in the cave, combined with an extensive dataset of U-Th dates obtained from the mammillary calcites deposited below the water table, to date water-table highstands and lowstands over the past 350,000 years. Their results indicate that water table highstands (i.e, wet periods) generally correspond to MIS 10, MIS 9d-8, MIS 7a-6, and MIS 5d-2, whereas water-table lowstands (i.e, dry periods) appeared to have occurred during MIS 9e, MIS 7e, MIS 7c, MIS 5e, and MIS 1. Thus, if we are correct that the deepest paleosol in this profile formed during a wetter-than-today climate, and the overlying paleosol formed in a drier period, it is possible that these soils formed during MIS 9d-8 and MIS 7e, respectively. This would indicate that the deepest older alluvial deposits are about 320,000 years old, and the overlying sediments with the better developed but thinner soil are about 240,000 years old.

The faults exposed in this trench are confined to the bedrock and thus pre-date the deposition of the older alluvial sediments discussed above.

Soils in Trench LGC-FT-2 at Station 3+99

This trench exposed a series of unfaulted older alluvial and colluvial (mudflow) deposits along most of its length. Nested channels incised into underlying sedimentary packages, stonelines at some of these contacts, significant angular unconformities between the upper and lower mudflow packages, and soil remnants indicate that these deposits represent several episodes of sedimentation, soil formation and erosion over time measured in tens to hundreds of thousands of years.

In its westernmost approximately 25 feet however, the trench exposed several petals associated with a south-dipping flower (fault) structure related to the Chino fault. The petals, which at the far western end of the trench dip between about 16 and 28 degrees to the south (based on your log), become increasingly horizontal and even roll over to the northeast. These petals place bedrock, older colluvium and associated soils over younger materials, and indicate recurrent activity on this fault. The older petals are deeper in the section, and the youngest petal was observed approximately six feet below the current ground surface.

The location of the soil profile described in this trench was selected to obtain an age estimate for the youngest, unfaulted soil capping this youngest fault petal. The soil profile is just beyond the area of fault influence and thus not impacted by the fault petals, but the upper individual soils recognized here could be traced westward toward the fault zone, allowing us to estimate the age of the most recent faulting event.

The soil profile described included a surface soil and two buried soils. The surface soil is comprised of two A soil horizons (A1/A2) with a combined total thickness of 2.6 feet (80 cm). The characteristics of these horizons suggest a Holocene age of between about 6,000 and 8,000 years. In fact, even though this surface soil is considerably thicker than the surface soil described in trench FT-1, the SDI and MHI values that we calculated for both of these soils are for all practical purposes identical. The surface soil here is thicker because it is at the base of a slope that is shedding sediment; the sediment is transported downhill and deposited at the base of the slope, in the area where we described the soil profile.

The first buried soil described in this profile consists of a series of argillic horizons (2Bt1/2Bt2/2Bt3/2Bt4) that developed in slopewash and/or mudflow deposits as indicated by the fine-grained nature of the matrix, the varying concentrations of angular to rounded gravel and cobbles, and abundance of large, randomly oriented pores. These are cumulic soil horizons, overthickened as a result of parent material additions. The uppermost argillic soil horizon has 10YR colors in the matrix and 7.5YR clay films; all other horizons below it have only 10YR colors. Textures of these horizons vary from silty clay loam to clay to silty clay. The high concentration of silt in this profile is likely sourced from siltstone of the Puente Formation that crops out upslope. Clay films in these horizons are generally described as common to many and thin to moderately thick. Structure of the uppermost argillic soil horizon is strong medium prismatic; the deeper horizons have weak to strong angular to subangular blocky structure.

The SDI and MHI values calculated for this now-buried soil returned minimum, median and maximum estimates of soil formation of approximately 11,000, 32,000 and 98,000 years, respectively. Given the 7.5YR colors of the clay films and prismatic structure of the top argillic horizon, our preferred estimate of the length of time this soil was exposed at the surface is between 27,000 and 38,000 years. Adding to these values the estimated age of the overlying surface soil yields estimated ages for this buried soil of approximately 33,000 to 46,000 years. If we were conservative and use the minimum estimates of length of soil formation instead, this buried soil would be between about 15,000 and 21,000 years old. However, because soils are not likely to form during periods of extensive downcutting such as during the last glacial maximum (dated at between 20,000 and 15,000 years ago, approximately), the first age estimate is preferred. Thus, the sediments that this soil formed are likely correlative with MIS 3, dated between about 25,000 and 60,000 years ago.

The second buried soil interpreted in this profile has a fairly thick (3-foot; 92 cm) and likely truncated argillic soil horizon (3Bt5) that developed in mudflow sediments deposited over siltstone bedrock of the Puente Formation. The argillic horizon has 10YR colors in both the matrix and clay films, many to continuous thin clay films on ped faces and bridging grains, and some scattered gravel weathered to McFadden et al.'s (1982) stage III. These characteristics indicate that these sediments were exposed to soil-forming processes at the ground surface for 20,000-25,000 years (median) to as much as 61,000-78,000 years (maximum). Combined with the age estimate for the overlying buried soil, the minimum age of this deeper soil is 53,000 years, but more likely between 94,000 and 124,000 years (Table 1). This preferred age estimate is correlative with MIS5.

The youngest fault petal places bedrock over a well-developed argillic soil, and the bedrock is in turn overlain by the surface soil described farther east, at station 3+99. The surface soil extends across the fault unbroken, so the minimum age for the last faulting event is provided by the age of the surface soil, of between about 6,000 and 8,000 years. This age estimate correlates well with the findings by Madden and Yeats (2008), who estimated that the last event on the faults they exposed in McMasters Canyon occurred between about 5,000 and 11,000 years ago.

Deeper petals observed in trench LGC-FT-2 placed bedrock over well-developed argillic soils that given their red colors, clay content, and soil structure we estimate each took a minimum of 40,000 years to form. This suggests a long recurrence interval between earthquake events on this fault.

Soils in Trench LGC-FT-3

The first soil profile described in this trench, at station 0+25 includes a surface soil and four buried paleosols that developed in a thick section of unfaulted, interbedded alluvial and colluvial (mudflow) deposits. Breaks within the different paleosols were based on abrupt contacts between horizons, sometimes defined by stonelines, and changes in texture and/or color that suggest different sedimentary deposits and periods of soil formation. Our preferred age for the entire soil section, using the minimum age estimate for the surface soil (for conservative reasons), is between about 223,000 and 349,000 years (see Table 1). This age range correlates with MIS 7-9.

The second profile described in trench FT-3 was made at station 0+90. In this area bedrock of the Puente Formation is overlain by a sequence of pedogenically altered older alluvial deposits. We interpreted four soils developed in these alluvial sediments; a surface soil (A1/A2/Bt1/Bt2) that is similar to, but thicker than the surface soil described at station 0+25, and three truncated paleosols with varying accumulations of calcium carbonate. We chose to interpret these horizons as separate soils because of differences in their original grain size, a stoneline at the contact between horizons 3Btk2 and 4Btk3, and color differences that suggest different lengths of soil formation for each.

As with the other profiles, we conservatively use the minimum age estimate for the surface soil to derive a preferred age for the entire section of between about 226,000 and 255,000 years, correlative with MIS 7. We chose the maximum age estimate for the underlying first buried soil because of its 7.5YR colors, many to continuous thick clay films, and calcium carbonate content. As before, an older age estimate is certainly plausible, especially since the surface soil has characteristics (prismatic structure, 7.5YR hues locally, clasts weathered up to stage III) that are more in line with the median age value.

Soils Observed in Trenches LGC-FT-5 through LGC-FT-7

In February 2020 we reviewed the last set of trenches excavated onsite. The purpose of our review was to evaluate whether any additional soils different to those previously described were exposed in these excavations, and provide opinions regarding the recency of activity of the faults observed therein. Trench LGC-FT-5 exposed steeply dipping bedrock of the Puente Formation capped by a thin section of soil developed in mudflow deposits. A stoneline was observed locally at the interface with the bedrock. In our opinion, the few shears observed in the bedrock are accommodation features that developed as the entire section was tilted over hundreds of thousands of years to millennia. None of these features appeared to extend upward into the soil, although extensive bioturbation locally obscures these relations.

Trench LGC-FT-6 exposed a thick section of older alluvial and colluvial deposits at its western end that are very similar to the alluvial and colluvial deposits previously described in trenches LGC-FT-1 through LGC-FT-3. The eastern portion of the trench exposed nearly vertical bedrock of the Puente Formation, again capped by a thin soil section developing in place from a combination of weathered bedrock and colluvial (slopewash) deposits. Irregularities in the contact between the surface soil and the bedrock are generally reflecting the strength of the underlying materials. Where conglomerate beds in the bedrock are prevalent, the soil above is thinner, as these beds are cemented and strongly resistant to weathering and erosion.

Similar observations were made in trench LGC-FT-7, where older alluvial and colluvial deposits fill in incised channels carved into the underlying steeply dipping bedrock. No faults were observed in these older units.

Table 1: Length of Time (LofT) Soils Have Been Exposed to Soil-Forming Processes at the Ground Surface (rounded to the nearest 1000 years)

Soil	SDI (normalized to 200 cm)	MHI	Average LofT (years)	Minimum LofT (years)	Maximum LofT (years)
FT-1 at 3+25					
Surface Soil	74.14		**8,000**	24,000	74,000
		0.3707	**6,000**	18,000	55,000
Buried Soil 1	116.54		16,000	48,000	**143,000**
		0.5827	21,000	59,000	**165,000**
Buried Soil 2	70.98		7,000	23,000	**71,000**
		0.4274	8,000	25,000	**74,000**
Total Estimated Age of Section			31,000 to 35,000	95,000 to 102,000	288,000 to 294,000
Preferred Age of Section			**220,00 to 247,000 years** (using the preferred values shown in bold)		
FT-2 at 3+99 (and 3+75)					
Sur face Soil	73.00		**8,000**	24,000	73,000
		0.3770	**6,000**	19,000	57,000
Buried Soil 1	82.24		9,000	**27,000**	84,000
		0.5055	13,000	**38,000**	111,000
Buried Soil 2	76.96		8,000	25,000	**78,000**
		0.3903	7,000	20,000	**61,000**
Estimated Age of Total Section			22,000 to 29,000	66,000 to 87,000	202,000 to 262,000
Preferred Age of Section			**94,000 to 124,000 years** (using the preferred values shown in bold)		
FT-3 at 0+25					
Surface Soil	127.36		**19,000**	57,000	168,000
		0.6496	**31,000**	86,000	235,000
Buried Soil 1	130.22		19,000	**59,000**	176,000
		0.6511	31,000	**87,000**	236,000
Buried Soil 2	122.16		17,000	**52,000**	155,000
		0.6108	25,000	**69,000**	192,000
Buried Soil 3	141.46		23,000	**71,000**	209,000
		0.7073	44,000	**119,000**	317,000
Buried Soil 4	68.58		7,000	**22,000**	68,000
		0.5241	15,000	**43,000**	122,000
Estimated Age of Total Section			62,000 to 85,000	195,000 to 247,000	587,000 to 697,000
Preferred Age of Section			**223,000 to 349,000 years** (using the preferred values shown in bold)		
FT-3 at 0+90					
Surface Soil	103.68		**13,000**	39,000	117,000
		0.5505	**17,000**	49,000	140,000
Buried Soil 1	104.93		13,000	39,000	**119,000**
		0.5247	15,000	43,000	**122,000**
Buried Soil 2	112.00		14,000	**44,000**	133,000
		0.5600	18,000	**52,000**	147,000
Buried Soil 3	119.56		16,000	**50,000**	149,000
		0.5978	23,000	**64,000**	179,000
Estimated Age of Total Section			55,000 to 66,000	166,000 to 192,000	496,000 to 550,000
Preferred Age of Section			**226,000 to 255,000 years** (using preferred values shown in bold)		

SUMMARY

Earth Consultants International (ECI) provided soil-stratigraphic and paleoseismic services for this project with an emphasis on using soil development to estimate the age of the older alluvial and colluvial sediments forming the elevated terraces in this area, and providing opinions regarding the age of the faults exposed in several trenches. Bedrock assigned to the Sycamore Canyon member of the Puente Formation, estimated to be late Miocene to early Pliocene (about 6 million years old), underlies the site. The bedrock, which was deposited in a predominantly marine environment, and consists of siltstone, sandstone and conglomerate beds, has been folded and faulted so the originally horizontal layers are now tilted, locally steeply to nearly vertical.

Alluvial (terrace) deposits associated with an older, proto Santa Ana River and mudflow deposits cap the tilted bedrock in this area. Based on their degree of soil development, and using conservative values that emphasize the minimum and median age estimates provided by the soil-age regressions used, we assign ages of between about 200,000 and 300,000 years for these deposits. These age estimates indicate that these terraces are generally correlative with marine isotope stages (MIS) 7 to 9. These age estimates are consistent with values suggested by previous investigators.

The faults and shears observed to be confined to the bedrock predate these alluvial deposits and have thus not moved in more than 300,000 years. The uppermost south-dipping petal (presumed to be the eastern half of a flower structure that most likely merges with the main Chino fault to the west, at depth) that was exposed at the western end of trench LGC-FT-2, is capped by an unfaulted surface soil that we estimate to be mid-Holocene in age (about 6,000 to 8,000 years old). This finding is similar to interpretations made by Madden and Yeats (2008) of a fault exposed in a trench excavated on the property, in McMasters Canyon. These researchers, using a combination of radiocarbon dating and soil development, estimated that the fault they exposed last moved between about 5,000 and 11,000 years ago.

Although we did not conduct detailed soil descriptions of the paleosols tucked under the deeper (and older) petals of the flower structure, the three paleosols observed in the trench had characteristics that suggest moderately long periods of soil formation. Using the median age estimates we obtained for the soils described, we suggest that each of these paleosols represents about 40,000 years of exposure to soil-forming processes at the ground surface before being buried by a faulting event. Thus, unless several additional events were not readily apparent in the exposure, we suggest that the recurrence interval on this south-dipping structure, is fairly long, in the tens of thousands of years.

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LGC FT-1 at Station 3+25 Profile described 9/25/2014
South Wall
Oldest elevated alluvial terrace exposed in trenches; soil developed in older alluvium.

Depth (cm)	Horizon Designation:	Description
0-13	A soil horizon	**LOAM**; brown (10YR-7.5YR 4/3) with reddish brown (2.5YR 4/4) fragments when dry, dark brown (7.5YR 3/2.5) with red (2.5YR 4/6) fragments when moist; weak to moderate medium subangular blocky breaking to moderate fine granular soil structure; hard when dry, friable when moist, slightly sticky to sticky and slightly plastic when wet; common thin clay films on ped faces, many thin clay films lining pores; common scattered gravel and small cobbles, predominately rounded, some broken; many roots and root casts; many krotovina; many pinhole pores; abrupt wavy lower boundary.
13-45	2Bt1 soil horizon	**CLAY**; reddish brown (5YR 4/5) with brown (7.5YR 4/3) zones when dry, dark reddish brown (5YR 3.5/4) with dark brown (7.5YR 3/2) zones when moist; strong very coarse angular blocky to strong coarse prismatic soil structure; very hard when dry, firm to very firm when moist, very sticky and very plastic when wet; many moderately thick and common thick clay films on ped faces, many moderately thick clay films bridging grains, many moderately thick clay films lining pores, continuous moderately thick clay films coating clast pockets; scattered cobbles at weathering stage II-III, generally rounded; abrupt to clear and wavy lower boundary.
45-100	3Bt2/E soil horizon	**LOAM**; brown (7.5YR 5/4) with reddish brown (5YR 4/5) mottles when dry, dark brown (7.5YR 3/4) with reddish brown (5YR 4/4) mottles when moist; moderate medium to coarse angular blocky soil structure; very hard when dry, firm when moist, slightly sticky and slightly plastic when wet; continuous thin clay films bridging grains, common thin clay films on ped faces; pinhole pores; some carbonate filaments along root casts; many coarse gravel especially in top 20 cm.; abrupt to clear and irregular lower boundary.
100-165	3Bt3 soil horizon	**SANDY CLAY LOAM**; light brown (7.5YR-5YR 6/4) with yellowish red (5YR 5/6) clay films when dry, brown (7.5YR-5YR 4/4) with reddish brown (5YR 4/4) clay films when moist; massive breaking to moderate medium subangular blocky soil structure; very hard when dry, friable to firm when moist, slightly sticky to sticky and slightly plastic when wet; common moderately thick clay films on ped faces, many thin to moderately thick clay films bridging grains, many to continuous thin clay films lining pores; many fine angular to broken gravel; many grussified cobbles weathered to stage III; boundary not observed (at bench).
165-235	$3Bt_{lam}$ soil horizon	**Matrix: SANDY LOAM**; strong brown (7.5YR 5/6) when dry, strong brown (7.5YR 4/6) when moist; single-grained soil structure; loose when dry, loose when moist, non-sticky to slightly sticky and non-plastic when wet; many rounded to subrounded gravel; clear wavy lower boundary. **Lamellae: SANDY LOAM** to **SANDY CLAY LOAM**; light brown to reddish brown (7.5YR 6/5) with brown (7.5YR 4/4) clay films when dry,

Depth (cm)	Horizon Designation:	Description
		strong brown (7.5YR 4/6) with strong brown to yellowish red (7.5YR-5YR 4/6) clay films when moist; weak medium subangular blocky soil structure; extremely hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common to many thin and few moderately thick clay films on ped faces, many thin clay films bridging grains, many moderately thick clay films lining pores; manganese oxide stains.
235-325+	4Cox soil horizon	**SANDY CLAY LOAM** to **SANDY CLAY**; light brown to reddish brown (7.5YR 6/5) with strong brown (7.5YR 4/6) clay films when dry, brown (7.5YR 4/4) with dark brown (7.5YR 3/4) clay films when moist; massive breaking to strong medium angular blocky soil structure; extremely hard when dry, friable when moist, sticky and plastic when wet; common thin clay films on ped faces, common to many thin clay films lining pores, many to continuous thin clay films coating clast pockets; manganese oxide stains; gravelly, with rounded to angular clasts; many pinhole pores; lower boundary not observed.

LGC Trench FT-2, Station 3+99 Profile described 9/25/2014
South Wall, near fault zone
Soils developed in colluvial and mudflow deposits overlying bedrock of the Puente Formation.

Depth (cm)	Horizon Designation:	Description
0-25	A1 Soil Horizon	**SILTY CLAY LOAM**; brown (10YR 4.5/3) when dry, very dark grayish brown (10YR 3/2) when moist; weak fine subangular blocky to moderate fine granular soil structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic to plastic when wet; few to common thin clay films lining pores; with gravel locally armoring the surface; abundant organics, many roots and rootlets, many krotovina; clear wavy lower boundary.
25-80	A2 soil horizon	**SILTY CLAY LOAM** to **SILTY CLAY**; brown (10YR 4/3) when dry, very dark grayish brown (10YR 3/2) when moist; moderate medium subangular blocky breaking to moderate to strong coarse angular blocky and granular soil structure; slightly hard and fragic to very hard when dry, friable when moist, sticky and plastic when wet; few thin clay films on ped faces; common to many scattered rounded to subangular cobbles and gravel; extensively bioturbated, many rootlets, many pinhole pores; abrupt wavy lower boundary.
80-100	2Bt1 soil horizon	**SILTY CLAY** to **CLAY**; brown (10YR 4/3) locally with strong brown (7.5YR 4/6) and brown (10YR 4/3) clay films when dry, dark brown (10YR 3/3) locally with brown (7.5YR 4.5/4) and dark brown (10YR 3/3) clay films when moist; strong medium prismatic breaking to strong fine to medium angular blocky soil structure; very hard to extremely hard when dry, friable to very firm when moist, sticky and plastic to very plastic when wet; locally common to continuous thin clay films on ped faces, many to continuous thin to moderately thick clay films lining pores, many to continuous moderately thick clay films bridging grains, many to continuous thin clay films coating clast pockets; abundant pinhole porosity; boundary not observed (at bench). [Mudflow deposit]
100-190	2Bt2 soil horizon	**CLAY**; yellowish brown (10YR 5/4) with brown (10YR 4/3) clay films when dry, dark yellowish brown (10YR 3/4) with dark brown (10YR 3/3) clay films when moist; moderate medium subangular blocky soil structure; extremely hard when dry, friable to firm when moist, sticky to very sticky and very plastic when wet; common to many thin clay films on ped faces, many thin and common moderately thick clay films bridging grains, common thin clay films lining pores, continuous thin clay films coating clast pockets; common to many scattered angular to rounded gravel and cobbles, some broken; large pores to 2 cm in diameter, many pinhole pores; gradual wavy lower boundary.
190-213	2Bt3 soil horizon	**SILTY CLAY LOAM** to **CLAY**; brown (10YR 5/3) with brown (10YR 4/3) clay films when dry, dark yellowish brown (10YR 3.5/4) with dark brown (10YR 3/3) clay films when moist; weak to moderate medium subangular blocky soil structure; very hard to extremely hard when dry, friable when moist; very sticky and plastic to very plastic when wet; many moderately thick clay films on ped faces, many thin clay films bridging grains, common thin clay films lining pores; many pinhole pores and fine rootlets; scattered angular to subangular gravel; clear

Depth (cm)	Horizon Designation:	Description
		wavy lower boundary.
213-223	2Bt4 soil horizon	**SILTY CLAY LOAM**; yellowish brown (10YR 5/4) with brown to yellowish brown (10YR 5/3.5) clay films when dry, dark yellowish brown (10YR 4/4) with brown (10YR 4/3) clay films when moist; strong medium to coarse angular blocky soil structure; extremely hard when dry, friable when moist, sticky and plastic when wet; many moderately thick clay films on ped faces, many to continuous moderately thick clay films bridging grains, many to continuous moderately thick clay films lining pores; few scattered angular to subangular gravel; lower boundary not observed (at bench).
223-315	3Bt5 soil horizon	**SILTY CLAY**; yellowish brown (10YR 5/4) with dark yellowish brown to yellowish brown (10YR 4.5/4) clay films when dry, dark yellowish brown (10YR 4/4) with dark yellowish brown (10YR 3/4) clay films when moist; moderate medium subangular blocky soil structure; very hard to extremely hard when dry, friable to firm when moist, sticky and plastic when wet; continuous thin clay films lining pores, many to continuous thin and common moderately thick clay films on ped faces and bridging grains; few scattered angular to rounded gravel at weathering stages I-III; many pinhole pores, common pores to 3 mm in diameter; clear wavy to irregular lower boundary.
315-355	4BC soil horizon	**SILTY CLAY**; yellowish brown (10YR 5/4) with dark yellowish brown (10YR 4/4) and few brownish yellow (10YR 6/8) mottles when dry, dark yellowish brown (10YR 4/4) with few yellowish brown (10YR 5/8) mottles when moist; moderate medium prismatic breaking to moderate to strong fine angular blocky soil structure; very hard to extremely hard when dry, friable when moist, sticky and plastic when wet; few to common thin clay films on ped faces; many rootlets, pinhole porosity, few manganese oxide stains; few marine worm casts; clear irregular lower boundary. [Weathered, pedogenically altered Puente Formation]
355-362	4Cox soil horizon	**SILTSTONE**; pale yellow to very pale brown (2.5Y 7/4- 10YR 7/4) with reddish yellow (7.5YR 6/6) mottles when dry, light olive brown (2.5Y 5/4) with brown (7.5YR 4/4) mottles when moist; massive; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; few pinhole pores due to roots, few root casts; lower boundary not observed. [Weathered Puente Formation]

LGC-FT-3 at station 0+25 Profile described 9/25/2014
South Wall
Soil developed in thick section of alluvium and colluvium.
Several soils interpreted.

Depth (cm)	Horizon Designation:	Description
0-20	A soil horizon	**SILTY CLAY LOAM** to **SILTY CLAY**; brown (10YR 4/3) when dry, very dark grayish brown (10YR 3/2) when moist; moderate medium subangular blocky breaking to moderate to strong fine granular soil structure; hard to very hard when dry, firm to friable when moist, sticky and plastic when wet; very dense in top 5 cm; many fine roots and rootlets; pores up to 0.5 cm in diameter, especially near base; clear wavy lower boundary.
20-34	Bt1 soil horizon	**SILTY CLAY**; brown (10YR 4/3) with brown (7.5YR 5/4) mottles when dry, dark brown (10YR 3/3) with brown (7.5YR 4/4) mottles when moist; moderate medium subangular blocky breaking to strong fine subangular blocky soil structure; extremely hard when dry; friable to firm when moist, sticky to very sticky and very plastic when wet; few thin to moderately thick clay films on ped faces, common moderately thick clay films bridging grains, many moderately thick clay films coating clasts pockets; scattered angular gravel; few fine rootlets; some pinhole-sized pores, few larger pores to 0.5 cm in diameter; clear wavy lower boundary. [Degrading Bt horizon]
34-50	Bt2 soil horizon	**SILTY CLAY** to **CLAY**; brown (10YR 4/3) with brown (7.5YR 4/4) worm or root casts when dry, dark brown (10YR 3/3) with brown (7.5YR 4/4) worm or root casts when moist; moderate medium prismatic breaking to moderate to strong fine subangular blocky soil structure; very hard to extremely hard when dry, friable to firm when moist, sticky and plastic to very plastic when wet; common to many moderately thick clay films on ped faces, many moderately thick clay films bridging grains, common to many thin clay films lining pores, continuous moderately thick clay films coating clast pockets; rootlets and root holes; common pinhole-sized pores, some up to 4 mm in diameter; clear wavy lower boundary.
50-70	2Bt3 soil horizon	**SANDY CLAY** to **CLAY**; strong brown (7.5YR 4/6) with yellowish red (5YR 5/6) mottles and dark grayish brown to brown (10YR 4/2.5) worm or root casts when dry, brown to reddish brown (7.5YR-5YR 4/4) with very dark grayish brown (10YR 3/2) worm or root casts when moist; strong medium prismatic breaking to strong fine angular blocky soil structure; extremely hard when dry, very firm when moist, sticky and plastic to very plastic when wet; many thin and common moderately thick clay films on ped faces, many thin clay films bridging grains; angular to rounded grussified clasts to weathering stages II-III (aphanitic at stage II, phaneritic at stage III); common pinhole pores; abrupt to clear wavy lower boundary at a stone line.
70-90	3Bt4 soil horizon	**SANDY CLAY**; strong brown (7.5YR 4/6) with brown (10YR-7.5YR 4/3) mottles and reddish brown (5YR 4/4) clay films when dry, brown (7.5YR 4/4) with dark brown (10YR-7.5YR 4/3) mottles and reddish brown (5YR 4/4) clay films when moist; strong coarse prismatic breaking to strong medium to coarse angular blocky soil structure; extremely hard when

Depth (cm)	Horizon Designation:	Description
		dry, extremely firm when moist, very sticky and very plastic wen wet; common thin clay films on ped faces, many thin clay films bridging grains, many moderately thick clay films lining pores, many moderately thick clay films coating clast pockets; subangular to rounded gravel- to cobble-sized clasts weathered to stage III, some coarse-grained sand; abrupt wavy lower boundary.
90-112	4Bt5 soil horizon	**CLAY**; strong brown (7.5YR 5/6) with brown to reddish brown (7.5YR-5YR 4/4) clay films when dry, strong brown (7.5YR 5/6) with strong brown (7.5YR 4/6) clay films when moist; strong medium to coarse prismatic breaking to strong medium angular blocky soil structure; extremely hard when dry, extremely firm when moist, sticky to very sticky and very plastic when wet; continuous moderately thick and common moderately thick clay films on ped faces, continuous thick clay films lining pores, many moderately thick clay films bridging grains; matrix is finer-grained than above; many gravel-sized clasts weathered to stages II to III; abrupt to clear wavy lower boundary.
112-145	5Bt6 soil horizon	**SILTY CLAY** to **CLAY**; brown (10YR 4/3) with brown (7.5YR 4/4) worm or root casts when dry, dark brown (10YR 3/3) with brown (7.5YR 4/4) worm or root casts when moist; strong coarse angular blocky soil structure; extremely hard when dry, very firm when moist, sticky to very sticky and plastic when wet; many thin and common moderately thick clay films on ped faces, many moderately thick clay films lining pores, many moderately thick clay films bridging grains; matrix coarser-grained than above; root casts on ped faces lined with calcium carbonate; lower boundary not observed (at bench).
145-165	5Bt$_{lam}$1 soil horizon	**Matrix**: Gravelly medium to coarse **SAND**; reddish brown (7.5YR 6/6) when dry, strong brown (7.5YR 4/6) when moist; moderate fine subangular blocky soil structure breaking to single-grained; loose when dry and moist, non-sticky and non-plastic when wet; abrupt smooth to wavy lower boundary. [Fluvial deposit with well-defined bedding] **Lamellae**: **SANDY LOAM**; strong brown (7.5YR 4/6) with red (2.5YR 4/8) clay films when dry, dark brown to brown (7.5YR 3.5/4) with reddish brown to yellowish red (5YR 4/5) clay films when moist; moderate to strong medium angular blocky soil structure; soft to slightly hard when dry, slightly firm to friable when moist, non-sticky and non-plastic when wet; many moderately thick clay films bridging grains, few thin clay films on ped faces; lamellae are 1-5 cm thick, thicker at bottom of unit, developed along beds.
165-190	6Bt$_{lam}$2 soil horizon	**Matrix**: Very fine **SANDY LOAM**; brownish yellow to reddish yellow (10YR-7.5YR 6/6) when dry, strong brown (7.5YR 4/6) when moist; massive breaking to single-grained; very hard when dry, friable when moist, slightly sticky and non-plastic when wet; many moderately thick clay films lining pores; pinhole porosity; cemented; abrupt wavy lower boundary. [Fine-grained overbank or mudflow deposit] **Lamellae**: **SANDY CLAY LOAM** to **SANDY CLAY**; reddish yellow (7.5YR 6/6) with red (2.5YR 4/6) clay films when dry, strong brown (7.5YR 4/6) with reddish brown (5YR 4/4) clay films when moist; strong coarse to very coarse angular blocky soil structure; extremely hard when dry, firm to very firm when moist, sticky and plastic when wet; many thin clay films on ped faces, many thin clay films on ped faces,

Depth (cm)	Horizon Designation:	Description
		many thin clay films bridging grains, many to continuous thin clay films lining pores; lams are 3-6 cm thick.
190-270	7Bt$_{lam}$3 soil horizon	**Matrix**: Gravelly **SAND**; strong brown (7.5YR 5/6) when dry, brown (7.5YR 4/4) when moist; single-grained; loose when dry and moist, non-sticky and non-plastic when wet; coarse-grained alluvium with distinct bedding, varies from mostly clast-supported sections consisting of cobbles and gravel to sandy sections; Bt lams are irregular and unevenly spaced, defined locally by stonelines; clear irregular lower boundary with underlying unit locally carved out by this high-energy deposit. [Fluvial deposit] **Lamellae**: **SILTY CLAY** and **LOAMY SAND**; brownish yellow to reddish yellow (10YR-7.5YR 6/6) with yellowish red (5YR 5/6) clay films when dry, yellowish brown to strong brown (10YR-7.5YR 5/6) with reddish brown (5YR 4/4) clay films when moist; weak fine subangular blocky soil structure breaking to single-grained; slightly hard when dry, slightly firm when moist, sticky and plastic to very plastic when wet; few to common thin clay films on ped faces, many thin clay films lining pores, common thin clay films bridging grains; lamellae are 4 to 6 cm thick and occur in both the sandy and gravelly to cobbly sand sections.
270-335	8Bt$_{lam}$4 soil horizon	**Matrix**: **SANDY CLAY LOAM**; light yellowish brown to brownish yellow (10YR 6/5) with strong brown (7/5YR 5/6) clay films when dry, dark yellowish brown to yellowish brown (10YR 4.5/6) with strong brown (7.5YR 5/6) clay films when moist; massive soil structure; hard to very hard when dry, very firm to extremely firm when moist, sticky and plastic when wet; common to many thin clay films lining pores; many scattered subangular to rounded gravel and cobbles; cemented; clear wavy to irregular lower boundary. [Mudflow deposit; matrix-supported with scattered clasts] **Lamellae**: **SANDY CLAY**; brownish yellow to reddish yellow (7.5YR 5/6) with reddish brown (5YR 4/4) clay films when dry, dark yellowish brown to brown (7.5YR 4/4) with yellowish red (5YR 4/6) clay films when moist; massive soil structure; very hard when dry, extremely firm when moist, sticky and plastic when wet; common to many thin clay films lining pores, many thin to moderately thick clay films bridging grains; lams are 4 to 8 cm thick, locally occur as zones instead of lams, zones are generally associated with coarser material.
335-350+	9Bt$_{lam}$5 soil horizon	**Matrix**: Gravelly fine to coarse **SAND**; light brown (10YR-7.5YR 6/6) when dry, brown to strong brown (7.5YR 5/4 to 5/6) when moist; single-grained; loose when dry and moist, non-sticky and non-plastic when wet; fluvial deposit consisting mostly of sand and fine gravel; lower boundary not observed. [Fluvial deposit] **Lamellae**: **LOAMY SAND**; strong brown (7.5YR 5/6) with reddish brown to yellowish red (5YR 4/4 to 4/6) clay films when dry, brown (7.5YR 4/4) when moist; weak fine to medium subangular blocky soil structure breaking to single-grained; soft to slightly hard when dry, very friable when moist, non-sticky and non-plastic when wet; common thin clay films bridging grains, common thin clay films lining pores; lams are 2 to 6 cm thick.

F-3 at Station 0+90 Profile described 9/25/2014
South Wall
Older alluvium over Puente Formation

Depth (cm)	Horizon Designation:	Description
0-17	A1 soil horizon	**SILTY CLAY LOAM** to **SILTY CLAY**; brown (10YR 4/3) when dry, very dark grayish brown (10YR 3/2) when moist; moderate medium subangular blocky breaking to moderate fine granular and single-grained soil structures; hard to very hard when dry, firm to very firm when moist, sticky and slightly plastic when wet; many roots, dense in top 7 cm; many very fine pinhole-sized pores; abundant organics; clear wavy lower boundary.
17-33	A2 soil horizon	**SILTY CLAY**; brown (10YR 4/3) with dark brown to brown (10YR 3.5/3) clay films when dry, dark brown (10YR 3/3) with very dark grayish brown (10YR 3/2) clay films when moist; moderate medium to coarse subangular blocky breaking to strong fine granular soil structure; slightly hard when dry, very friable when moist, sticky to very sticky and plastic when wet; common thin clay films on ped faces; many roots, pores to 0.3 cm in diameter; bioturbated, many organics including bone fragments, earthworm casts; abrupt to clear and wavy lower boundary.
33-90	Bt1 soil horizon	**CLAY**; brown (10YR 4/3) with brown (7.5YR 4/4) mottles and dark brown to brown (10YR 3.5/3) clay films when dry, dark brown (10YR 3/3) with dark brown to brown (7.5YR 3.5/4) mottles and very dark grayish brown (10YR 3/2) clay films when moist; strong medium angular blocky soil structure; extremely hard when dry, friable to firm when moist, very sticky and plastic to very plastic when wet; continuous thin and common moderately thick clay films on ped faces, many moderately thick clay films bridging grains, common thin clay films lining pores; scattered angular to subrounded gravel and cobbles, weathered to stages II-III; many large roots; gradual wavy lower boundary.
90-116	Bt2 soil horizon	**CLAY**; dark yellowish brown (10YR 4/4) with very dark grayish brown (10YR 3/2) mottles and brown (10YR 4/3) clay films when dry, dark yellowish brown (10YR 3/4) with very dark brown (10YR 2/2) mottles and dark brown (10YR 3/3) clay films when moist; moderate coarse prismatic breaking to moderate medium to coarse angular blocky soil structure; extremely hard when dry, very firm to extremely firm when moist, sticky and plastic to very plastic when wet; many moderately thick clay films on ped faces, many moderately thick clay films bridging grains, many to continuous thick clay films lining pores; scattered angular to rounded gravel and cobbles, more than unit above, weathered to stages I-III; clear wavy lower boundary.
116-131	2Btk1 soil horizon	**CLAY**; brown (7.5YR 5/3) with brown (10YR 4/3) clay films when dry, dark brown (7.5YR 3/2) with brown (10YR 4/3) clay films when moist; strong coarse angular blocky soil structure; extremely hard when dry, very firm to extremely firm when moist, sticky and plastic to very plastic when wet; many to continuous moderately thick clay films on ped faces, continuous moderately thick clay films lining pores, many moderately thick to thick clay films bridging grains; few to common thin calcium carbonate filaments on ped faces and along root casts;

Depth (cm)	Horizon Designation:	Description
		common fine gravel to coarse sand; lower boundary not observed.
131-150	3Btk2 soil horizon	**CLAY**; yellowish brown (10YR 5/6) when dry, dark yellowish brown (10YR 4/5) when moist; strong coarse angular blocky soil structure; extremely hard when dry, very firm to extremely firm when moist, very sticky and very plastic when wet; continuous moderately thick and many thick clay films on ped faces, continuous moderately thick clay films lining pores, many to continuous moderately thick clay films bridging grains; few scattered rounded cobbles up to 30 cm in diameter with thick calcium carbonate coatings, common moderately thick calcium carbonate coatings on ped faces; clear wavy lower boundary on a stoneline.
150-200	4Btk3 soil horizon	**CLAY**; dark yellowish brown (10YR 4/6) when dry, dark yellowish brown (10YR 4/6) when moist; strong very coarse angular blocky breaking to strong medium angular blocky soil structure; extremely hard when dry, extremely firm when moist, sticky and plastic to very plastic when wet; few scattered angular to subrounded clasts; many to continuous moderately thick to thick calcium carbonate coatings on ped faces and in pores; clear wavy to irregular boundary.
200-295+	5C	Fine-grained **SANDSTON**E; reddish yellow to strong brown (7.5YR 6/6 to 5/6) with very pale brown (10YR 7/3) mottles when dry, strong brown (7.5YR 5/6) with pale brown (10YR 6/3) mottles when moist; massive; hard when dry, very friable when moist, non-sticky and non-plastic when wet; no clay films; near-vertical beds; lower boundary not observed. [Puente Formation]

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Geotechnical Map

PROJECT NAME	Trumark - Shady View
PROJECT NO.	18117-01
ENG. / GEOL.	DJB / KTM
SCALE	1" = 60'
DATE	March 2020

PROJECT NAME	Trumark - Shady View
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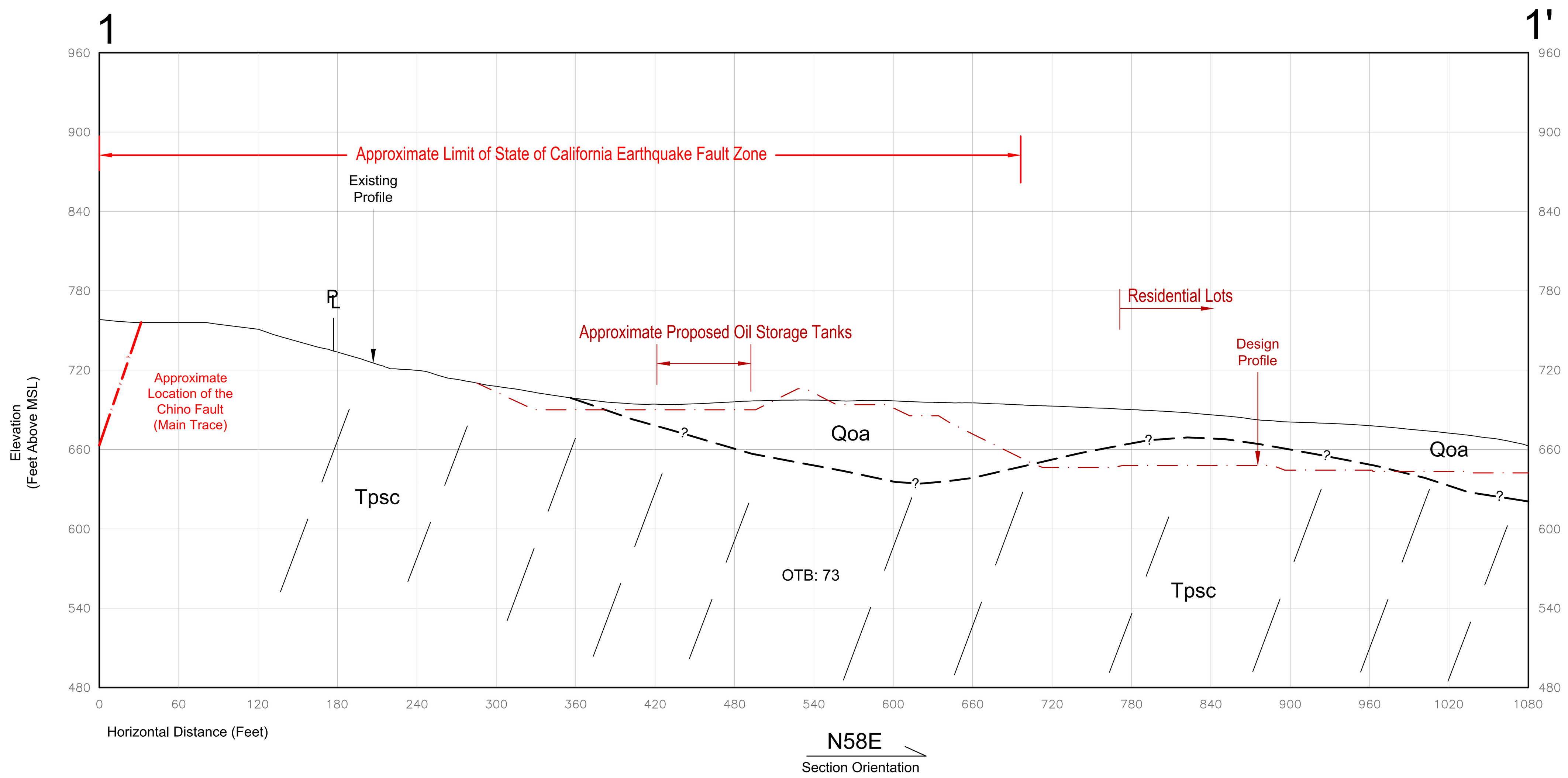
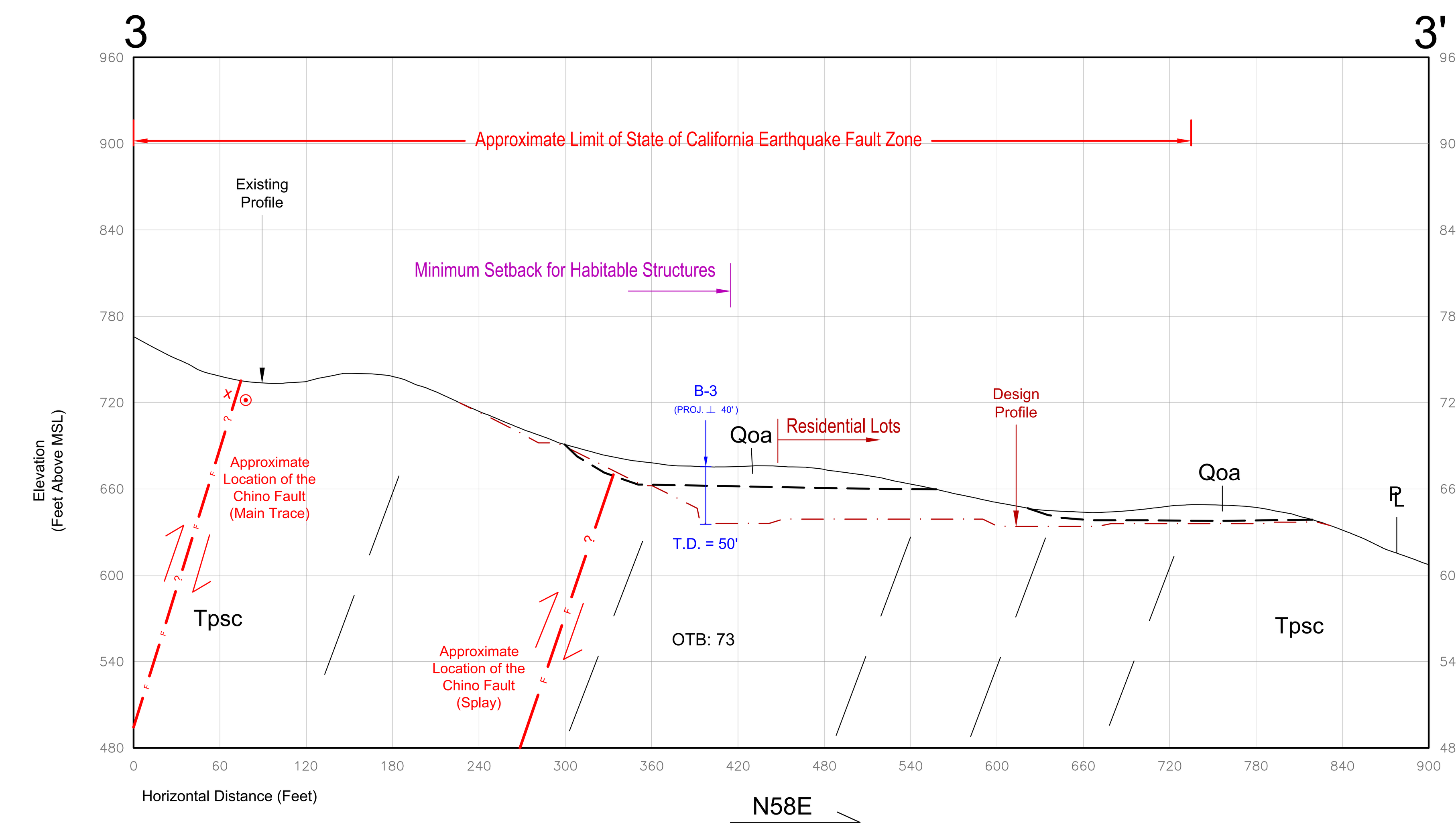
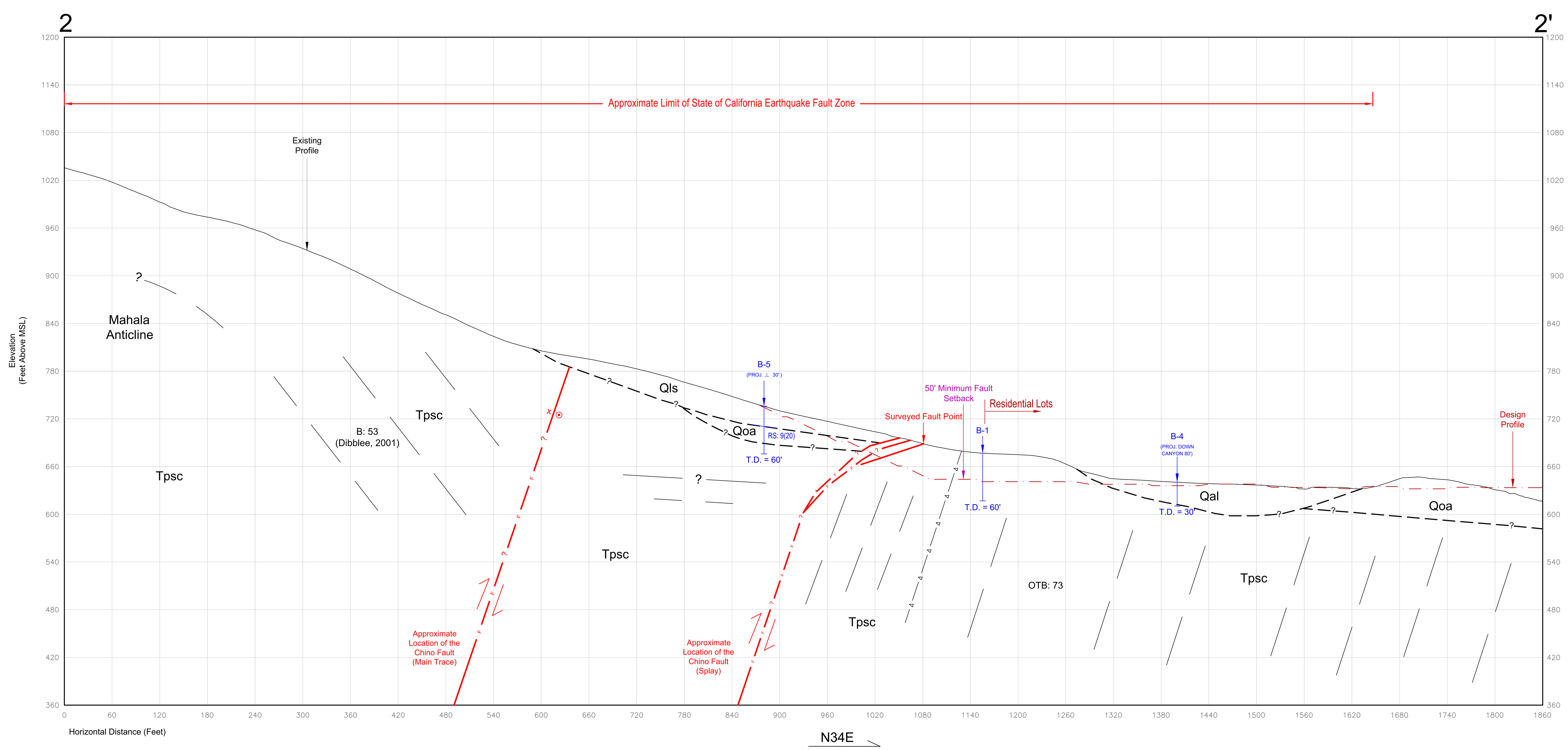
Geotechnical Map

SHEET 2 of 10







SCALE: 1"=60'

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Geotechnical Cross Sections 1-1' through 3-3'

PROJECT NAME	Trumark - Shady View
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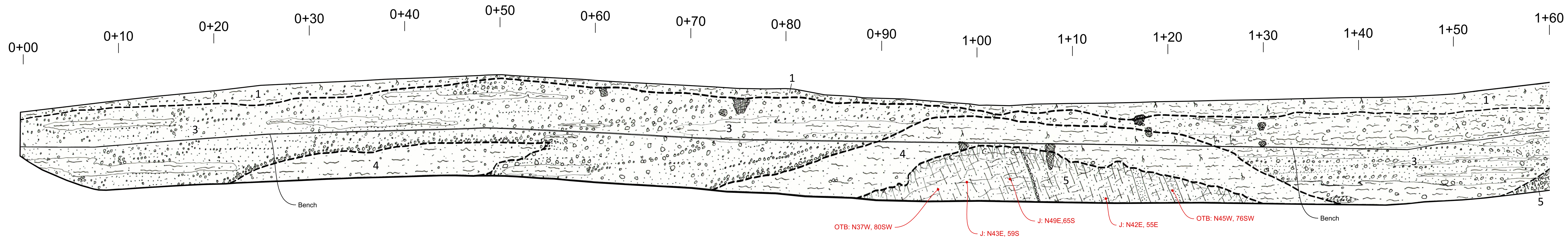
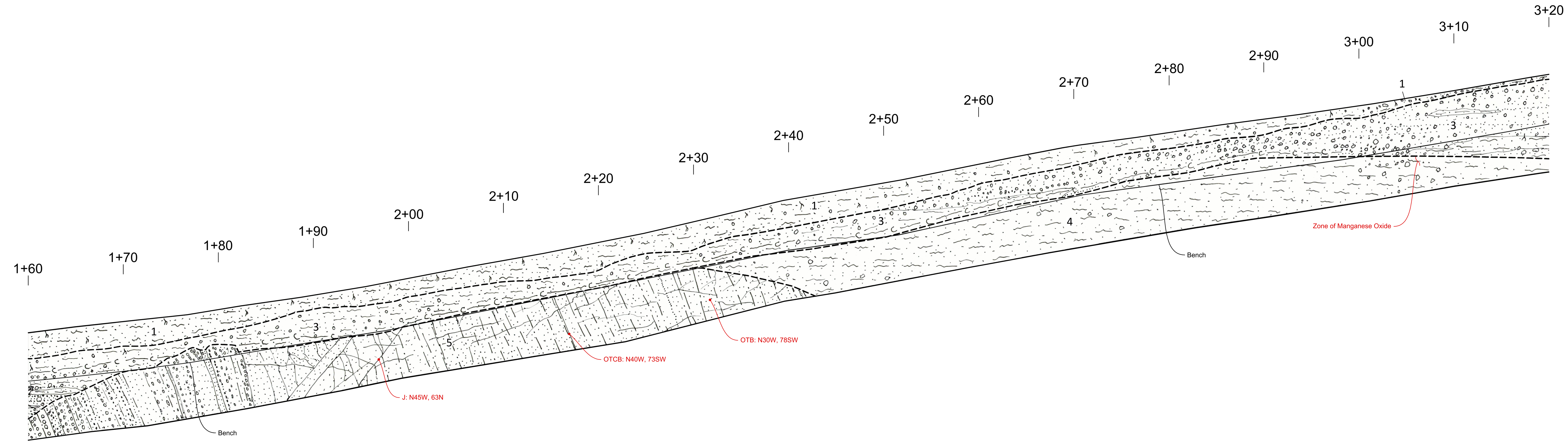
SHEET 3 of 10

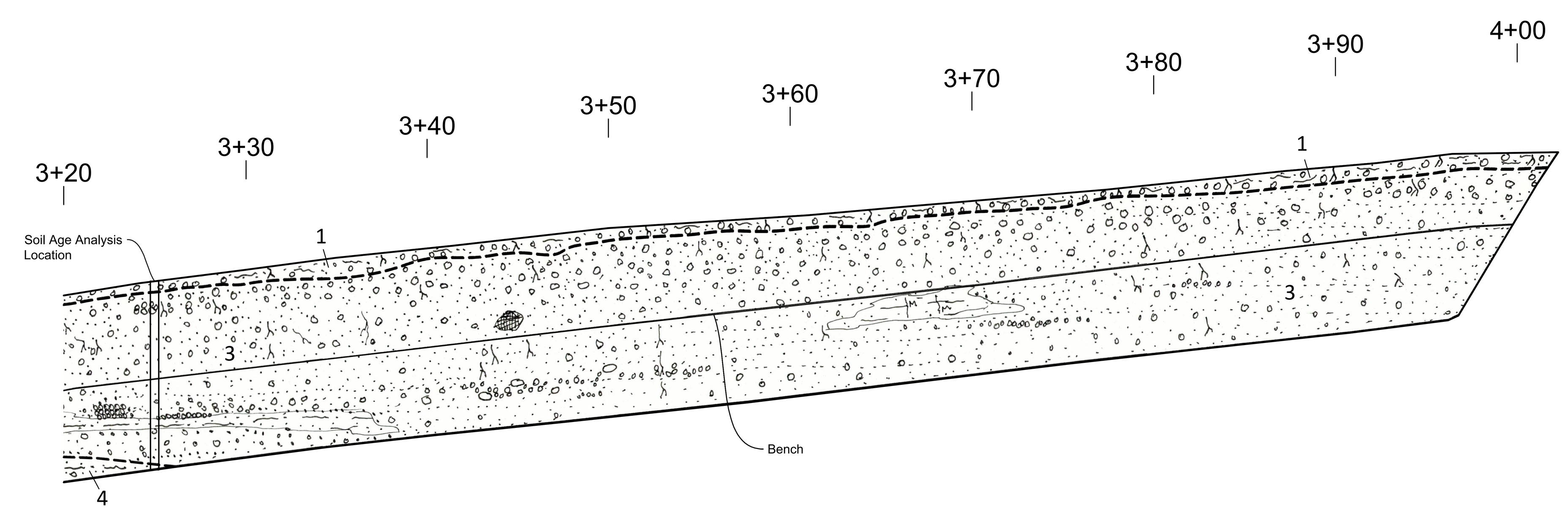
Fault Trench Log FT-1

Southern Wall

Logged by KTM/CNJ







LITHOLOGIES

1 **Topsoil** - Clayey Sandy Silt with Gravel and Cobbles to fine Sandy Silt with Clay and Gravel: brown to (7.5YR, 4/3 to 10YR, 4/3), dry to moist, soft to medium stiff; indurated; abundant rootlets; krotovina; rounded clasts; grades into unit below

2 **BT Argillic Horizon -** Silty Clay to Sandy Clay with scattered rounded Cobbles: reddish brown to dark yellowish brown (5YR 4/3 to 10YR 3/4), slightly moist to moist, stiff to very stiff; krotovina; rectilinear weathering with blocky texture; faint clay film on weathering surfaces

3 P**leistocene Alluvium** - Clayey Silt to Silty Sand with Gravel and Cobbles with interfingered zones of Clayey Sandy Gravel, coarse Sand, and Silty Sand: reddish yellow to strong brown (5YR 7/6 to 7.5 YR 5/6), slightly moist, dense to very dense; indurated; zones of variable cementation; caliche horizons and nodules; manganese stringers and staining; pinhole weathering; cross bedding visible in sandy zones; sub-horizontal gravel beds interfingered clay films developed around cobbles and gravels; rootlets; cobbles are rounded to sub-rounded, very weathered to rotted, granitic and metamorphic clasts

4 **Pleistocene Mudflow Deposits** - Clayey Silt with fine Sand, Gravel, and Cobbles: dark yellowish brown (10YR 7/6), slightly moist, stiff to very stiff; lacks structure; pinhole weathering; manganese oxide; root traces; rounded cobbles; krotovina; slightly to moderately indurated

Puente Formation (Tpsc)

5 **Tertiary Puente Formation, Sycamore Canyon Member -** Fine Sandy Siltstone to Silty fine Sandstone: light greenish gray to greenish gray GLEY 1 6-7/10Y) with reddish yellow (7.5 YR 6/8) mottle, slightly moist, dense to very dense; slightly to well cemented; very fractured; iron oxide staining; manganese oxide and root traces in upper zone; highly weathered with well-developed jointing; bedding defined by sandstone interbeds; calcium carbonate along jointing

Conglomerate with Sand Matrix: yellowish red to very pale brown (5YR 5/8 to 10YR 8/3), slightly moist, very dense; cemented; sub-rounded to subangular, granitic and metamorphic clasts; few sandstone interbeds; iron oxide

SCALE: 1"=5'
5' 0 5' 10'

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Fault Trench Log
FT-1

PROJECT NAME	Trumark - Shady View
PROJECT NO.	18117-01
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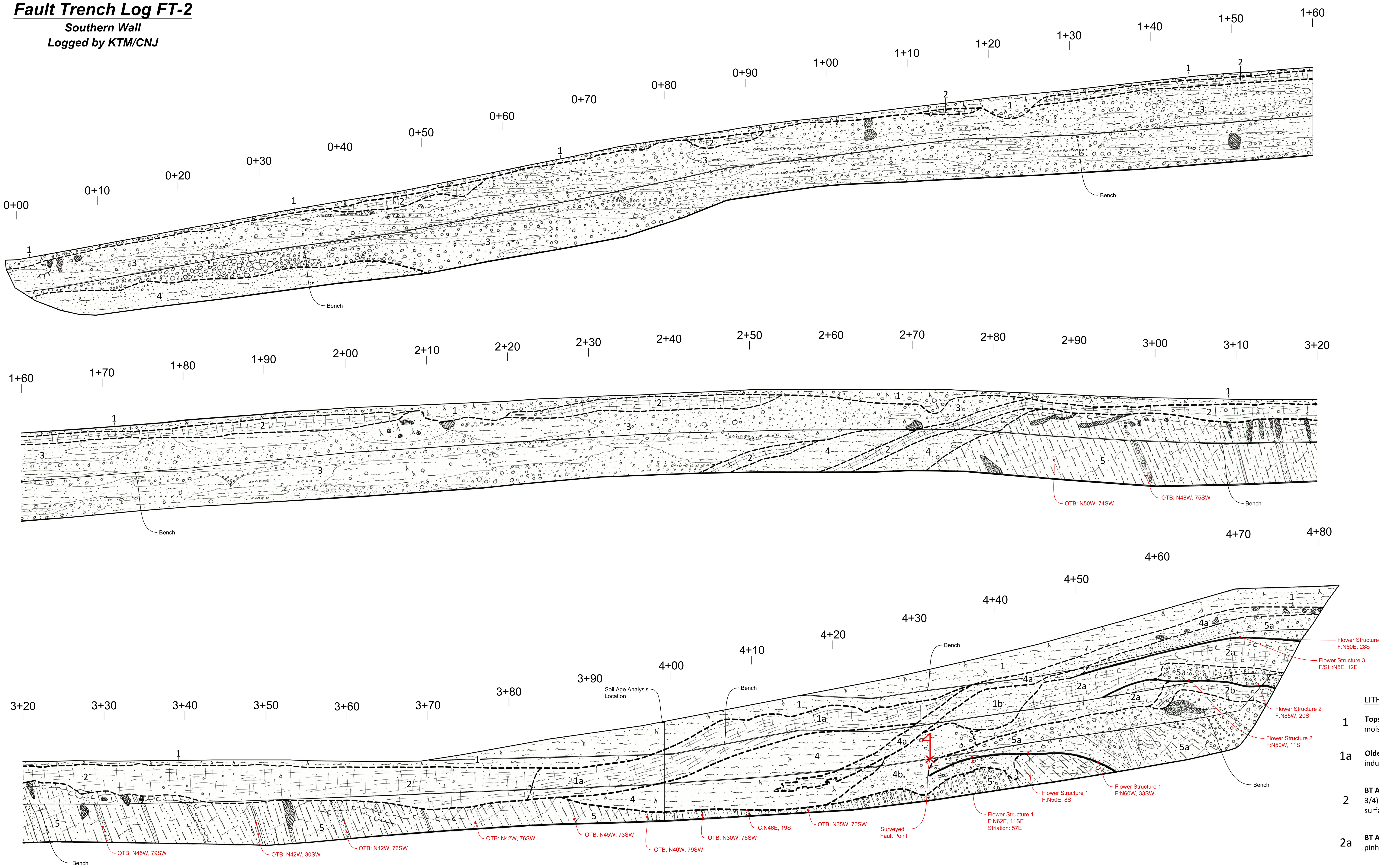
Fault Trench Log FT-2

Southern Wall
Logged by KTM/CNJ



LITHOLOGIES

1 **Topsoil** - Clayey Sandy Silt with Gravel and Cobbles to fine Sandy Silt with Clay and Gravel: brown to (7.5YR, 4/3 to 10YR, 4/3), dry to moist, soft to medium stiff; indurated; abundant rootlets; krotovina; rounded clasts; grades into unit below

1a **Older Topsoil** - Silty Clay: brown (7.5YR, 4/3), slightly moist to moist, medium stiff to stiff; scattered rounded gravel and cobbles; well indurated zones; slightly friable; thin clay films on ped surfaces; porous

2 **BT Argillic Horizon -** Silty Clay to Sandy Clay with scattered rounded Cobbles: reddish brown to dark yellowish brown (5YR 4/3 to 10YR 3/4), slightly moist to moist, stiff to very stiff; krotovina; rectilinear weathering with blocky texture; faint clay film on weathering surfaces

2a **BT Argillic Horizon -** Clayey fine Sand with Gravels: light brown (7.5YR 6/4), slightly moist to moist, stiff to very stiff; calcium carbonate; pinhole pores; well indurated

2b **BT Argillic Horizon -** Silty Sand with Gravel: light yellowish brown (10YR 6/4), slightly moist to moist, stiff to very stiff; well indurated; pinhole porosity; iron oxide; calcium carbonate staining; angular to sub-rounded gravels

3 P**leistocene Alluvium** - Clayey Silt to Silty Sand with Gravel and Cobbles with interfingered zones of Clayey Sandy Gravel, coarse Sand, and Silty Sand: reddish yellow to strong brown (5YR 7/6 to 7.5 YR 5/6), slightly moist, dense to very dense; indurated; zones of variable cementation; caliche horizons and nodules; manganese stringers and staining; pinhole weathering; cross bedding visible in sandy zones; sub-horizontal gravel beds interfingered clay films developed around cobbles and gravels; rootlets; cobbles are rounded to sub-rounded, very weathered to rotted, granitic and metamorphic clasts

4 **Pleistocene Mudflow Deposits** - Clayey Silt with fine Sand, Gravel, and Cobbles: dark yellowish brown (10YR 7/6), slightly moist, stiff to very stiff; lacks structure; pinhole weathering; manganese oxide; root traces; rounded cobbles; krotovina; slightly to moderately indurated

4a **Pleistocene Mudflow Deposits -** Clayey Sand with Gravel: reddish yellow (5YR, 6/6) dry, stiff to very stiff; pinhole porosity; few root hairs

4b **Pleistocene Mudflow Deposits** - Clayey Sand with Gravel and Cobbles: reddish yellow (5YR, 6/6) dry, stiff to very stiff; well indurated; pinhole porosity; few root hairs

Puente Formation (Tpsc)

5 **Tertiary Puente Formation, Sycamore Canyon Member -** Fine Sandy Siltstone to Silty fine Sandstone: light greenish gray to greenish gray GLEY 1 6-7/10Y) with reddish yellow (7.5 YR 6/8) mottle, slightly moist, dense to very dense; slightly to well cemented; very fractured; iron oxide staining; manganese oxide and root traces in upper zone; highly weathered with well-developed jointing; bedding defined by sandstone interbeds; calcium carbonate along jointing

Conglomerate with Sand Matrix: yellowish red to very pale brown (5YR 5/8 to 10YR 8/3), slightly moist, very dense; cemented; sub-rounded to subangular, granitic and metamorphic clasts; few sandstone interbeds; iron oxide

5a **Uplifted/Displaced Tertiary Puente Formation, Sycamore Canyon Member** - Conglomerate with Sand Matrix: yellow (2.5 Y 7/6), slightly moist, dense; highly weathered; variable cementation; calcium carbonate stained; deformed and recemented; thinly interbedded; rounded cobbles

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Fault Trench Log
FT-2

PROJECT NAME	Trumark - Shady View
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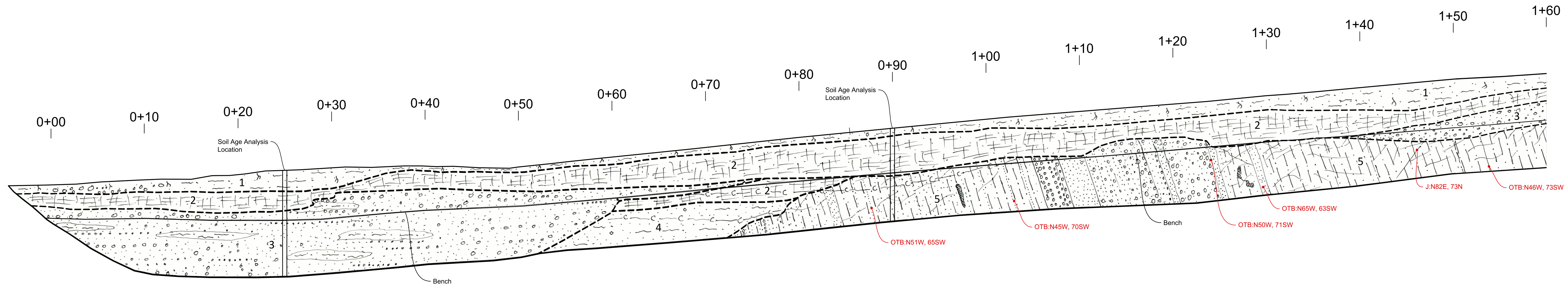
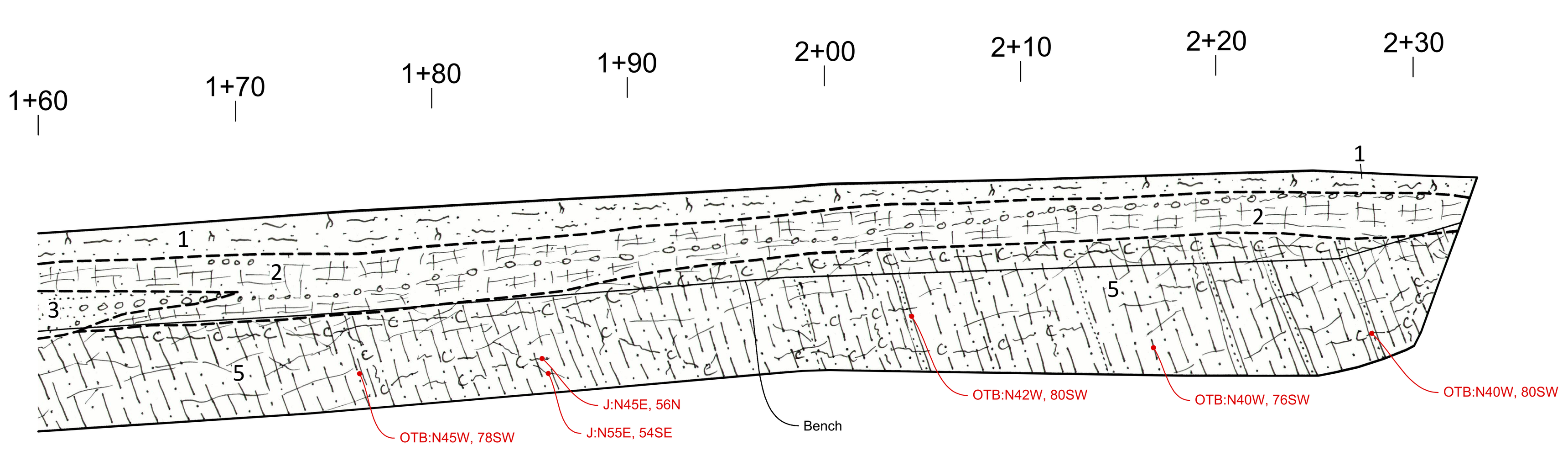
ENG. / GEOL.	DJB / KTM
SCALE	1" = 5'
DATE	March 2020

Fault Trench Log FT-3

Southern Wall

Logged by KTM/CNJ





LITHOLOGIES

1 **Topsoil** - Clayey Sandy Silt with Gravel and Cobbles to fine Sandy Silt with Clay and Gravel: brown to (7.5YR, 4/3 to 10YR, 4/3), dry to moist, soft to medium stiff; indurated; abundant rootlets; krotovina; rounded clasts; grades into unit below

2 **BT Argillic Horizon -** Silty Clay to Sandy Clay with scattered rounded Cobbles: reddish brown to dark yellowish brown (5YR 4/3 to 10YR 3/4), slightly moist to moist, stiff to very stiff; krotovina; rectilinear weathering with blocky texture; faint clay film on weathering surfaces

3 **Pleistocene Alluvium** - Clayey Silt to Silty Sand with Gravel and Cobbles with interfingered zones of Clayey Sandy Gravel, coarse Sand, and Silty Sand: reddish yellow to strong brown (5YR 7/6 to 7.5 YR 5/6), slightly moist, dense to very dense; indurated; zones of variable cementation; caliche horizons and nodules; manganese stringers and staining; pinhole weathering; cross bedding visible in sandy zones; sub-horizontal gravel beds interfingered clay films developed around cobbles and gravels; rootlets; cobbles are rounded to sub-rounded, very weathered to rotted, granitic and metamorphic clasts

4 **Pleistocene Mudflow Deposits** - Clayey Silt with fine Sand, Gravel, and Cobbles: dark yellowish brown (10YR 7/6), slightly moist, stiff to very stiff; lacks structure; pinhole weathering; manganese oxide; root traces; rounded cobbles; krotovina; slightly to moderately indurated

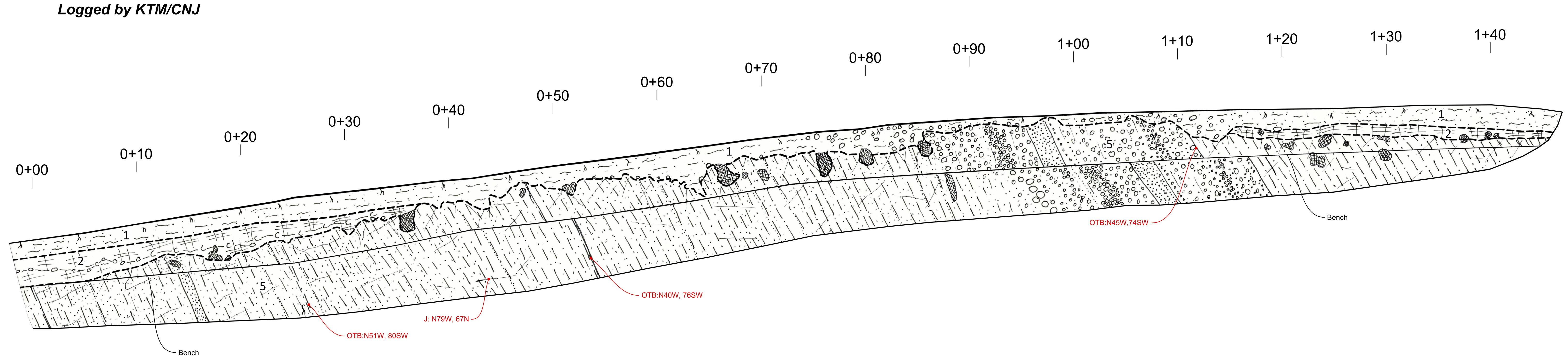
Puente Formation (Tpsc) 5 **Tertiary Puente Formation, Sycamore Canyon Member -** Fine Sandy Siltstone to Silty fine Sandstone: light greenish gray to greenish gray GLEY 1 6-7/10Y) with reddish yellow (7.5 YR 6/8) mottle, slightly moist, dense to very dense; slightly to well cemented; very fractured; iron oxide staining; manganese oxide and root traces in upper zone; highly weathered with well-developed jointing; bedding defined by sandstone interbeds; calcium carbonate along jointing

Conglomerate with Sand Matrix: yellowish red to very pale brown (5YR 5/8 to 10YR 8/3), slightly moist, very dense; cemented; sub-rounded to subangular, granitic and metamorphic clasts; few sandstone interbeds; iron oxide

Fault Trench Log FT-4

Southern Wall

Logged by KTM/CNJ



SCALE: 1"=5'

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Fault Trench Logs
FT-3 & FT-4

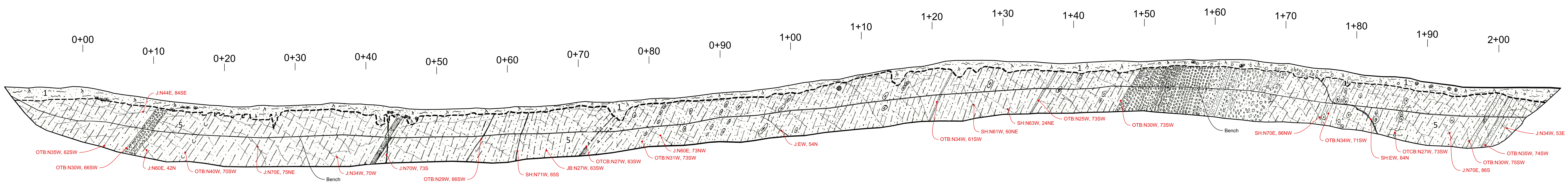
PROJECT NAME	Trumark - Shady View
PROJECT NO.	18117-01
ENG. / GEOL.	DJB / KTM
SCALE	1" = 5'
DATE	March 2020

SHEET 6 of 10

Fault Trench Log FT-5

Northern Wall

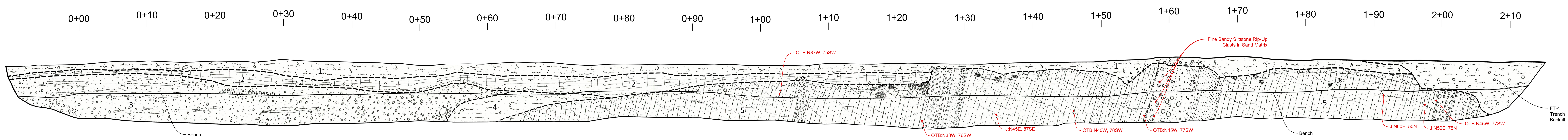
Logged by KTM/CNJ



Fault Trench Log FT-6

Northern Wall

Logged by KTM/CNJ



LITHOLOGIES

1 **Topsoil** - Clayey Sandy Silt with Gravel and Cobbles to fine Sandy Silt with Clay and Gravel: brown to (7.5YR, 4/3 to 10YR, 4/3), dry to moist, soft to medium stiff; indurated; abundant rootlets; krotovina; rounded clasts; grades into unit below

2 **BT Argillic Horizon -** Silty Clay to Sandy Clay with scattered rounded Cobbles: reddish brown to dark yellowish brown (5YR 4/3 to 10YR 3/4), slightly moist to moist, stiff to very stiff; krotovina; rectilinear weathering with blocky texture; faint clay film on weathering surfaces

3 **Pleistocene Alluvium** - Clayey Silt to Silty Sand with Gravel and Cobbles with interfingered zones of Clayey Sandy Gravel, coarse Sand, and Silty Sand: reddish yellow to strong brown (5YR 7/6 to 7.5 YR 5/6), slightly moist, dense to very dense; indurated; zones of variable cementation; caliche horizons and nodules; manganese stringers and staining; pinhole weathering; cross bedding visible in sandy zones; sub-horizontal gravel beds interfingered clay films developed around cobbles and gravels; rootlets; cobbles are rounded to sub-rounded, very weathered to rotted, granitic and metamorphic clasts

4 **Pleistocene Mudflow Deposits** - Clayey Silt with fine Sand, Gravel, and Cobbles: dark yellowish brown (10YR 7/6), slightly moist, stiff to very stiff; lacks structure; pinhole weathering; manganese oxide; root traces; rounded cobbles; krotovina; slightly to moderately indurated

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Conglomerate with Sand Matrix: yellowish red to very pale brown (5YR 5/8 to 10YR 8/3), slightly moist, very dense; cemented; sub-rounded to subangular, granitic and metamorphic clasts; few sandstone interbeds; iron oxide

SCALE: 1"=5'

5' 0 5' 10'

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Fault Trench Logs
FT-5 & FT-6

PROJECT NAME	Trumark - Shady View
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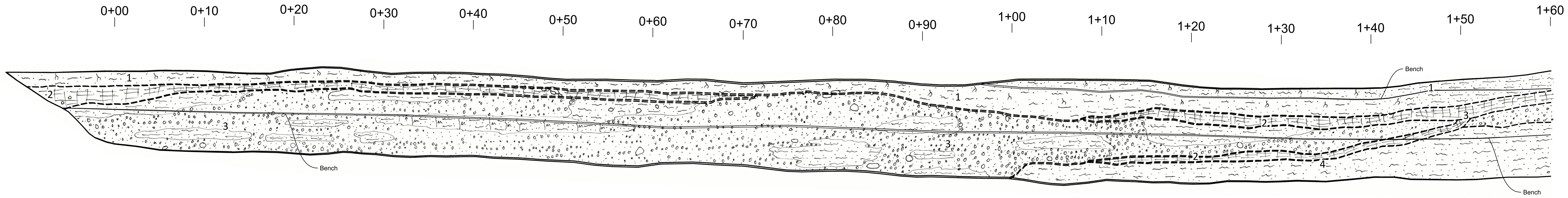
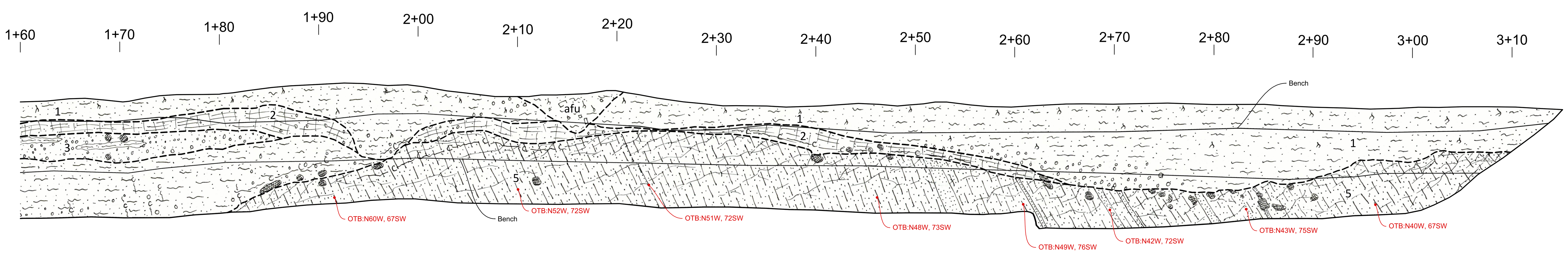
DATE	March 2020

Fault Trench Log FT-7

Southern Wall

Logged by KTM/CNJ





LITHOLOGIES

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4 **Pleistocene Mudflow Deposits** - Clayey Silt with fine Sand, Gravel, and Cobbles: dark yellowish brown (10YR 7/6), slightly moist, stiff to very stiff; lacks structure; pinhole weathering; manganese oxide; root traces; rounded cobbles; krotovina; slightly to moderately indurated

Puente Formation (Tpsc)

5 **Tertiary Puente Formation, Sycamore Canyon Member -** Fine Sandy Siltstone to Silty fine Sandstone: light greenish gray to greenish gray GLEY 1 6-7/10Y) with reddish yellow (7.5 YR 6/8) mottle, slightly moist, dense to very dense; slightly to well cemented; very fractured; iron oxide staining; manganese oxide and root traces in upper zone; highly weathered with well-developed jointing; bedding defined by sandstone interbeds; calcium carbonate along jointing

Conglomerate with Sand Matrix: yellowish red to very pale brown (5YR 5/8 to 10YR 8/3), slightly moist, very dense; cemented; sub-rounded to subangular, granitic and metamorphic clasts; few sandstone interbeds; iron oxide

SCALE: 1"=5'

5' 0 5' 10'

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Fault Trench Log

FT-7

PROJECT NAME	Trumark - Shady View
PROJECT NO.	18117-01
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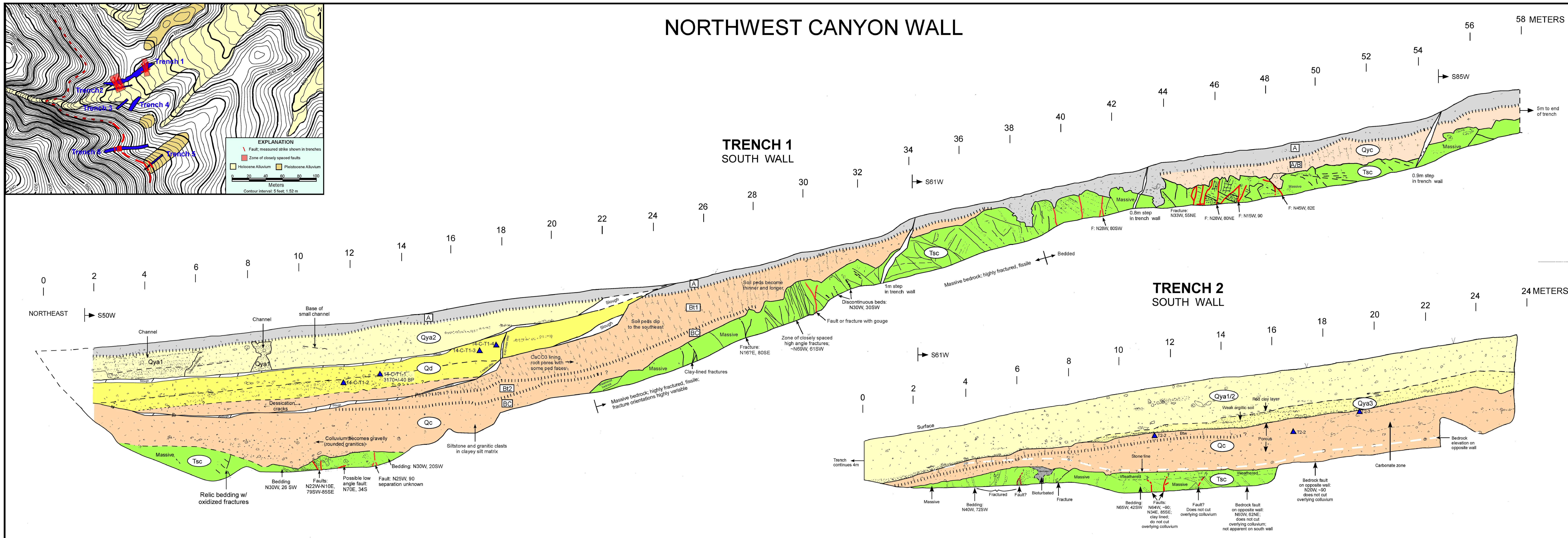
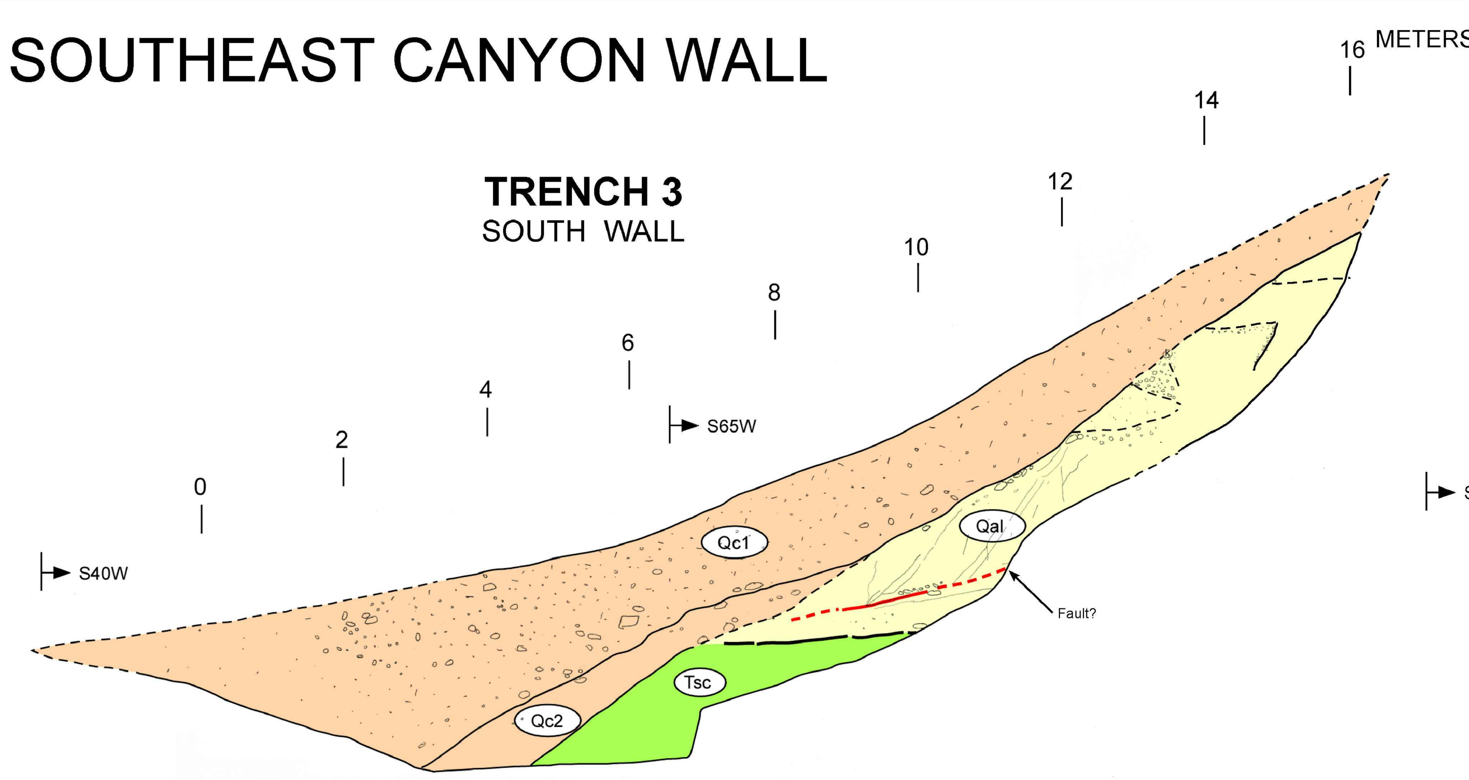
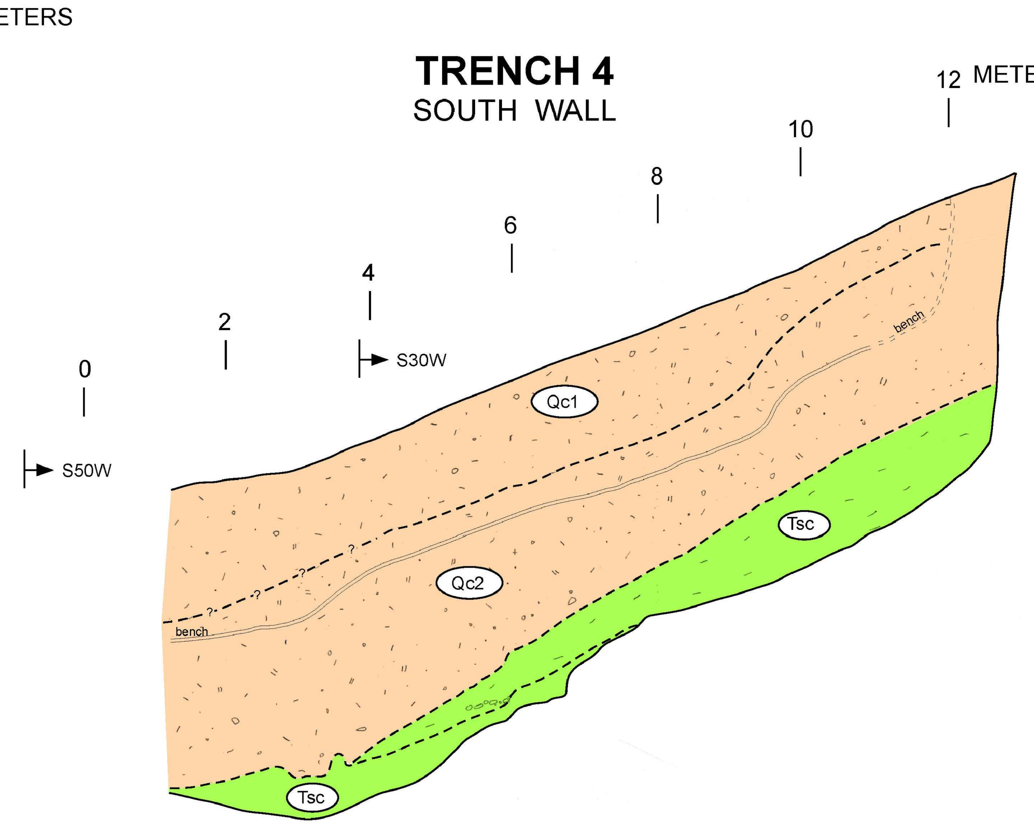
SCALE	1" = 5'
DATE	March 2020



SOUTHEAST CANYON WALL





EXPLANATION

UNIT	DEPOSITS	DESCRIPTION	AGE
Qya1	Young Channel Alluvium	Silty Sand with abundant coarse Gravel and Cobbles. Very loose and friable.	Modern
Qya2	Young Channel Alluvium	Silty Sand with scattered Gravel and Cobbles. Friable.	Latest Holocene
Qya3	Young Channel Alluvium	Silty Sand with scattered Gravel and Cobbles.	Late Holocene
Qyc	Young Colluvium	Active hillslope colluvium. Clayey Sand and Silt with scattered fine Gravel.	Modern/Latest Holocene
Qd	Debris Flow	Fine Gravel in a Clayey matrix.	Mid to late Holocene (3,170+/-40)
Qc 1/2	Colluvium	Clayey fine Sand and Silt, locally with fine Gravel.	Early to mid Holocene (?)
Qal	Alluvium	Fluvial Sand and Gravel: Terrace deposit.	Late Pleistocene (?)
Tsc	Puente Formation *Siltstone Facies of Soquel Member*	Bedded to Massive fine Siltstone and Sandstone. Rare Conglomerate.	Miocene

Charcoal sample

BEDROCK	DEPOSITS	SOILS	CONTACTS
Bedded siltstone	Clay	A Horizon	Depositional (Dashed where gradational)
Massive siltstone	Sand	Argillic Horizon *with columnar peds*	Soil
Sandstone	Silt	C Horizon	Bench
	Gravel		Fault
			Fracture

3-D Paleoseismic Trenching of the Southern Chino Fault

PLATE 1 CANYON TRENCHES

Earth Consultants International

SCALE: 1"=5'

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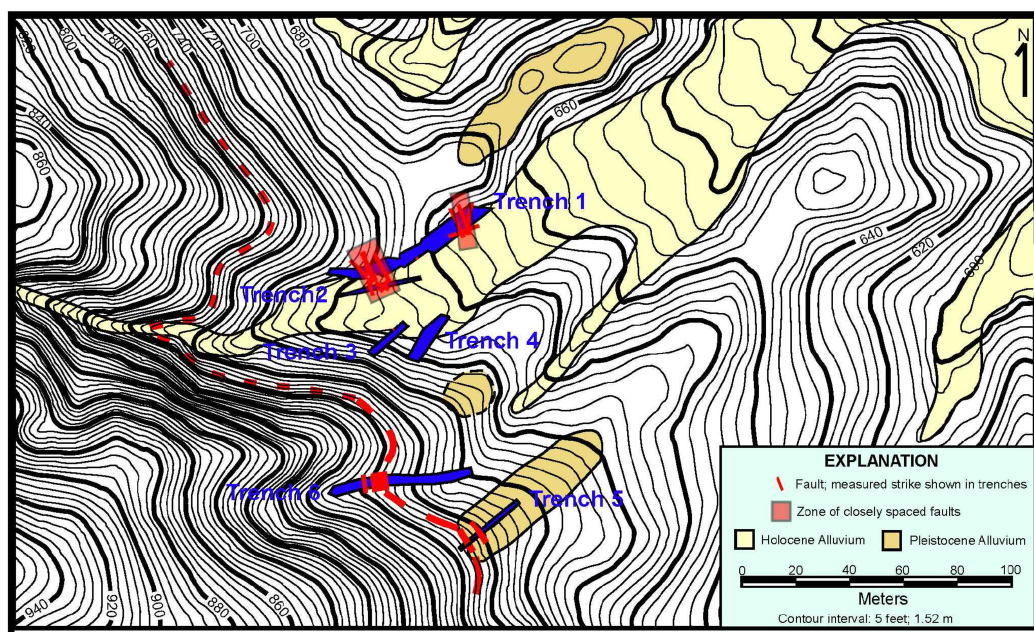
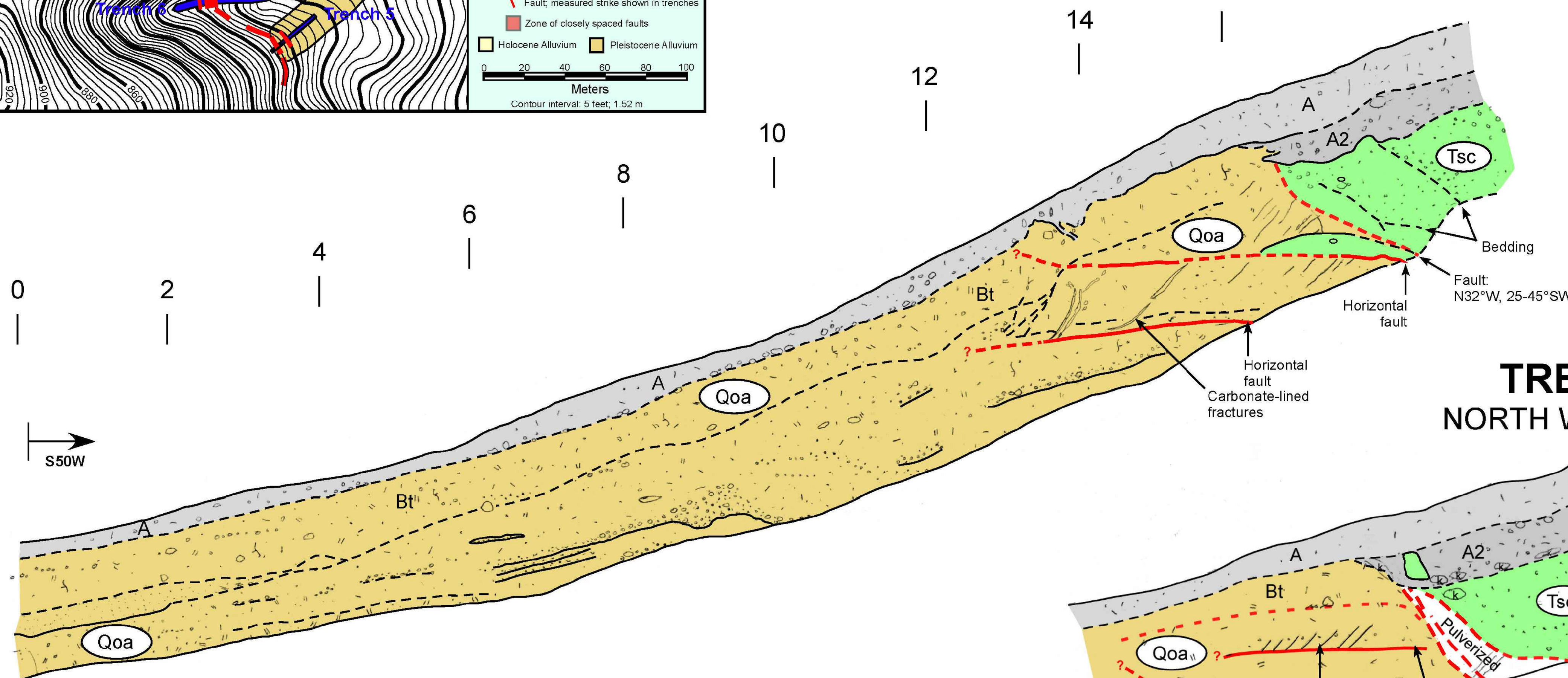
Fault Trench Logs by Others
ECI-1 through ECI-4

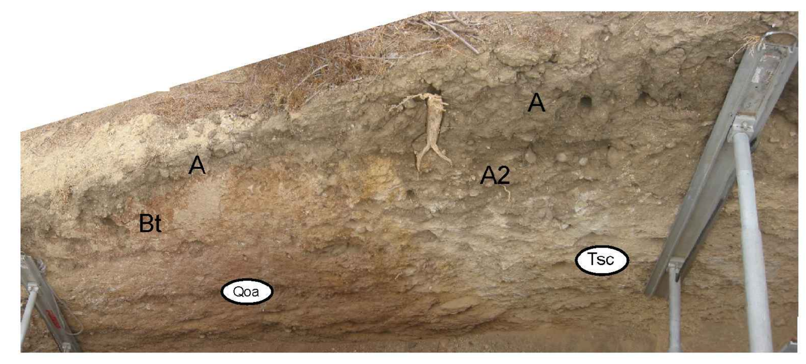
PROJECT NAME	Trumark - Shady View
PROJECT NO.	18117-01
ENG. / GEOL.	DJB / KTM
SCALE	1" = 5'
DATE	March 2020



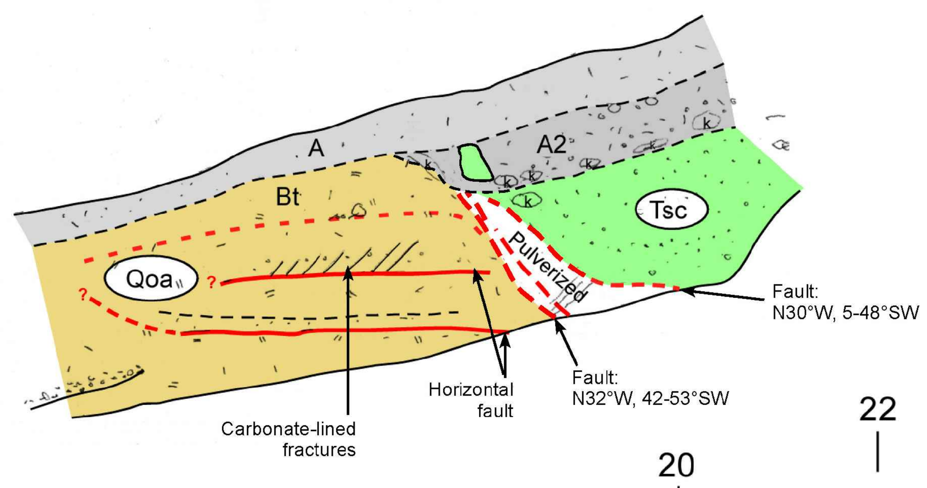
TRENCH 5
SOUTH WALL



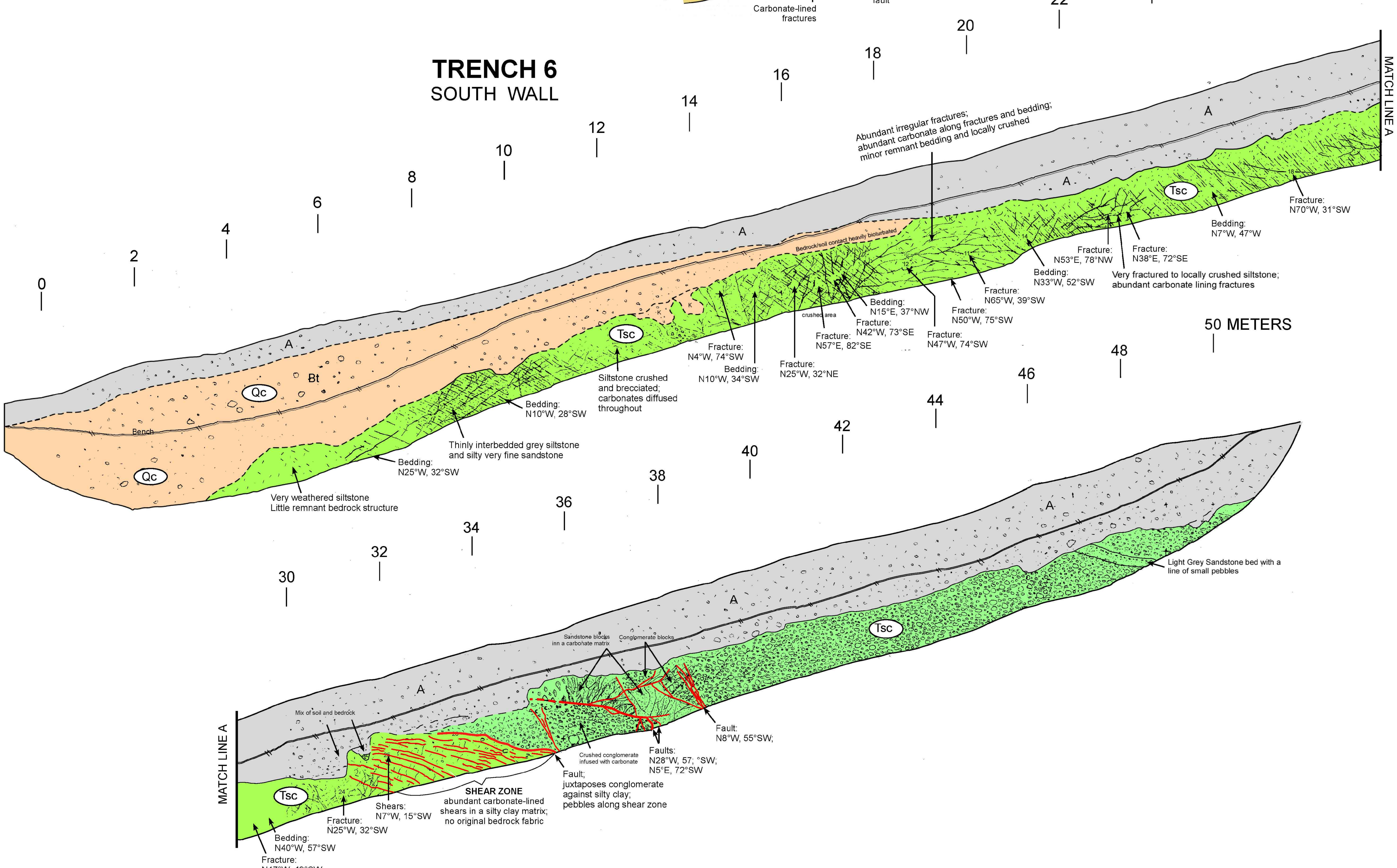
TRENCH 5
NORTH WALL (flipped)



TRENCH 5
NORTH WALL (flipped)



TRENCH 6
SOUTH WALL



EXPLANATION

	UNIT	DESCRIPTION	AGE
Qc	Colluvium	Silty fine Sandy Clay with scattered Pebbles and small Cobbles.	Early to mid Holocene (?)
Qoa	Older Alluvium	Clay Silt with lenses of Sand and Gravel.	Late Pleistocene
Tsc	Puente Formation *Siltstone Facies of Soquel Member*	Bedded to Massive fine Siltstone; locally with Sandstone interbeds.	Miocene
Tsc	Puente Formation *Conglomerate Facies of Soquel Member*	Massive Sandstone and Conglomerate, locally weakly bedded.	Miocene

BEDROCK	DEPOSITS	SOILS	CONTACTS (Dashed where gradational)
Bedded siltstone	Clay	A1 A2 A Horizon	Depositional
Massive siltstone	Silt	Bt Argillic Horizon	Soil
Sandstone	Sand	C C Horizon	Bench
Conglomerate	Gravel		Fault
			Fracture
			k Krotavina

3-D Paleoseismic Trenching of the Southern Chino Fault

PLATE 2
HILLSLOPE TRENCH

Earth Consultants International

SCALE: 1"=40'
40' 0 40' 80'

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Fault Trench Logs by Others ECI-5 through ECI-6

PROJECT NAME	Trumark - Shady View
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SCALE	1" = 5'
DATE	March 2020