PROJECT STUDY REPORT

SAN JUAN CREEK (BRIDGE 197.9) REPLACEMENT
SAN JUAN CAPISTRANO, CALIFORNIA

Prepared by:

METROLINK®

Southern California Regional Rail Authority (SCRRA)

FINAL
March 26, 2014

Submitted By:

HDR

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Submitted: ___________________________________ Date 03/26/2014
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1.0 PROJECT LOCATION

The bridge is located in the City of San Juan Capistrano near the Camino Capistrano exit of the Interstate 5 (I-5) freeway. Bridge 197.9 crosses over the San Juan Creek between Control Point (CP) Oso at MP 196.1 and CP Capistrano at Mile Post (MP) 198.0 on the Orange Subdivision.

The bridge is contained within an Orange County Transportation Authority (OCTA) right-of-way, operated and maintained by Metrolink (SCRRA). The surrounding developments consist of light industrial and professional businesses. The San Juan Creek Bike Trail travels under a bridge just north of the northerly abutment. A County of Orange Flood Division maintenance road is located near the southerly abutment.

2.0 PROJECT DESCRIPTION

The San Juan Creek Bridge Retrofitting or Replacement Project involves retrofitting or replacing a three (3) span steel railroad bridge along the Los Angeles to San Diego (LOSSAN) rail corridor. The bridge is a 300-foot ballast deck thru-plate girder (TPG) type. The bridge is estimated to have a normal load rating below expected demands, and requires frequent maintenance by SCRRA due to age, fatigue, and typical deterioration associated with the surrounding environment. HDR was tasked by Metrolink to provide an analysis of retrofitting the existing bridge to accommodate current rail loading and alternatively to evaluate the possibility of a full bridge replacement. The retrofit discussion is contained within a separate memo. This report discusses alternatives for a full bridge replacement.

3.0 SCOPE OF WORK

The scope of work is to prepare this Project Study Report (PSR) that describes the replacement strategy, engineering opportunities, engineering constraints, environmental strategy, and develop a Total Project Cost and Schedule for delivery of the project. The report discusses the following topics:

- Hydrology and Hydraulics
- Geotechnical
- Track and Operations
- Bridge
- Bike Trail
- Environmental
- Constructability
- Staging and Phasing
- Exhibits and Cost Estimate

4.0 PROJECT NEED

The San Juan Creek Bridge Replacement Project involves replacing a three (3) span steel railroad bridge along the LOSSAN rail corridor. The bridge is a 300-foot ballast deck TPG type. A previous bridge rating performed by JLP Associates in August 2011 estimated the bridge to have a normal load rating below expected demands. Bridge members with capacity ratings exceeded by the demand may become over stressed and begin to deteriorate and develop cracks, adding additional maintenance costs. Increased inspections are also required to monitor and catch cracks before the bridge becomes unable to safely pass trains. In addition, it appears that the bridge has a scour problem based on the installation of timber sheet piling around the existing piers to retain soil. The sheet piling is a temporary fix that may begin to deteriorate and fail, allowing erosion of the soil surrounding the piers. Hydraulic modeling also verified that the scour depth of the design storm would undermine the foundation and 14-foot timber piles; potential settlement and failure of the pier may result from an extreme storm. Pier failure would result in extended track outage and large costs of both the repair and service loss.

5.0 BENEFITS

Replacing Bridge 197.9 will bring the bridge up to current design standards and load capabilities. The new bridge would be designed to support current rail loading, thus reducing the amount of maintenance and increasing the safety for freight and passenger traffic. The current structure would also be designed to accommodate the desired design level storm, decreasing the risk and potential repair cost the railroad is currently holding with the current structure.

6.0 EXISTING SITE CONSTRAINTS

The existing single track geographic north (Railroad West) of the bridge is centered in the right-of-way that is 50 feet wide. There is an existing siding track on the west side of the main track from MP 197.20 to MP 197.69 (2,330 feet). The siding is bisected by the Del Obispo Street At-Grade Crossing at MP 197.4. This is a major street and cannot be disrupted by train traffic for an extended period of time. There is an existing bike and pedestrian trail on the northerly bank of San Juan Creek. In 2006/2007, an underpass was constructed for the bike trail that is 25 feet north of Bridge 197.9. The existing trail does not meet current standards for maximum grades.

The City of San Juan Capistrano's Department of Public Works facility is located adjacent to the corridor on the west side and north of the current bike trail. This is a major hub for the City's water and sewer facilities and has a number of water mains crossing the rail corridor just to the north of the bike trail underpass rail structure. A fiber optic line runs underground on the west side of the track, which surfaces aboveground where it is attached to the west side of both structures.

The track south of the project area becomes a double track (Sierra Siding) at CP Capistrano, MP 198.00 with a No. 20 left hand turnout switch. The posted speed along the corridor from the San Juan Capistrano Station to MP 197.9 at the existing San Juan Creek Channel Bridge is 60 miles per hour (mph) passenger and 55 mph freight. It decreases at that point to 40 mph passenger and 35 mph freight due to a sweeping 6 degree 36 minute curve beginning at MP 198.1. This is the ruling curve that controls the train speed and acceleration.

7.0 TECHNICAL ANALYSIS

7.1 HYDROLOGY AND HYDRAULICS

Floodplain Regulations

Metrolink San Juan Creek Bridge 197.9 is located within a Federal Emergency Management Agency (FEMA) regulatory floodway. Therefore, providing a FEMA "no rise" certificate is required to document that no increases to flood levels would occur due to modifications or replacement of the bridge. The bridge is shown in FEMA Flood Insurance Rate Map (FIRM) 06059C Panel 0506J.

Hydrology

Bridge 197.9 is located in the San Juan Creek watershed. The hydrology considered in this study was obtained from various sources, including the FEMA Flood Insurance Study (FIS) (FEMA 2009), the San Juan Creek Watershed Hydrology Study (PACE 2008) and the San Juan Creek Hydrologic Analysis by the U.S Army Corps of Engineers (USACE) (USACE 2011). Per Orange County Flood Control Section staff, the PACE 2008 hydrology is the approved hydrology, and was based on the Orange County Hydrology Manual. The 1986 Orange County Hydrology Manual (OCHM) yields High Confidence (HV) peak discharge and volumes that are appropriate for flood control design purpose. Addendum No. 1 to the OCHM states that Expected Value (EV) discharges are appropriate for development mitigation, floodplain delineation, sediment transport, and water quality purposes.

Table 7.1.1 shows the peak discharges for San Juan Creek at the project site from the available sources. The results from the La Novia Bridge stream gage analysis were used by the USACE to calibrate their HEC-HMS rainfall runoff model. The Orange County Flood Control Section-approved 100-year High Confidence discharge of 43,700 cubic feet per second (cfs) from PACE (2008) is used in this hydraulic analysis for the 100-year design discharge. The 50-year storm event High Confidence discharge is not available from the PACE report. However, since the 100-year High Confidence discharge from PACE (2008) is similar to the USACE present condition HEC-HMS discharge (43,960), the future conditions discharge of 29,004 cfs from the USACE report is used in this hydraulic analysis for the 50-year design discharge to be conservative.

Table 7.1.1: San Juan Creek Peak Discharge Summary Table (cfs)

Source	Drainage Area (sq.mi.)	50-Year (cfs)	100-Year (cfs)	500-Year (cfs)	Description
FEMA FIS (2009)	116.8	22,000	32,000	60,000	
PACE (2008)		28,664	31,900		Expected Value
PACE (2008)			43,700		High Confidence
USACE (2011)	109.0	27,200	41,700	92,800	La Novia Bridge Stream Gage Analysis
USACE (2011)	115.85	28,671	43,960	97,353	Present Conditions HEC-HMS
USACE (2011)	115.85	29,004	44,764	97,612	Future Conditions HEC-HMS

Hydraulic Analysis

The existing and proposed bridges were analyzed using the USACE HEC-RAS program (v.4.1) (USACE 2010). The effective FIS hydraulic model was obtained from FEMA; however; the effective model does not include Bridge 197.9. Bridge 197.9 hydraulic modeling was included in PACE (2010) San Juan Creek Hydraulic study. It is the best available data; therefore, it was used as a base model to evaluate the existing and proposed bridges. Per the FEMA FIS, San Juan Creek has been improved by the construction of concrete slope protection; however, the channel capacity is not adequate for large floods.

It should be noted that due to the limited information currently available, bridge dimensions, stream cross sections, and rail elevations should be considered approximate in this study. New survey data should be obtained to update the hydraulic model for design. For this reason, the hydraulic model results in this report should be considered approximate and will need to be updated when new survey data is available. The conclusions presented herein may change as a result.

Hydraulic Design Criteria

The *Metrolink, SCRRA Design Criteria Manual*, July 2010 PRE-FINAL, Section 8.3 General Drainage Design Requirements was used as the source of the hydraulic design criteria:

1. New and replacement bridge and culvert openings shall be sized for two high-water design discharge events, designated “low chord/soffit” event and “subgrade” event.
2. For SCRRA mainline and mainline siding trackage, the low chord/soffit” event is the 50-year flood and the subgrade event is the 100-year flood.
3. At locations where an established FEMA-mapped floodplain exists, bridges, culverts, and channel improvements shall also comply with the requirements of the NFIP as administered by the local FEMA floodplain administrator.
4. Regardless of whether the structure is in a FEMA-designated floodplain, the 100-year water surface elevation of any replacement opening shall be compared with the existing condition 100-year water surface elevation, and the waterway shall be sized such that impacts on the water surface profile conform to SCRRA, FEMA, or other local water surface or freeboard criteria, whichever is more restrictive.
5. For all cases, the opening would be sized so that the water surface for a low chord/soffit event would rise no higher than the lowest low chord of the bridge or soffit (crown) of the culvert.
6. For all cases, the opening would be sized so that the energy grade line for a subgrade event would not rise above the adjacent subgrade elevation (defined as 2.52 feet below top of rail elevation for timber ties and 2.81 feet below top of rail elevation for concrete ties).

Existing Condition Bridge

The base hydraulic model from Pace was modified as following for the existing condition:

- The cross section upstream and downstream of the bridges are skewed in the PACE model. Based on the field measurements and measurement from Google Earth, the channel widths were modified to better fit the measurements. Skewed length was removed from cross sections 13088, 13595, 13772 and 13964 but kept at cross section 13427 as in the PACE model.
- The bridge as-built drawing is dated 1917. It shows three 100-foot bridge spans. The concrete channel is not identified in the plan. The bridge middle span length matches rough field measurements by HDR, but the end spans do not match the field measurements. Therefore, it is assumed the concrete channel was placed after the bridge was built.
- Revised the bridge configuration. The center to center pier distance was based on the as-built plans. From the center of pier to the toe of the concrete channel and the channel side slope were based on the field measurements.
- Pier dimensions were revised based on the as-built plans.
- Copied the bridge upstream configuration to the downstream.

- Revised the low flow bridge modeling approach from Energy Only to Highest Energy Answer of Energy, Momentum and Yarnell methods, and selected Pressure and Weir Flow for high flow method.
- Revised the bridge top of deck elevation to 85.3 feet, which considers the steel diaphragm.
- Two feet of debris were added on each side of the piers.

Proposed Condition Bridge Alternatives

The proposed conditions channel geometry and modeling approach are identical to those in the Existing Conditions Bridge Model for all sections outside of the bridge area. There are two alternatives identified for the Bridge 197.9: a Steel Through Plate Girder Alternative (Alternative 1) and a Steel Rolled Beam Alternative (Alternative 2). Proposed conditions for Bridge 197.9 were taken from the preliminary design plans. Changes made to the model are based on the following configurations:

- ***Alternative 1*** – The proposed 358-foot long structure (three spans) has two concrete pier walls. The bridge profile was designed as steel through plate girder with ties, subgrade, and rails. The superstructure is supported on the cast-in-place 3-foot wide concrete pier. The concrete pier is supported by a pile cap founded on 30-inch diameter cast-in-drilled-hole (CIDH) piles. The flow impacts the bridge piers at approximately 3.5-degree skew angle, which is insignificant. Therefore, the skew angle is not considered in the modeling.
- ***Alternative 2*** – The proposed 361-foot-long structure (five spans) has four concrete pier walls. The bridge profile was designed as steel rolled beam with ties, subgrade, and rails. The superstructure is supported on the cast-in-place 3-foot wide concrete pier. The concrete pier is supported by a pile cap founded on 30-inch diameter CIDH piles. The flow impacts the bridge piers at approximately 3.5-degree skew angle, which is insignificant. Therefore, the skew angle is not considered in the modeling.

Hydraulic Model Results

The results obtained from the multiple flow rates of Bridge 197.9 are shown for cross section 13595 in Table 7.1.2. Cross section 13595 is located just upstream of Bridge 197.9.

Table 7.1.2: Hydraulic Model Results at Cross Section 13595

Model		Revised Existing Condition Bridge Model	Alternative 1 Bridge Model	Alternative 2 Bridge Model
50-Yr USACE (29,004 cfs)	WSE	71.84	71.45	72.4
	EGL	73.83	73.57	74.21
	Velocity	11.32	11.7	10.8
	Froude #	0.58	0.61	0.54
100-Yr HC (43,700 cfs)	WSE	80.66	75.04	76.29
	EGL	82.09	77.78	78.57
	Velocity	9.61	13.3	12.15
	Froude #	0.38	0.62	0.54

WSE = water surface elevation (ft); EGL = energy grade line elevation (ft); Velocity = main channel average velocity (ft/s); Froude # = main channel Froude number. All elevations are NGVD 1929.

The hydraulic results compared to hydraulic design criteria for the existing condition bridge is presented in Table 7.1.3. The results indicate that the existing bridge meets the low-chord event criterion, but it does not meet the subgrade event criterion. The hydraulic results compared to hydraulic design criteria for the proposed bridges are presented in Table 7.1.4 and Table 7.1.5 for Alternative 1 and Alternative 2, respectively. Concrete ties are proposed for the proposed bridge. Therefore, the top of subgrade elevation is defined as 2.81 feet below top of rail elevation for concrete ties. As shown in Table 7.1.4 and Table 7.1.5, the proposed bridge configuration meets SCRRA criteria. Hydraulic results are considered approximate until dimensions and elevations are confirmed or updated by new survey data.

Table 7.1.3: Existing Bridge Hydraulic Design Criteria

Criterion	Standard	Model Results	Criterion Met?
50-yr WSE < Low-chord	Low chord = 76.1	50-yr WSE = 71.84	Yes (-4.26)
100yr EGL < Top of SBGD	Top of SBGD = 78.21	100-yr EGL = 82.09	No (-3.88)

WSE = water surface elevation (ft); EGL = energy grade line elevation (ft); SBGD = subgrade. All elevations are NGVD 1929

Table 7.1.4: Proposed Bridge Alternative 1 Hydraulic Design Criteria

Criterion	Standard	Model Results	Criterion Met?
50-yr WSE < Low-chord	Low chord = 78.06	50-yr WSE =71.45	Yes (-6.61)
100yr EGL < Top of SBGD	Top of SBGD = 80.64	100-yr EGL = 77.78	Yes (-2.86)

WSE = water surface elevation (ft); EGL = energy grade line elevation (ft); SBGD = subgrade. All elevations are NGVD 1929

Table 7.1.5: Proposed Bridge Alternative 2 Hydraulic Design Criteria

Criterion	Standard	Model Results	Criterion Met?
50-yr WSE < Low-chord	Low chord = 78.06	50-yr WSE = 72.4	Yes (-5.66)
100yr EGL < Top of SBGD	Top of SBGD = 80.64	100-yr EGL =78.57	Yes (-2.07)

WSE = water surface elevation (ft); EGL = energy grade line elevation (ft); SBGD = subgrade. All elevations are NGVD 1929

Bridge Scour

Bridge scour analysis for proposed Bridge 197.9 was conducted using Federal Highway Administration (FHWA) Hydraulic Engineering Circular 18 (HEC-18), Evaluating Scour at Bridges methodology (FHWA 2012). The parameters for the scour analysis were obtained from the HEC-RAS model. The scour analysis is evaluated at the 100-year High Confidence discharge. The scour analysis results are summarized in Table 7.1.6. The proposed foundation design should account for the scour.

Table 7.1.6: Scour Analysis Results for the Alternatives

Scour Type	Scour Depth (ft) Alternative 1	Scour Depth (ft) Alternative 2
Contraction	3.8	6.0
Pier	16.6	17.4
Pier + Contraction	20.4	23.4

The scour depth is based on available information and subject to the accuracy of survey information and final design configurations. Changes to input data might trigger complex pier scour if the pile caps are exposed to the flow, which may result in a greater scour depth.

Abutments are founded outside the concrete channel side slope and, therefore, abutment scour is not computed. However, the toe down or termination depth of the channel side slopes is not available for this study. Abutments would be subject to scour if the channel side slopes failed as a result of undermining.

Finally, current bridge scour design guidelines (FHWA 2012) recommend a scour design flood greater than the hydraulic design flood. For a 100-year hydraulic design flood, the recommended scour design flood is the 200-year flood, and the bridge design should be checked for stability at the 500-year flood. Scour analysis for these larger floods has not been conducted.

Hydraulic Conclusion

Using the data and resources available, the hydraulic conditions were modeled for Bridge 197.9 for the proposed alternatives. The results of the modeling indicate that both alternatives would meet SCRRA criteria. Bridge scour analysis for both alternatives was conducted. The proposed foundation design should account for the computed scour. New survey data and soil parameters at the project location would be required to finalize the hydraulic and scour analysis for design.

7.2 ENVIRONMENTAL

The purpose of this section is to provide a preliminary assessment of the environmental clearance process and permitting strategy that would likely be required in order to construct the bridge replacement project. This section identifies environmental resources within the preliminary study area (see Figure 1) and potential constraints associated with replacement of the existing bridge structure (Bridge 197.9). Based on these potential constraints, this section provides recommendations for the future environmental clearance process, potential permitting requirements, and the required technical studies to support the environmental clearance and permitting processes. This preliminary analysis is based on a review of publically available information and mapping resources. Where additional project or site-specific details are required, this fact is noted.

Environmental Baseline

To support the development of an environmental clearance strategy for the project, HDR considered resource criteria outlined in the Federal Transit Administration’s (FTA) Environmental Impact and Related Procedures (23 C.F.R. 771). These criteria were then evaluated against readily available baseline environmental resource information for the project study area to determine key resource issues for the environmental clearance strategy. Source documentation reviewed as part of this effort included the following:

- Public web-based information including municipal (e.g., City of San Juan Capistrano) and other public websites (e.g. Southern California Steelhead Recovery Plan).
- Public mapping resources, including Google Earth, floodplain maps produced by FEMA, the National Register of Historic Places (NRHP), the EnviroStor Database produced by the Department of Toxic Substances Control (DTSC), the National Wetlands Inventory (NWI), local geologic maps, and the California Natural Diversity Database (CNDDB).
- Reconnaissance of the Preliminary Study Area on August 26, 2013.

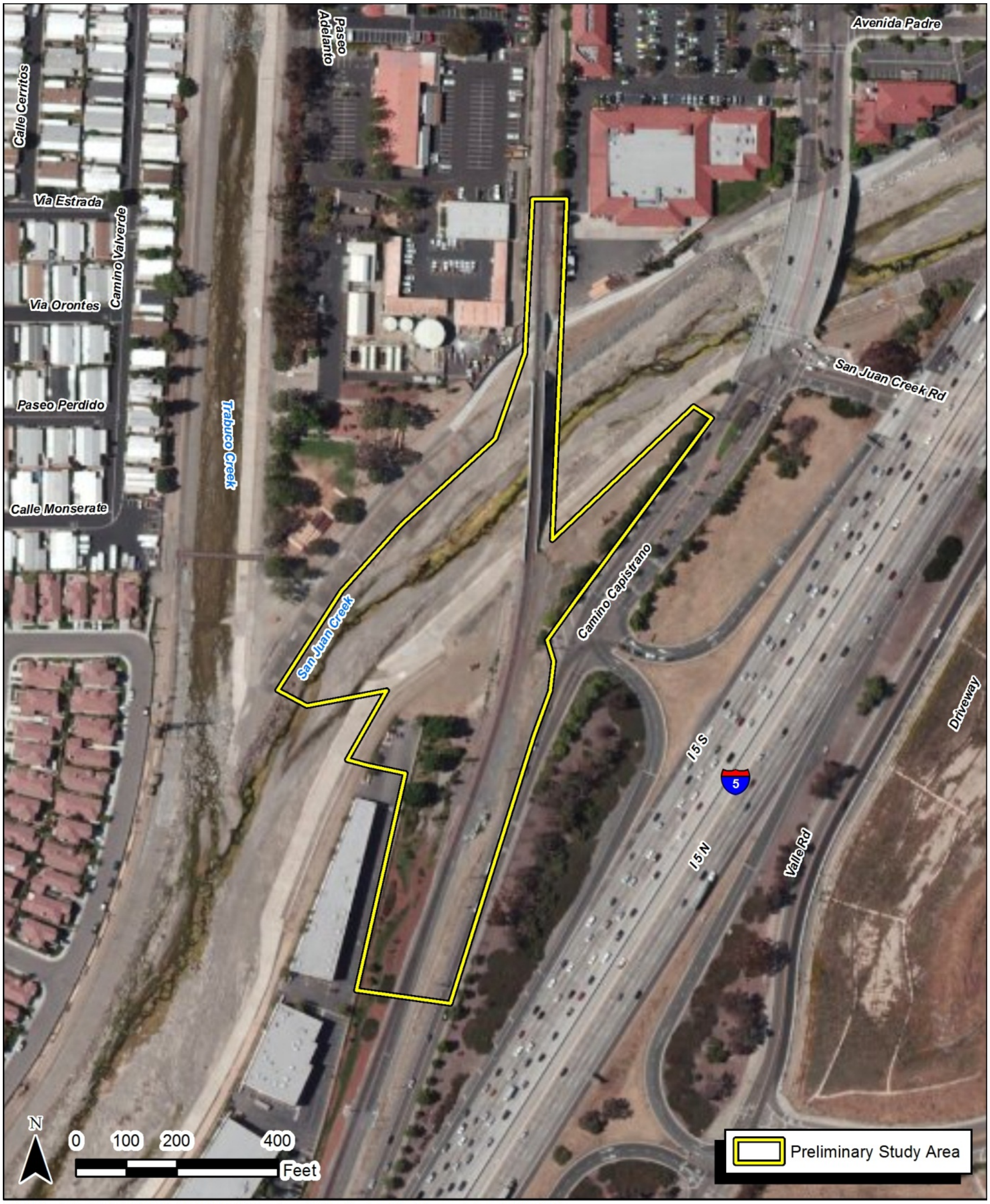

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Figure 1: Preliminary Study Area

No public outreach or resource-specific field visits or surveys were conducted in support of this preliminary assessment.

Biological Resources

The preliminary study area is located within an urbanized section of the City of San Juan Capistrano and is generally comprised of developed and disturbed habitats (see Figure 2–Site Photograph). The existing Metrolink Bridge (Bridge 197.9) spans the San Juan Creek which in the vicinity of the project consists of an unvegetated, trapezoidal channel. The channel banks are concrete-lined. The preliminary study area is located outside and approximately 1.7 miles east of the Coastal Zone. Special status plant and wildlife species located within a two-mile proximity of the preliminary study area include the following (see Figure 3–CNDDB):

- Tidewater Goby (*Eucyclogobius newberry*, Endangered)
- Coastal California Gnatcatcher (*Polioptia californica california*, Threatened)
- Least Bell's Vireo (*Vireo bellii pusillus*, Endangered)
- Arroyo Toad (*Anaxyrus californicus*, Endangered)
- Riverside Fairly Shrimp (*Streptocephalus woottoni*, Endangered)
- Southern Steelhead (*Onocorhynchus mykiss irideus*, Endangered)
- Thread-Leaved Brodiaea (*Brodiaea filifolia*, Threatened)
- Big-Leaved Crownbeard (*Verbesina dissita*, Threatened

Figure 2: Site Photograph

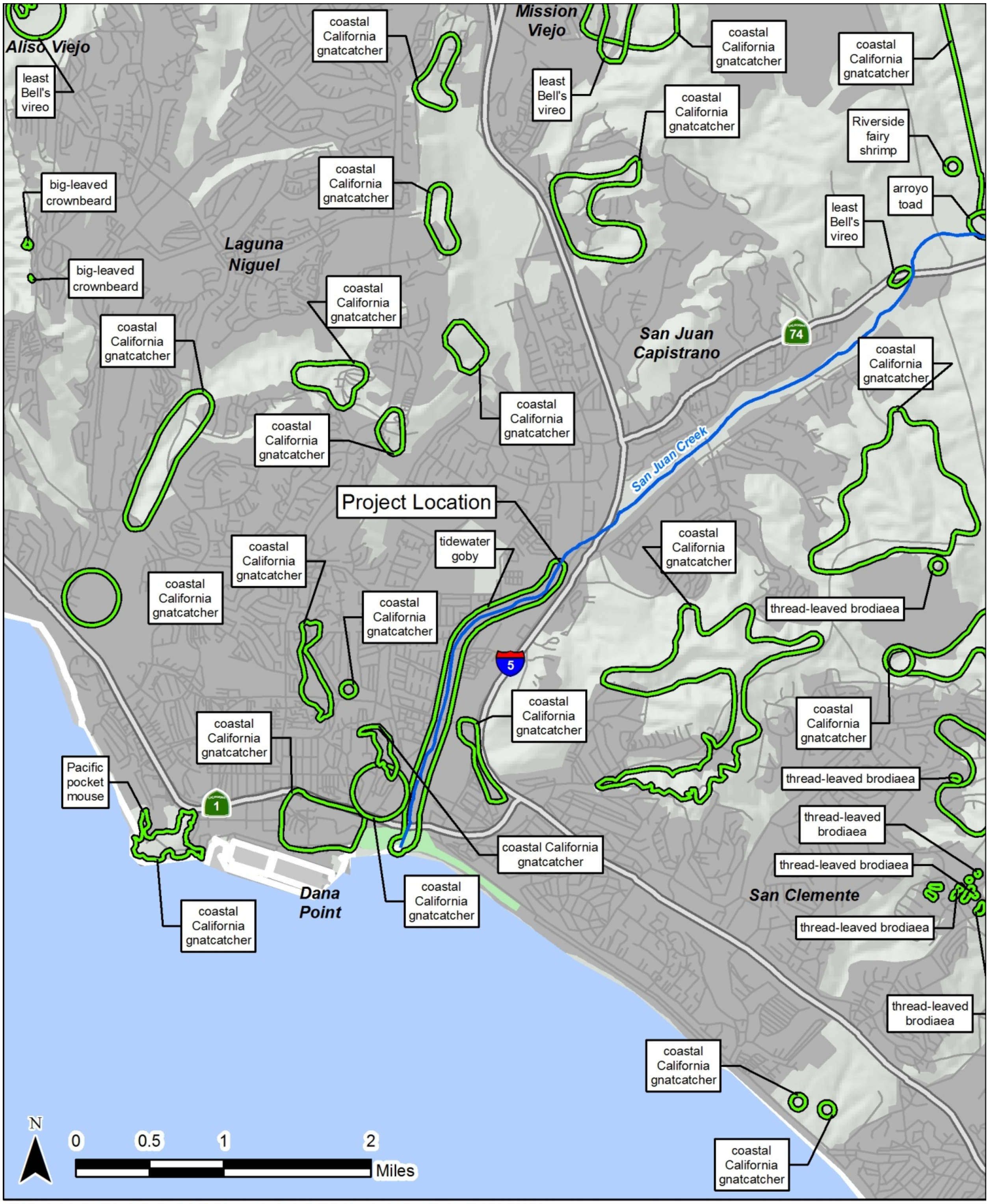

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Figure 3: California Natural Diversity Database

Based on the site conditions observed and the sensitive biological resources identified in the CNDDB (2013) and NWI (2007), the biological resource constraints for the project are likely to include the following:

- Based on the NWI (2007), San Juan Creek is considered "waters of the U. S." and, therefore, construction activities within San Juan Creek will be subject to the jurisdiction of the USACE. The delineation of USACE jurisdiction within the study area is recommended through the preparation of a jurisdictional wetland delineation.
- The San Juan Creek Hydrological Unit (4901) is designated as critical habitat for the Southern California steelhead. This designation appears to extend from where San Juan Creek empties into the Pacific Ocean upstream to its confluence with the Trabuco Creek, approximately 770 feet downstream of the existing Bridge 197.9. Additional coordination with the National Marine Fisheries Service (NMFS) is recommended to define where this critical habitat designation ends in relation to the preliminary study area.
- Based on the CNDDB (2013), tidewater goby habitat is identified along the San Juan Creek, downstream of the preliminary study area, ending at the confluence with Trabuco Creek. Similar to steelhead, additional coordination with NMFS is recommended to define where suitable habitat occurs in relation to the study area.
- The observation or presence of suitable habitat for one or more of the special status wildlife species. A habitat assessment by a qualified biologist is recommended to assess the suitability of the study area for federally listed terrestrial and aquatic wildlife species.

Cultural and Historic Resources

The preliminary study area is located in area with a long history of human occupancy. Agricultural cultivation combined with more recent urban development and projects including, but not limited to, the construction of I-5, Camino Capistrano, the existing LOSSAN corridor, and flood control improvements to San Juan Creek have dramatically altered the natural landscape (and topography) within the vicinity of the preliminary study area. Based on a review of the NRHP database, no historical resources are documented within the study area. The closest listed resource, the Joel R. Congdon House (32701 Alipaz Street), is located approximately 0.43 miles west of the rail corridor at MP 198.12. Due to the alluvial nature of the local geology, the potential for encountering paleontological resources is unlikely. Based on the site conditions observed and the review of available literature, the cultural resources constraints for the project are likely to include the following:

- No evaluation of the existing bridge has been conducted to determine it's eligibility for listing on the NRHP. Further evaluation of the bridge by a qualified architectural historian is recommended.
- No pedestrian survey for archaeological resources has been completed and, therefore, the potential for accidental discovery exists. A records search and pedestrian survey of the study area by a qualified archaeologist is recommended.

Hazards and Hazardous Materials

Potential sources of hazards and hazardous materials within the study area were evaluated by reviewing the EnviroStor database maintained by DTSC and reviewing local planning documents. Based on the results of the EnviroStor database (2013), no hazardous material cleanup sites are documented within the study area. Within a 0.25 mile radius of the study area, approximately five closed sites, six permitted underground storage tank (UST) facilities, one Leaking Underground Storage Tank (LUST) Cleanup site, and approximately 40 monitoring wells were identified. As some of these sites are located in close proximity to the rail corridor, there is the potential for one or more sources of contamination to migrate into the study area. Based on the site conditions observed and review of state databases, the hazardous materials-related constraints for the project are likely to include the following:

- Encountering one or more sources of undocumented sources of contamination during construction. A Phase I Environmental Site Assessment is recommended to verify the presence or absence of any sources of on-site contamination.

The preliminary study area is not located with an airport hazard zone, a wildfire hazard zone, or along a designated emergency access route and, therefore, no additional consideration of these issues is warranted.

Hydrology and Water Quality

The bridge spans San Juan Creek, which drains an approximately 79,330 acre watershed that extends north into the Santa Ana Mountains (see Figure 4–Watershed Area). In the vicinity of the study area, San Juan Creek consists of a channelized waterway with sloped concrete side walls. At the Metrolink Bridge crossing (Bridge 197.9), San Juan Creek has a bottom width of approximately 160 feet with an average height of about 14 feet. Because of a combination of natural flow and return flows from landscape irrigation, structure and vehicle washing, and golf course irrigation, water may be evident within the channel year round. However, flow is more consistent during the winter and spring months. Based on stream gage records for San Juan Creek, at La Novia Bridge, average daily flows of at least one (1) cfs are present more than half the time from December through June with flows resembling a braided stream during low flow conditions (see Figure 2).

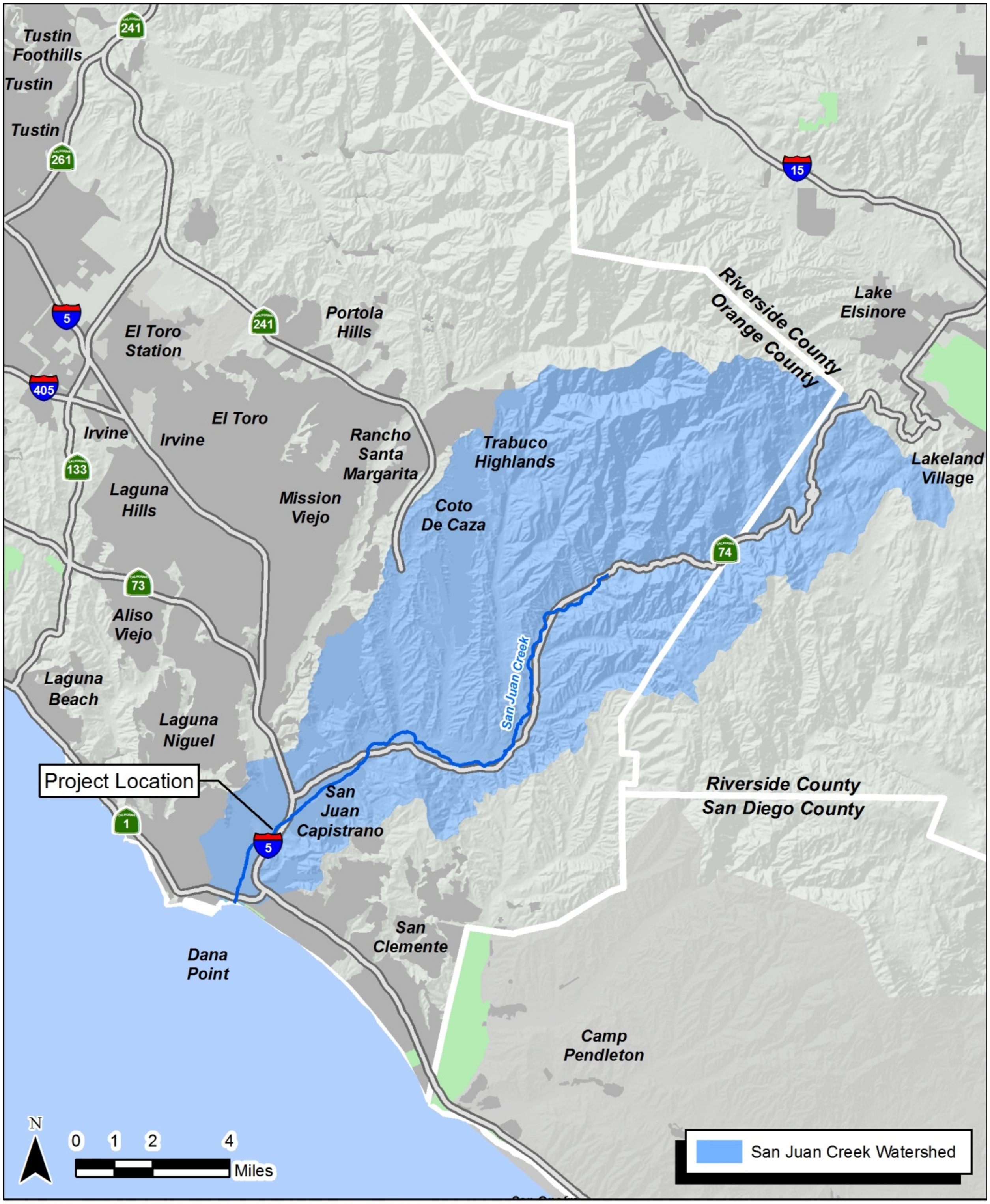

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Figure 4: Watershed Area

The Water Quality Control Plan for the San Diego Basin (Basin Plan) designates the following beneficial uses for San Juan Creek: municipal, agriculture, industrial, contact and non-contact recreation, warm and cold freshwater habitat, and wildlife habitat. San Juan Creek is listed as an impaired water body on the Clean Water Act (CWA), 303(d) list, for the San Diego Regional Water Quality Control Board (RWQCB). Specific water quality pollutants for which San Juan Creek is listed as impaired include: dichlorodiphenyldichloroethylene (DDE), bacteria, phosphorus, selenium, total nitrogen, and toxicity.

Based on a review of available information and mapping, the potential hydrology and water quality constraints for the project are likely to include the following:

- Based on geotechnical borings completed in the vicinity of I-5, the depth to groundwater ranges from 1 foot to 34 feet below the existing ground surface in portions of San Juan Creek upstream of the study area and, therefore, the potential for construction-related dewatering is possible.
- The channel for San Juan Creek is mapped as Zone AE (Floodway) with adjacent areas within the study area mapped as Zone A or AR (see Figure 5). Areas mapped Zone AE are required to be maintained free of encroachments so that the 100-year flood can be carried without substantial increases in flood heights. Additional hydrologic and hydraulic (H&H) analysis would be required to verify whether the new bridge structure satisfies FEMA criteria.
- The timing and extent of bridge construction remains unknown. Depending on the actual timing of construction and other regulatory requirements, the diversion of flow around the construction area may be required. This would require the preparation of a temporary flow diversion plan.
- Potential water quality impacts will require compliance with the National Pollutant Discharge Elimination System (NPDES) General Construction Permit and preparation of a Stormwater Pollution Prevention Plan (SWPPP) would be required. The receiving water risk is anticipated to be low. Further evaluation of on-site soil materials would be required to calculate the project's sediment risk.
- Potential low-impact development (LID) requirements per the Orange County Municipal Stormwater Permit or post-construction runoff requirements from the NPDES General Construction Permit. These requirements may trigger the need for a Water Quality Management Plan (WQMP) or equivalent.
- Improvements to the concrete-lined sections of the channel as a result of new abutments or side-drains would likely require approvals from USACE per Section 14 of the Rivers and Harbors Act Approval (33 U.S.C. Section 408) and the local flood control sponsor Orange County Flood Control District. These approvals would require the preparation of additional hydraulic and hydrology (H&H) analysis for the new bridge structure along with supplemental structural and geotechnical evaluation.

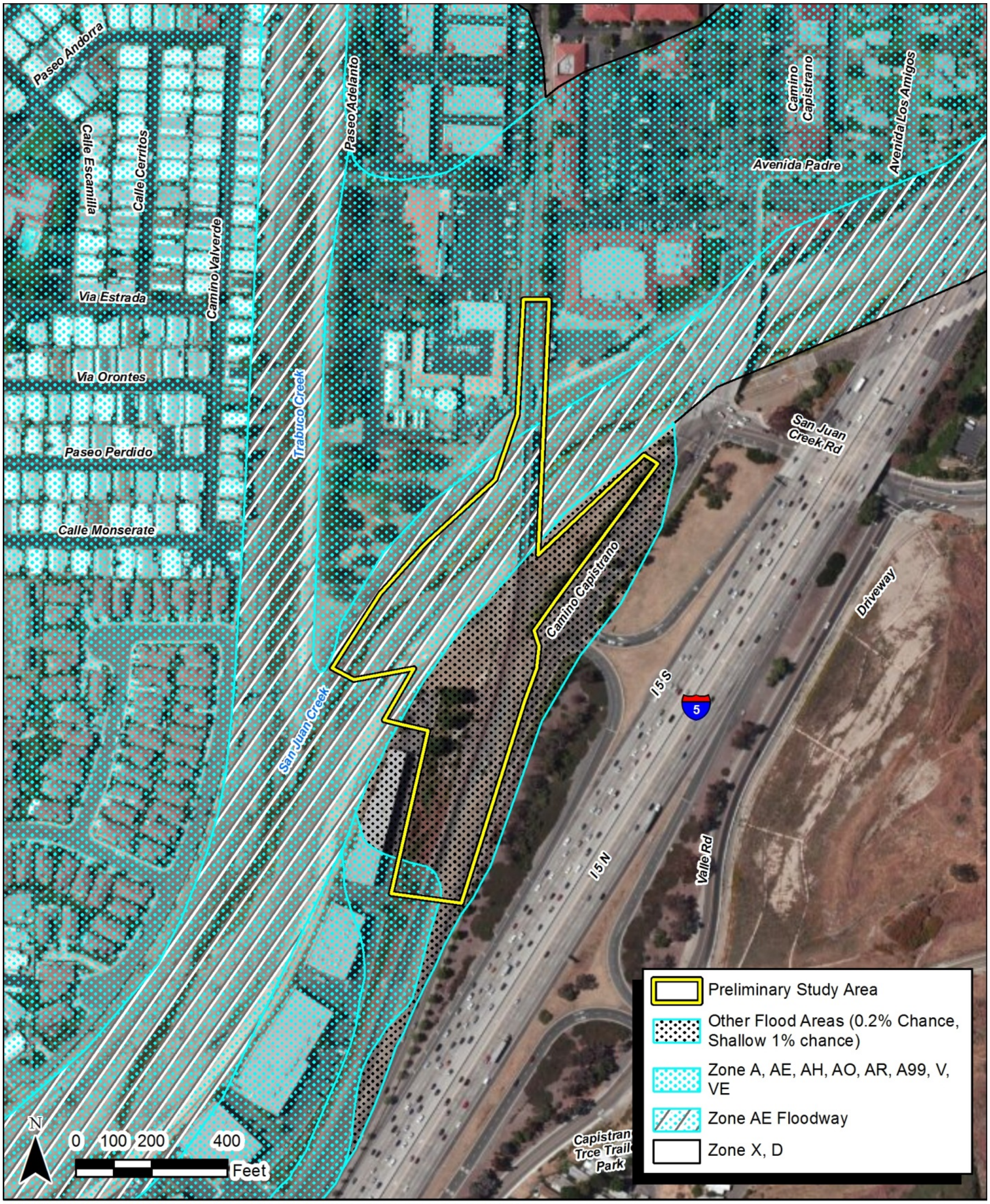

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Figure 5: Designated Flood Hazard Areas

Noise and Vibration

The project is located within an urbanized portion of the City of San Juan Capistrano. The ambient noise environment within the vicinity of the study area is influenced by both mobile and stationary noise sources. The dominant mobile sources include vehicle traffic along I-5 and local roadways and, to a lesser extent, train movements along the LOSSAN corridor. The closest noise sensitive receptor(s) consist of residential structures situated over 400 feet to the west of the southwestern edge of the study area. Additionally, a small neighborhood park and the San Juan Creek Bike Trail border the northern edge of the study area.

No operational changes would result from the bridge replacement; hence, the consideration of noise and vibration is focused on construction. The City's Noise Ordinance limits construction and demolition hours to 7 AM to 6 PM, Monday through Friday, and 8:30 AM to 4:30 PM on Saturday. Typical construction activities can result in noise levels that are in excess of 90 decibels (A-Weighted – dBA) depending on the equipment involved (e.g., cranes, pile driver, etc.). These noise levels would attenuate over distance (e.g., 6 dBA per doubling distance); however, HDR is unable to verify whether these noise levels would exceed federal standards without additional analyses of potential noise and vibration effects. Based on this uncertainty, additional acoustical analysis is recommended; especially if pile driving techniques are employed for bridge construction.

Schools, Parks, and Recreation

The San Juan Creek Bike Trail runs beneath a bridge just north of the northerly abutment of the San Juan Creek Bridge at MP 197.84. This bike trail would likely qualify as a "resource" under Section 4(f) of the 1966 Department of Transportation Act. This qualification will require a consideration of the potential for the project to result in a direct use, temporary occupancy, and/or constructive use to the resource. A similar designation may apply to the adjacent park site. Based on these considerations, the major park and recreation-related constraints for the project include:

- Maintaining access along the bike trail during construction through detours or other means.
- Direct use of the adjacent park as a result of potential realignment of the bike trail.
- Direct and temporary use of the bike trail as a result of bridge reconstruction and feasibility of satisfying current design standards for bike trails. A Section 4(f) analysis is recommended to determine if one or more Section 4(f) uses of the bike trail could occur as a result of the project.

No educational facilities are located in the immediate vicinity of the preliminary study area; hence, the project would have no effect on schools.

Public Utilities

Numerous public and private utilities traverse the study area which may or may not require encroachment permits. Additional utility coordination and investigation would be required in the next phase of design. Further detail is discussed in the Utilities section 7.9 below. .

Air Quality

Projects commonly have two major sources of air quality impacts: (1) pollutant emissions generated during construction, and (2) long-term operational emissions after construction, such as vehicular emissions from new trips generated by the new land use. The project by its nature would facilitate continued passenger rail service and, therefore, no new vehicular trips would be generated by the project after development. Although, the improvements proposed as part of the project are of a small scale, relative to the air basin and the level of emissions considered significant by the South Coast Air Quality Management District (SCAQMD), the improvements could generate construction-related emissions as a result of the operation of heavy, emission-generating equipment.

The SCAQMD has established significance thresholds for construction (and demolition) emissions for six categories of pollutants. These thresholds are based on their potential adverse short-term health effects. Further quantification of construction emissions is recommended to verify whether project-related construction could exceed thresholds for the following:

- Reactive Organic Compounds (ROC) - 75 pounds per day (lbs/day)
- Nitrogen Oxides (NOx) - 100 lbs/day
- Carbon Monoxide (CO) - 550 lbs/day
- Particulates of less than 10 mm (PM10) - 150 lbs/day
- Particulates of less than 25 mm (PM25) - 55 lbs/day
- Sulfur Oxides (SOx) - 150 lbs/day

Environmental Justice

Based on a review of CalEnviroScreen 1.1, the preliminary study area is located within a zip code where the poverty level is 47.9 percent. As a result, one or more census tracts and block groups within the project vicinity may qualify as an environmental justice community. For this reason, further assessment of environmental justice is recommended, including the delineation of low-income and minority census tracts surrounding the study area.

7.3 OTHER ENVIRONMENTAL TOPICS CONSIDERED

Aesthetics

The rail corridor travels through primarily developed areas to the west of I-5. According to the California Scenic Highway Mapping System, there are no designated scenic routes along the project section of the LOSSAN corridor. Although State Route (SR) 74 to the east of the project is mapped as an eligible state scenic highway, the project is not visible from SR 74.

Land Use, Planning, and Ownership

According to the City's Land Use Map, land use designations for the study area and surrounding area are (3.1) General Commercial and (4.1) Quasi Industrial. The City's Zoning further defines the segment of the rail corridor subject to the proposed improvements as General Open Space (GOS). Zoning for adjacent areas include Commercial District (GC), Commercial Manufacturing District (CM), and Industrial Park District (IP). Construction of the bridge replacement would not conflict with these use designations and land use following construction would be similar to existing conditions. All improvements would be contained within Metrolink's railroad right-of-way and, therefore, effects to adjacent properties would likely be limited to temporary construction easements.

Traffic and Transportation

Access to the project site is provided by Calle Perfecto, which terminates at the southern end of the study area. Beyond the use of this roadway for the entry and exit of construction vehicles, the low level of truck trips required for the project would have no physical effect on the local roadway network or significant impacts to the current operating conditions for local roadways and intersections. Based on these considerations, no additional traffic impact analysis is warranted.

Geology, Soils, and Mineral Resources

Geology and soils were analyzed in the Preliminary Foundation Study for the San Juan Creek Bridge (HDR 2013). According to the Preliminary Foundation Study, there are no known active or potentially active faults mapped across the preliminary study area. The closest active faults that could generate ground motion within the preliminary study area are the Newport-Inglewood fault, San Joaquin Hills fault, and the Newport-Inglewood fault zone, located approximately 5.1 miles, 7.2 miles, and 10.4 miles, respectively, from the study area. Notwithstanding additional geotechnical investigation and preparation of a final geotechnical report for the project, the integration of standard engineering practices is expected to minimize any adverse effects relating to geology and soils.

The project would entail the replacement of an existing bridge structure; hence, the project would not interfere with the availability or limit access to important mineral resources.

Environmental Clearance and Permitting Approvals

Based on the environmental resource constraints identified in Section 1, this section presents an environmental clearance strategy to support the construction of a steel-through-plate girder or steel rolled beam bridge alternative. The replacement of the existing bridge under either alternative would be subject to the jurisdiction and regulations of a number of federal resource agencies, acts and processes, regardless of whether the proposed improvements are within or outside of the existing railroad right-of-way. Per Section 10501(b) of the ICCTA, the Surface Transportation Board (STB) retains exclusive jurisdiction over “transportation by rail carriers” and expressly preempts any state and local regulations, including the California Environmental Quality Act (CEQA). Based on this regulatory framework, this clearance strategy focuses on a compliance strategy for the following federal laws and regulations:

- National Environmental Policy Act (NEPA)
- Section 7 of the Endangered Species Act (ESA)
- Section 106 of the NHPA (National Historic Preservation Act)
- Sections 401, 402, and 404 of the Clean Water Act (CWA)
- Section 14 of the Rivers and Harbors Act (33 U.S.C. §408)
- Section 4(f) of Department of Transportation Act (49 U.S.C. §303)
- Fish and Wildlife Coordination Act

The approach for complying with each of these laws and regulations is provided under the following headings.

NEPA Compliance

NEPA compliance for the project is only required if a federal nexus exists and, if applicable, the participating federal agency is required to initiate the NEPA process per its implementing policies and procedures. In the case of the project, the most plausible federal nexus for the project is the use of federal funding from either the FTA or Federal Railroad Administration (FRA). If NEPA clearance is required, the project is anticipated to be processed under NEPA through the preparation of a categorical exclusion (CE) or, potentially an environmental assessment (EA). Multiple technical studies would be required to determine if the project would satisfy criteria necessary to qualify for a CE. These include, but may not be limited to, the preparation of a biological assessment (BA), cultural resources report, H&H analysis, noise study, air quality impact analysis, environmental justice assessment, Phase 1 Environmental Site Assesment, and Section 4(f) analysis, as recommended in Section 1.

If the findings of the technical studies indicate that no adverse environmental effects would result from the project, then a CE could be pursued provided that the replacement structure occupies substantially the same geographic footprint and does not result in a change in functional use. Both FTA and FRA have CEs that could be pursued for the project; a Class 5 (Activities, including Repairs, Replacements, And Rehabilitations) through FTA or a Class 22 (Bridge Rehabilitation, Reconstruction or Replacement) through FRA. If one or more of the technical studies conclude that an adverse effect could result, an EA would be necessary for NEPA compliance. The typical processing time for a CE averages less than 6 months; whereas the processing time for an EA averages 12 or more months.

Section 7 Consultation

Based on available documentation, San Juan Creek potentially supports the federally listed Southern California steelhead and tidewater goby. Per the requirements of NEPA, the federal lead agency is required to consult with the U.S. Fish and Wildlife Service (USFWS) and NMFS in accordance with Section 7 of the ESA regarding potential impacts to federally listed species. Because suitable habitat for listed species may be impacted by the project, Section 7 Consultation would be required. To support the federal lead agency's consultation requirements in addition to developing recommendations for practical avoidance and minimization measures, the preparation of a BA is recommended. The findings of the BA would determine the need for either formal or informal consultation with USFWS and/or NFMS. Formal Section 7 consultation typically takes 60 to 135 days following the submittal of a BA, with the USFWS or NMFS issuing a Biological Opinion (BO) at the end of the consultation process.

It is important to note that when implementing the Section 7 process, there are two separate environmental review and permit processes that would trigger Section 7. As described above, the lead agency would be required to conduct Section 7 consultation if the project requires NEPA review. In addition to NEPA, the USACE is required to consult with USFWS and/or NMFS as part of the Section 404 process of the CWA (described below). As a result, the Section 7 process can be implemented at different points in the environmental clearance process depending on which federal agency takes the lead on Section 7 consultation.

Section 106 Consultation

Similar to the Section 7 consultation process, the federal NEPA lead agency and USACE in accordance with the CWA, is required to consult with the State Historic Preservation Officer (SHPO) in accordance with Section 106 of the NHPA. SHPO is responsible for the review and comment on federally sponsored projects that may result in adverse effects to archaeological and historical resources listed on or eligible for listing on the NRHP. As discussed in Section 1, further evaluation of the existing bridge by a qualified architect/historian is warranted to confirm that the bridge is not a historic structure eligible for listing on the NRHP. This evaluation along with the delineation of an area of potential effect (APE), records search, and preparation of a cultural resource report is recommended in order to support the Section 106 consultation process with SHPO. If no properties are determined to be eligible for listing in the NRHP or if NRHP eligible properties are unaffected by the project, the SHPO review would likely be completed within 30 days from receipt of the inventory documentation.

Although compliance with Section 106 is the responsibility of the federal lead agency, the work necessary to fulfill compliance can be delegated to others. For example, SCRRA can request the federal NEPA lead agency to delegate Section 106 consultation authority to the local project sponsor in order to expedite the process.

7.4 REGULATORY PERMITTING

Section 14 of the Rivers and Harbors Act (33 USC 408 Permit)

Section 14 of the Rivers and Harbors Act (RHA) requires that entities proposing to build upon, alter, deface, destroy, move, injure, or obstruct in any manner that impairs the integrity or functionality of a flood control facility constructed by the United States must obtain authorization from USACE in the form of a “408 Permit.” The section of San Juan Creek subject to the proposed bridge replacement is believed to be a USACE-constructed facility, which is now maintained by the Orange County Flood Control District (OCFCD) as the local sponsor. Presuming that USACE determines that a Section 408 Permit is required based on the contemplated improvements, SCRRA should attempt to pursue a “minor” 408 permit through the USACE and OCFCD following USACE’s CECW-PM Memorandum. The 408 Permit process for a “minor” alteration can range from six to twelve months and should be initiated in advance of submitting the Section 404 permit (described below). Based on this timeline, immediate outreach to the OCFCD is recommended to confirm applicability and associated design criteria.

Since San Juan Creek in the vicinity of the project is designated as a “Floodway” or Zone AE (see Figure 5), additional H&H Analysis is recommended to provide confirmation that no change in flood conveyance capacity occurs with the proposed bridge replacement for the 100-year flood event. If the H&H Analysis concludes reductions in capacity would result and no design modifications can be made to avoid this situation, the project may be required to proceed with a “major” 408 permit, which requires approvals from USACE headquarters in Washington, along with the preparation of a letter of map revision (LOMR) for approval by FEMA. For this reason, the H&H Analysis should proceed immediately once a decision is made to proceed with a bridge replacement alternative. Multiple design options should be considered in the H&H Analysis in order to facilitate the selection of a design option that avoids the need for a “major” 408 Permit and LOMR.

Section 404 of the Clean Water Act (Nationwide Permit)

Construction of the proposed project would result in impacts to the waters of the U.S. as a result of the placement of fill materials and excavation within the San Juan Creek to accommodate the replacement bridge. Consequently, a Section 404 Permit would be required prior to construction of the project. Depending upon the quantity of impacts to jurisdictional areas the USACE may issue a nationwide permit (NWP) or individual permit (IP). NWPs are general permits for specific categories of activities that result in minimal impacts to aquatic resources. NWP 14 (Linear Transportation) authorizes impacts for the construction of transportation projects and would be the most likely NWP category in which to process the project under Section 404. Under a NWP 14, permanent impacts to non-tidal waters of the U.S. must not exceed 0.5 acre or 0.33 acre of tidal waters. To qualify for NWP authorization, the project must comply with the NWP General Conditions. The processing time for a NWP 14 would be contingent on several interrelated issues including, but not limited to, applicability of Section 14 of the RHA, presence of threatened or endangered species (e.g., Section 7), and the extent of USACE's jurisdiction within the preliminary study area, and typically ranges from six to twelve months. To the extent allowable by USACE, both the NWP 14 and "Minor" 408 Permit approvals should be pursued concurrently.

Section 401 of the Clean Water Act (Water Quality Certification)

In order for the USACE to issue a 404 permit, a 401 water quality certification (401 Certification) must be obtained from the U. S. Environmental Protection Agency (USEPA). In California, the USEPA has delegated the 401 Certification process to the State Water Resources Control Board (SWRCB) and the nine Regional Water Quality Control Boards (RWQCB). The study area is within the jurisdiction of the San Diego (Region 9) RWQCB, who would be responsible for issuing the 401 Certification to certify that the discharge of dredged or fill material into waters of the U.S. does not violate state water quality standards.

The 401 Certification process typically ranges between 60 and 135 days depending on RWQCB staff workload. As part of the application for a 401 Certification, evidence of compliance with CEQA must be provided. For this project, the CEQA documentation would presumably include SCRRA's Statutory Exemption for the Southern California Regional Rail Project, which was adopted in 1991. It is important to note that the application for a 401 Certification is also subject to a 15-day public notice period.

Section 402 of the Clean Water Act (National Pollutant Discharge Elimination System)

The SWRCB has adopted a General Construction Activity Storm Water Permit (General Construction Permit) in compliance with Section 402 of the CWA for storm water discharges associated with any construction activity that results in the disturbance of at least one acre of total land area. The project is expected to affect greater than one acre and, therefore, would be subject to the General Construction Permit. The General Construction Permit requires the site owner (or project applicant) to file a notice of intent with the SWRCB, to prepare and implement a Storm Water Pollution Prevention Plan (SWPPP), and to monitor the effectiveness of the SWPPP consistent with the project's water quality risk level. Typically the construction contractor will prepare the SWPPP and apply for the General Construction Permit. Additionally, once the means and methods for construction are better defined, compliance with other General Permits may be required, such as those required for dewatering discharges.

Section 4(f) of the Department of Transportation Act (49 U.S.C. §303)

Based on this preliminary analysis, the project has a potential to result in a direct use, temporary occupancy, and/or a constructive use of existing park and trail facilities. The use of a Section 4(f) resource would preclude the potential for processing the project under NEPA through the use of a CE. For this reason, a Section 4(f) analysis should be completed in order to assess the potential for one or more use of local 4(f) resources, develop recommendations or alternatives for avoiding or minimizing these uses, and enable for coordination with the appropriate landowner (e.g., City of San Juan Capistrano). The Section 4(f) analysis will be particularly important for assessing potential uses associated with different design options for the San Juan Creek Trail Bridge.

Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act requires federal agencies to consult with USFWS, the NMFS, and California Department of Fish and Wildlife (CDFW) before they approve projects that modify surface water. The act requires federal agencies to "give full consideration" to measures recommended by these agencies in NEPA documents to reduce impacts on wildlife and fisheries resources. For the project, the act requires consultation with USFWS and NMFS because federal action would be required. It is also through the Fish and Wildlife Coordination Act that most USFWS, NMFS, and CDFW comments would be conveyed to USACE as part of the application for permits under Section 404 of the CWA.

7.5 GEOTECHNICAL

Based on the conditions at the bridge, the life of the timber piles may last 100 years or longer (per FHWA manual), but the protection method used on the existing piles is unknown. According to the as-built drawings, the timber bridge deck was treated with creosote oil and heavy road oil during construction. There is no existing information regarding any treatment on the timber piles. Also, due to its location in a creek channel, the Bridge has likely experienced many cycles of varying water levels, which is particularly degrading to timber piling. Keeping the timber piles in any rebuild alternative should not be considered. Regardless of pile condition, the existing pile lengths are far too short by modern standards, and they do not extend beyond liquefiable soil layers.

Based on our evaluation of existing data, the proposed bridge may be supported on CIDH piles or driven steel piles. Existing bridges in the project area are supported on Caltrans Class 70 driven piles, 45-ton Raymond step-taper (concrete-filled corrugated steel shell) piles, CIDH piles, and 70-ton steel pipe piles. The existing foundations built within San Juan Creek have approximate cutoff elevations between 27 and 14 feet mean sea level (MSL) with pile lengths between 43 and 45 feet at the bent locations. Based on this information, driven steel piles are expected to have approximate cutoff elevations between 10 and 20 feet MSL. Actual pile capacities would vary depending on pile type, soil conditions, and site-specific liquefaction analysis.

Based on the existing soils and as-built information, several foundation constructability issues are likely to exist at the bridge location. Special construction techniques such as predrilling, casing, wet-method installation, or jetting may be required to construct new foundations at the site. Based on the existing borings near the project site, free groundwater is expected near the creek surface. Due to the nature of the sandy soils anticipated on site, caving may be encountered during the CIDH pile construction and temporary casing or drilling slurry may be necessary to facilitate the construction of CIDH piles. According to existing as-built information, casing was used to construct the CIDH piles used in the 1967 widening of Bridge No. 55-298. Based on the existing borings near the project site, gravelly soils and very dense sands are expected at varying depths below the creek. These conditions may cause drivability issues for driven piles. Pile driving shoes, predrilling, or jetting methods may be required for driven pile installation. According to existing as-built information, jetting was used to aid with the installation of the Raymond step-taper piles used in the 1967 widening for Bridge No. 55-228. Further detail is provided in the attached Preliminary Foundation Report.

7.6 TRACK AND OPERATIONS

Replace Existing Bridge – Off-Line Alignment

This track analysis discusses the option of constructing a proposed rail bridge to the west of the existing rail structures. The proposed replacement bridges must be constructed out of the influence of the existing structure to minimize impacts the existing rail service and simplify constructability. Some of the benefits of relocating the bridge off line vs. replacing the existing bridge in place include:

- The schedule for construction and track outages would be reduced.
- Construction methods would be simplified and as a result would likely reduce costs.
- The higher the new structure needs to be raised, the larger the horizontal distance is required between the new and existing structure to accommodate track construction.
- Most structure, track, and utility work can be completed before any track outages are required.
- The time that construction equipment impacts the San Juan Creek bed can be reduced by using the newly set spans as access for the crane to set the next span using “piggy-back” method.
- If the same structure type is used, the new bents and abutments can be constructed in line with the existing ones. This may help reduce San Juan Creek’s hydraulic impacts.
- The new bridge alignment would improve constructability of a second track and structure if warranted in the future.

Some of the challenges of constructing the track and structure off line are:

- Acquiring permits and scheduling work windows to construct bridge bents in the San Juan Creek bed. Depending on the structural type, it may be necessary to increase the number of bents required in the creek bed. This may reduce the existing hydraulic opening. Therefore, the existing hydraulic opening should be maintained at a minimum, by proposing a structure type that would minimizes the number of bents in the creek and minimizes the depth below the rail ties. This would minimize the amount of track raise that may be needed to achieve the required free board needed under the bridge. We have assumed that it would be necessary to raise the track bed by about 2.5'. This would require re-gradeing the rail bed under the No. 10 turnout to the north and the No. 20 turnout to the south, along with portions of the main and siding track.
- The 50-foot-wide railroad right-of-way north of the San Juan Creek limits potential bridge and track alternatives. Proposing the off-line bridge alternative would require right-of-way acquisition of the neighboring property from the City Department of Public Works facility maintenance yard (approximately 2,100 square feet. The proposed alternative would have to account for drainage and constructability in a limited workspace.

The preferred off-line alignment would be designed in a way that the new structures can be constructed without impacting the existing structures or track. A minimum of 25 feet from centerline to centerline of tracks at the thru-plate girder bridge abutment will be needed to allow for enough clearance to build the proposed structure.

The existing rail structure over San Juan Creek has to accommodate approximately 160 feet of curved track. The proposed track alignment reduces this length of curved track on structure to about 50 feet. This may help decrease the complexity of the bridge structure and cost.

The proposed track alignment assumed the same train speeds (Vp/Vf) and used the same degree of curvature (Dc) as the existing alignment for design. The proposed spiral lengths (Ls) are calculated using current Metrolink Standards and are considerably shorter than the existing ones (see Appendix A - Track Plan and Profile Sheets CT-01 through CT-04). If the proposed rail alignment does not need to be raised, there would be only minimum grading required to bring the track to proposed grade. The maximum offset from existing centerline to proposed centerline is about 43 feet. The proposed alignment would impact a landscaped area within railroad right-of-way. There may be a necessity to mitigate the landscaping that is impacted.

At Control Point Capistrano, it would be necessary to install a new No. 20 left hand turnout for staging purposes. The existing turnout can be salvaged and used elsewhere. It appears the existing Control Point (CP) location (signal bungalow) can remain at its existing location, but would be an additional 33 feet away from the proposed track than it is from the existing track. The existing rail signals which are about 500 feet south of CP Capistrano would need to be relocated prior to shifting tracks to their final location. The existing Sierra Siding would be taken out of service temporarily to install the signals in their final location on the east side of the tracks.

The proposed track alignments, MT-1 and Sierra Siding, join into the existing 6°36‘00” curve by increasing the delta angle of the simple curve. This lengthens the curve by about 40 feet, which is minor impact to the overall operation. The alignment maintains the existing track center spacing, reducing to a minimum 15 feet T/C adjacent to CP Capistrano No. 20 turnout. The Sierra Siding track is shown being slightly modified through the entire curve. Both tracks would need to be re-surfaced and there is a non-standard tangent (105’+/-) between this curve and a complex compound curve (Ls – 330’, 3°58’00”, Ls – 120’, 1°53’00”, Ls – 120’) to the south, just north of MP 198.7, that also may need to be resurfaced.

Future Expansion – Double Track

The proposed Off-Line Track Alignment would be able to accommodate a future proposed double track expansion. The existing condition through the project limits has a siding track from the San Juan Capistrano Station that terminates just north of the rail structures and to the south there is the Sierra Siding. The crossing over the San Juan Creek is the only area that has a single track and could be double tracked due to this project opening up the corridor north of the structures. With the double track, operations would be changed due to possible locations of crossovers and turnouts that may be needed to accommodate future train operations. There is little or no space or proper track geometry to allow for the installation of crossovers within the limits of the project. Possible locations for a crossover or a universal crossover would be on either side of Avenida Aeropuerto between MP 198.60 and MP 198. 85. The Sierra Siding ends at 199.9 and would only accommodate about a one mile siding between existing CP Sierra and a new crossover or universal.

This study has investigated a track alignment that utilizes the existing structures as a double track adjacent to the proposed Off-Line track alignment. The alignment is less than desirable north of the existing structure due to fact that it would create four curves, one over the existing rail structures and three curves north of the existing rail structures. The necessity of these curves would be to shift the existing MT-1 track to the east to maintain a minimum 15-foot track center spacing to proposed Off-Line Alignment. The reversing tangents between the curves all meet the SCRRA Standards for tangent lengths, (L = V*3 = 180’), the shortest of which is approximately 196’.

The existing thru-plate girder structure would need to be retrofitted if used to accommodate the double track. It would cost less to retrofit the existing bridge if the alignment over the existing structure was used only for passenger trains and the Off-Line Alignment was used for both passenger and freight trains.

A more favorable track alignment can be achieved by demolishing the existing bridge and constructing a new structure for the second track. Currently there are no plans for double track expansion; the track plans in Appendix A only show a single track alternative but the alignment may be modified to accommodate a second track.

7.7 STRUCTURE

The proposed new track alignment crosses over the San Juan Creek and the adjacent bike trail west of the existing bridges. Our study indicated that for the portion of the bridge crossing over the San Juan Creek, either ballasted deck steel through girder or steel rolled beam would be most suitable. For the portion over the bike trail, because of the short span that the bridge has to cross over, precast prestressed concrete double box beam would be most suitable. The advantage, constraints and the layout of each of these two options is discussed below:

San Juan Creek Bridge Alternative 1: Steel Through Plate Girder

This alternative consists of constructing a three-span bridge over the San Juan Creek. The existing three-span steel bridge is a through plate girder superstructure with span lengths of 102', 100.5', 102.17'. Whereas the proposed bridge span lengths would be 141'-0", 108'-0", and 108'-0" resulting in a total bridge length of 357’-0”. A bridge layout with equal span lengths was considered and rejected due to potential conflicts that the new bridge footings would have with the existing bridge piers. The superstructure of the proposed bridge would consists of steel through plate girder supported on two reinforced concrete pier walls and two seat type abutments. The girders would be simply supported on the pier walls and the abutment seat. To match the direction of water flow in San Juan Creek, the abutments and piers would have a skew angle of 41°30'00". This skew angle is larger than 30° recommended for steel structures per Metrolink SCRRA Grade Separation Guidelines. To reduce the effect due to this skew angle for the superstructure, the pier caps and the abutment seats could be made wide enough to square off the superstructure at support location.

Placement of the substructure components required special consideration. Abutment 1 is placed to avoid a conflict with the existing abutment wingwall. The abutments and pier walls would be supported on CIDH concrete piles and pile caps. The 100-year flooding analysis predicts a total scour depth of 27.4 feet. 10.8 Feet of the total scour depth is due to contraction scour of the existing stream bed. The AREMA recommends embedding the top of the pier wall footings under the contraction scour line. Therefore, it is proposed to set the top of the footings 11 feet below the current stream bed. To satisfy the total scour depth and seismic requirements, a group of 30 inch diameter CIDH concrete piles is being proposed. These groups of piles would be designed to both provide the lateral and vertical capacity needed to withstand the seismic and service loadings after the site has experienced the full scour depth. The piles would also be extended beyond the liquefiable soil layers to address the potential liquefaction issue present at the site.

It must be noted that portions of the existing concrete channel lining would be removed during construction of the abutment walls. These concrete linings would be replaced with new concrete linings and would be connected to the existing linings. Therefore, construction of the substructure must start and be completed during the dry season.

This alternative would also match the existing steel through plate girder bridge. It would therefore not require raising of the rail profile if it is determined that the bottom of the existing girders meet the free board and hydraulics requirements of the waterway and the tie-in to the existing rail track beyond the bridge limits would be relatively easier.

San Juan Creek Bridge Alternative 2: Steel I-Girder Rolled Beams

This alternative would consist of five 72'-2" spans, resulting in a total bridge length of 361'-0". The superstructure of the proposed bridge would consist of five steel beams similar to the steel rolled beam standards used by Union Pacific Railroad (UPRR). This type of structure is very common for railroad bridges. The center-line bearing to center-line-bearing of the rolled beam is 69'-0". These beams would be simply supported on four reinforced concrete pier walls and two seat type abutments. To follow the direction of water flow in San Juan Creek, the abutments and pier walls would have a skew angle of 41°30'00" to accommodate the proposed track alignment and direction of stream flow. This skew angle is larger than 30° recommended for steel structures per Metrolink SCRRA Grade Separation Guidelines. To reduce the effect due to this skew angle for the superstructure, the pier caps and the abutment seats could be made wide enough to square off the superstructure at support location. The foundation for this bridge would be similar to the one discussed for Alternative 1. However, due to constructing additional pier walls in the creek, the hydraulics and environmental issues would be different than those for Alternative 1. This alternative would adversely affect scour, water level and environmental issues.

Because the use of steel rolled beams would result in a deeper structure as compared to the through plate girders, the rail profile may need to be raised to provide for the free-board requirements which as a minimum should match the existing conditions. Raising the rail profile would make the connection of the new to the existing tracks more challenging.

After evaluating the above alternatives against the critical design elements, it is the recommendations of the design team that Alternative 1 with the steel through plate girders be used as the preferred alternative.

Bike Trail Bridge

This is a short span bridge that would cross over the existing bike trail. A 35’-4” long simply supported span bridge with a 15 degree skew is being proposed for this site. Precast prestressed concrete double box beams would be the most economical and suitable structural configuration for this site. The existing vertical clearance over the bike trail is 12 feet and meets the minimum requirement of 10 feet. Therefore, the proposed precast prestressed concrete double box beam would provide adequate vertical clearance over the bike trail. A steel rolled beams type superstructure was also considered and rejected because of high initial cost and long term maintenance costs associated with steel structures. The bridge would be supported on reinforced concrete seat type abutments on CIDH pile footings. An existing 18 inch diameter utility waterline in 48 inch diameter casing runs close to the northern Abutment 1. The orientation, shape and location of the piles and the pile cap were adjusted to avoid a conflict with this waterline. During the final design stage this must be further refined.

During construction of the abutments, portions of the existing bike trail and retaining walls near the front faces of proposed abutments would have to be removed for the construction of the abutment foundations and then reconstructed upon completion of the abutment construction.

Below is a construction cost comparison of the two bridge alternative:

	Alternative 1	Alternative 2

Creek Bridge Type	Steel Through Plate Girder	Steel Rolled Beam
Creek Bridge Cost	$9,996,000	$5,776,000
Bike Trail Bridge Cost	$450,000	$450,000
Creek Bridge Demolition	$450,000	$450,000
Total Cost	$10,896,000	$6,676,000

7.8 BIKE TRAIL

The grade of the existing bike trail underpass does not meet current standards for bike trails. The existing underpass grade of 8.23% is greater than the maximum standard of 5%. The grade is restricted by storm drain pipes that are located very close to the bike trail's finished surface. To avoid impact to the bike trail, the new off-line rail profile would need to be raised an additional 1 foot, compared to the existing bridge, in order to maintain the current standard for vertical clearance.

7.9 UTILITIES

There are several utilities that could be impacted by the construction of the proposed bridges. If the bike trail would need improvement to meet current standards for maximum grade, the two storm drains that cross underneath it would need to be modified or relocated. In addition, there is an adjacent sewer within the City Public Works Facility where impacts would be minor. There are three water mains that cross under the existing rail and run parallel to the bike trail. The new structures would need to be designed so as to not impact these water lines.

A fiber optic line is located on the same side of the existing structures as the preferred off-line alignment. Approximately 1,900 feet of the fiber optic line would need relocating during project construction. Upon completion of the proposed structures, the fiber optic line would be relocated and permanently affixed to the new bridge.

7.10 RIGHT-OF-WAY

Additional right-of-way would need to be acquired for the project northwest of the rail line crossing San Juan Creek. This would allow adequate clearance to build the new off-line rail bridge structure without impacting the existing bridges and rail service. The partial property take is 390 feet long with an approximate square footage of 2,100 foot^2. The impacted parcel is designated as APN 668-10-23 and is owned by the City of San Juan Capistrano Department of Public Works. The area is currently used for storage and appears not to be of critical importance. Mitigation opportunities for the partial property acquisition would need to be explored further in the next phase of design.

7.11 STAGING AND PHASING

The replacement of the existing bridge with a single track bridge located off-line is proposed to be constructed in a three phased approach. A staging area within the railroad right-of-way would be located in dirt area just southwest of the existing Bridge 197.9

Phase 1 of construction would begin with the temporary relocation of the MCI fiber optic line to allow for the construction of the proposed bridges, removal of the existing bridge wingwalls. Removal of the existing bridge wing walls in this phase would allow adequate clearance for construction of the new bridge foundations. Proposed Bridges 197.88 and 197.90 will then be constructed off line. The existing track north of the existing bridge will be re-profiled to minimize the amount of work that will be required during the first weekend work window in Phase 2. Then new track north and south of newly constructed bridges would be constructed and a new turnout at CP Capistrano will be installed. Lastly signal conduit and hardware would be prepared for the first weekend work window cutover.

Phase 2 would require and begin with a full weekend work window closure. Existing track on both the north and south sides of the existing bridge would be removed to make room for installation on the proposed alignment. The existing turnout at MP 197.72 would then be raised to match the proposed grade of the new track. The existing track north of the proposed bridges and MT-1 south of CP Capistrano would then be shifted and connected to the proposed grade of the track across the new bridge. The signals would then be activated for the intermediate track condition and the new track and adjacent curves would be surfaced. Operations would continue as a single track as the Serra siding would be out of service for one week.

Phase 3 would begin with the removal of all existing track no longer in use. The Serra siding, which would be out of service, would be re-graded in the area near CP Capistrano. This work would be completed prior to the second weekend work window. The second work window would only require a partial weekend, where Serra siding would be connected to the new turnout at CP Capistrano and the signals would be activated for the final proposed track condition. The MCI fiber would be relocated to its final location onto the newly constructed bridges. The existing San Juan Creek Bridge 197.9 would then be demolished.

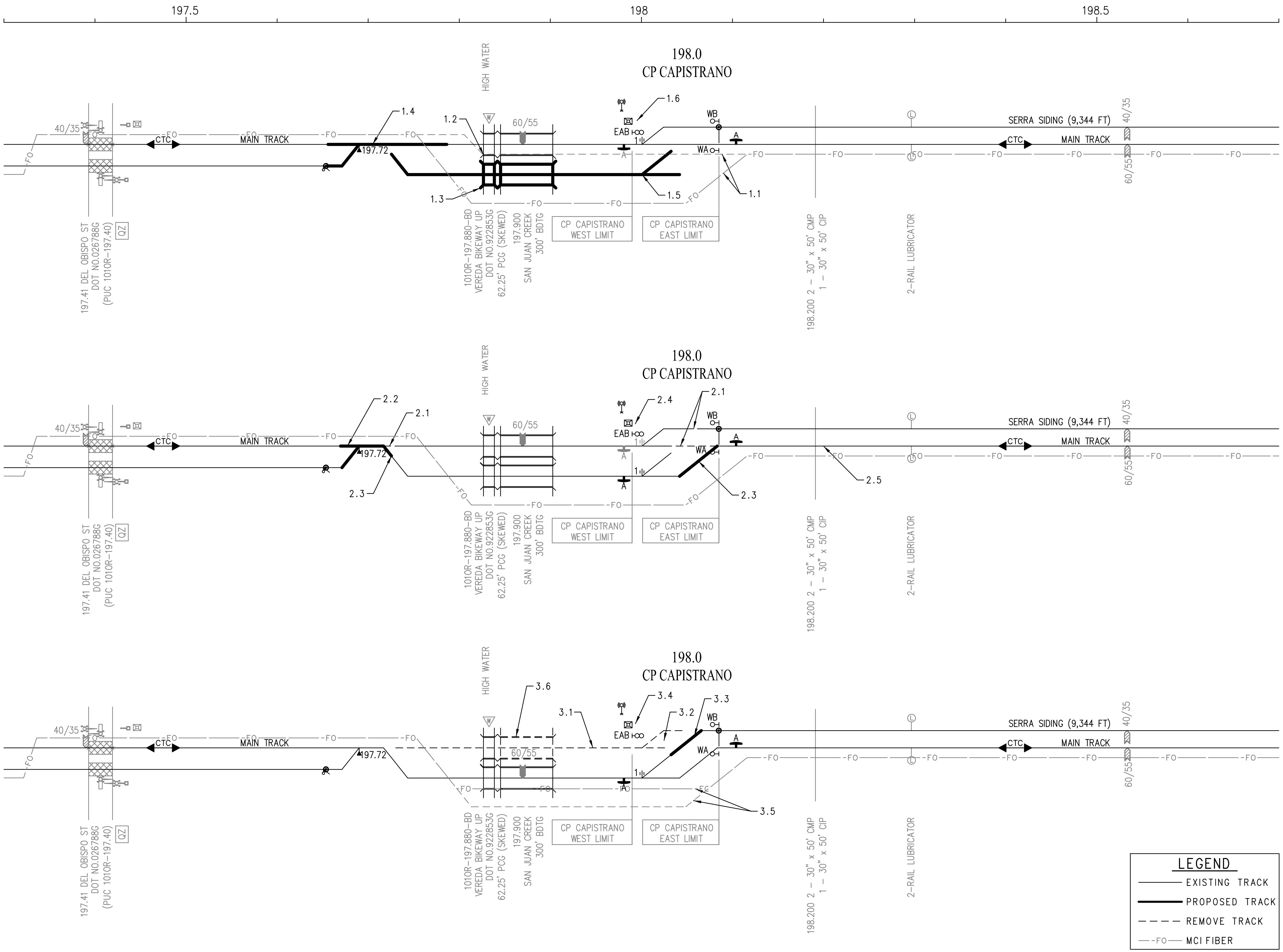
7.12 CONCLUSION

The bridge replacement alternative would allow the newly constructed bridge to be raised above the 100 year design storm requirements and accommodate the resulting scour. The capacity of the new structure will meet current design standards and begin a new lifespan minimizing the future maintenance and monitoring costs.

HDR recommends replacement of the San Juan Creek Bridge with an off-line track alignment. Constructing the new bridge off-line allows minimal impact to rail traffic and reduces construction complications and cost associated with an in-line replacement.

The preferred bridges for construction are in Alternative 1, consisting of the through plate girder bridge over San Juan Creek and a precast concrete girder bridge over the bike trail. The cost for the through plate girder structure alone is much larger than the rolled beam Alternative 2. However, items required to accommodate the rolled beam superstructure increase the costs similar to Alternative 1. The superstructure depth of the rolled beam section would require a larger track raise. This raise results in significant changes to the track phasing and construction. Temporary turnouts and additional weekend work windows would be required to accommodate this amount of raise, resulting in upwards of 3 million dollars in additional track and earthwork costs. Metrolink's train service may also see a loss in revenue due to the weekend work windows required to install the temporary trackwork and turnouts. The rolled beam bridge alternative also has two additional piers in San Juan Creek compared to both the existing structure and the preferred Alternative 1. Increasing the number of piers in the creek would complicate and delay the environmental permitting. If this alternative was able to receive permitting, the mitigation cost associated with the increased impact to the existing channel would also be much larger. Therefore, the resulting costs associate with each bridge alternative would be comparable, but the preferred Alternative 1 would be easier to permit and construct.

APPENDIX A
ALTERNATIVE EXHIBITS



CONSTRUCTION SEQUENCING

PHASE 1

1.1 TEMPORARILY RELOCATE MCI FIBER

1.2 REMOVE PORTIONS OF EXISTING BRIDGE WINGWALLS TO PROVIDE CLEARANCE FOR NEW BRIDGE FOUNDATION

1.3 CONSTRUCT PROPOSED BRIDGES 197.88 AND 197.90

1.4 RE-PROFILE PARTIAL RAISE IN TRACK TO FACILITATE CONSTRUCTION IN WEEKEND WORK WINDOW 1

1.5 CONSTRUCT PORTION OF PROPOSED TRACK AND NEW TURNOUT AT CP CAPISTRANO

1.6 PREP SIGNAL CONDUIT AND HARDWARE FOR WEEKEND WORK WINDOW CUTOVER

PHASE 2

FULL WEEKEND WORK WINDOW 1

2.1 REMOVE PORTION OF EXISTING TRACK TO MAKE ROOM FOR PROPOSED ALIGNMENT

2.2 RAISE EXISTING TURNOUT AT MP 197.72 TO PROPOSED GRADE

2.3 SHIFT AND CONNECT EXISTING TRACK TO PROPOSED NORTH OF BRIDGES AND ON MAIN TRACK 1 SOUTH OF CP CAPISTRANO

2.4 ACTIVATE SIGNALS FOR INTERMEDIATE TRACK CONDITION

2.5 SURFACE NEW TRACK AND SURROUNDING CURVES

2.6 OPERATIONS CONTINUE ON SINGLE TRACK (SERRA SIDING OUT OF SERVICE) FOR ONE WEEK

PHASE 3

3.1 REMOVE EXISTING TRACK NO LONGER IN USE

3.2 RE-GRADE SERRA SIDING AREA NEAR CP CAPISTRANO

PARTIAL WEEKEND WORK WINDOW 2

3.3 CONNECT SERRA SIDING WITH NEW TURNOUT AT CP CAPISTRANO

3.4 ACTIVATE SIGNALS FOR FINAL PROPOSED TRACK CONDITION

3.5 MOVE MCI FIBER ONTO NEWLY CONSTRUCTED BRIDGE

3.6 DEMOLISH EXISTING SAN JUAN CREEK BRIDGE 197.9

REV.	DATE		BY	SUB.	APP.

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DESIGNED BY K.WARFIELD
DRAWN BY M.MILLER
CHECKED BY A.RUBIO
APPROVED BY
DATE

XX% SUBMITTAL
NOT FOR CONSTRUCTION

METROLINK®

HDR
HDR Engineering, Inc.
3230 El Camino Real
Suite 200
Irvine, Ca 92602

SUBMITTED: ____________ PROJECT MANAGER
APPROVED: ____________

SAN JUAN CREEK BRIDGE PRELIMINARY ENGINEERING PROJECT

TRACK PHASING SCHEMATIC

CONTRACT NO. C0000-00
DRAWING NO. CP-01
REVISION
SHEET NO. X OF X
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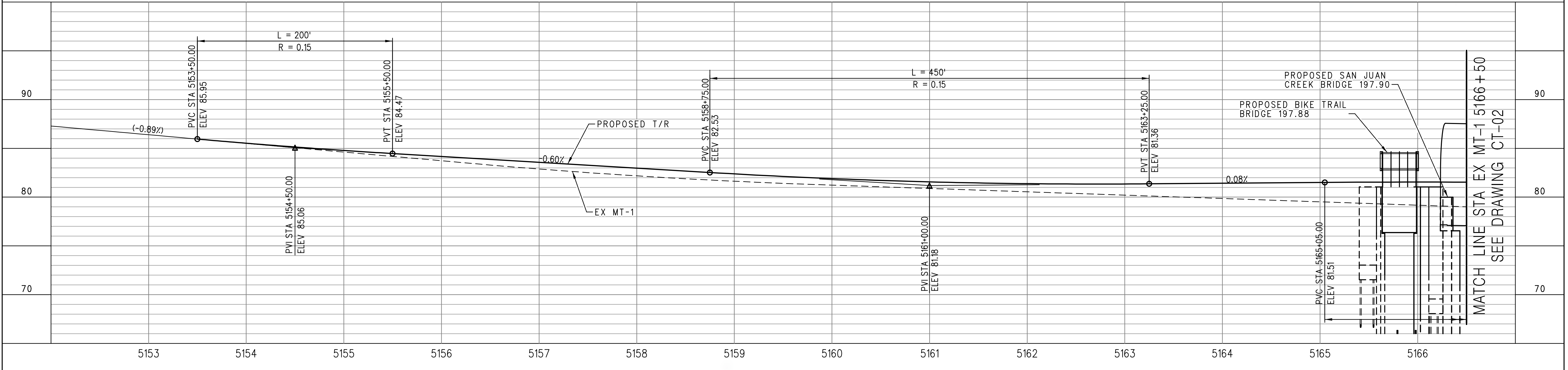

EX MT-1 PROFILE

REV.	DATE		BY/SUB.	APP.

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Irvine, Ca 92602

SUBMITTED: ____________
PROJECT MANAGER

APPROVED: ____________

SAN JUAN CREEK BRIDGE
PRELIMINARY ENGINEERING PROJECT

TRACK PLAN AND PROFILE
BEGIN PROJECT TO MT-1 STA 5166+50

CONTRACT NO. C0000-00
DRAWING NO. CT-01
REVISION
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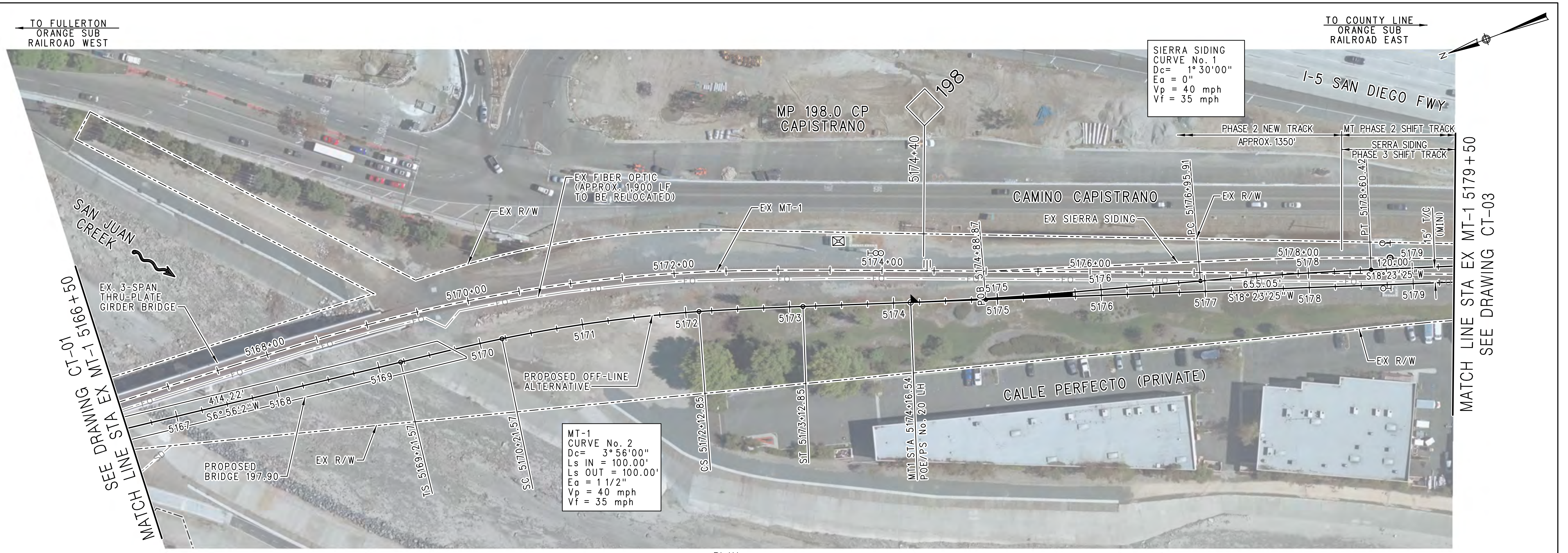

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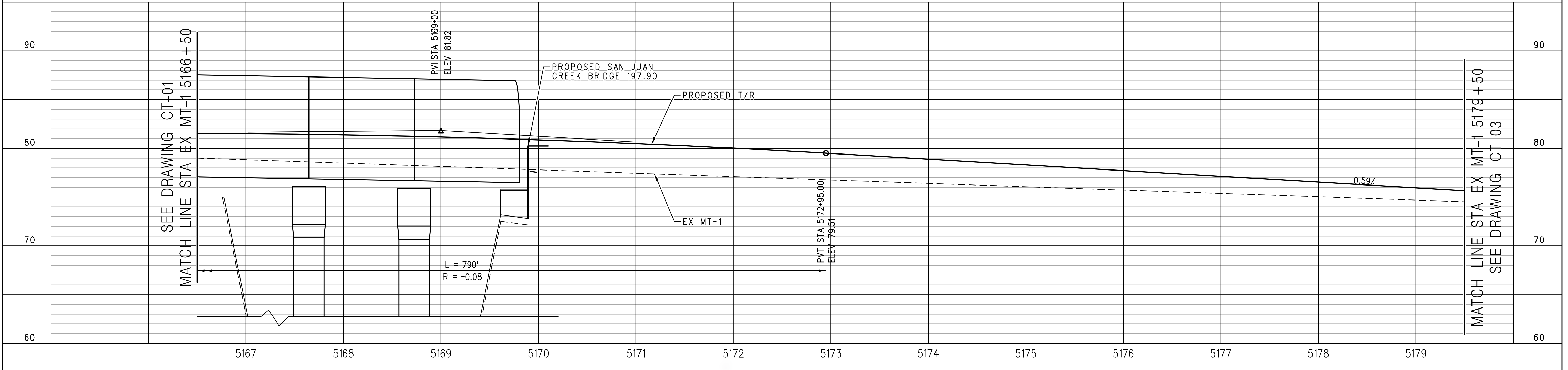

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SAN JUAN CREEK BRIDGE
PRELIMINARY ENGINEERING PROJECT

TRACK PLAN AND PROFILE
EX MT-1 STA 5166+50 TO STA 5179+50

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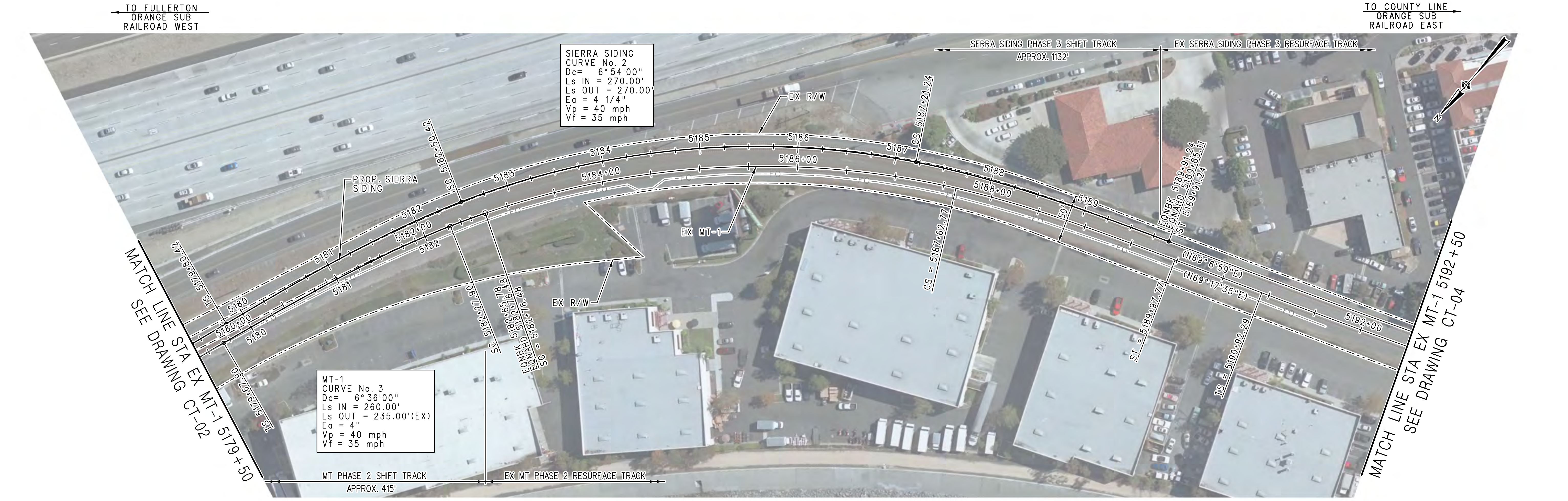

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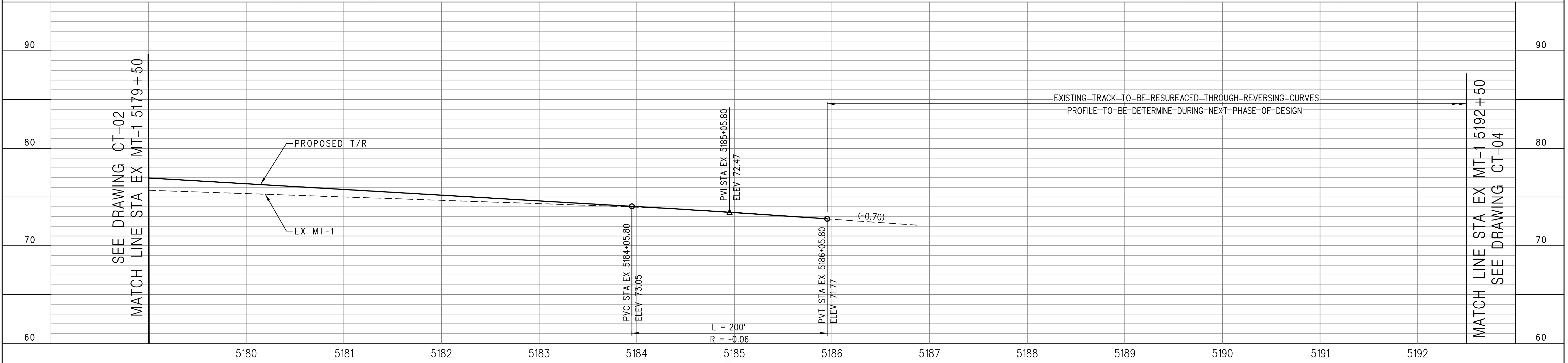

EX MT-1 PROFILE

REV.	DATE		BY / SUB.	APP.

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Irvine, Ca 92602

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APPROVED: ____________

SAN JUAN CREEK BRIDGE PRELIMINARY ENGINEERING PROJECT

TRACK PLAN AND PROFILE
EX MT-1 STA 5179+50 TO STA 5192+50

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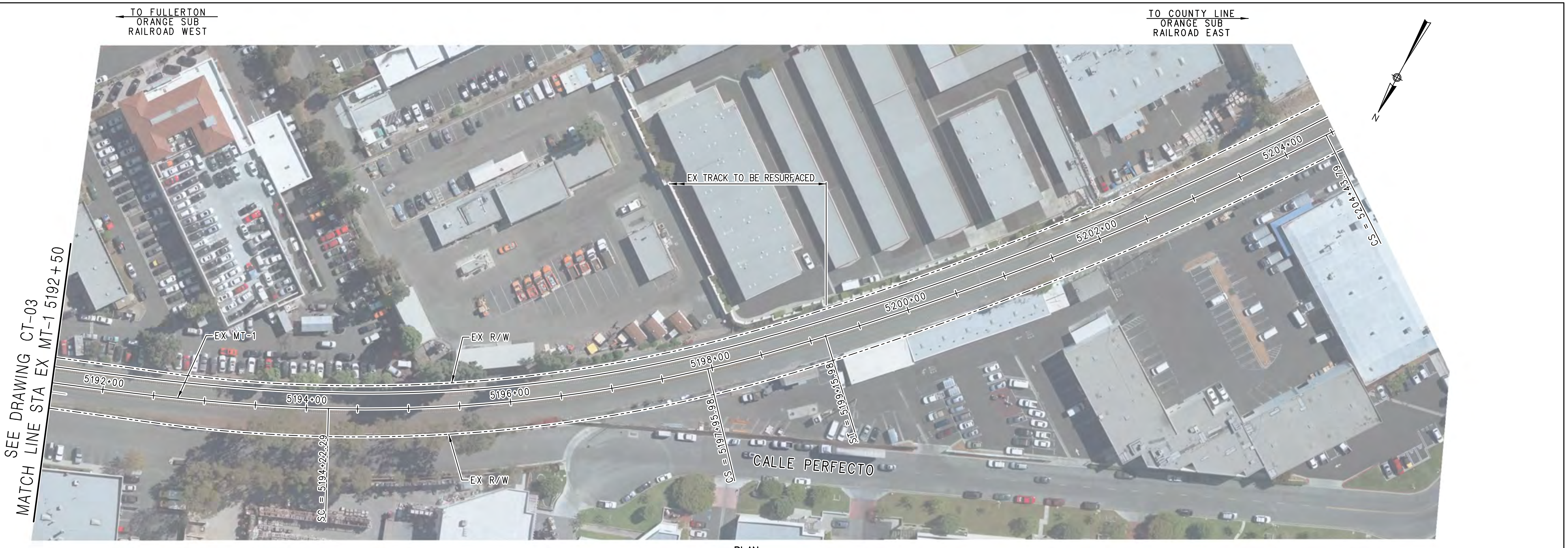

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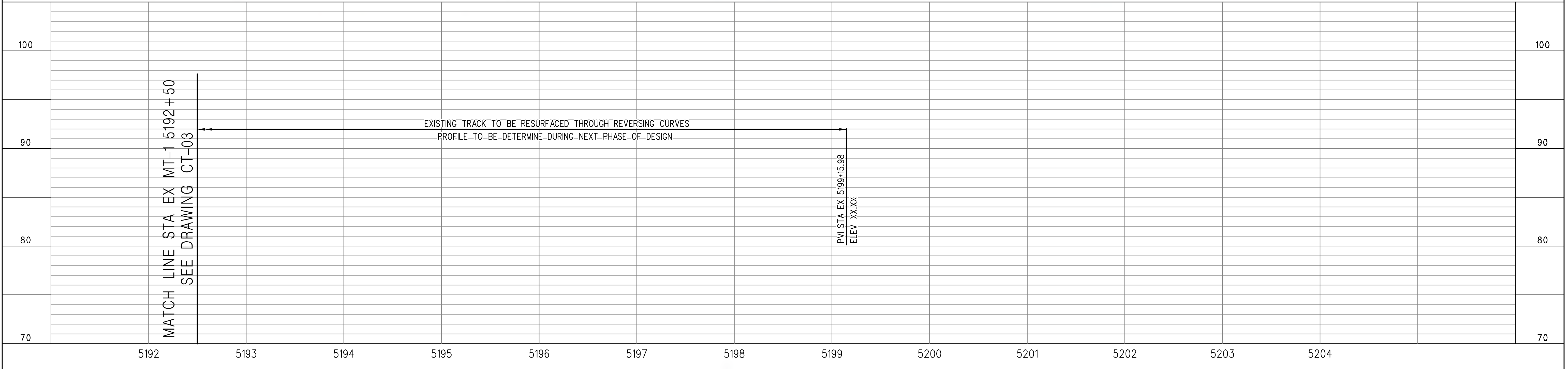

EX MT-1 PROFILE

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Irvine, Ca 92602

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PROJECT MANAGER

APPROVED: ____________

SAN JUAN CREEK BRIDGE
PRELIMINARY ENGINEERING PROJECT

TRACK PLAN AND PROFILE
EX MT-1 STA 5192+50

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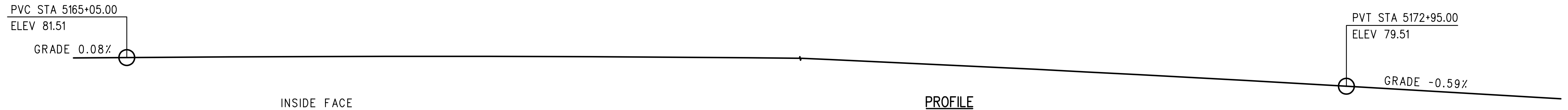

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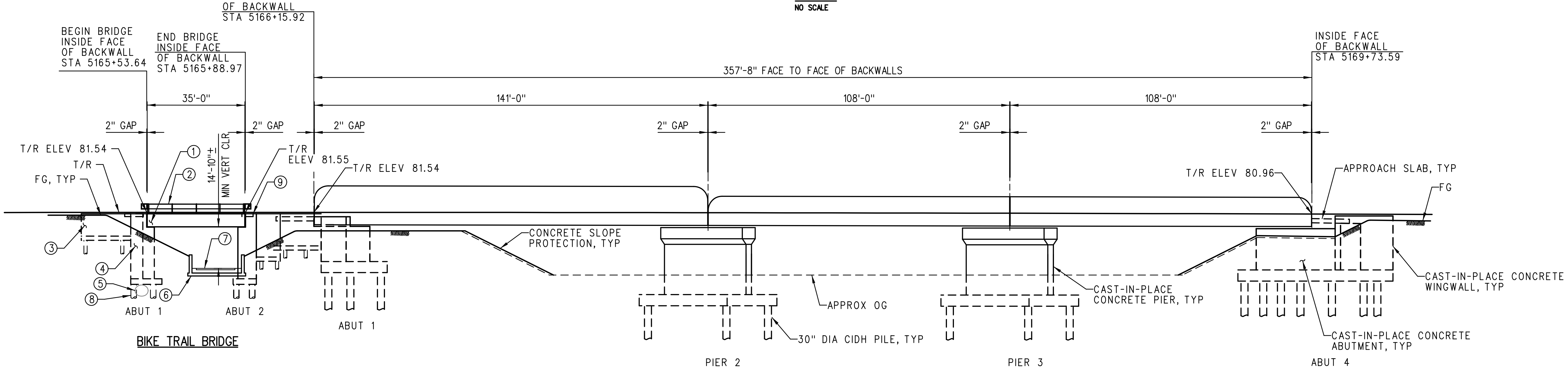
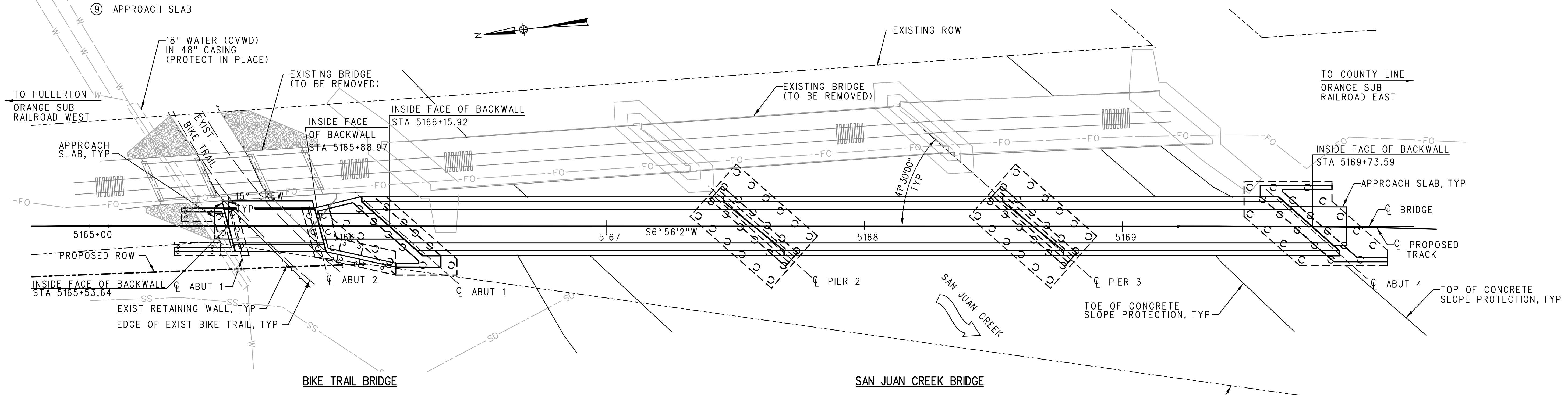


① 33" PRECAST/PRESTRESSED CONCRETE DOUBLE BOX BEAM
② HANDRAIL
③ CAST-IN-PLACE CONCRETE WINGWALL,TYP
④ CAST-IN-PLACE CONCRETE ABUTMENT,TYP
⑤ 18" WATER (CVWD) IN 48" CASING (PROTECT IN PLACE)
⑥ EXISTING RETAINING WALL
⑦ EXISTING TRAIL
⑧ 24" CIDH PILE
⑨ APPROACH SLAB

ELEVATION

1"=20'-0"



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1"=20'-0"

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APPROVED BY AR
DATE 11-04-2013

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3230 El Camino Real
Suite 200
Irvine, Ca 92602

SUBMITTED: ____________
PROJECT MANAGER

APPROVED: ____________

SAN JUAN CREEK BRIDGE
PRELIMINARY ENGINEERING PROJECT

GENERAL PLAN
STEEL THROUGH PLATE GIRDER ALTERNATIVE

CONTRACT NO. C0000-00
DRAWING NO. S-01
REVISION
SHEET NO. X
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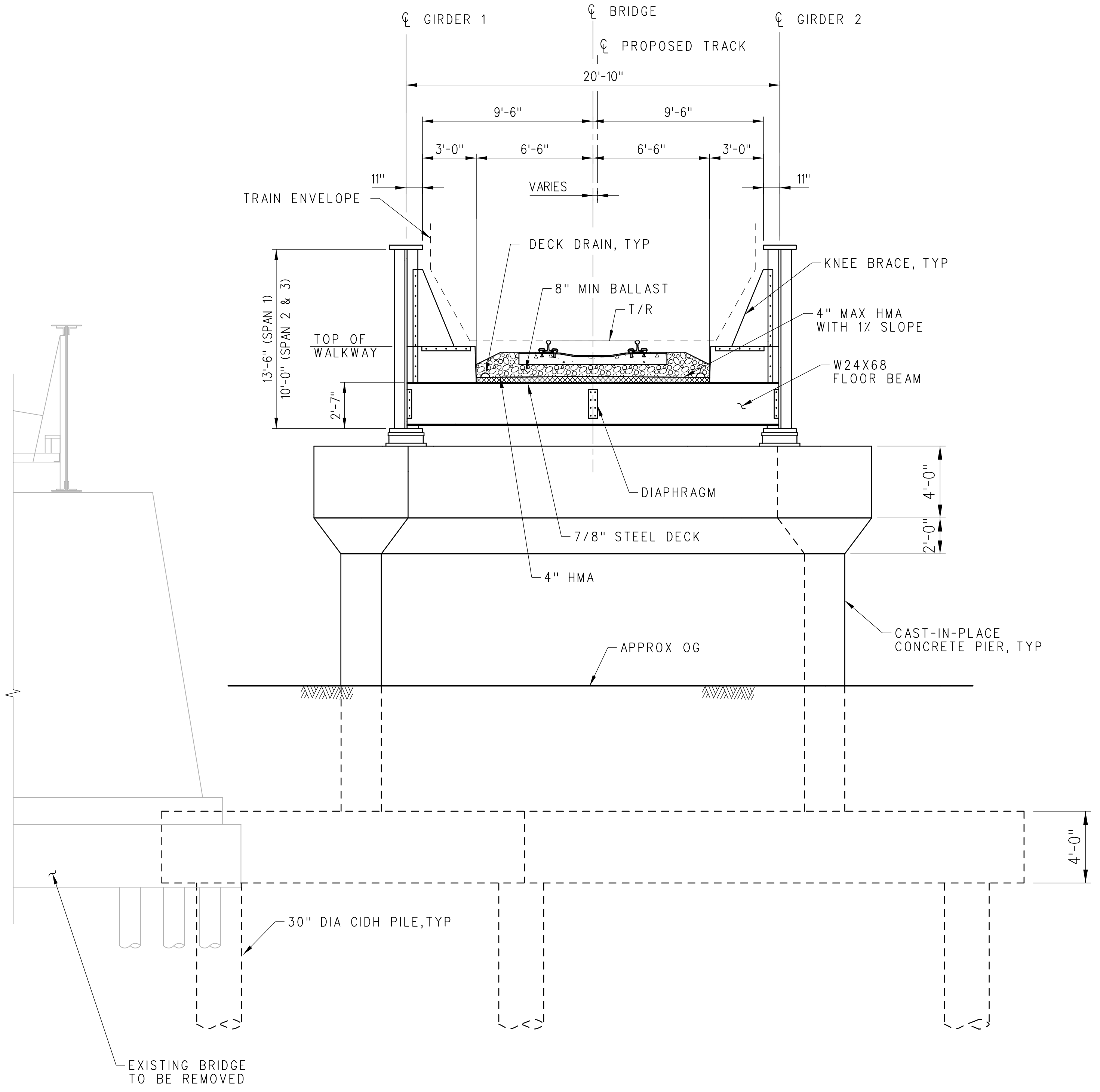
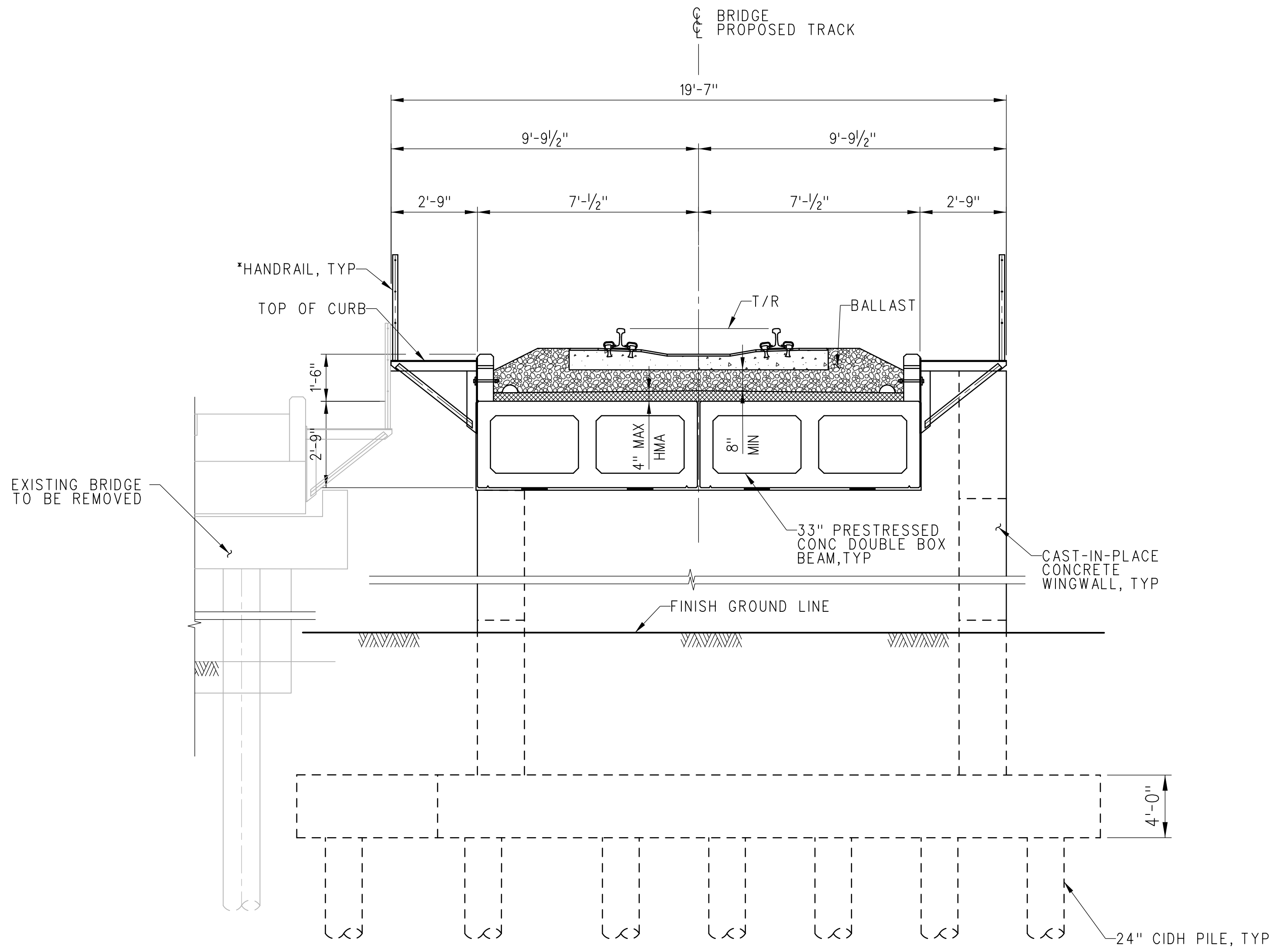


SAN JUAN CREEK BRIDGE TYPICAL SECTION

1/4"=1'-0"



BIKE TRAIL BRIDGE TYPICAL SECTION

3/8"=1'-0"

* INSTALL EAST SIDE WALKWAY AND HANDRAIL AFTER REMOVING EXISTING BRIDGE.

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Irvine, Ca 92602

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SAN JUAN CREEK BRIDGE PRELIMINARY ENGINEERING PROJECT

TYPICAL SECTION
STEEL THROUGH PLATE GIRDER ALTERNATIVE

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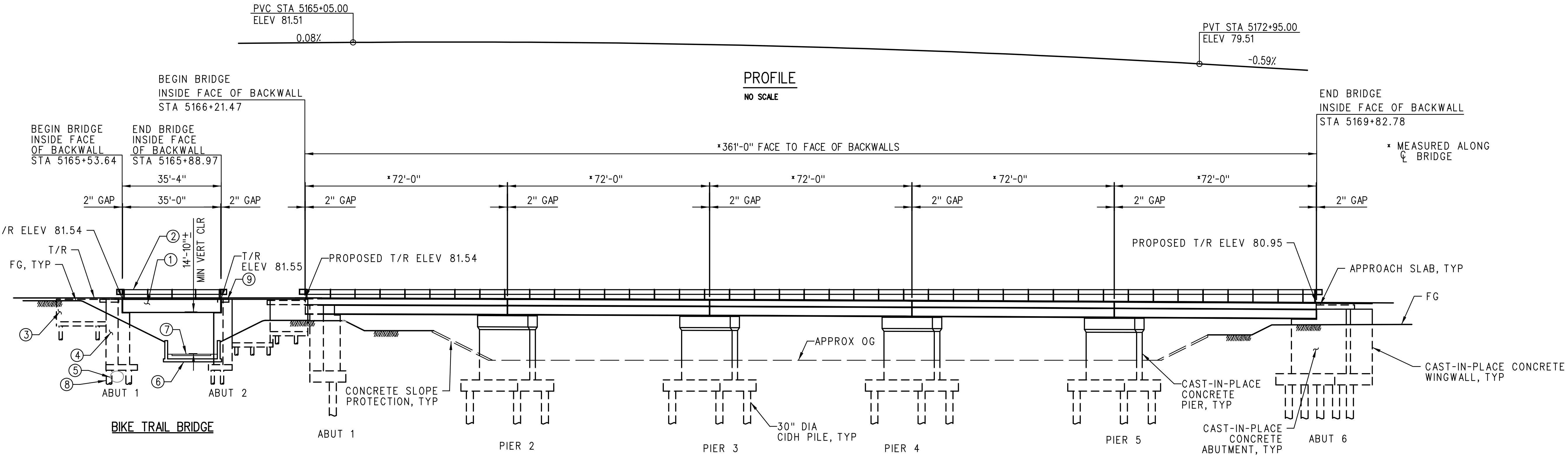
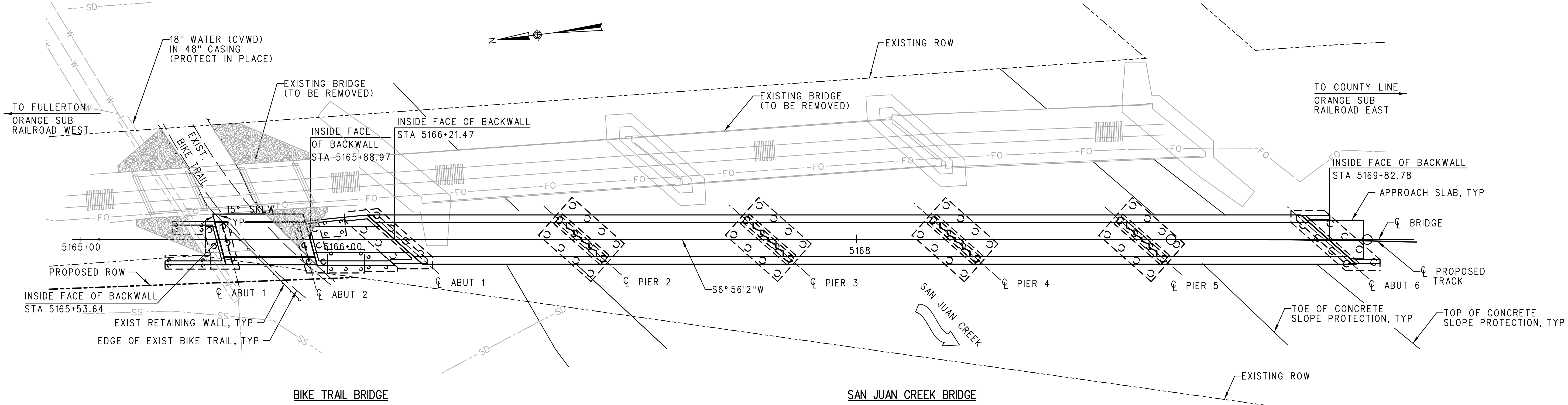


ELEVATION

1"=20'-0"

① 33" PRECAST/PRESTRESSED CONCRETE DOUBLE BOX BEAM
② HANDRAIL
③ CAST-IN-PLACE CONCRETE WINGWALL,TYP
④ CAST-IN-PLACE CONCRETE ABUTMENT,TYP
⑤ 18" WATER (CVWD) IN 48" CASING (PROTECT IN PLACE)
⑥ EXISTING RETAINING WALL
⑦ EXISTING BIKE TRAIL
⑧ 24" CIDH PILE
⑨ APPROACH SLAB



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Suite 200
Irvine, Ca 92602

SUBMITTED: ____________
PROJECT MANAGER
APPROVED: ____________

SAN JUAN CREEK BRIDGE
PRELIMINARY ENGINEERING PROJECT

GENERAL PLAN
STEEL ROLLED REAM ALTERNATIVE

CONTRACT NO. C0000-00
DRAWING NO. S-02
REVISION
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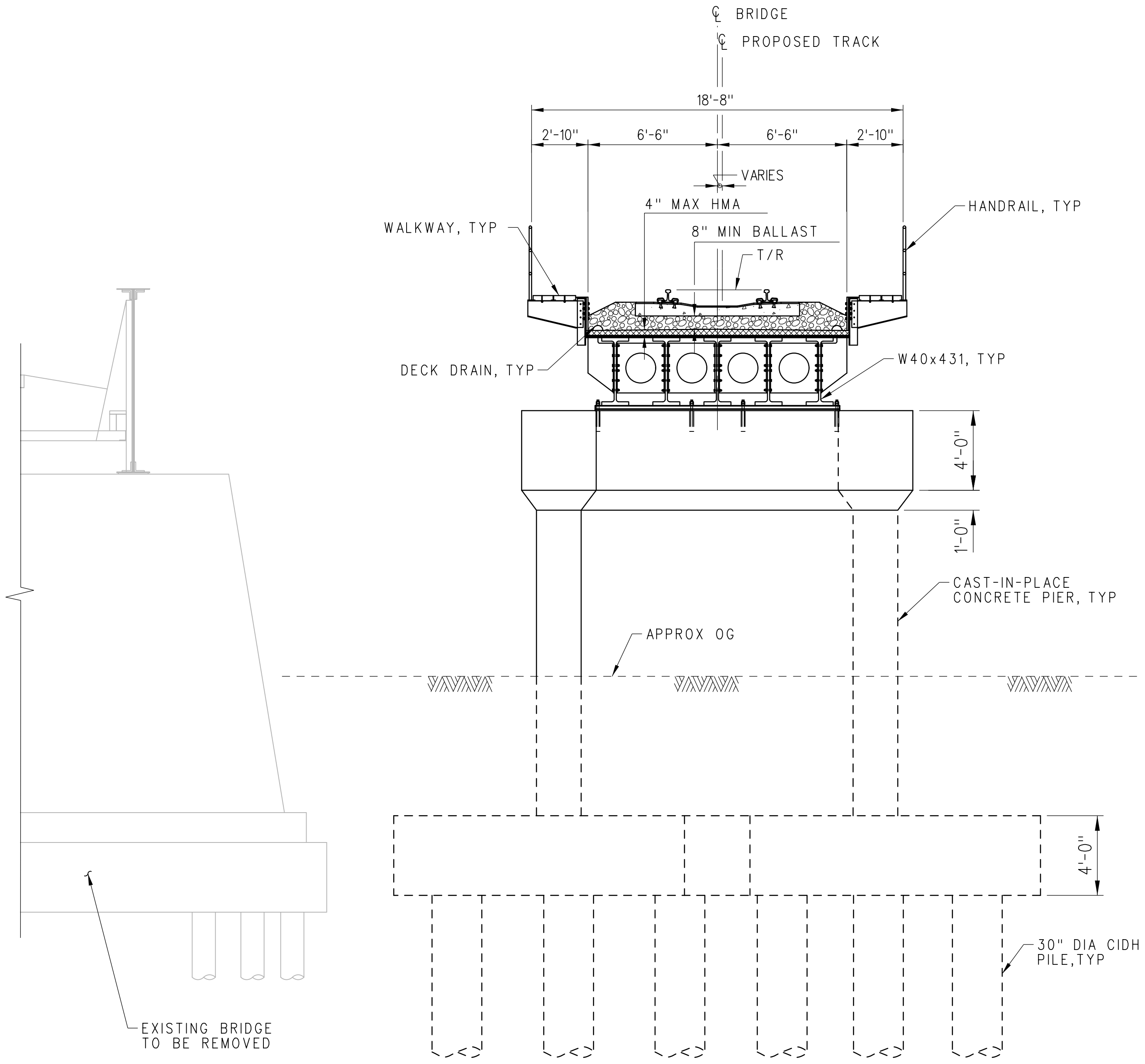
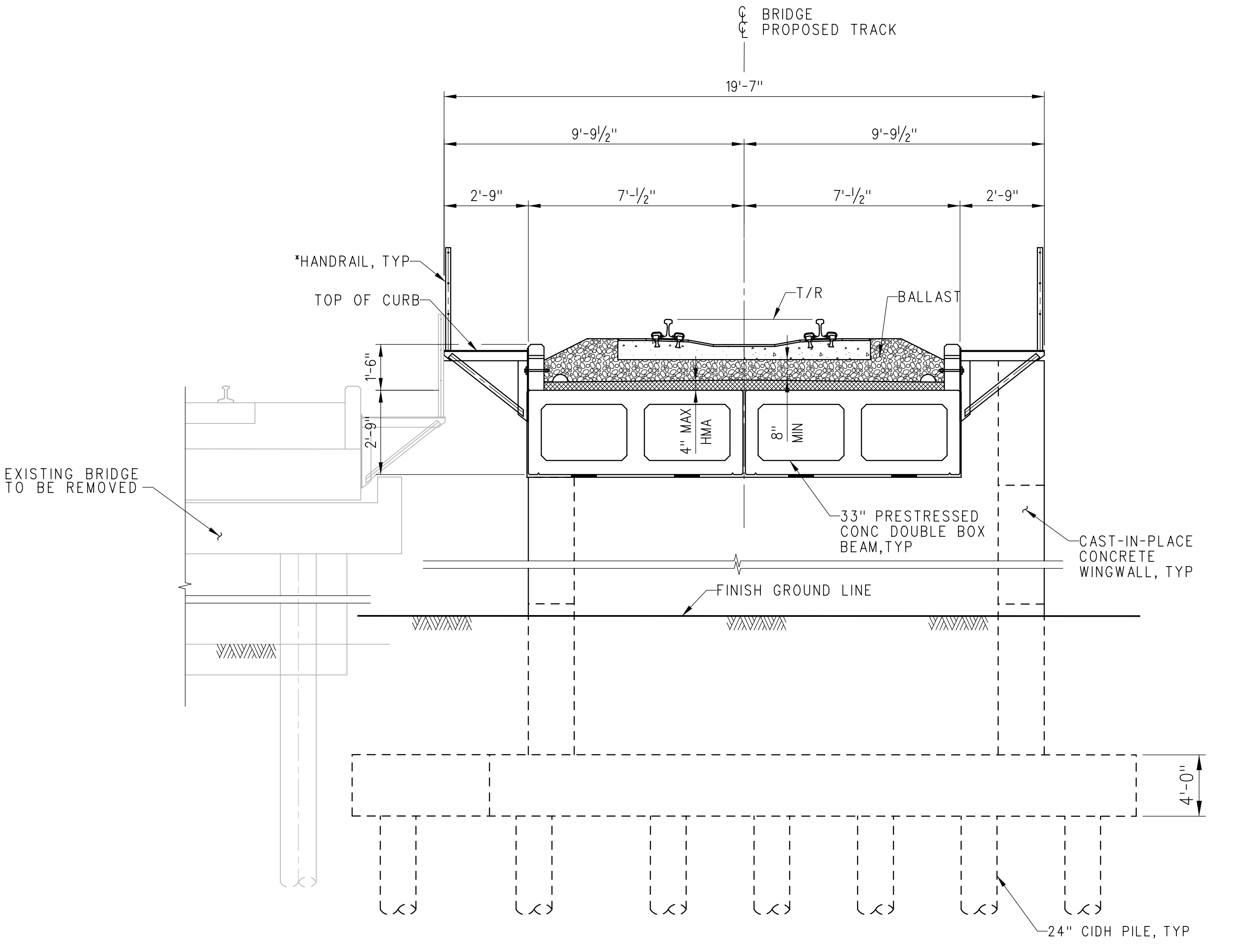


SAN JUAN CREEK BRIDGE TYPICAL SECTION

1/4"=1'-0"



BIKE TRAIL BRIDGE TYPICAL SECTION

3/8"=1'-0"

* INSTALL EAST SIDE WALKWAY AND HANDRAIL AFTER REMOVING EXISTING BRIDGE.

REV.	DATE		BY/SUB.	APP.

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APPROVED BY	AR
DATE	11-01-2013

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HDR Engineering, Inc.
3230 El Camino Real
Suite 200
Irvine, Ca 92602

SUBMITTED: ____________
PROJECT MANAGER

APPROVED: ____________

SAN JUAN CREEK BRIDGE PRELIMINARY ENGINEERING PROJECT

TYPICAL SECTION
STEEL ROLLED BEAM ALTERNATIVE

CONTRACT NO.	C0000-00
DRAWING NO.	S-02A
REVISION	SHEET NO.
SCALE	

APPENDIX B
PROJECT COST ESTIMATE

PROJECT COST ESTIMATE

METROLINK

Project Name: CTO 51 - San Juan Creek Rail Bridge Replacement Project Study Report

Design Level: Preliminary Concept Design

Last Updated: 3/27/2014

ITEM	DESCRIPTION	QUANTITY	UNIT COST	TOTAL COST	NOTES
01 00 00	GENERAL REQUIREMENTS			$1,541,574	
02 00 00	EXISTING CONDITIONS			$439,200	
05 00 00	BRIDGE STRUCTURES			$10,456,800	
31 00 00	EARTHWORK			$137,569	
33 00 00	UTILITIES			$1,075,000	
34 00 00	TRANSPORTATION			$1,323,781	
SUB-TOTAL: CONSTRUCTION COSTS				$14,973,924	
	%				
	CONSTRUCTION CONTINGENCY DPM 15%			$2,246,089	
	CIVIL DESIGN & DESIGN SUPPORT DPM 10%			$1,497,392	
	S&C DESIGN AND DESIGN SUPPORT DPM 3%			$449,218	
	PROJECT MANAGEMENT DPM 4%			$598,957	
	CONSTRUCTION MANAGEMENT DPM 8%			$1,197,914	
	FLAGGING DPM 6%			$898,435	
	AGENCY COSTS DPM 8%			$1,197,914	
	MAINTENANCE OF WAY				
	TRACK/STRUCT. MAINTENANCE SUPPORT			$0	
	S&C MAINTENANCE SUPPORT			$0	
	MATERIAL PROCUREMENT LIST (From DPM -17)			$0	
	RIGHT-OF-WAY ACQUISITION	2100 SF	$24.00	$50,400	
	RAILROAD WORK ORDERS			$0	
	OTHERS (PERMITS, FEES, LEGAL)	1	$250,000.00	$250,000	
	ENVIRONMENTAL MITIGATION AND MONITORING	1	$250,000.00	$250,000	
SUB-TOTAL: PROJECT RELATED OVERHEAD COSTS				$8,636,319	
	%				
	PROJECT RESERVE/CONTINGENCY DPM 20%			$4,722,049	
	INFLATION Rate:	3% # Years:	2	$1,725,437	
TOTAL PROJECT COST:				**$30,057,729**	

ENGINEER'S ESTIMATE

METROLINK

Project Name: CTO 51 - San Juan Creek Rail Bridge Replacement Project Study Report

Design Level: Preliminary Concept Design

Last Updated: 3/27/2014

ITEM NO.	WORK DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL COST	ITEM CONT.	NOTES
BASE BID							
01 00 00	**GENERAL REQUIREMENTS**						
	Mobilization	LS	7%	$13,665,742.50	$956,602		
	Demobilization	LS	3%	$13,665,742.50	$409,972		
	SWPPP Best Management Practices Implementation (Including, but not limited to dust control, Stormwater Pollution Prevention (SWPPP),	LS	1	$100,000	$100,000		
	Unsuitable Material/Soils (Incl. Remove, Dispose, and Compact	Allow	1	$75,000	$75,000		
	GENERAL REQUIREMENTS SUBTOTAL				**$1,541,574**		
02 00 00	**EXISTING CONDITIONS**						
	Demolish Existing Bridge 197.90	SF	5,490	$80.00	$439,200		
	EXISTING CONDITIONS SUBTOTAL				**$439,200**		
05 00 00	**BRIDGE STRUCTURES**						
	Steel Through Plate Girder San Juan Creek Bridge 197.90	TF	357	$28,000.00	$9,996,000		
	Precast Concrete Bike Trail Bridge 197.88	TF	36	$12,800.00	$460,800		
	BRIDGE STRUCTURES SUBTOTAL				**$10,456,800**		
31 00 00	**EARTHWORK**						
	Imported Borrow	CY	2,751	$50.00	$137,569		
	EARTHWORK SUBTOTAL				**$137,569**		
32 00 00	**EXTERIOR IMPROVEMENTS**						
	Chain Link Fence - 6' tall	LF	325	$20.50	$6,663		
	Chain Link Fence 6' tall Gate	EA	1	$1,730.00	$1,730		
	Landscape and Irrigation	LS	1	$50,000.00	$50,000		
	EXTERIOR IMPROVEMENTS SUBTOTAL				**$58,393**		
33 00 00	**UTILITIES**						
	US Sprint/AT&T Fiber Optic Relocation	LS	1	$750,000.00	$750,000		
	8" Perforated HDPE With Geotextile Fabric	LF	6,000	$36.00	$216,000		
	24" CSP	LF	400	$150.00	$60,000		
	Type G2 DI per Caltrans Std. Plan No. D73	EA	2	$5,000.00	$10,000		
	Junction Structure per SPPWC Std. Plan No. 331-3	EA	1	$5,000.00	$5,000		
	Concrete Collar per SPPWC Std. Plan No. 380-4	EA	1	$1,000.00	$1,000		
	Underdrain Cleanout	EA	10	$800.00	$8,000		
	Drainage Ditch	LF	1,000	$25.00	$25,000		
	UTILITIES SUBTOTAL				**$1,075,000**		
34 00 00	**TRANSPORTATION**						
	Construct Track Subballast	CY	1,189	$80.00	$95,156		
	PTC Modifications and Compliance	LS	1	$400,000.00	$400,000		
	Relocate signals (CP Capistrano)	EA	2	$15,000.00	$30,000		
	Raise No. 10 HTTO	EA	1	$50,000.00	$50,000		
	Remove and Re-Install PO Double Point Switch Derail	EA	1	$5,000.00	$5,000		
	Shift Track	TF	2,197	$125.00	$274,625		
	Install and remove Temporary Earthen Bumper	EA	1	$5,000.00	$5,000		
	Remove and Dispose Rail and Wood Ties	TF	1,900	$30.00	$57,000		
	Construct 136# CWR, Concrete Ties	TF	1,600	$220.00	$352,000		
	Guard Rail (double side)	TF	1,100	$50.00	$55,000		
	TRANSPORTATION SUBTOTAL				**$1,323,781**		
BASE BID TOTAL CONSTRUCTION COST [Without Mobilization and Demobiliztion]:					**$13,665,743**		
BASE BID TOTAL CONSTRUCTION COST [With Mobilization and Demobiliztion]:					**$15,032,317**		

APPENDIX C
TRACK CHART

METROLINK - ORANGE SUBDIVISION | CORRIDOR MAP

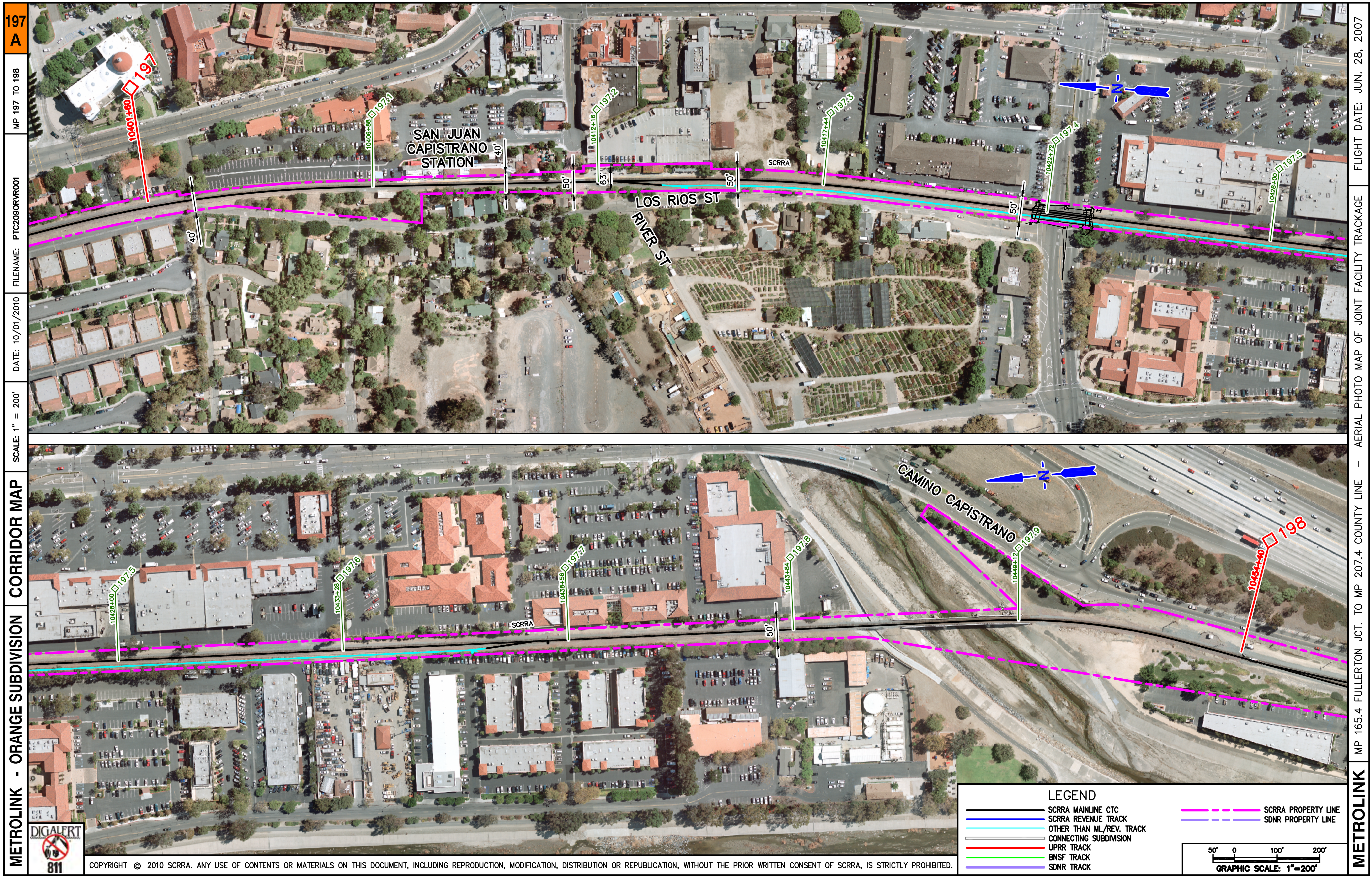
SCALE: 1" = 200'

DATE: 10/01/2010

FILENAME: PTC209ORVR001

MP 197 TO 198

197 A



LEGEND

- SCRRA MAINLINE CTC
- SCRRA REVENUE TRACK
- OTHER THAN ML/REV. TRACK
- CONNECTING SUBDIVISION
- UPRR TRACK
- BNSF TRACK
- SDNR TRACK
- SCRRA PROPERTY LINE
- SDNR PROPERTY LINE

50' 0 100' 200'
GRAPHIC SCALE: 1"=200'

DIGALERT 811

METROLINK | MP 165.4 FULLERTON JCT. TO MP 207.4 COUNTY LINE - AERIAL PHOTO MAP OF JOINT FACILITY TRACKAGE | FLIGHT DATE: JUN. 28, 2007

jma Oct 27, 2010 – 10:25am H:\Projects\SCR09447\04-CAD\04.3-Subdivision\Orange\Sheets\ROW Maps\PTC209ORVR001.dwg

Nov 12, 2010 - 11:49am H:\Projects\SCR09447\04-CAD\04.3-Subdivision\Orange\Sheets\TrackChart\PTC209ORTC01.dwg

bho

LEGEND

MILE POST

HMAC XING SURFACE

CONCRETE PANEL XING SURFACE

RUBBER PANEL XING SURFACE

AT-GRADE CROSSING

TUNNEL

CULVERT

OVERPASS

BRIDGE

SCHEMATIC

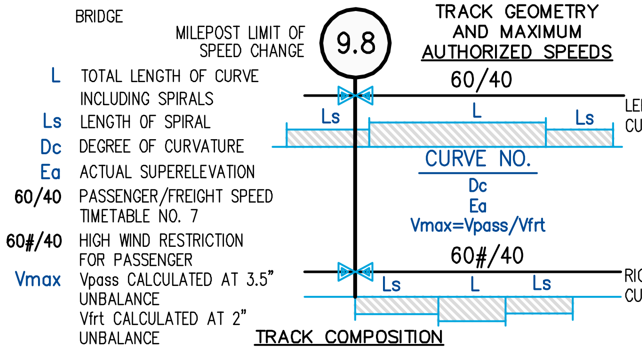
- SCRRA MAINLINE CTC
- SCRRA REVENUE TRACK
- OTHER THAN ML/REV. TRACK
- UPRR TRACK
- BNSF TRACK
- SDNR TRACK
- CONNECTING SUB.

PTC CRITICAL POINTS

- SIGNAL CANTILEVER
- SIGNAL BRIDGE
- DWARF SIGNAL
- SIGNAL W/ ONE HEAD
- SIGNAL W/ TWO HEADS
- SIGNAL W/ THREE HEADS
- HAND OPERATED SWITCH
- POWER OPERATED SWITCH
- CLEARANCE POINT
- SIGNAL HOUSE
- ANTENNA
- A ACTIVE AUTOMATIC TRAIN STOP
- P PASSIVE AUTOMATIC TRAIN STOP
- ELECTRIC LOCK SWITCH
- HAND OPERATED DERAIL
- POWER OPERATED DERAIL

OTHER TRACK FEATURES

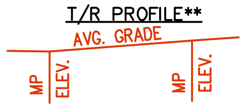
- STANDARD 8A – CANTILEVERED FLASHING LIGHT
- STANDARD 9A – CANTILEVERED FLASHING LIGHT WITH GATE
- STANDARD 9 – FLASHING LIGHT WITH GATE
- STANDARD 9E – FLASHING LIGHT WITH GATE ON EXIT SIDE
- STANDARD 8 – DUAL FLASHING LIGHTS
- STANDARD 8 – SIGNAL FLASHING LIGHT
- MODIFIED STANDARD 9 – PEDESTRIAN GATE
- STANDARD 1R – CROSSBUCK
- STANDARD 1X – PRIVATE CROSSING SIGN
- RAIL LUBRICATOR
- DRAGGING EQUIPMENT DETECTOR
- HOT BOX DETECTOR
- HIGH WIDE LOAD DETECTOR
- HIGH WATER DETECTOR
- SLIDE FENCE DETECTOR
- BUMPER
- CTC CENTRALIZED TRAFFIC CONTROL TERRITORY
- WESTBOUND SPEED DECREASE
- WESTBOUND SPEED INCREASE
- EASTBOUND SPEED DECREASE
- EASTBOUND SPEED INCREASE



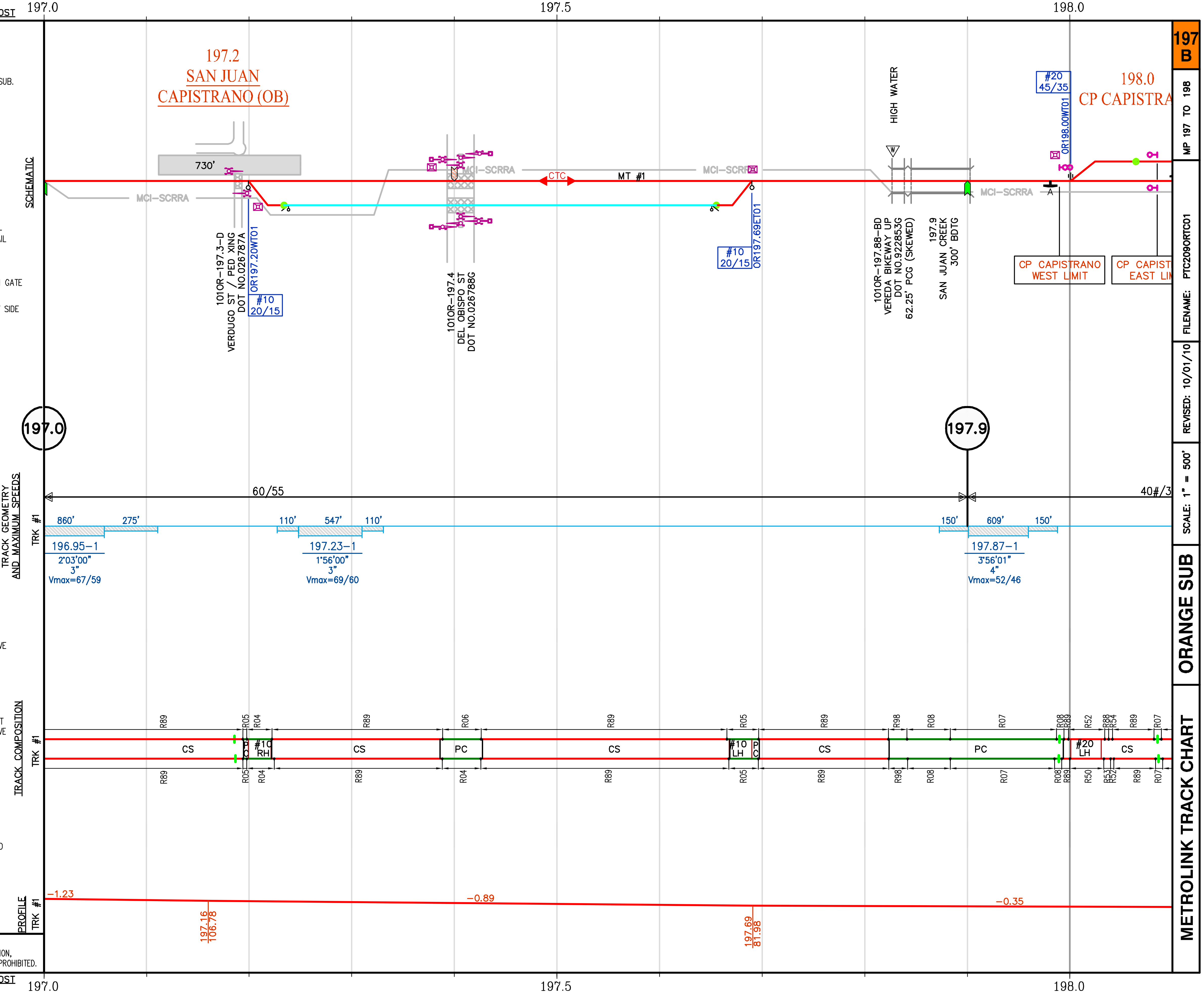
L	TOTAL LENGTH OF CURVE INCLUDING SPIRALS
Ls	LENGTH OF SPIRAL
Dc	DEGREE OF CURVATURE
Ea	ACTUAL SUPERELEVATION
60/40	PASSENGER/FREIGHT SPEED TIMETABLE NO. 7
60#/40	HIGH WIND RESTRICTION FOR PASSENGER
Vmax	Vpass CALCULATED AT 3.5" UNBALANCE Vfrt CALCULATED AT 2" UNBALANCE

TRACK COMPOSITION

- R99 YEAR RAIL ROLLED
- INSULATED JOINT
- WELD JOINT
- BOLT JOINT
- CS WOOD TIE WITH CUT SPIKE
- NF WOOD TIES WITH FAST CLIP
- PC WOOD TIES WITH PANDROL CLIP
- CONCRETE TIE WITH FAST CLIP
- CONCRETE TIE WITH MCKAY
- CONCRETE TIE WITH PANDROL CLIP
- STEEL TIE WITH PANDROL CLIP
- 136RE, JOINTED
- 136RE, CWR
- 133RE, JOINTED
- 133RE, CWR
- 132HF, JOINTED
- 132HF, CWR
- 119RE OR LOWER, JOINTED
- 119RE OR LOWER, CWR



**VERTICAL DATUM BASED ON NAVD 88



197 B

MP 197 TO 198

FILENAME: PTC209ORTC01

REVISED: 10/01/10

SCALE: 1" = 500'

ORANGE SUB

METROLINK TRACK CHART

198 A

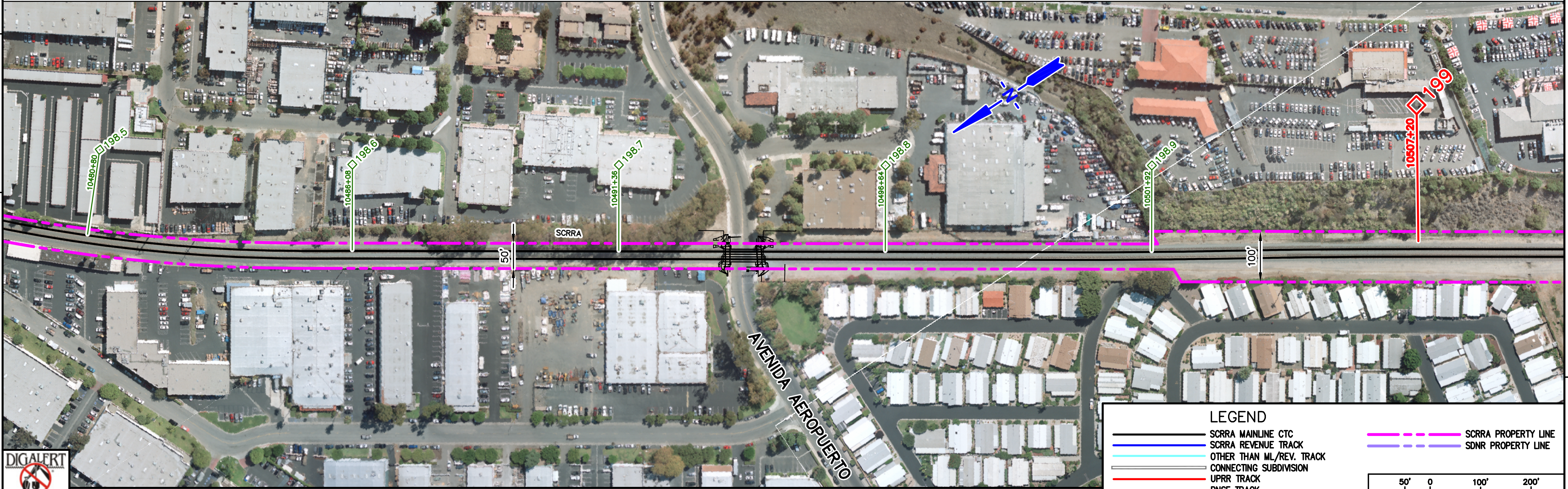
MP 198 TO 199

FILENAME: PTC209ORVR001

DATE: 10/01/2010

SCALE: 1" = 200'

METROLINK - ORANGE SUBDIVISION CORRIDOR MAP



DIGALERT 811

LEGEND

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- OTHER THAN ML/REV. TRACK
- CONNECTING SUBDIVISION
- UPRR TRACK
- BNSF TRACK
- SDNR TRACK
- SCRRA PROPERTY LINE
- SDNR PROPERTY LINE

50' 0 100' 200'

GRAPHIC SCALE: 1"=200'

METROLINK

MP 165.4 FULLERTON JCT. TO MP 207.4 COUNTY LINE – AERIAL PHOTO MAP OF JOINT FACILITY TRACKAGE

FLIGHT DATE: JUN. 28, 2007

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LEGEND

SCHEMATIC

- SCRRA MAINLINE CTC
- SCRRA REVENUE TRACK
- OTHER THAN ML/REV. TRACK
- UPRR TRACK
- BNSF TRACK
- SDNR TRACK
- CONNECTING SUB.

HMAC XING SURFACE

CONCRETE PANEL XING SURFACE

RUBBER PANEL XING SURFACE

AT-GRADE CROSSING

TUNNEL

CULVERT

OVERPASS

BRIDGE

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- HIGH WATER DETECTOR
- SLIDE FENCE DETECTOR
- BUMPER
- CTC CENTRALIZED TRAFFIC CONTROL TERRITORY
- WESTBOUND SPEED DECREASE
- WESTBOUND SPEED INCREASE
- EASTBOUND SPEED DECREASE
- EASTBOUND SPEED INCREASE

MILEPOST LIMIT OF SPEED CHANGE 9.8

TRACK GEOMETRY AND MAXIMUM AUTHORIZED SPEEDS

60/40 Ls L Ls LEFT CURVE CURVE NO. Dc Ea Vmax=Vpass/Vfrt

60#/40 Ls L Ls RIGHT CURVE

L	TOTAL LENGTH OF CURVE INCLUDING SPIRALS
Ls	LENGTH OF SPIRAL
Dc	DEGREE OF CURVATURE
Ea	ACTUAL SUPERELEVATION
60/40	PASSENGER/FREIGHT SPEED TIMETABLE NO. 7
60#/40	HIGH WIND RESTRICTION FOR PASSENGER
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	CONCRETE TIE WITH FAST CLIP
	CONCRETE TIE WITH MCKAY
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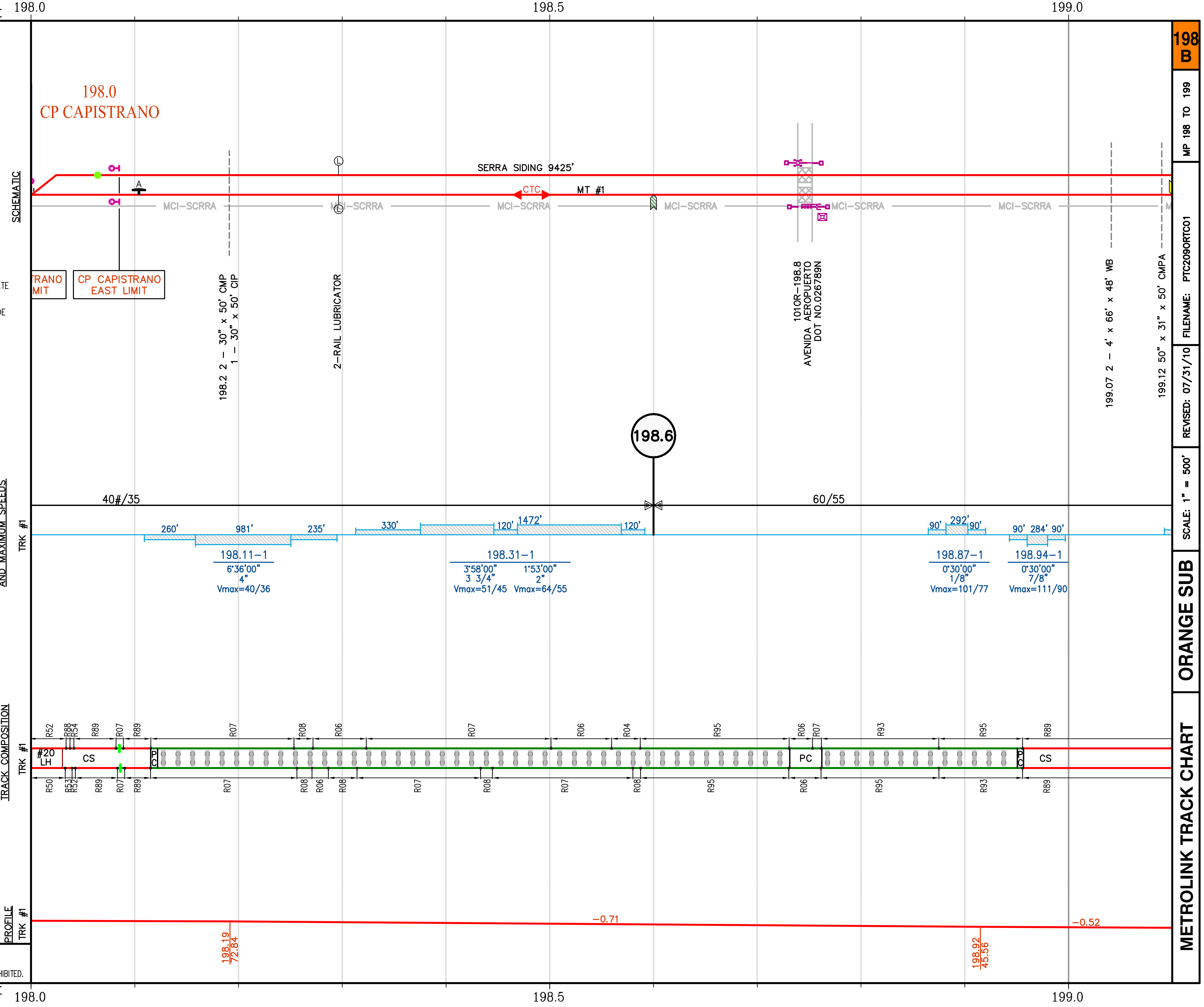
	STEEL TIE WITH PANDROL CLIP

- 136RE, JOINTED
- 136RE, CWR
- 133RE, JOINTED
- 133RE, CWR
- 132HF, JOINTED
- 132HF, CWR
- 119RE OR LOWER, JOINTED
- 119RE OR LOWER, CWR

T/R PROFILE**

AVG. GRADE MP ELEV. MP ELEV.

**VERTICAL DATUM BASED ON NAVD 88



198 B

MP 198 TO 199

FILENAME: PTC209ORTC01

REVISED: 07/31/10

SCALE: 1" = 500'

ORANGE SUB

METROLINK TRACK CHART

TRACK LEGEND

- SCRRA MAINLINE CTC
- SCRRA REVENUE TRACK
- OTHER THAN MAINLINE/ REVENUE TRACKS
- UPRR
- BNSF
- LIGHT RAIL TRANSIT (LRT)
- AMTRAK
- SDNR
- TUNNEL

PROPERTY LINE LEGEND

- SCRRA PROPERTY LINE (ROW)
- UPRR PROPERTY LINE
- BNSF PROPERTY LINE
- SDNR PROPERTY LINE
- LACMTA LINE
- CITY/COUNTY LIMIT
- ▨ STREET CROSSING
- STATION PLATFORM

UTILITIES

- KM-10"
- KM-16"
- MCI-SCRRA-FXX
- SCRRA-FXX (Future)
- SPRINT

ALL PVC PIPES ARE 4" DIAMETER ELECTRICAL CONDUITS UNLESS OTHERWISE NOTED

CONTRACT NO.	PTC209
DRAWING NO.	PTC2090R-VJ053
REVISION	0
SHEET NO.	53 OF 71
SCALE	HORIZ 1"=100' VERT 1"=20'

METROLINK COMMUTER RAIL SYSTEM
POSITIVE TRAIN CONTROL PROJECT
ORANGE SUBDIVISION
COMPOSITE MAP
PLAN AND PROFILE

SOUTHERN CALIFORNIA REGIONAL RAIL AUTHORITY
Professional Engineering Services and Staff Support for the Metrolink Regional Rail System

METROLINK

APPROVED: Darrell V. Maxey

Rail Surveyors & Engineers, Inc.
1075 Old County Road
Belmont, CA 94002

SUBMITTED:
PROJECT MANAGER

FLIGHT DATE: JUNE 28, 2007

TRACK LEGEND	PROPERTY LINE LEGEND	UTILITIES
SCRRA MAINLINE CTC	SCRRA PROPERTY LINE (ROW)	KM-10"
SCRRA REVENUE TRACK	UPRR PROPERTY LINE	KM-16"
OTHER THAN MAINLINE/ REVENUE TRACKS	BNSF PROPERTY LINE	MCI-SCRRA-FXX
UPRR	SDNR PROPERTY LINE	SCRRA-FXX (Future)
BNSF	LACMTA LINE	
LIGHT RAIL TRANSIT (LRT)	CITY/COUNTY LIMIT	SPRINT
AMTRAK	▨ STREET CROSSING	
SDNR	TUNNEL	STATION PLATFORM	

ALL PVC PIPES ARE 4" DIAMETER ELECTRICAL CONDUITS UNLESS OTHERWISE NOTED

CONTRACT NO. PTC209
DRAWING NO. PTC2090R-VJ054
REVISION 0
SHEET NO. 54 OF 71
SCALE HORIZ 1"=100' VERT 1"=20'

METROLINK COMMUTER RAIL SYSTEM POSITIVE TRAIN CONTROL PROJECT

ORANGE SUBDIVISION
COMPOSITE MAP
PLAN AND PROFILE

SOUTHERN CALIFORNIA REGIONAL RAIL AUTHORITY
Professional Engineering Services and Staff Support for the Metrolink Regional Rail System

METROLINK

APPROVED: Darrell V. Maxey

Rail Surveyors & Engineers, Inc.
1075 Old County Road
Belmont, CA 94002

SUBMITTED: Fergusen
PROJECT MANAGER

TRACK LEGEND

- SCRRA MAINLINE CTC
- SCRRA REVENUE TRACK
- OTHER THAN MAINLINE/ REVENUE TRACKS
- UPRR
- BNSF
- LIGHT RAIL TRANSIT (LRT)
- AMTRAK
- SDNR
- TUNNEL

PROPERTY LINE LEGEND

- SCRRA PROPERTY LINE (ROW)
- UPRR PROPERTY LINE
- BNSF PROPERTY LINE
- SDNR PROPERTY LINE
- LACMTA LINE
- CITY/COUNTY LIMIT
- STREET CROSSING
- STATION PLATFORM

UTILITIES

- KM-10" KM-10"
- KM-16" KM-16"
- MCI-SCRRA-FXX MCI-SCRRA-FXX
- SCRRA-FXX SCRRA-FXX (Future)
- SPRINT SPRINT

ALL PVC PIPES ARE 4" DIAMETER ELECTRICAL CONDUITS UNLESS OTHERWISE NOTED

CONTRACT NO. PTC209
DRAWING NO. PTC2090R-VJ055
REVISION 0
SHEET NO. 55 OF 71
SCALE HORIZ 1"=100' VERT 1"=20'

METROLINK COMMUTER RAIL SYSTEM
POSITIVE TRAIN CONTROL PROJECT
ORANGE SUBDIVISION
COMPOSITE MAP
PLAN AND PROFILE

SOUTHERN CALIFORNIA REGIONAL RAIL AUTHORITY
Professional Engineering Services and Staff Support for the Metrolink Regional Rail System

METROLINK
APPROVED: Darrell V. Maxey

Rail Surveyors & Engineers, Inc.
1075 Old County Road
Belmont, CA 94002
SUBMITTED: Nguyen
PROJECT MANAGER

APPENDIX D
PRELIMINARY FOUNDATION REPORT

SOUTHERN CALIFORNIA REGIONAL RAIL AUTHORITY

Preliminary Foundation Study

San Juan Creek Bridge

San Juan Capistrano, Orange County, California

March 2014

Prepared for:

Southern California Regional Rail Authority – Metrolink
279 E Arrow Highway, Suite A
San Dimas, CA 91773

Prepared by:

HDR Engineering, Inc.
3230 El Camino Real, Suite 200
Irvine, CA 92602

HDR ONE COMPANY | *Many Solutions*®

March 27, 2014

Southern California Regional Rail Authority - Metrolink
Attn: Mr. Naresh Patel
279 E Arrow Highway, Suite A
San Dimas, CA 91773

Re: Geotechnical Data Report for San Juan Creek Bridge Project, San Juan Capistrano, Orange County, California

Dear Mr. Patel:

In response to your request, HDR Engineering, Inc. (HDR) has performed a preliminary geotechnical study for the San Juan Creek Bridge (Bridge), in the City of San Juan Capistrano, California. This project is sponsored by the Southern California Regional Rail Authority (SCRRA). The purpose of our study was to evaluate the foundation of the existing structure as well as to provide preliminary recommendations for a potential replacement structure. These preliminary recommendations include potential foundation types and constructability issues pertaining to substructure design based on the data gathered from soils reports in the project area.

The existing structure was built in 1917. The Bridge is a single-track, 305-foot-long, three-span, steel thru-plate girder structure supported on timber piles.

Based on our review of the existing borings in the general vicinity of the project area, the soils generally consist of medium dense to very dense sand between elevation 75 feet and elevation 63 feet above mean sea level (MSL). Soils below elevation 63 feet to elevation 49 feet generally consist of loose to dense sand and gravelly sand. From elevation 49 feet to a maximum depth explored at elevation -25 feet soils generally consist of loose to very dense sand and silty sand. An isolated layer of stiff to hard clay and silt was indentified between elevation 8 feet and elevation -2 feet. Groundwater was found near the ground surface in the existing borings within San Juan Creek. The elevation of San Juan Creek at the project site is estimated to be approximately 60 feet MSL.

Based on our review and preliminary evaluations, construction of the proposed improvements at the site is feasible from a geotechnical viewpoint. This report summarizes the results of our preliminary foundation study and presents approximate existing foundation capacities as well as preliminary geotechnical recommendations for design and construction of a proposed replacement structure.

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

Respectfully submitted,

HDR ENGINEERING, INC.

Jim Starick, PE C77738
Senior Staff Engineer

REGISTERED PROFESSIONAL ENGINEER
JIM STARICK
No. C77738
CIVIL
STATE OF CALIFORNIA

Reviewed by
Gary R. Goldman, PE, GE 2587
Geotechnical Section Manager

REGISTERED PROFESSIONAL ENGINEER
GARY R. GOLDMAN
No. 2587
GEOTECHNICAL
STATE OF CALIFORNIA

TM/JMS/GG

Table of Contents

List of Tables

List of Appendices

1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

The San Juan Creek Bridge Project involves retrofitting or replacing a three (3) span steel railroad bridge along the Los Angeles to San Diego (LOSSAN) rail corridor. The Bridge currently consists of a 305-ft ballast-deck thru-plate girder (TPG) type. The Bridge is estimated to have a normal load rating below expected future demands and requires frequent maintenance by SCRRA due to age, fatigue, and typical deterioration associated with the surrounding environment. The Bridge is located in the City of San Juan Capistrano near the Camino Capistrano exit of the Interstate 5 (I-5) freeway. The San Juan Creek Bike Trail is located under the bridge adjacent to the West Abutment and a County of Orange Flood Division maintenance road is located near the East Abutment. The Bridge is located between Mile Post (MP) 197.69 and MP 198.0. The location of the Bridge is shown on Figure 1, Site Location Map, in Appendix A.

The existing structure was built in 1917. The Bridge is a single-track, 305-foot-long, three-span, steel thru-plate girder structure supported on timber piles. This report presents geotechnical considerations to develop retrofit or replacement recommendations for the existing Bridge.

1.2 PURPOSE AND SCOPE

The purpose of this report is to present preliminary recommendations for the foundation of the proposed structure and present potential constructability issues pertaining to the substructure design based on existing data and information from soils reports in the adjacent areas.

Our scope of work for this project included the following tasks:

- *Literature Review*: We reviewed various documents pertinent to the project site. A list of references used in preparation of this report is presented in Section 4.0. As-built drawings for the existing Bridge are presented in Appendix B. Existing boring logs and laboratory test results from nearby projects are presented in Appendices C and D, respectively.
- *Preliminary Seismic Analysis*: Based upon the subsurface conditions from nearby soils reports and regional seismicity of the area, we performed preliminary ground motion analysis for the project site for use in preliminary structural analysis and design.
- *Preliminary Geotechnical Design and Analysis*: Preliminary geotechnical analysis was performed on the existing data to develop preliminary recommendations for design and construction of the proposed project.
- *Report Preparation*: Relevant geotechnical data were compiled in this report along with our preliminary recommendations for the proposed project.

2.0 DATA REVIEW

2.1 GEOLOGIC SETTING

The project site is located in the Peninsular Ranges Province that is bounded on the north by the Santa Monica, San Gabriel, and San Bernardino Mountains of the Transverse Ranges Province. The Mojave Desert Province lies to the east. The Peninsular Ranges Province is characterized by a series of northwest-southwest trending mountains and faults. The Orange County portion of the province is comprised of a large basin that is bounded on the west and southwest by the Pacific Ocean, and on the north, east, and southeast by the Puente Hills, Santa Ana Mountains, and San Joaquin Hills, respectively.

In general, based on the regional geologic map, the site is underlain by young alluvial valley deposits near the abutment areas, and alluvial wash deposits near the bent areas. The young alluvial valley deposits generally consist of unconsolidated to slightly consolidated, un-dissected to slightly dissected clayey, silt, sand and gravel along stream valleys and alluvial flats of larger rivers. The alluvial wash deposits generally consist of unconsolidated sandy and gravelly sediment in active channels, and may contain loose to moderately loose sands and silty sands. A geologic map of the area is presented on Figure 2 in Appendix A.

2.2 FAULTING AND SEISMICITY

Our review of available in-house literature indicates that there are no known active or potentially active faults that have been mapped at the site, and the site is not located within an Alquist-Priolo Earthquake Fault Zone. The principal seismic hazard that could affect the site is ground shaking resulting from an earthquake occurring along one of several major active or potentially active faults in southern California. Based on the review of the Caltrans ARS website (Caltrans, 2013) the closest active faults that could affect the site are the Newport-Inglewood fault, San Joaquin Hills fault, and Newport-Inglewood fault zone (S. Los Angeles Basin section – southern), located approximately 8.2 kilometers (km), 11.6 km, and 16.7 km, respectively, from the site. The locations of these faults with respect to the site are shown on Figure 3 in Appendix A.

We have used the USGS deaggregation hazard online program (USGS, 2008) for the probabilistic seismic hazard analysis. The estimated peak ground accelerations for different seismic levels per the AREMA are summarized in Table 2-1.

Table 2-1. Peak Horizontal Ground Accelerations

Seismic Event Level	Return Period (years)	Peak Horizontal Accelerations(1), g
I	108	0.19
II	475	0.33
III	2475	0.56

(1): Vs30 = 260 m/s

Review of the Caltrans Deterministic PGA Map (Caltrans, 2007) indicates that the Newport-Inglewood fault zone (S. Los Angeles Basin section-southern) is capable of generating a maximum credible earthquake (MCE) magnitude of 7.2. The Caltrans Deterministic PGA Map (Caltrans, 2007) shows that the design peak bedrock acceleration at the site is 0.4g.

2.3 EXISTING GEOTECHNICAL DATA

Several soils reports from projects in the general vicinity of the project area were available for review. Soils reports for the Interstate-5 (I-5) widening project for the San Juan Creek Road UC Bridge (Bridge No. 55-298) (CH2M Hill, 1992a) and San Juan Creek Bridge (Bridge No. 55-228) (CH2M Hill, 1992b), located approximately 700 feet east and 1,200 feet northeast of the Bridge, respectively, contained soil information from three borings by Ninyo & Moore and 5 borings by CH2M Hill with a maximum exploration depth of 88.5 feet. Another soils report prepared by Ninyo & Moore for an adjacent pipeline project contained one boring near the project site with a maximum exploration depth of 16.5 feet (Ninyo & Moore, 2009). The approximate locations of the borings are presented on Figure 4 in Appendix A.

2.4 SEISMIC HAZARDS

2.4.1 Fault Rupture

Based on available literature and reports, no active faults are known to traverse the project site, and the site is not located within a currently designated Alquist-Priolo Earthquake Fault Zone. Based on Alquist-Priolo Special Studies Zone Map (USGS, 1980), the nearest special study zone is approximately 32.5 km from the site. Therefore, the principal seismic hazard that could impact the site is ground shaking resulting from an earthquake occurring along one of several major active or potentially active faults in the region as discussed in Section 2.2.

2.4.2 Preliminary Liquefaction

Liquefaction is the loss of soil strength or stiffness due to a buildup of pore-water pressure during ground shaking. Liquefaction is associated primarily with loose (low-density), saturated, fine- to medium-grained, cohesionless soils. Effects of liquefaction can include sand boils, excessive displacements, bearing capacity failures, and lateral spreading.

The site is located within an area designated as potentially liquefiable on the Seismic Hazard Zones map for the Dana Point 7.5-Minute Quadrangle (USGS, 2001), as shown on Figure 5 in Appendix A.

Based on existing borings from nearby projects, soils at depths between approximately 0 to 10 feet and 14 to 20 feet below the creek channel are potentially susceptible to liquefaction. Boring B-104 drilled for Bridge No. 55-228 indicates that soils at depths between approximately 20 and 38 feet below the creek channel are potentially susceptible to liquefaction.

2.4.3 Seiches and Tsunamis

Seiches are large waves generated in enclosed bodies of water in response to ground shaking. Tsunamis are waves generated in large bodies of water by fault displacement or major ground movement. Based on the absence of enclosed bodies of water near the site and the Tsunami Inundation Map (CGS, 2009), seiche and tsunami risks at the site are considered negligible.

2.4.4 Subsurface Earth Materials

Based on our review of the existing borings in the general vicinity of the project area, the soils generally consist of medium dense to very dense sand between elevation 75 feet and elevation 63 feet MSL. Soils below elevation 63 feet to elevation 49 feet generally consist of loose to dense sand and gravelly sand. From elevation 49 feet to a maximum depth explored at elevation -25 feet soils generally consist of loose to very dense sand and silty sand. An isolated layer of stiff to hard clay and silt was shown between elevation 8 feet and elevation -2 feet. The elevation of San Juan Creek at the project site is estimated to be approximately 60 MSL.

2.4.5 Groundwater

Groundwater was encountered in the existing borings at varying depths. Groundwater data from the existing borings from nearby projects is shown in Table 2-2.

Table 2-2. Groundwater Information

Boring No.	Location	Surface Elevation (feet)(1)	Groundwater Depth (feet)(2)	Groundwater Elevation (feet)(1)
SB-4	I-5 over San Juan Creek Road UC - North Abutment	106	43	63
SB-5	I-5 over San Juan Creek - South Abutment	106	27	79
B-101	I-5 over San Juan Creek – Creek	68	9	59
B-113	I-5 over San Juan Creek – Creek	62	1	61
B-114	I-5 over San Juan Creek – Creek	62	1	61
B-104	I-5 over San Juan Creek – Creek	60	2	58
SB-6	I-5 over San Juan Creek – North Abutment	102	34	68

(1) above mean sea level (MSL)
(2) below ground surface (BGS)

Fluctuations of the groundwater level, localized zones of perched water, and an increase in soil moisture should be anticipated during and following the rainy seasons or periods of locally intense rainfall or storm water runoff.

2.5 EXISTING FOUNDATION

According to the existing as-built information (American Bridge Co., 1917), the Bridge is supported on approximately one-foot diameter timber piles with approximately three-foot center-to-center spacing. The West Abutment is supported on 99 piles with an average penetration depth of 15.3 feet. The bents are each supported on 73 piles with an average penetration depth of 14.3 and 16.2 feet at Piers 1 and 2, respectively. No information was available for the east abutment. Assuming the piles have not experienced any degradation, we estimate the West Abutment and each bent to have total ultimate axial capacities of approximately 2,000 kips and 1,500 kips, respectively based on a preliminary axial capacity analysis. Based on a preliminary lateral analysis, we estimate the West Abutment and each bent to have a total lateral shear capacity of approximately 4,600 kips and 3,400 kips, respectively, at one inch of lateral displacement.

The integrity of timber piles varies based on factors including soil conditions, groundwater, wood type, and protection method. Based on the conditions at the Bridge, the timber piles may last 100 years or longer (FHWA, 1998), but the protection method used on the existing piles is unknown. According to the as-built drawings, the timber bridge deck was treated with creosote oil and heavy road oil during construction. There is no existing information regarding any treatment on the timber piles. Also, due to its location in a creek channel, the Bridge has likely experienced many cycles of varying water levels, which is particularly degrading to timber piling.

2.6 NEARBY STRUCTURES

Existing reports from the two nearby I-5 bridges present as-built data from the initial construction and widening of these two bridges. As-built information for these nearby structures is presented in Table 2-3.

Table 2-3. As-Built Information – Existing Structures

Structure	Approx. Ground Surface Elevation (feet)	Pile Type	Number of Piles	Average Tip Elevation (feet)	Approx. Pile Length (feet)	Pile Construction Technique
Camino Capistrano over San Juan Creek (Bridge No. 55C-034) – Initial Construction (Approximately 1984)						
Abutment 1	80	Class 70 driven piles	155	18	60	Information not available
Pier 2	60			17	43	
Abutment 3	78			27	51	
I-5 over San Juan Creek (Bridge No. 55-228) – Initial Construction (1957)						
Abutment 1	107	Driven, 45-ton Raymond step-taper (concrete-filled corrugated steel shell)	607	19	88	Information not available
Bents 1, 3, and 4	61			15	46	
Abutment 5	103			14	89	
I-5 over San Juan Creek (Bridge No. 55-228) – Widening (1967)						
Abutment 1	107	Driven, 45-ton Raymond step-taper (concrete-filled corrugated steel shell)	335	13	94	Most piles installed were jetted into place
Bents 1, 3, and 4	61			15	46	
Abutment 5	103			15	88	
I-5 over San Juan Creek Road UC (Bridge No. 55-298) – Initial Construction (1957)						
Abutment 1	105	Driven, 45-ton Raymond step-taper (concrete-filled corrugated steel shell)	64	45	60	Information not available
Bents 2 and 3	84			40	44	
Abutment 4	105			35	70	
I-5 over San Juan Creek Road UC (Bridge No. 55-298) – Widening (1967)						
Abutment 1	105	45-ton Cast-in-drill-hole (CIDH) piles	46(1)	45	60	Casing used
Bents 2 and 3	84			44	40	
Abutment 4	105			40	65	
I-5 over San Juan Creek Road UC (Bridge No. 55-298) – Widening (1994)						
Abutment 1	99	70-ton 16in x 0.5in steel pipe piles	50	34	65	Pre-drilled upper 20 feet for abutment piles
Bents 2 and 3	82			28	54	
Abutment 4	100			34	66	

(1) Number of piles was not available. Approximate number calculated based on total linear feet of piling in materials list.

3.0 CONCLUSIONS AND PRELIMINARY RECOMMENTATIONS

Based upon our evaluation of the soils and geologic information, we conclude that the proposed project is feasible from a geotechnical standpoint. During future stages of design, a field exploration should be performed and a detailed geotechnical report should be prepared. The preliminary recommendations in this report are considered a minimum and may be superseded by more stringent requirements of the structural engineer and/or the governing agencies.

3.1 FOUNDATION TYPE

Based on our evaluation of existing data, the proposed bridge may be supported on CIDH piles or driven steel piles. In the case of a rebuild alternative, we judge that reuse of the existing timber piles is not appropriate based on their age and likely deterioration. Additionally, the timber piles are short by modern standards and likely do not extend into competent materials in the case of a liquefaction event.

Existing bridges in the project area are supported on Caltrans Class 70 driven piles, 45-ton Raymond step-taper (concrete-filled corrugated steel shell) piles, CIDH piles, and 70-ton steel pipe piles. The existing foundations built within San Juan Creek have approximate cutoff elevations between 27 and 14 feet (MSL) with pile lengths between 43 and 45 feet at the bent locations. Based on this information, driven steel piles are expected to have approximate cutoff elevations between 10 and 20 feet (MSL). Actual pile capacities will vary depending on pile type, soil conditions, and site-specific liquefaction analysis.

3.2 FOUNDATION CONSTRUCTION CONSIDERATIONS

Based on the existing soils and as-built information, several foundation constructability issues are likely to exist at the Bridge location. Special construction techniques such as predrilling, casing, wet-method installation, or jetting may be required to construct new foundations at the site.

Based on the existing borings near the project site, free groundwater is expected near the creek surface. Due to the nature of the sandy soils anticipated on site, caving may be encountered during the CIDH pile construction and temporary casing or drilling slurry may be necessary to facilitate the construction of CIDH piles. According to existing as-built information, casing was used to construct the CIDH piles used in the 1967 widening of Bridge No. 55-298.

Based on the existing borings near the project site, gravelly soils and very dense sands are expected at varying depths below the creek. These conditions may cause drivability issues for driven piles. Pile driving shoes, predrilling, or jetting methods may be required for driven pile installation. According to existing as-built information, jetting was used to aid with the installation of the Raymond step-taper piles used in the 1967 widening for Bridge No. 55-228.

4.0 REFERENCES

The following references were used in preparation of this report:

American Bridge Co., 1917, As-Built Plans, A.T. & S.F.Ry. System, 3-100 foot S. T. Thru Pl. Girder Spans for 45 degree skew, February 1917

American Railway Engineering and Maintenance-of-Way Association (AREMA), 2010, Manual for Rail Engineering.

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CH2M Hill, 1992a, Bridge Foundation Report, I-5 Widening, San Juan Creek Road UC, Bridge No. 55-298, Orange County, California, September 1992.

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Federal Highway Administration (FHWA), Design and Construction of Driven Pile Foundations, November 1998.

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O’Neill, M. W. and Reese, L.C., 1999, Drilled Shafts: Construction Procedures and Design Methods prepared for U.S. Department of Transportation, Federal Highway Administration, Office of Infrastructure, Washington D.C., 1999.

USGS (formerly CDMG), 1980, Special Studies Zones for the Alberhill 7.5-Minute Quadrangle, Riverside County, California.

USGS, 2001, Seismic Hazard Zones for the Dana Point 7.5-Minute Quadrangle, Orange County, California.

USGS 2008, Interactive Deaggregation (Beta), https://geohazards.usgs.gov/deaggint/2008/

Appendix D.A

Figures

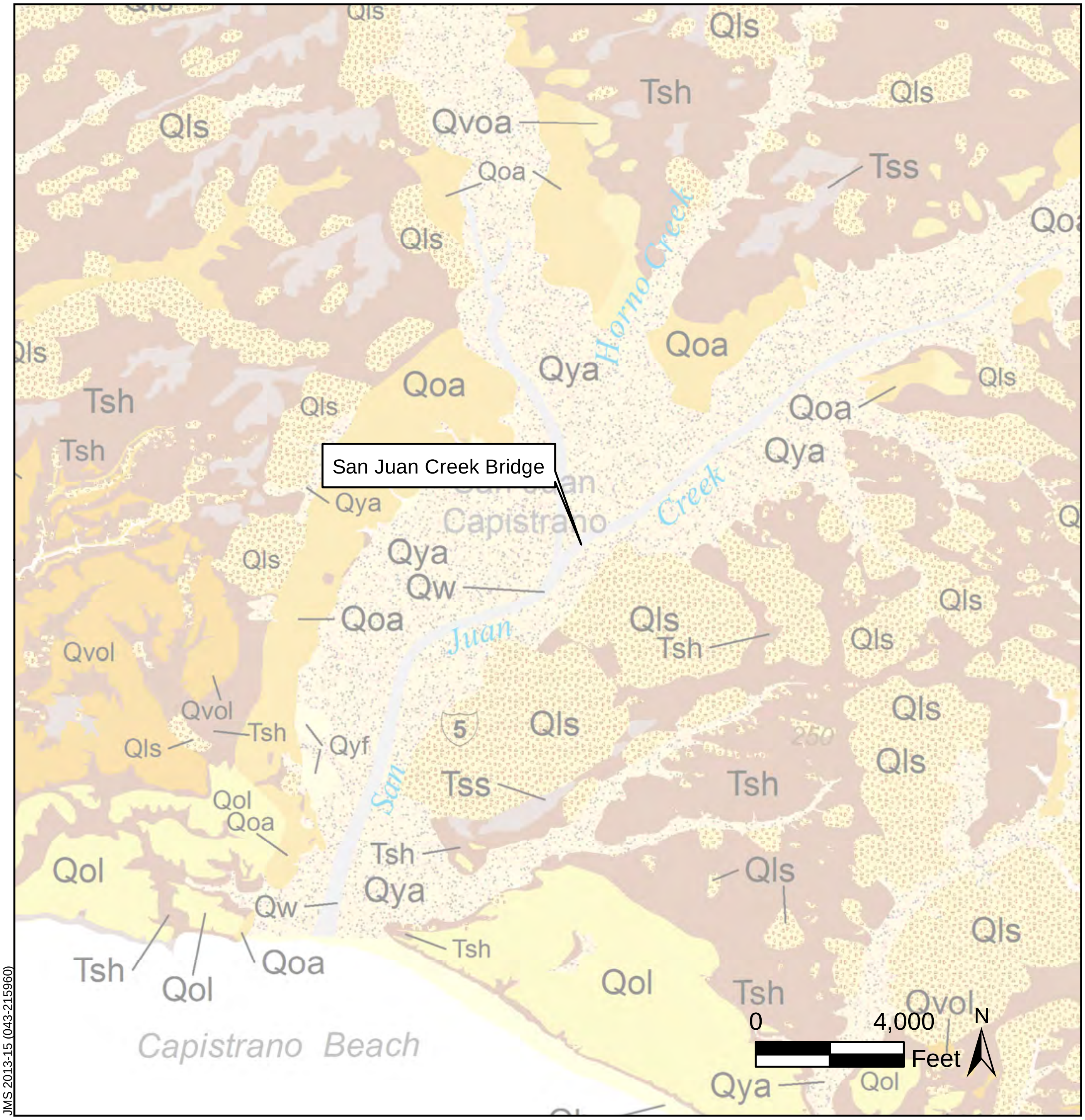
JMS 2013-08 (043-211783)

SITE LOCATION MAP

SAN JUAN CREEK BRIDGE

HDR

Figure 1



JMS 2013-15 (043-215960)

▨ Qya - Young alluvial valley deposits - unconsolidated to slightly consolidated, undissected to slightly dissected clay, silt, sand and gravel along stream valleys and alluvial flats of larger rivers.

▨ Qls - Landslide deposits - may include debris flows and older landslides of various earth material and movement types; unconsolidated to slightly well-consolidated

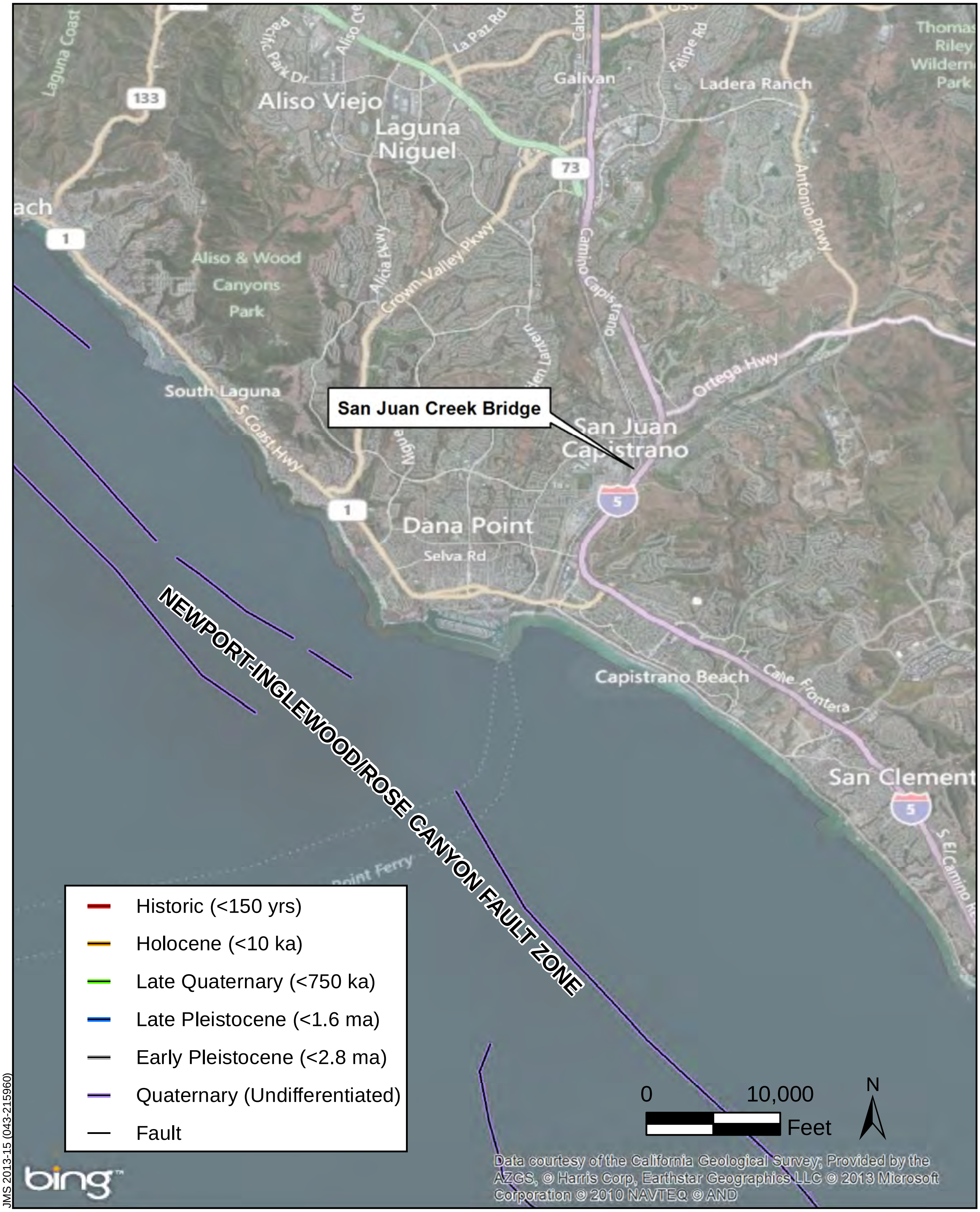
■ Qol - Old lacustrine, Playa, and Estuarine (Paralic) Deposits - slightly to moderately consolidated, fine sand, silt, mud, and clay from lake, playa and estuarine deposits of various types.

□ Qw - Alluvial wash deposits, unconsolidated sandy and gravelly sediment in active channels, may contain loose to moderately loose sand and silty sand.

GEOLOGIC MAP

SAN JUAN CREEK BRIDGE

Figure 2



Data courtesy of the California Geological Survey; Provided by the AZGS, © Harris Corp, Earthstar Geographics LLC © 2013 Microsoft Corporation © 2010 NAVTEQ © AND

JMS 2013-15 (043-215960)

FAULT MAP

SAN JUAN CREEK BRIDGE

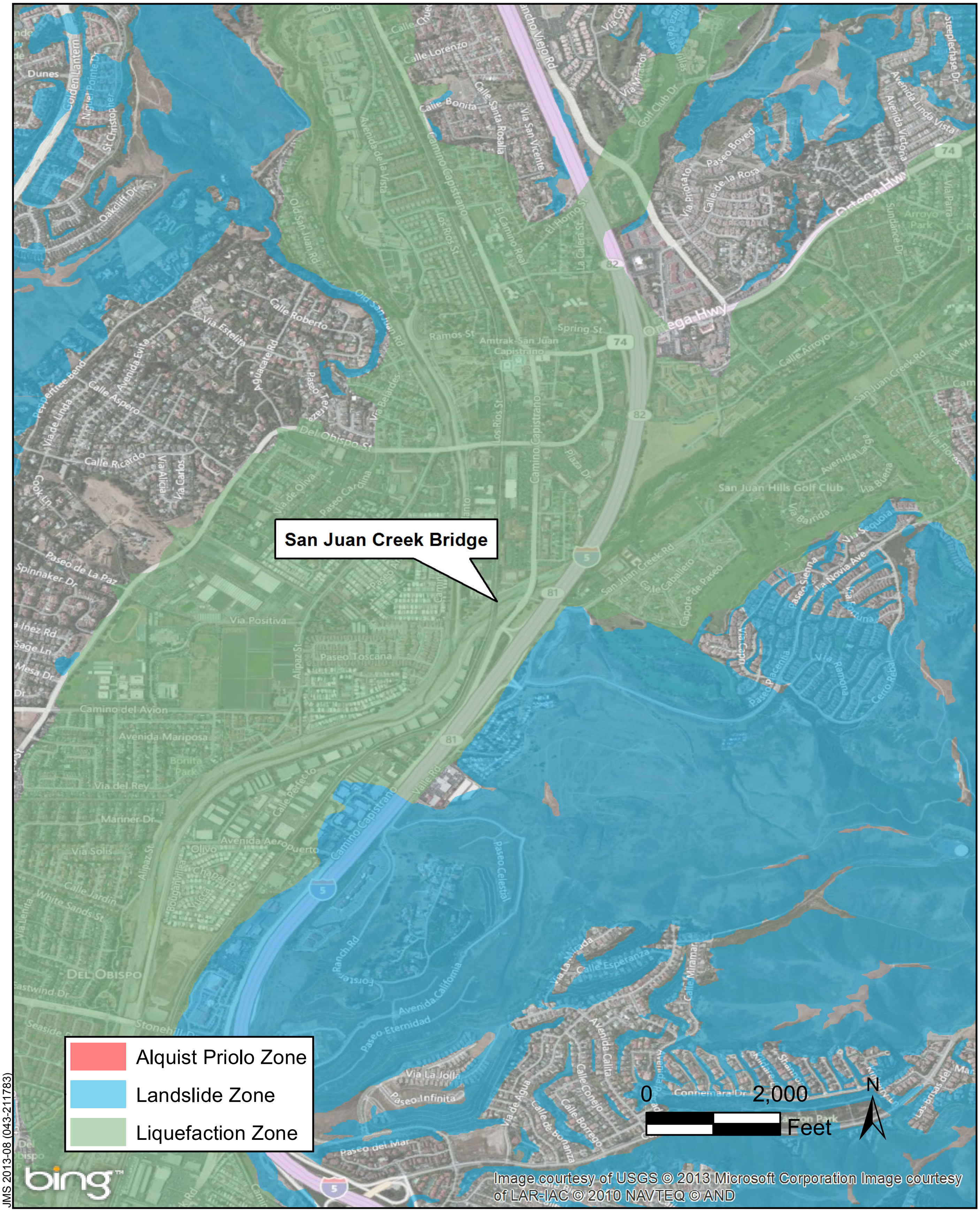
Figure 3

JMS 2013-08 (043-211783)

EXISTING DATA

SAN JUAN CREEK BRIDGE

Figure 4



JMS 2013-08 (043-211783)

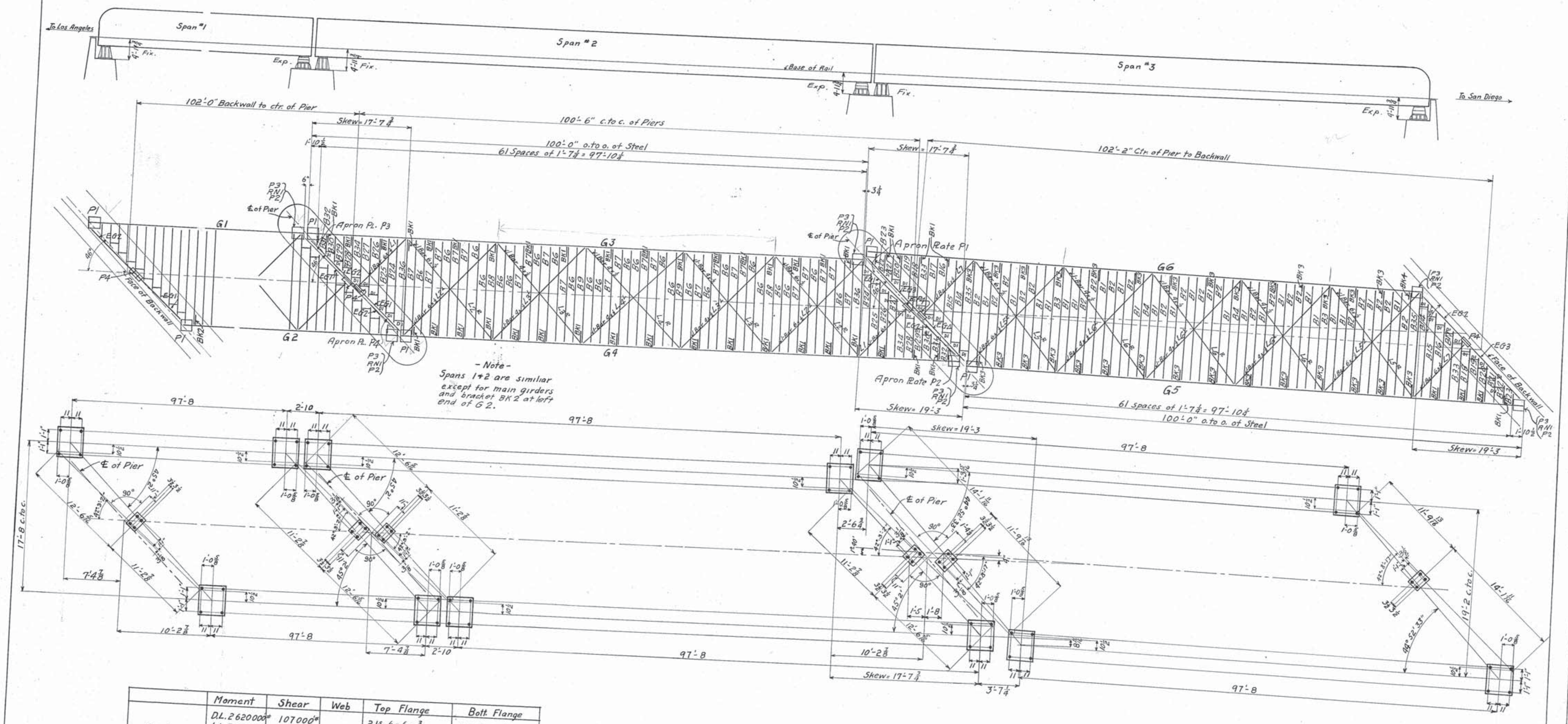
HAZARD MAP

SAN JUAN CREEK BRIDGE

Figure 5

Appendix D.B

As-Built Drawings



- Note -
Spans 1 + 2 are similiar except for main girders and bracket BK2 at left end of G2.

	Moment	Shear	Web	Top Flange	Bott. Flange
Girder	D.L. 2620000# L.L. 3075000 Total. 5695000	107000# 152 000 259 000	110 x 7/16	2 Ls 6 x 6 x 3/4 2 Side Pls. 12 x 5/8 3 Pls. 20 x 1/2 x F.L. 59'-0 & 42'-0	2 Ls 6 x 6 x 3/4 2 Side Pls. 12 x 5/8 1 Pl. 19 x 5/8 x F.L. 2 Pls. 16 x 5/8 x 58'-0 & 41'-0
Floor Beams in Spans 1 & 2	D.L. 10 600'# L.L. 71,900 Total 82,500	2 400 11,600 14000	18" Is @ 70# (U.S. = 9700#)		
Floor Beams in Span 3	D.L. 12000'# L.L. 82 500 Total 94 500	2700 11 600 14 300	18" Is @ 75# (U.S. = 9000#)		
End Floor Beams			1 Pl. 20 x 3/8 2 Ls 4 x 4 x 3/8		

B. of R. to Masonry

Tie	6"
Ballast at Ends	6 3/8
Planking	4
Floor I	1'-6
Flange L	0 3/4
Cov. Pl.	0 5/8
Shoe	2'-0
Total	4'-11 3/4

B of R. to Clearance

	6"
	6 3/8
	4
	1'-6
	0 3/4
Cover Pls.	1 7/8
Riv. Heads	0 5/8
Total	3-1 5/8

B. of R. to Top of Parapet

	6"
	6 3/8
	4
Total	1-4 3/8

Assumed Dead Load

Track	400
Ballast	1330
Planking	320
Steel	2350
Total	4400

- Notes -

Specifications - A.T. & S.F. Ry System
Live Load - Standard loading
Axle load - 60000# for floor
Dead Load Ass'm'd 4400# per lin. ft. of span

BES. 5102 sh. E1

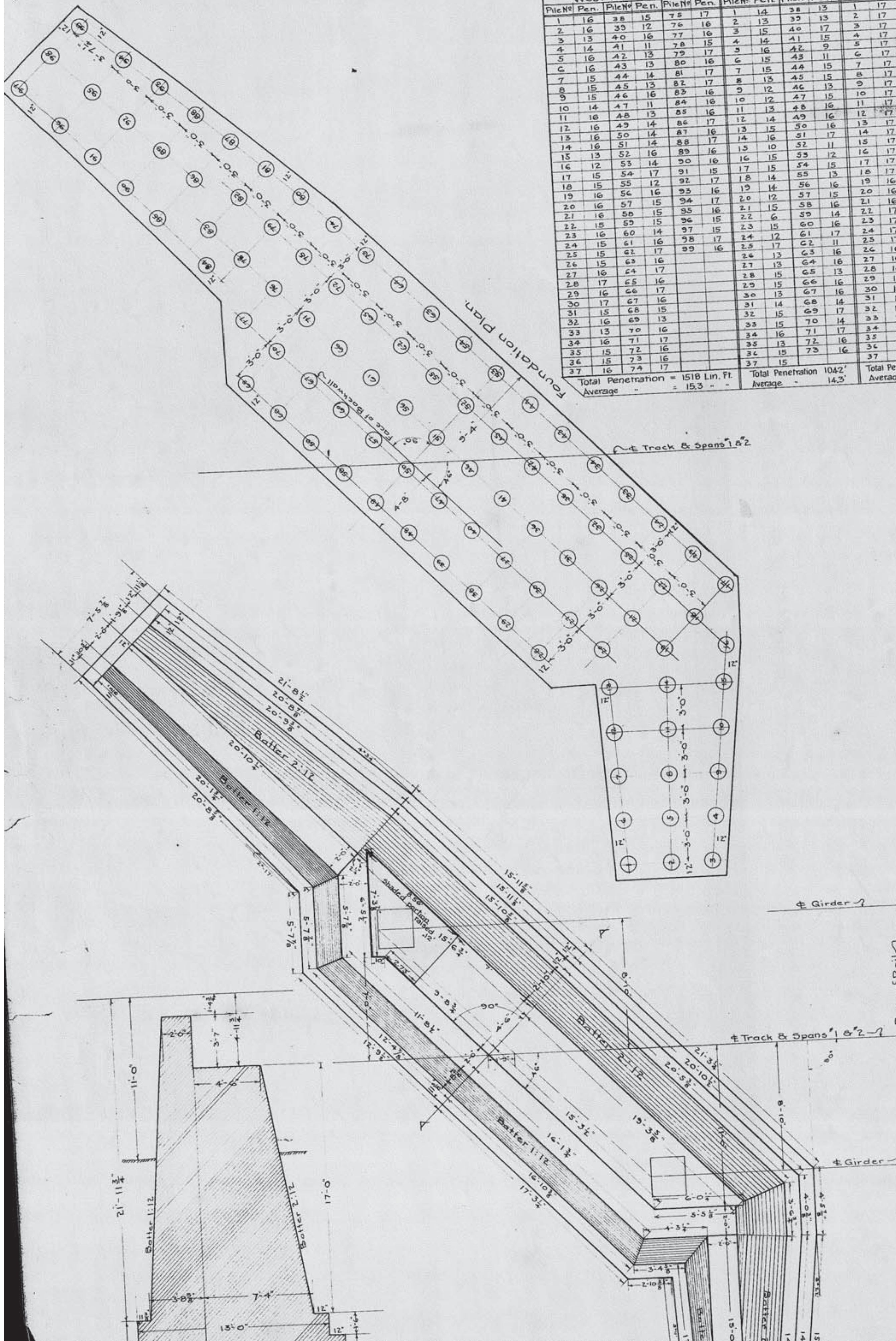
B.E.S. 5102

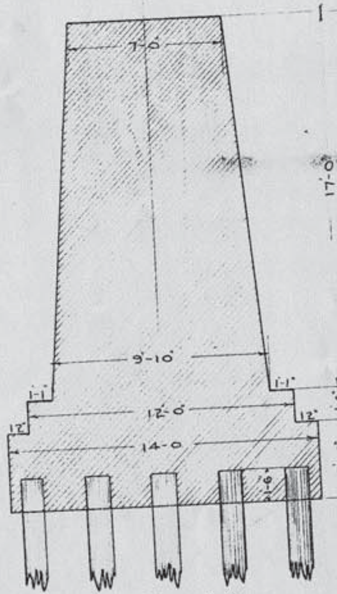
A. T. & S. F. RY. SYSTEM
3 100'-0" Skew Class "DD" Spans
DETAILS OF
Approved A. F. Robinson
BRIDGE ENGINEER SYSTEM
SCALE
AMERICAN BRIDGE CO
Gary Plant Drawing Room No. 3
E1

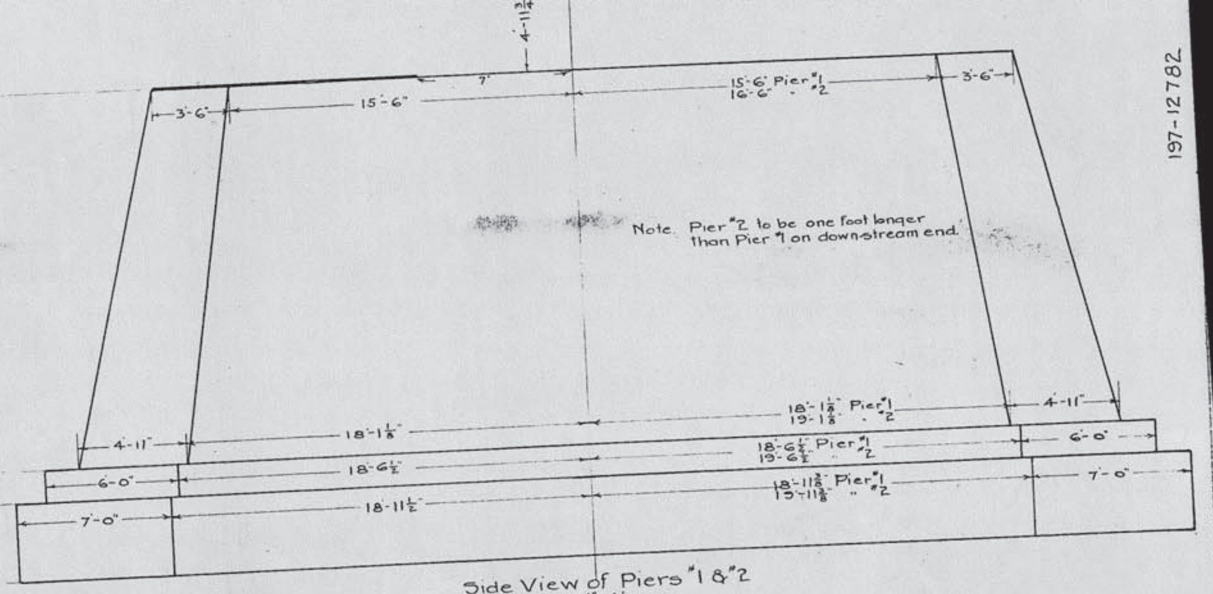
APK 7-2-17.

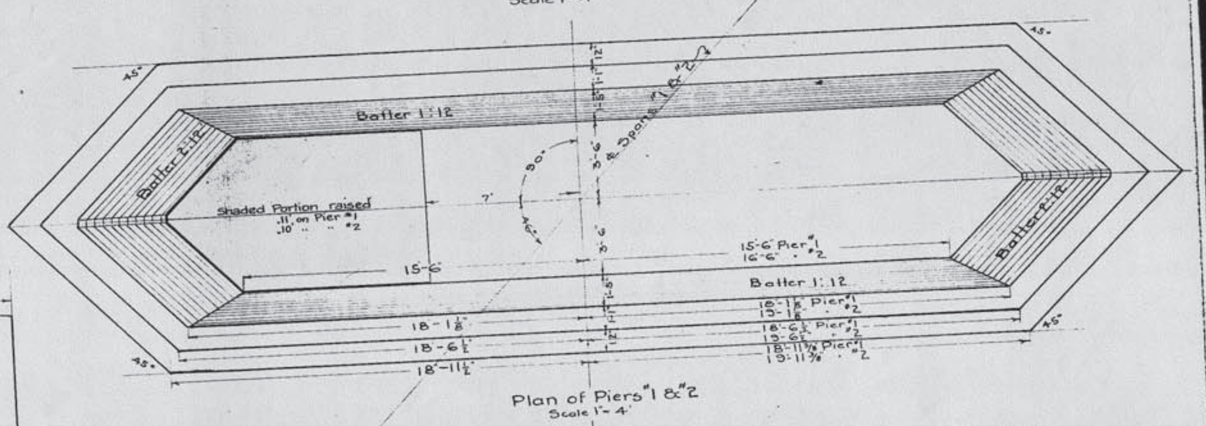
Table showing Penetration of Piles below Cutoff.

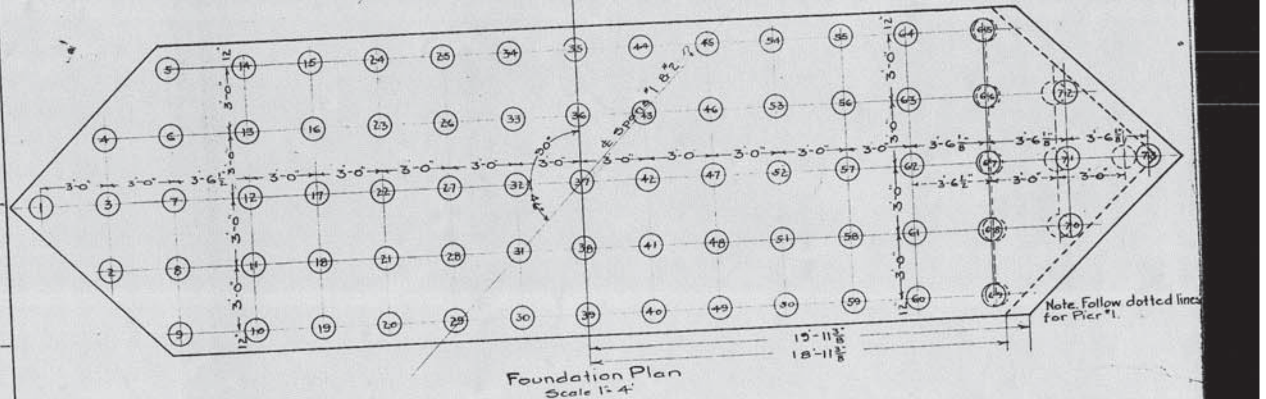
West Abutment.						Pier No. 2				Pier No. 1			
Pile No.	Pen.	Pile No.	Pen.	Pile No.	Pen.	Pile No.	Pen.	Pile No.	Pen.	Pile No.	Pen.	Pile No.	Pen
1	16	38	15	75	17	1	14	38	13	1	17	38	16
2	16	39	12	76	16	2	13	39	13	2	17	39	14
3	13	40	16	77	16	3	15	40	17	3	17	40	16
4	14	41	11	78	15	4	14	41	15	4	17	41	16
5	16	42	13	79	17	5	16	42	9	5	17	42	16
6	16	43	13	80	16	6	15	43	11	6	17	43	16
7	15	44	14	81	17	7	15	44	15	7	17	44	16
8	15	45	13	82	17	8	13	45	15	8	17	45	16
9	15	46	16	83	16	9	12	46	13	9	17	46	16
10	14	47	11	84	16	10	12	47	15	10	17	47	16
11	16	48	13	85	16	11	13	48	16	11	17	48	11
12	16	49	14	86	17	12	14	49	16	12	17	49	17
13	16	50	14	87	16	13	15	50	16	13	17	50	17
14	16	51	14	88	17	14	16	51	17	14	17	51	17
15	13	52	16	89	16	15	10	52	11	15	17	52	17
16	12	53	14	90	16	16	15	53	12	16	17	53	16
17	15	54	17	91	15	17	15	54	15	17	17	54	16
18	15	55	12	92	17	18	14	55	13	18	17	55	16
19	16	56	16	93	16	19	14	56	16	19	16	56	17
20	16	57	15	94	17	20	12	57	15	20	16	57	17
21	16	58	15	95	16	21	15	58	16	21	16	58	13
22	15	59	15	96	15	22	6	59	14	22	17	59	17
23	16	60	14	97	15	23	15	60	16	23	17	60	17
24	15	61	16	98	17	24	12	61	17	24	17	61	17
25	15	62	17	99	16	25	17	62	11	25	17	62	17
26	15	63	16			26	13	63	16	26	16	63	15
27	16	64	17			27	13	64	16	27	16	64	11
28	17	65	16			28	15	65	13	28	16	65	14
29	16	66	17			29	15	66	16	29	16	66	15
30	17	67	16			30	13	67	16	30	16	67	17
31	15	68	15			31	14	68	14	31	16	68	17
32	16	69	13			32	15	69	17	32	16	69	17
33	13	70	16			33	15	70	14	33	16	70	17
34	16	71	17			34	16	71	17	34	16	71	17
35	15	72	16			35	13	72	16	35	16	72	14
36	15	73	16			36	15	73	16	36	16	73	17
37	16	74	17			37	15			37	16		
Total Penetration = 1518 Lin. Ft. Average " = 15.3 " "						Total Penetration 1042' Average " 14.3'				Total Penetration = 1185' Average " = 16.2			




Section A-A
Piers #1 & #2


Side View of Piers #1 & #2
Scale 1" = 4'


Plan of Piers #1 & #2
Scale 1" = 4'


Foundation Plan
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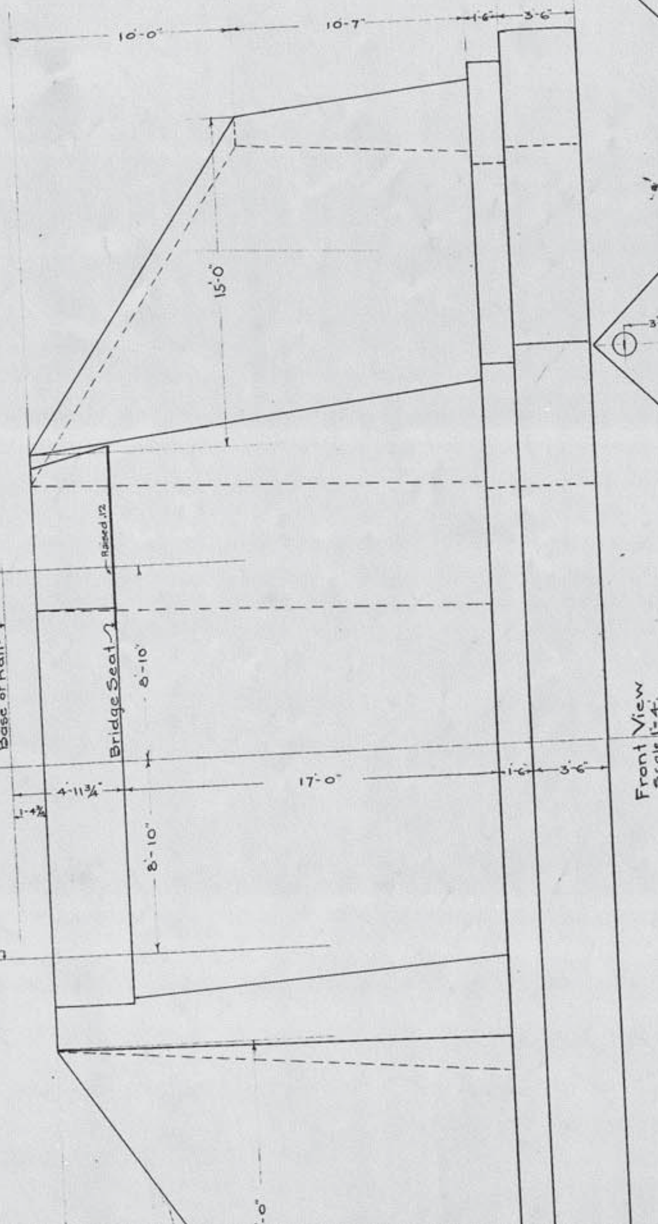

Front View
Scale 1" = 4'

197-12782

A

BES. 5102

T. AND S. F. RY. CO.
COAST LINES.
MILE 108, 4TH DISTRICT, L. A. DIVISION

Appendix D.C

Geotechnical Boring Logs by Others

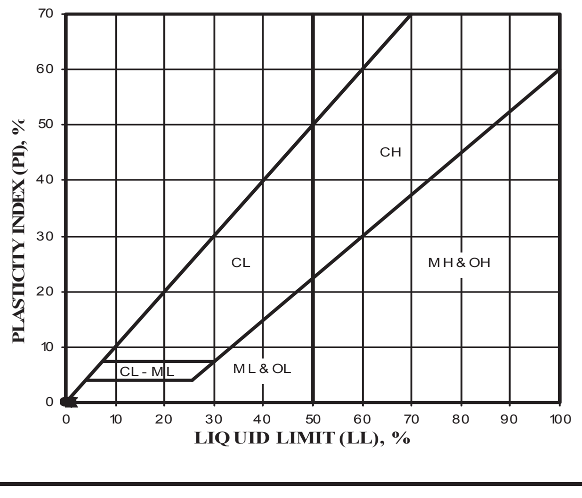
U.S.C.S. METHOD OF SOIL CLASSIFICATION

MAJOR DIVISIONS		SYMBOL	TYPICAL NAMES
COARSE-GRAINED SOILS (More than 1/2 of soil >No. 200 sieve size)	**GRAVELS** **(More than 1/2 of coarse fraction > No. 4 sieve size)**	GW	Well graded gravels or gravel-sand mixtures, little or no fines
		GP	Poorly graded gravels or gravel-sand mixtures, little or no fines
		GM	Silty gravels, gravel-sand-silt mixtures
		GC	Clayey gravels, gravel-sand-clay mixtures
	SANDS **(More than 1/2 of coarse fraction <No. 4 sieve size)**	SW	Well graded sands or gravelly sands, little or no fines
		SP	Poorly graded sands or gravelly sands, little or no fines
		SM	Silty sands, sand-silt mixtures
		SC	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS (More than 1/2 of soil <No. 200 sieve size)	**SILTS & CLAYS** **Liquid Limit <50**	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean
		OL	Organic silts and organic silty clays of low plasticity
	SILTS & CLAYS **Liquid Limit >50**	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic clays of medium to high plasticity, organic silty clays, organic silts
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils

GRAIN SIZE CHART

CLASSIFICATION	RANGE OF GRAIN SIZE	
	U.S. Standard Sieve Size	Grain Size in Millimeters
BOULDERS	Above 12"	Above 305
COBBLES	12" to 3"	305 to 76.2
GRAVEL **Coarse** **Fine**	3" to No. 4 3" to 3/4" 3/4" to No. 4	76.2 to 4.76 76.2 to 19.1 19.1 to 4.76
SAND **Coarse** **Medium** **Fine**	No. 4 to No. 200 No. 4 to No. 10 No. 10 to No. 40 No. 40 to No. 200	4.76 to 0.075 4.76 to 2.00 2.00 to 0.420 0.420 to 0.075
SILT & CLAY	Below No. 200	Below 0.075

PLASTICITY CHART



Ninyo & Moore | **U.S.C.S. METHOD OF SOIL CLASSIFICATION**

BORING LOG EXPLANATION SHEET

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	
0	■							Bulk sample.
		■						Modified split-barrel drive sampler.
		☒						No recovery with modified split-barrel drive sampler.
		▮						Sample retained by others.
		◩						Standard Penetration Test (SPT).
5		◿						No recovery with a SPT.
		▯	XX/XX					Shelby tube sample. Distance pushed in inches/length of sample recovered in inches.
		◸						No recovery with Shelby tube sampler.
		▥						Continuous Push Sample.
				♀				Seepage.
10				▽				Groundwater encountered during drilling.
				▼				Groundwater measured after drilling.
						▦	SM	ALLUVIUM: Solid line denotes unit change.
								Dashed line denotes material change.
15								Attitudes: Strike/Dip b: Bedding c: Contact j: Joint f: Fracture F: Fault cs: Clay Seam s: Shear bss: Basal Slide Surface sf: Shear Fracture sz: Shear Zone sbs: Sheared Bedding Surface
20								The total depth line is a solid line that is drawn at the bottom of the boring.

Ninyo & Moore

BORING LOG

EXPLANATION OF BORING LOG SYMBOLS

PROJECT NO.	DATE	FIGURE
	Rev. 01/03	

DATE DRILLED 4/6/09 BORING NO. B-1

GROUND ELEVATION 77' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING 8" Diameter Hollow Stem Auger (Martini Drilling)

DRIVE WEIGHT 140 lbs. DROP 30 inches

SAMPLED BY WY LOGGED BY WY REVIEWED BY GMC

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								ASPHALT CONCRETE: Approximately 4 inches thick.
							GP	BASE: Light gray, damp, medium dense, poorly graded GRAVEL; approximately 6 inches thick.
	■						ML	FILL: Dark brown, damp, medium dense, sandy SILT.
5		■	16	9.1	90.9			
							SP-SM	ALLUVIUM: Yellowish to grayish brown, moist, medium dense, poorly graded SAND with silt and gravel.
10		■	13	4.9	99.0			Reddish brown; loose.
15		■	12					
								Total Depth = 16.5 feet. No groundwater encountered during drilling. Backfilled with on-site soils and patched with rapid-set concrete with black dye on 4/6/09. Note: Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.
20								

Ninyo & Moore

BORING LOG

EASTERN WELLS AND PIPELINE PROJECT
SAN JUAN CAPISTRANO, CALIFORNIA

PROJECT NO.	DATE	FIGURE
207634001	9/09	A-1

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
12	Ora	5	6.7/18.9		

REGISTERED CIVIL ENGINEER

ELIZABETH M. SMITH
No. C-046851
Exp. 06-30-95

PLANS APPROVAL DATE

CH2M HILL
2510 RED HILL AVENUE
SANTA ANA, CA 92705

NOTES:

1. THE BORING LOGS AND RELATED INFORMATION REPRESENT THE OPINION OF THE GEOTECHNICAL ENGINEER AS TO THE CHARACTER OF THE MATERIALS AT THE LOCATIONS SHOWN. SOIL AND GROUNDWATER CONDITIONS BETWEEN ADJACENT TEST HOLES AND AT OTHER LOCATIONS MAY DIFFER FROM THOSE SHOWN. GROUNDWATER CONDITIONS MAY CHANGE WITH PASSAGE OF TIME.
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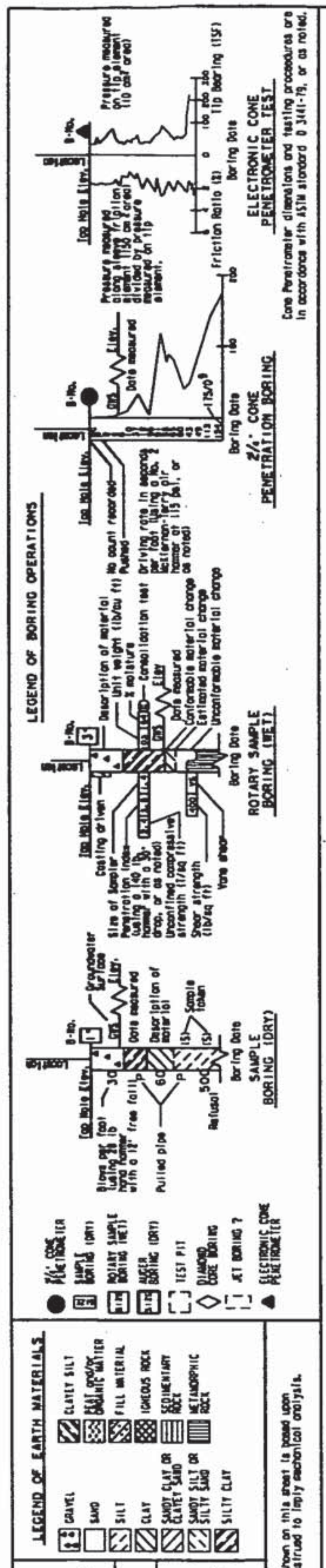
SOIL TEST DESIGNATIONS:

- (UU) UNCONSOLIDATED UNDRAINED TRIAXIAL AT 5% STRAIN
- (AL) ATTERBERG LIMITS
- (GS) SIEVE ANALYSIS



CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test

Penetration Index (Blows / Ft)	Granular	Cohesive
0-4	Very loose	Very soft
5-9	Loose	Soft
10-19	Slightly compact	Stiff
20-34	Compact	Very stiff
35-69	Dense	Hard
>70	Very dense	Very hard

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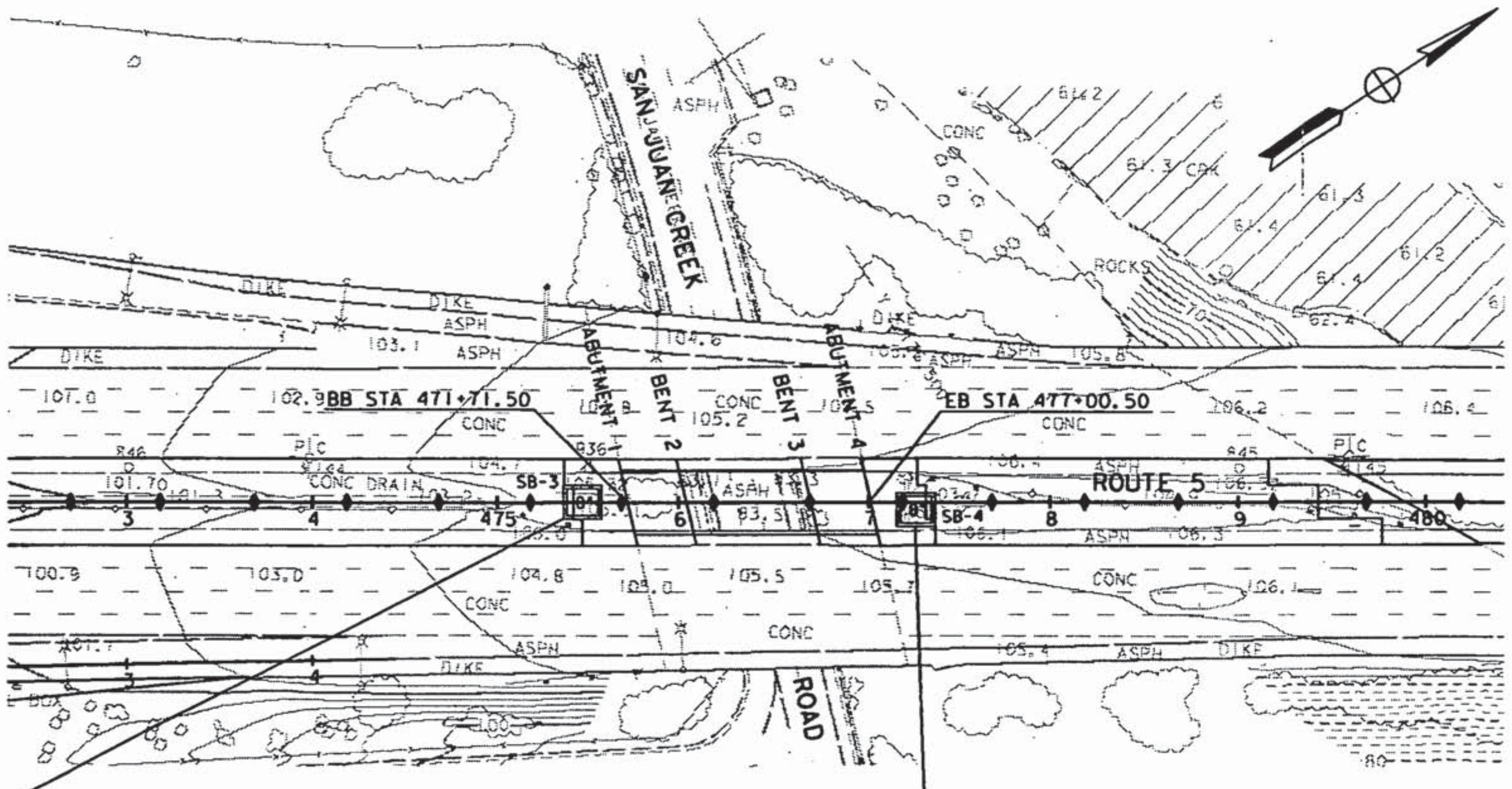
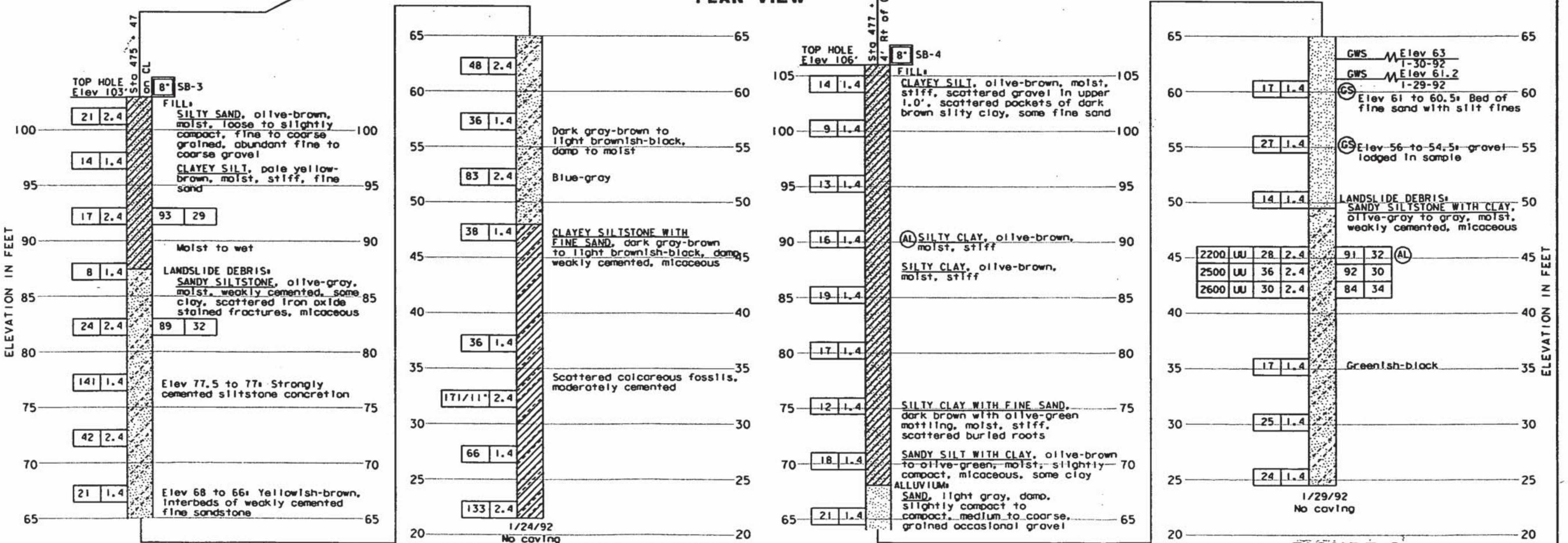


PLAN VIEW

50 0 50 100
SCALE IN FEET



ELEVATION

FIGURE 2

DESIGN OVERSIGHT	DRAWN BY	M.A. REICHERT	NINYO & MOORE
SIGN OFF DATE	CHECKED BY	C.P. POLITO	FIELD INVESTIGATOR DATE 1/29/92

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

PROJECT ENGINEER

REGISTERED CIVIL ENGINEER NO. ______

BRIDGE NO. 55-298

POST MILE 8.8

SAN JUAN CREEK ROAD UC WIDENING

LOG OF TEST BORING

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 12104
EA 107221

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

15A: 15abbr2.dgn

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
12	Ora	5	6.7/18.9		

REGISTERED CIVIL ENGINEER

ELIZABETH M. SMITH
No. C-046851
Exp. 06-30-95
CIVIL

PLANS APPROVAL DATE

CH2M HILL
2510 RED HILL AVENUE
SANTA ANA, CA 92705

50 0 50 100
SCALE IN FEET

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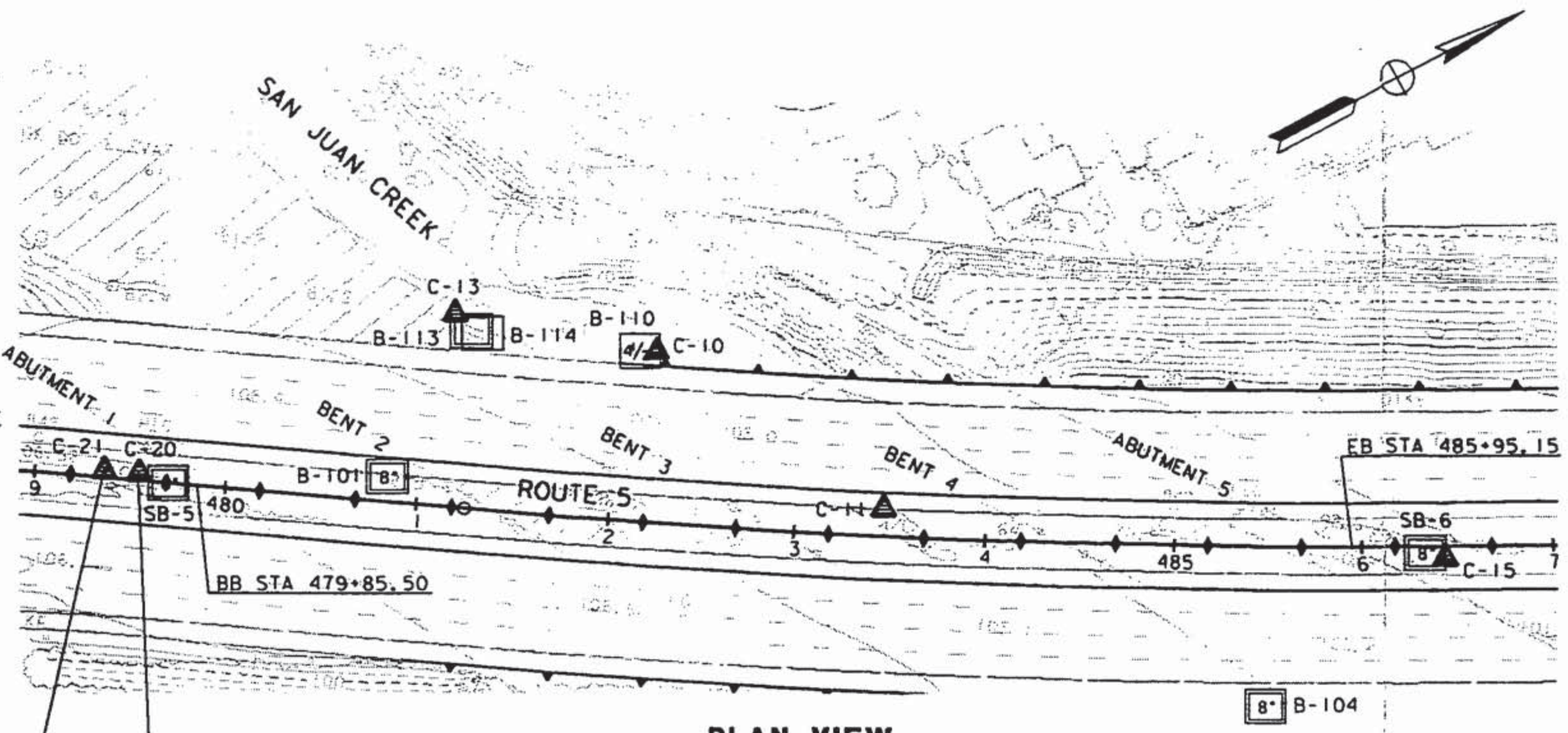
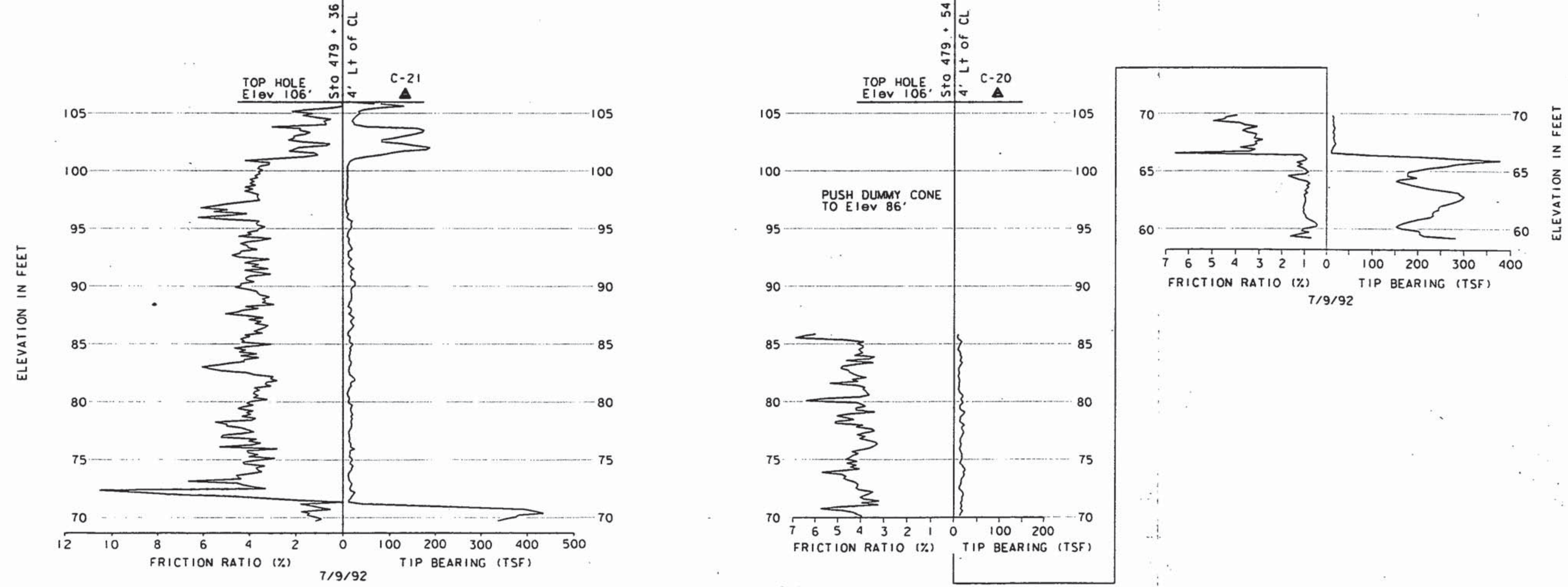
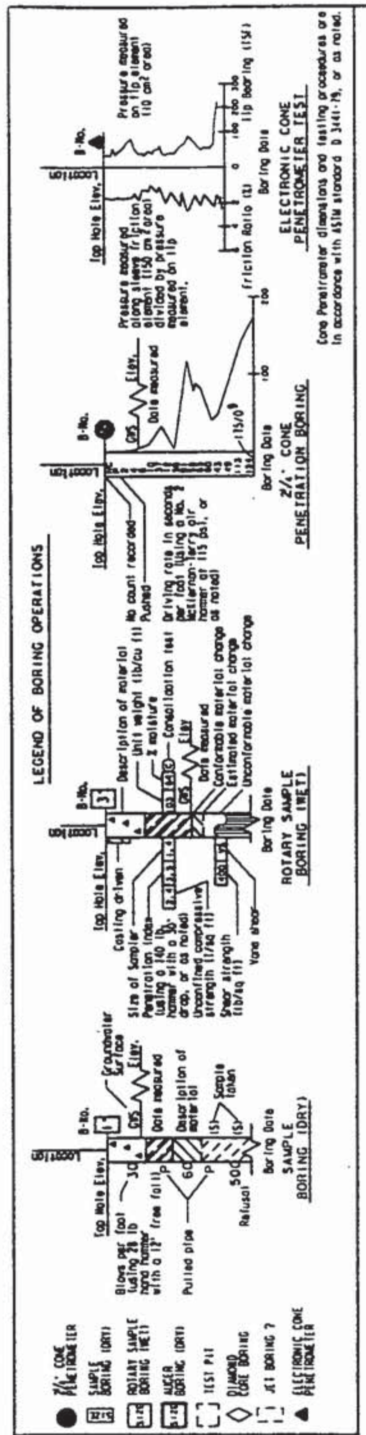
- (WA) #200 SIEVE
- (GS) SIEVE ANALYSIS



PLAN VIEW



ELEVATION



Cone Penetrometer dimensions and testing procedures are in accordance with ASTM standard D 3441-79, or as noted.

LEGEND OF EARTH MATERIALS

- GRAVEL
- SAND
- SILT
- CLAY
- SANDY CLAY OR CLAYEY SAND
- SANDY SILT OR SILTY SAND
- SILTY CLAY
- CLAYEY SILT
- PEAT and/or ORGANIC MATTER
- FILL MATERIAL
- IGNEOUS ROCK
- SEDIMENTARY ROCK
- METAMORPHIC ROCK

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test

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>70	Very dense	Very hard

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FIGURE 2

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY M.A. REICHERT

CHECKED BY C.P. POLITO

E.M. SMITH
FIELD INVESTIGATOR
DATE 7/9/92

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

PROJECT ENGINEER

REGISTERED CIVIL ENGINEER NO.

BRIDGE NO. 55-228

POST MILE 8.9

SAN JUAN CREEK BRIDGE WIDENING (1 OF 7)

LOG OF TEST BORING

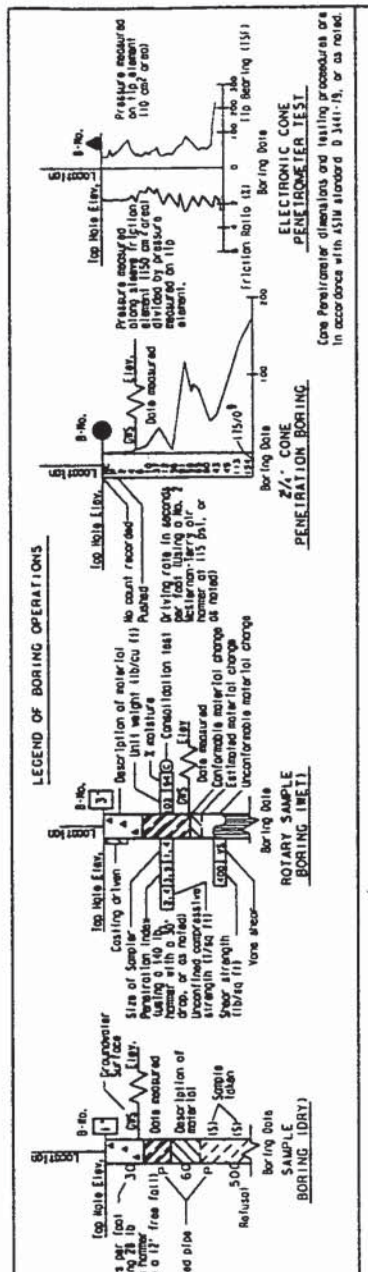
ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 12104
EA 107221

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY) SHEET OF

15abbr10.dgn



● 2½" CONE PENETROMETER
▭ SAMPLE BORING (DRY)
▭ ROTARY SAMPLE BORING (WET)
▭ AUGER BORING (DRY)
⌐¬ TEST PIT
◇ DIAMOND CORE BORING
⌐¬ JET BORING ?
▲ ELECTRONIC CONE PENETROMETER

LEGEND OF EARTH MATERIALS

- ▨ GRAVEL
- ▭ SAND
- ▨ SILT
- ▨ CLAY
- ▨ SANDY CLAY OR CLAYEY SAND
- ▨ SANDY SILT OR SILTY SAND
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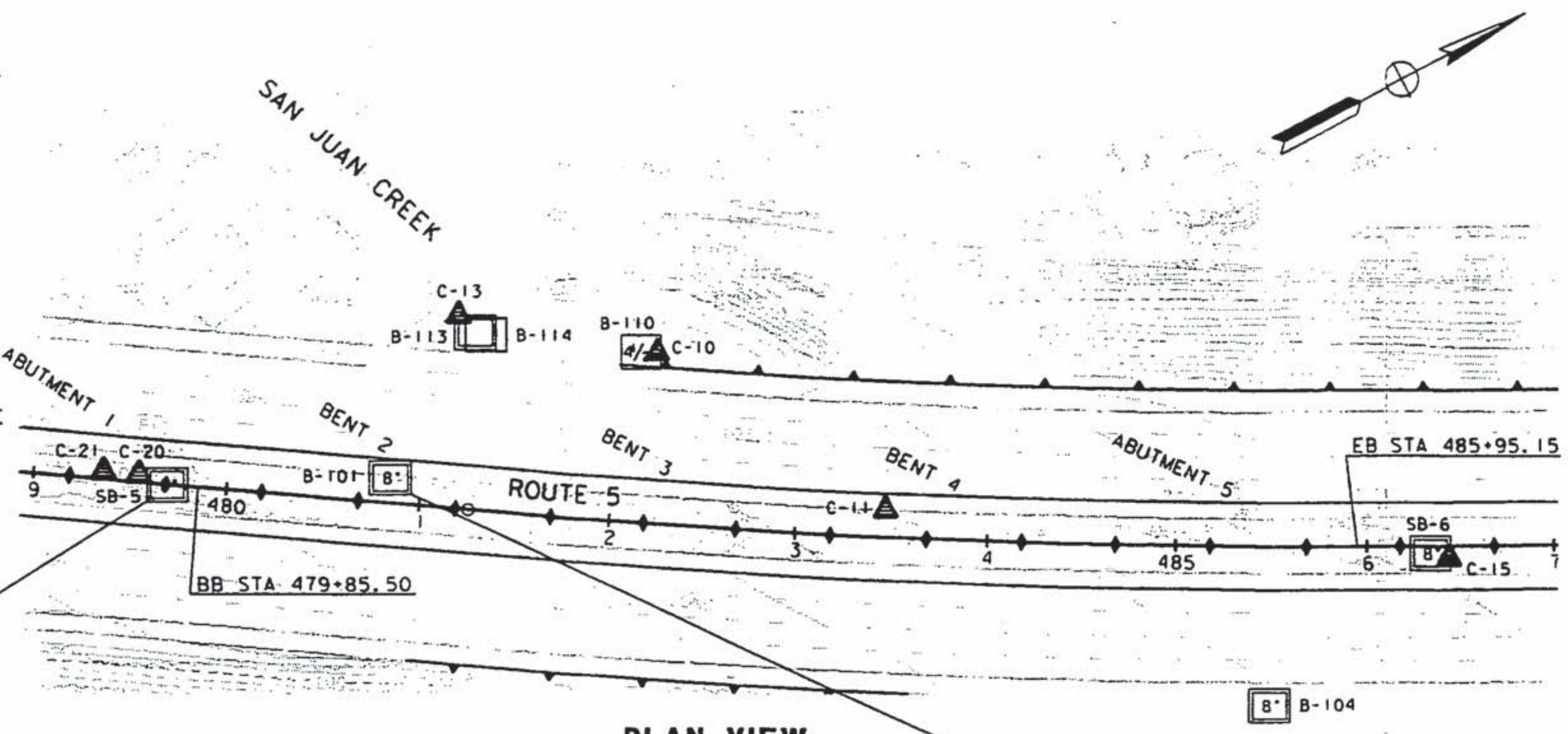


PLAN VIEW

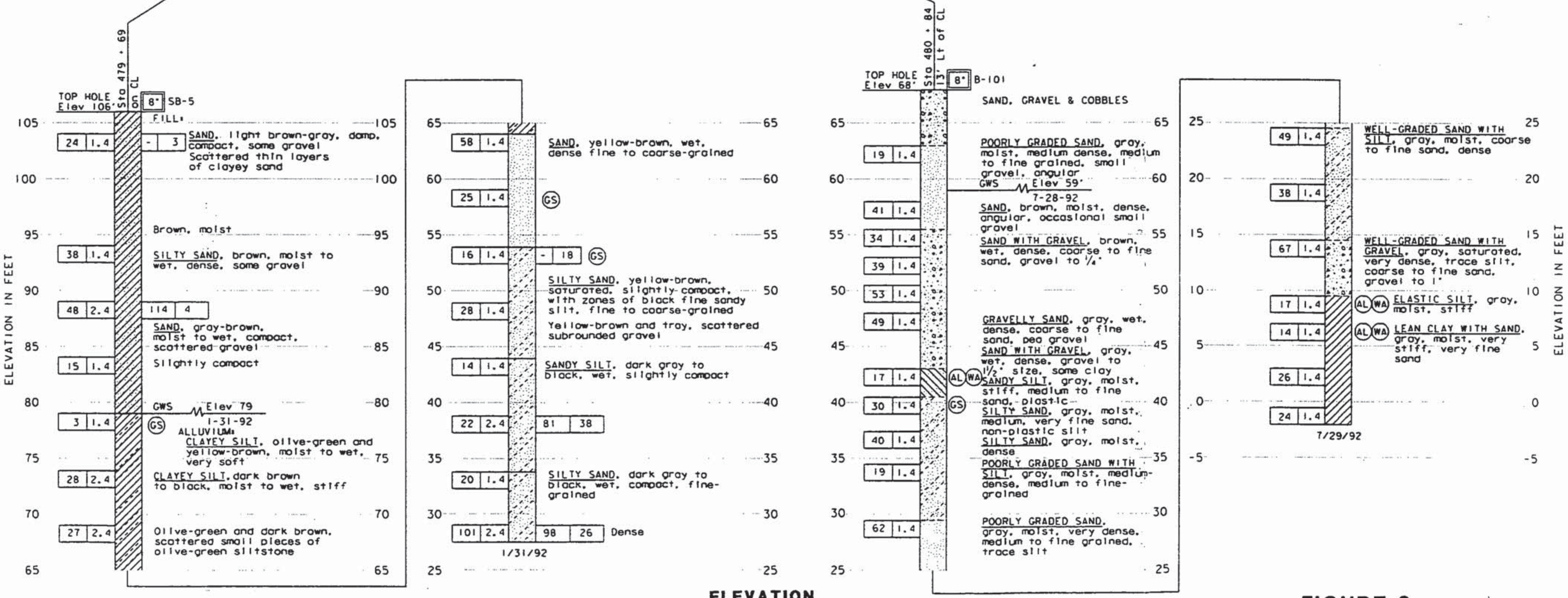
DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
12	Ora	5	6.7/18.9		

REGISTERED CIVIL ENGINEER

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER
ELIZABETH M. SMITH
No. C-046851
Exp. 06-30-95
CIVIL
STATE OF CALIFORNIA

CH2M HILL
2510 RED HILL AVENUE
SANTA ANA, CA 92705



SB-5:

FILL:

SAND, light brown-gray, damp, compact, some gravel
Scattered thin layers of clayey sand

Brown, moist

SILTY SAND, brown, moist to wet, dense, some gravel

SAND, gray-brown, moist to wet, compact, scattered gravel

Slightly compact

GWS Elev 79 1-31-92

(GS)

ALLUVIUM:

CLAYEY SILT, olive-green and yellow-brown, moist to wet, very soft

CLAYEY SILT, dark brown to black, moist to wet, stiff

Olive-green and dark brown, scattered small pieces of olive-green siltstone

SAND, yellow-brown, wet, dense fine to coarse-grained

(GS)

(GS)

SILTY SAND, yellow-brown, saturated, slightly-compact, with zones of black fine sandy silt, fine to coarse-grained

Yellow-brown and tray, scattered subrounded gravel

SANDY SILT, dark gray to black, wet, slightly compact

SILTY SAND, dark gray to black, wet, compact, fine-grained

Dense

B-101:

SAND, GRAVEL & COBBLES

POORLY GRADED SAND, gray, moist, medium dense, medium to fine grained, small gravel, angular

GWS Elev 59' 7-28-92

SAND, brown, moist, dense, angular, occasional small gravel

SAND WITH GRAVEL, brown, wet, dense, coarse to fine sand, gravel to ¼"

GRAVELLY SAND, gray, wet, dense, coarse to fine sand, pea gravel

SAND WITH GRAVEL, gray, wet, dense, gravel to 1½" size, some clay

(AL) (WA) SANDY SILT, gray, moist, stiff, medium to fine sand, plastic

(GS) SILTY SAND, gray, moist, medium, very fine sand, non-plastic silt

SILTY SAND, gray, moist, dense

POORLY GRADED SAND WITH SILT, gray, moist, medium-dense, medium to fine-grained

POORLY GRADED SAND, gray, moist, very dense, medium to fine grained, trace silt

WELL-GRADED SAND WITH SILT, gray, moist, coarse to fine sand, dense

WELL-GRADED SAND WITH GRAVEL, gray, saturated, very dense, trace silt, coarse to fine sand, gravel to 1"

(AL) (WA) ELASTIC SILT, gray, moist, stiff

(AL) (WA) LEAN CLAY WITH SAND, gray, moist, very stiff, very fine sand

ELEVATION

FIGURE 2

DESIGN OVERSIGHT	DRAWN BY	M.A. REICHERT	E.M. SMITH FIELD INVESTIGATOR
SIGN OFF DATE	CHECKED BY	C.P. POLITO	DATE 1/31/92

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 2 1 2 3

PROJECT ENGINEER

REGISTERED CIVIL ENGINEER NO.

CU 12104
EA 107221

BRIDGE NO. 55-228

POST MILE 8.9

SAN JUAN CREEK BRIDGE WIDENING (2 OF 7)

LOG OF TEST BORING

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES (PRELIMINARY STAGE ONLY) | SHEET | OF

i5abbr3.dgn

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
12	Ora	5	6.7/18.9		

REGISTERED CIVIL ENGINEER

ELIZABETH M. SMITH
No. C-046851
Exp. 06-30-95
CIVIL

PLANS APPROVAL DATE

CH2M HILL
2510 RED HILL AVENUE
SANTA ANA, CA 92705

50 0 50 100
SCALE IN FEET

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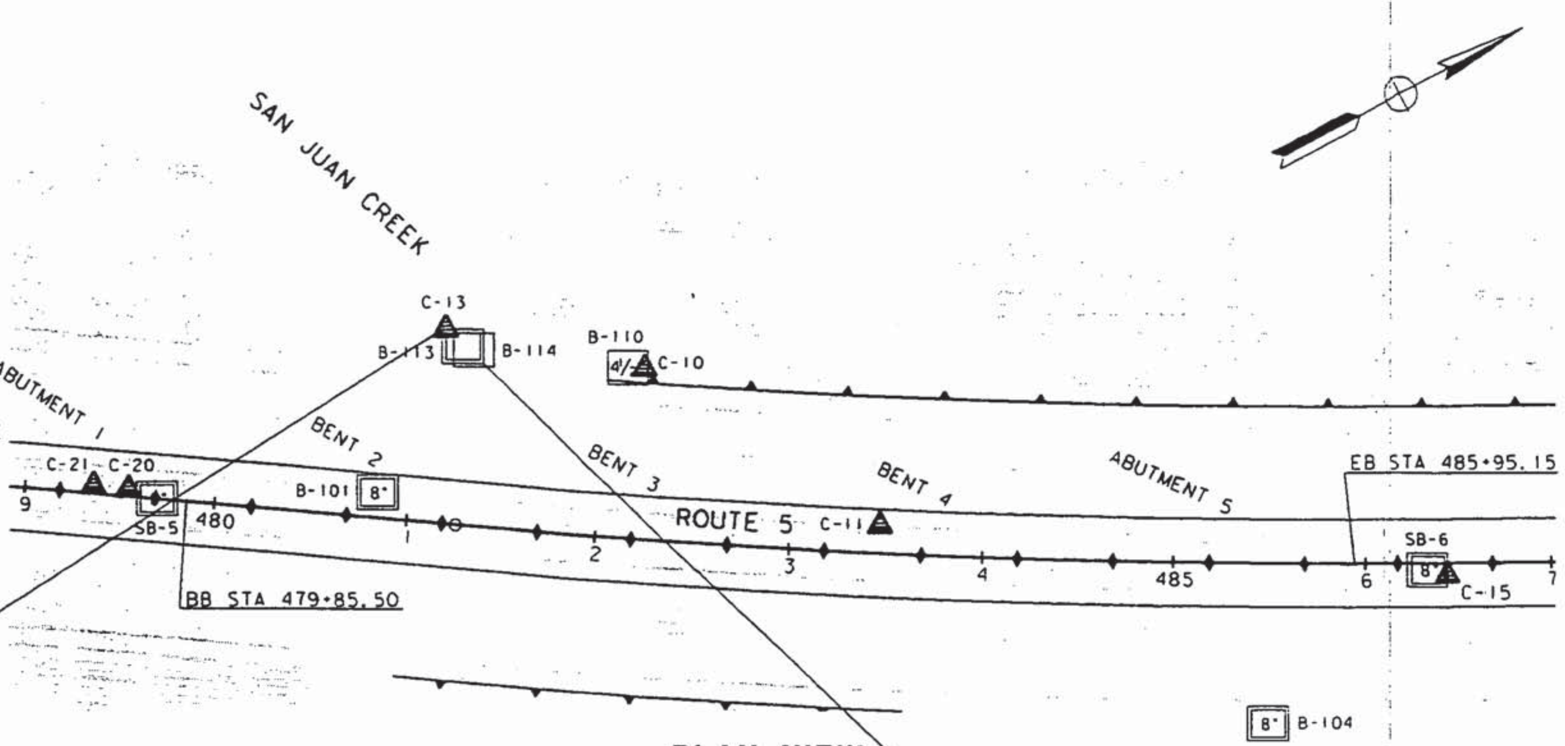
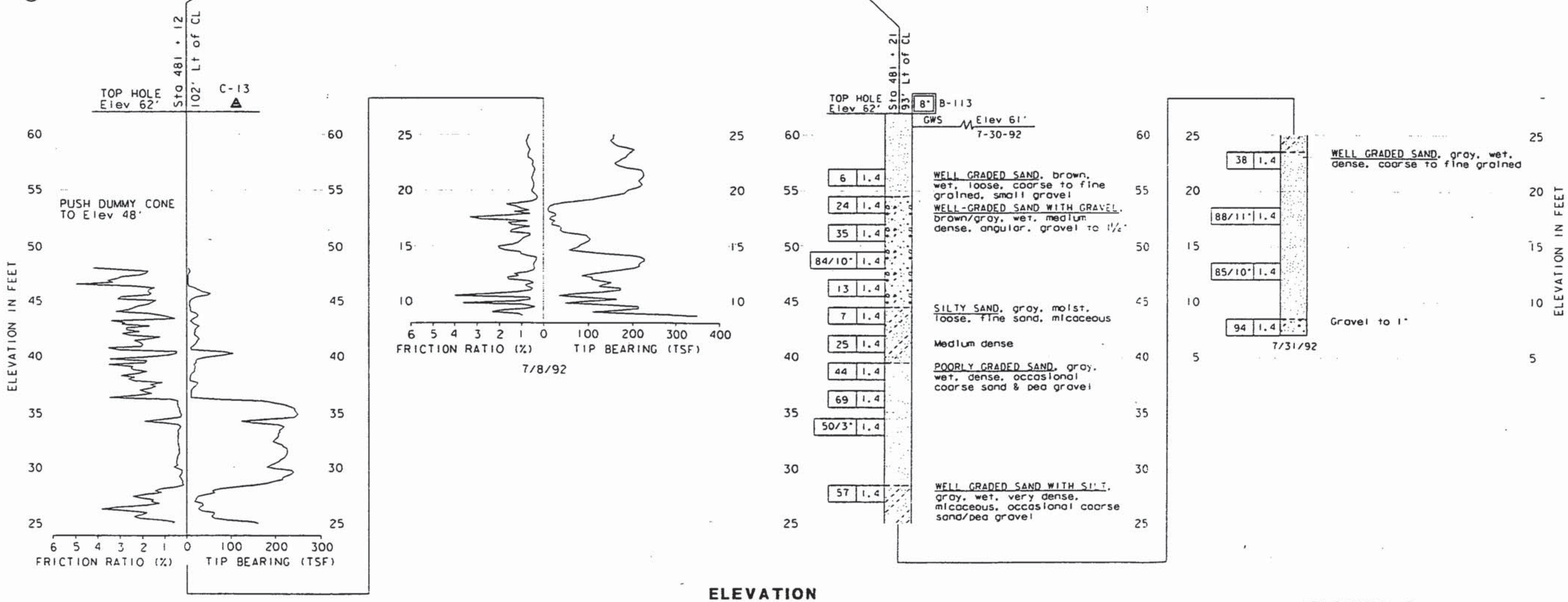
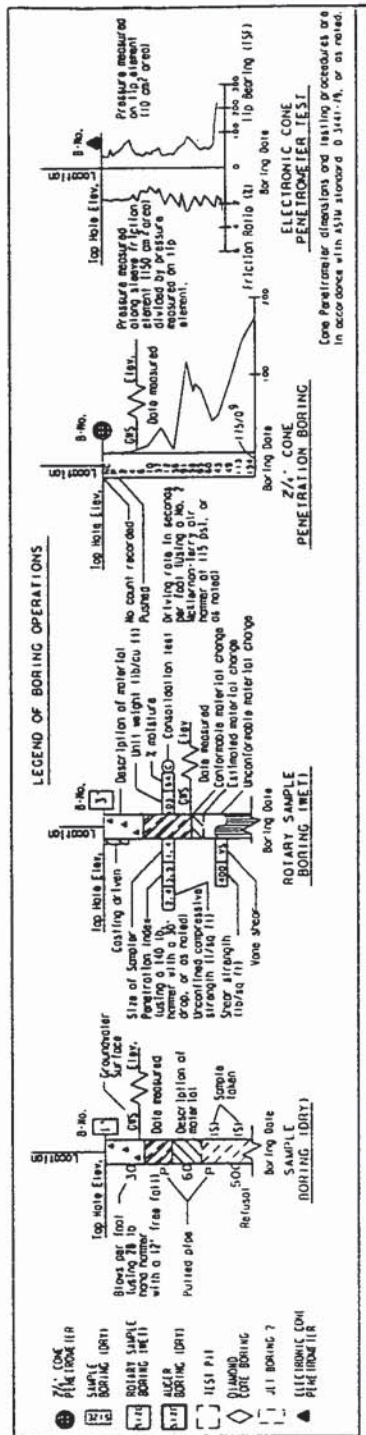


PLAN VIEW



ELEVATION

FIGURE 2



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LEGEND OF EARTH MATERIALS

▦	GRAVEL	▨	CLAYEY SILT
□	SAND	▩	PEAT and/or ORGANIC MATTER
▧	SILT	▨	FILL MATERIAL
▨	CLAY	▦	IGNEOUS ROCK
▧	SANDY CLAY OR CLAYEY SAND	▤	SEDIMENTARY ROCK
▧	SANDY SILT OR SILTY SAND	▥	METAMORPHIC ROCK
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SIGN OFF DATE

DRAWN BY M.A. REICHERT

CHECKED BY C.P. POLITO

E.M. SMITH
FIELD INVESTIGATOR
DATE 7/31/92

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

PROJECT ENGINEER

REGISTERED CIVIL ENGINEER NO. ______

BRIDGE NO. 55-228

POST MILE 8.9

SAN JUAN CREEK BRIDGE WIDENING (3 OF 7)

LOG OF TEST BORING

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

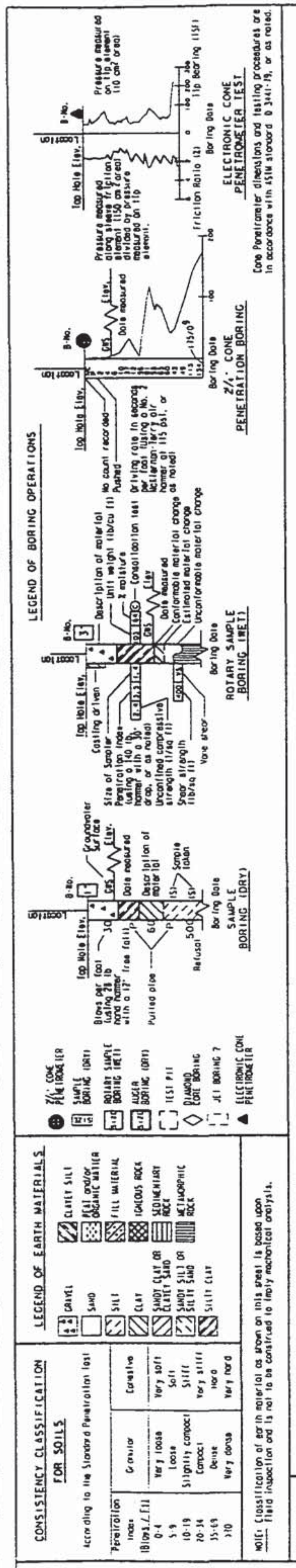
CU 12104
EA 107221

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)

SHEET OF

15c



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DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
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REGISTERED CIVIL ENGINEER

ELIZABETH M. SMITH
No. C-046851
Exp. 06-30-95

PLANS APPROVAL DATE

CH2M HILL
2510 RED HILL AVENUE
SANTA ANA, CA 92705

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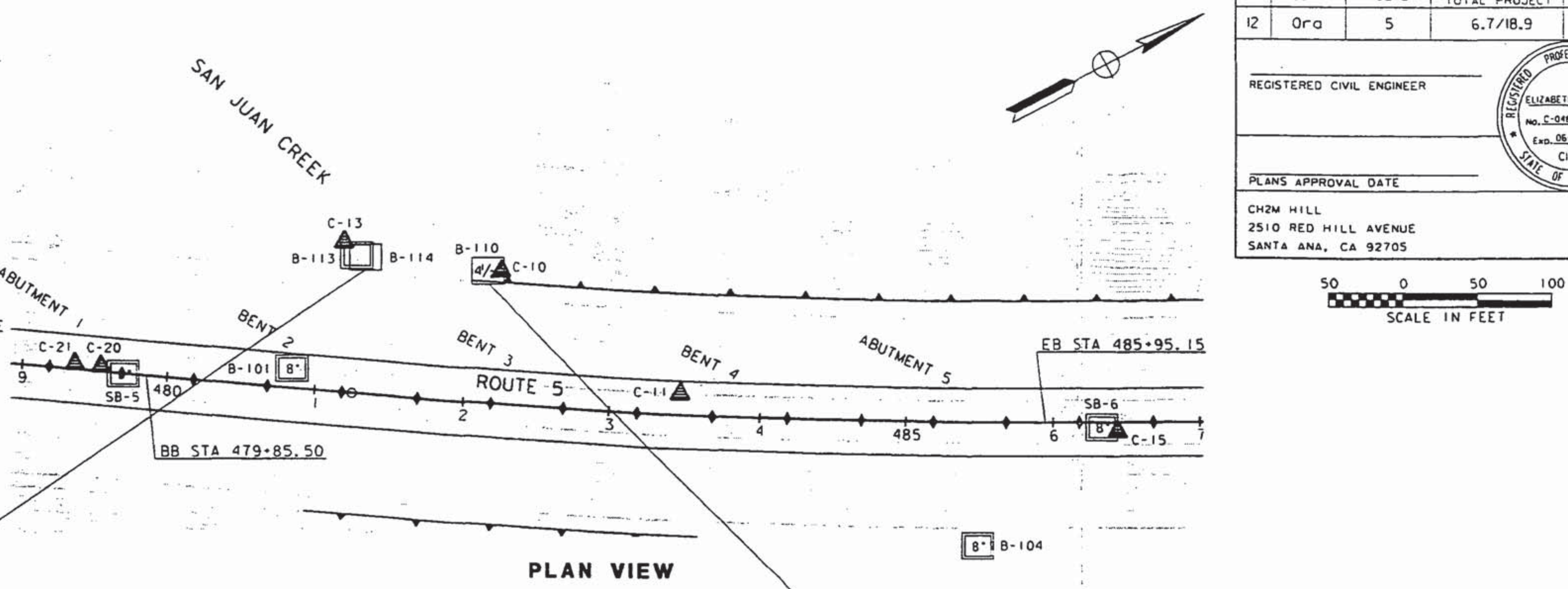
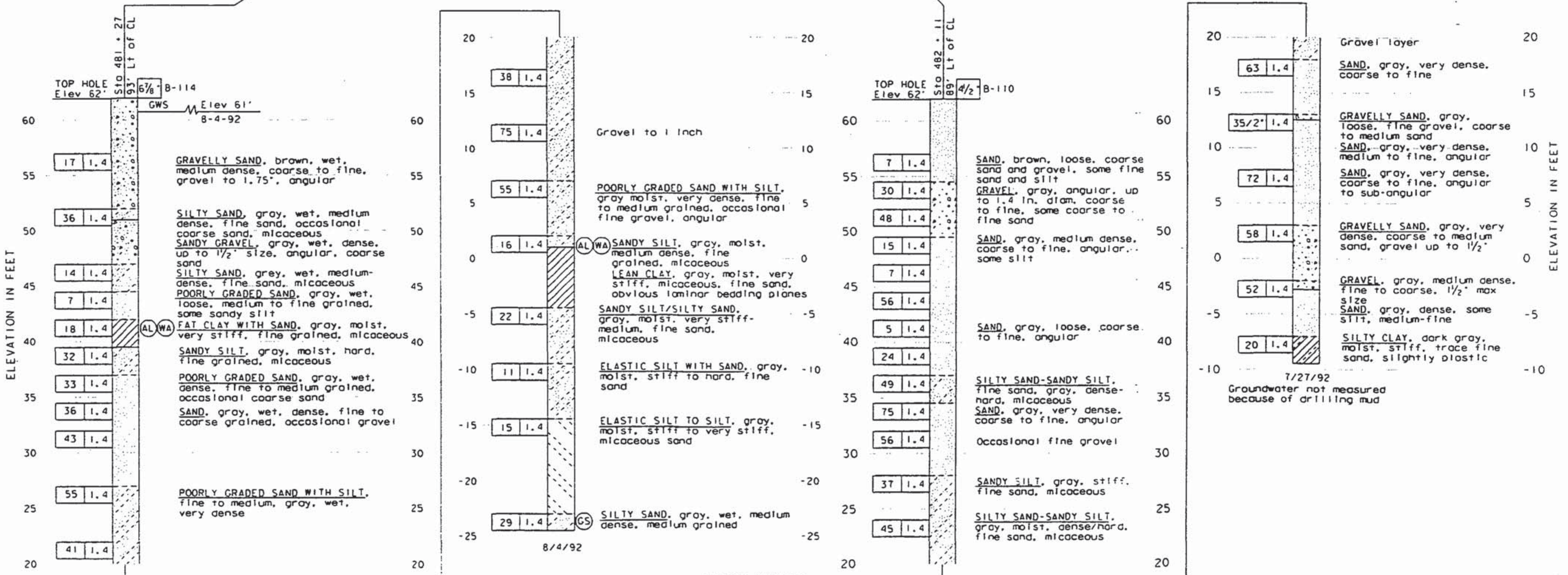


PLAN VIEW



B-114:

GRAVELLY SAND, brown, wet, medium dense, coarse to fine, gravel to 1.75", angular

SILTY SAND, gray, wet, medium dense, fine sand, occasional coarse sand, micaceous

SANDY GRAVEL, gray, wet, dense, up to 1½" size, angular, coarse sand

SILTY SAND, grey, wet, medium-dense, fine sand, micaceous

POORLY GRADED SAND, gray, wet, loose, medium to fine grained, some sandy silt

(AL) (WA) **FAT CLAY WITH SAND**, gray, moist, very stiff, fine grained, micaceous

SANDY SILT, gray, moist, hard, fine grained, micaceous

POORLY GRADED SAND, gray, wet, dense, fine to medium grained, occasional coarse sand

SAND, gray, wet, dense, fine to coarse grained, occasional gravel

POORLY GRADED SAND WITH SILT, fine to medium, gray, wet, very dense

Gravel to 1 inch

POORLY GRADED SAND WITH SILT, gray moist, very dense, fine to medium grained, occasional fine gravel, angular

(AL) (WA) **SANDY SILT**, gray, moist, medium dense, fine grained, micaceous

LEAN CLAY, gray, moist, very stiff, micaceous, fine sand, obvious laminar bedding planes

SANDY SILT/SILTY SAND, gray, moist, very stiff-medium, fine sand, micaceous

ELASTIC SILT WITH SAND, gray, moist, stiff to hard, fine sand

ELASTIC SILT TO SILT, gray, moist, stiff to very stiff, micaceous sand

(GS) **SILTY SAND**, gray, wet, medium dense, medium grained

B-110:

SAND, brown, loose, coarse sand and gravel, some fine sand and silt

GRAVEL, gray, angular, up to 1.4 in. diam, coarse to fine, some coarse to fine sand

SAND, gray, medium dense, coarse to fine, angular, some silt

SAND, gray, loose, coarse to fine, angular

SILTY SAND-SANDY SILT, fine sand, gray, dense-hard, micaceous

SAND, gray, very dense, coarse to fine, angular

Occasional fine gravel

SANDY SILT, gray, stiff, fine sand, micaceous

SILTY SAND-SANDY SILT, gray, moist, dense/hard, fine sand, micaceous

Gravel layer

SAND, gray, very dense, coarse to fine

GRAVELLY SAND, gray, loose, fine gravel, coarse to medium sand

SAND, gray, very dense, medium to fine, angular

SAND, gray, very dense, coarse to fine, angular to sub-angular

GRAVELLY SAND, gray, very dense, coarse to medium sand, gravel up to 1½"

GRAVEL, gray, medium dense, fine to coarse, 1½" max size

SAND, gray, dense, some silt, medium-fine

SILTY CLAY, dark gray, moist, stiff, trace fine sand, slightly plastic

7/27/92
Groundwater not measured because of drilling mud

ELEVATION

FIGURE 2

DESIGN OVERSIGHT
SIGN OFF DATE

DRAWN BY M.A. REICHERT
CHECKED BY C.P. POLITO

E.M. SMITH
FIELD INVESTIGATOR
DATE 7/30/92

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

PROJECT ENGINEER
REGISTERED CIVIL ENGINEER NO.

BRIDGE NO. 55-228
POST MILE 8.9

SAN JUAN CREEK BRIDGE WIDENING (4 OF 7)

LOG OF TEST BORING

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 12104
EA 107221

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)

SHEET OF

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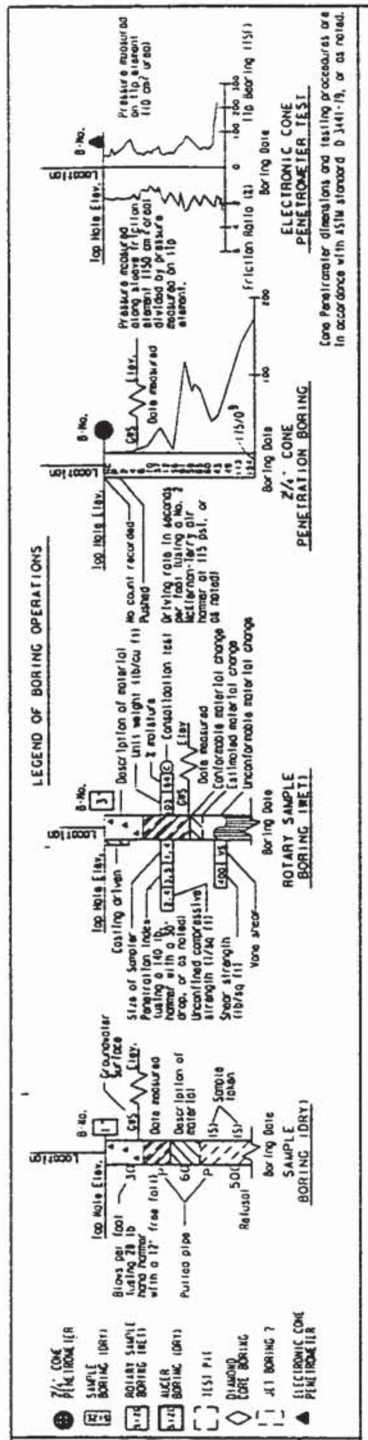

LEGEND OF EARTH MATERIALS

GRAVEL, SAND, SILT, CLAY, SANDY CLAY OR CLAYEY SAND, SANDY SILT OR SILTY SAND, SILTY CLAY, CLAYEY SILT, PEAT AND/OR ORGANIC MATTER, FILL MATERIAL, IGNEOUS ROCK, SEDIMENTARY ROCK, METAMORPHIC ROCK

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test

Penetration Index (Blows/Ft.)	Granular	Cohesive
0-4	Very loose	Very soft
5-9	Loose	Soft
10-19	Slightly compact	Stiff
20-34	Compact	Very stiff
35-69	Dense	Hard
70	Very dense	Very hard

NOTE: Classification of earth material as shown on this sheet is based upon field inspection and is not to be construed to imply mechanical analysis.

NOTES:

1. THE BORING LOGS AND RELATED INFORMATION REPRESENT THE OPINION OF THE GEOTECHNICAL ENGINEER AS TO THE CHARACTER OF THE MATERIALS AT THE LOCATIONS SHOWN. SOIL AND GROUNDWATER CONDITIONS BETWEEN ADJACENT TEST HOLES AND AT OTHER LOCATIONS MAY DIFFER FROM THOSE SHOWN. GROUNDWATER CONDITIONS MAY CHANGE WITH PASSAGE OF TIME.
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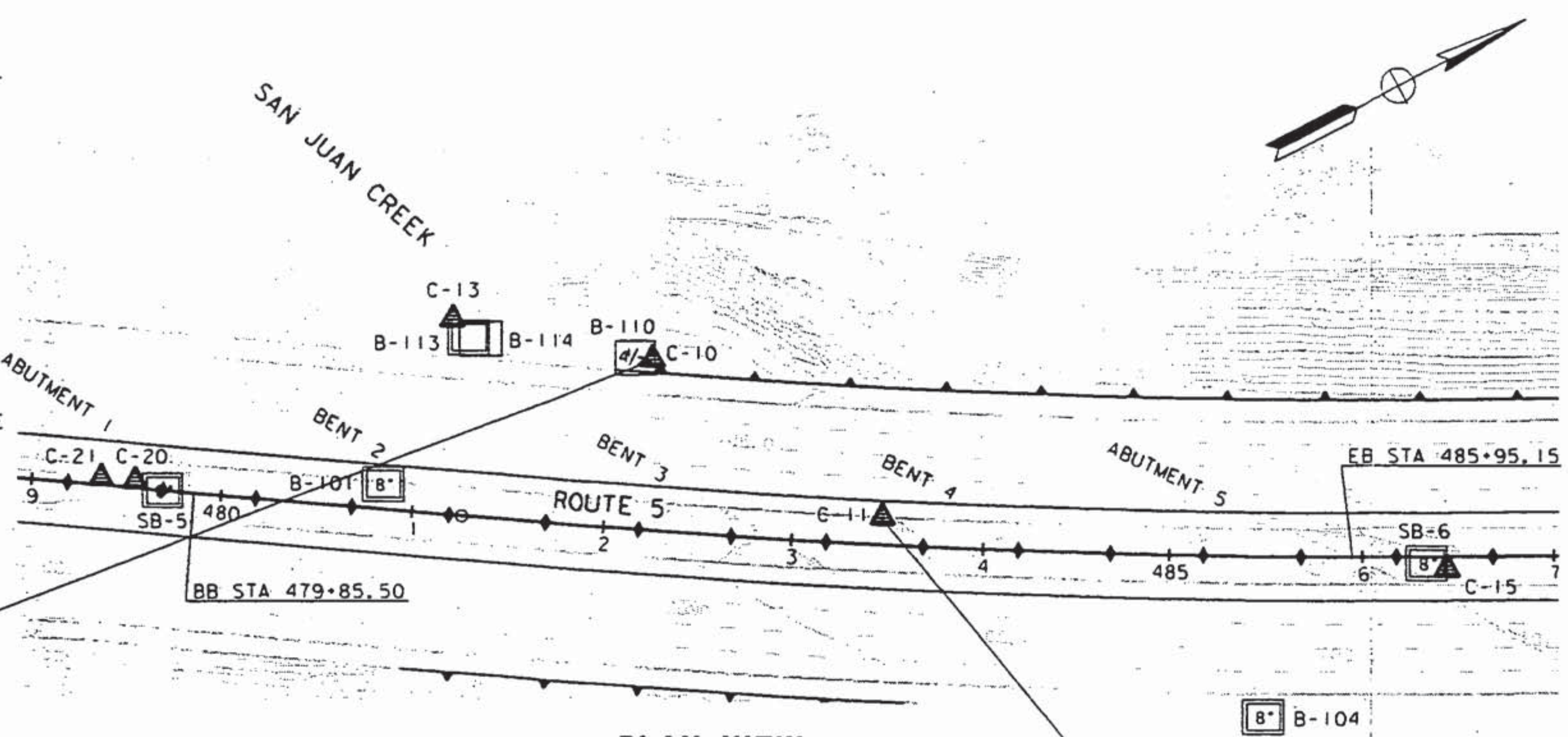
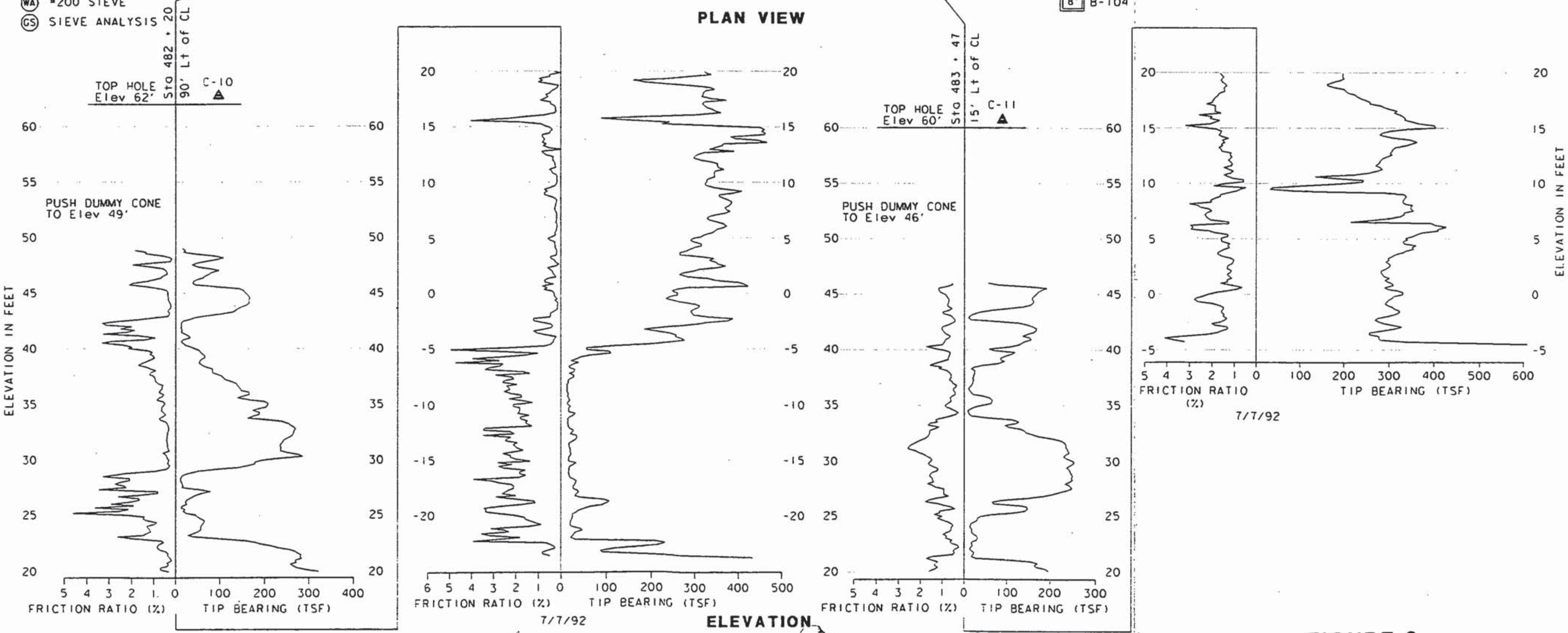
SOIL TEST DESIGNATIONS:

(AL) ATTERBERG LIMITS
(WA) #200 SIEVE
(GS) SIEVE ANALYSIS



PLAN VIEW



ELEVATION

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
12	Ora	5	6.7/18.9		

REGISTERED CIVIL ENGINEER

ELIZABETH M. SMITH
No. C-046851
Exp. 06-30-95
CIVIL

PLANS APPROVAL DATE

CH2M HILL
2510 RED HILL AVENUE
SANTA ANA, CA 92705

50 0 50 100
SCALE IN FEET

FIGURE 2

DESIGN OVERSIGHT
SIGN OFF DATE

DRAWN BY M.A. REICHERT
CHECKED BY C.P. POLITO

E.M. SMITH
FIELD INVESTIGATOR
DATE 7/7/92

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

PROJECT ENGINEER
REGISTERED CIVIL ENGINEER NO.

BRIDGE NO. 55-228
POST MILE 8.9

SAN JUAN CREEK BRIDGE WIDENING (5 OF 7)

LOG OF TEST BORING

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 12104
EA 107221

DISREGARD PRINTS BEARING EARLIER REVISION DATES ——

REVISION DATES (PRELIMINARY STAGE ONLY)
SHEET OF

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
12	Ora	5	6.7/18.9		

REGISTERED CIVIL ENGINEER

ELIZABETH M. SMITH
No. C-046851
Exp. 06-30-95
CIVIL

PLANS APPROVAL DATE

CH2M HILL
2510 RED HILL AVENUE
SANTA ANA, CA 92705

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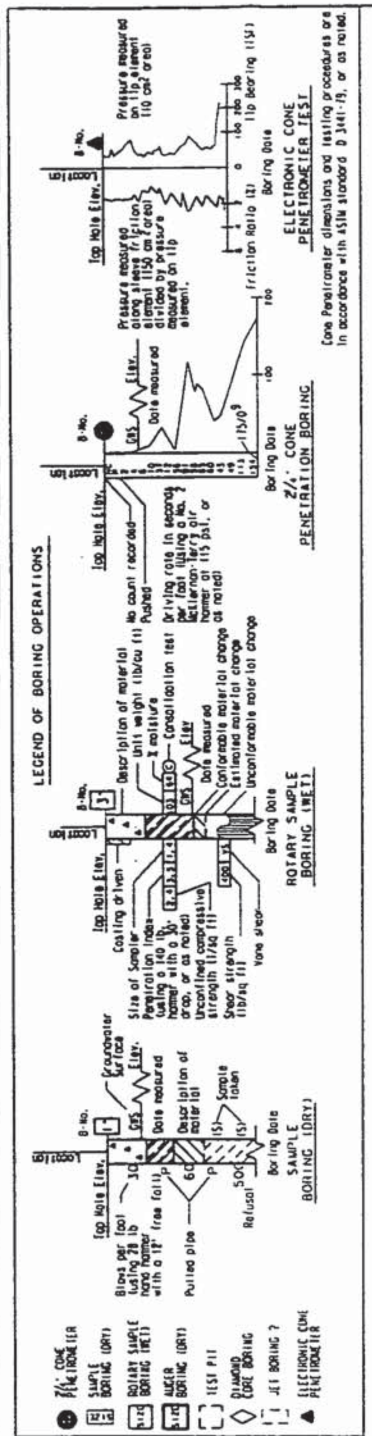
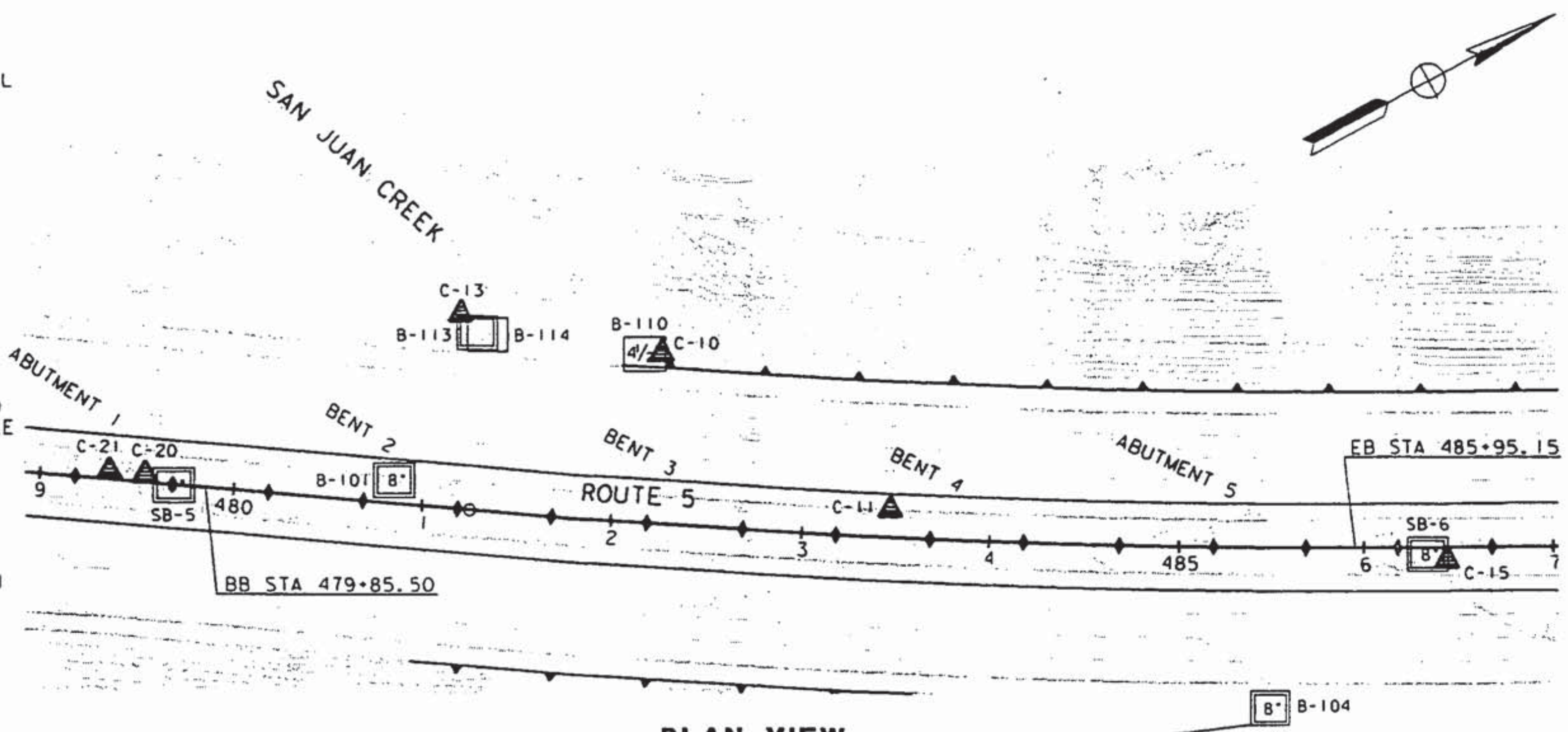
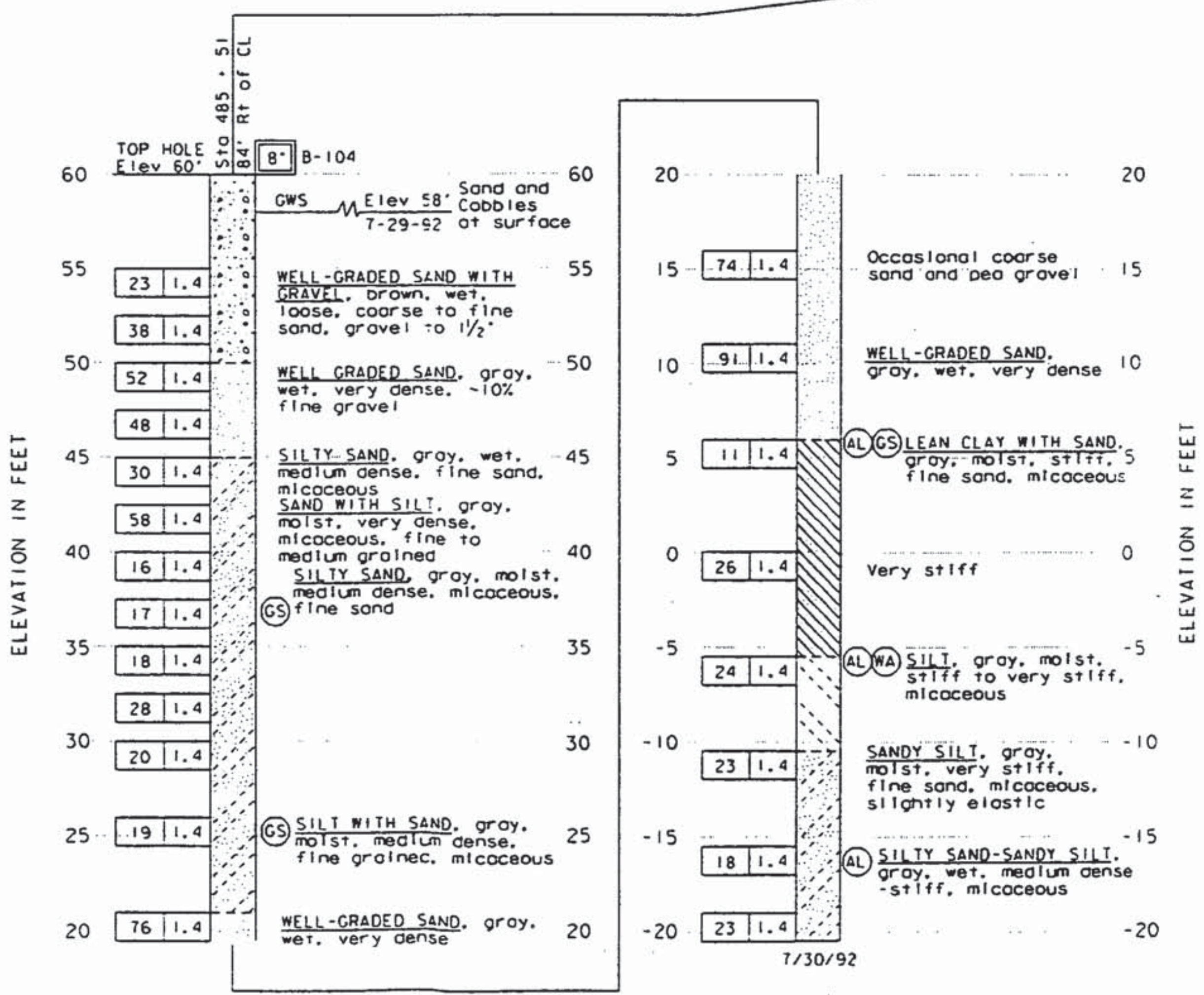
SOIL TEST DESIGNATIONS:

- (AL) ATTERBERG LIMITS
- (WA) #200 SIEVE
- (GS) SIEVE ANALYSIS





PLAN VIEW



Sand and Cobbles at surface

WELL-GRADED SAND WITH GRAVEL, brown, wet, loose, coarse to fine sand, gravel to 1½"

WELL GRADED SAND, gray, wet, very dense, ~10% fine gravel

SILTY SAND, gray, wet, medium dense, fine sand, micaceous

SAND WITH SILT, gray, moist, very dense, micaceous, fine to medium grained

(GS) SILTY SAND, gray, moist, medium dense, micaceous, fine sand

(GS) SILT WITH SAND, gray, moist, medium dense, fine grainec, micaceous

WELL-GRADED SAND, gray, wet, very dense

Occasional coarse sand and pea gravel

WELL-GRADED SAND, gray, wet, very dense

(AL)(GS) LEAN CLAY WITH SAND, gray, moist, stiff, fine sand, micaceous

Very stiff

(AL)(WA) SILT, gray, moist, stiff to very stiff, micaceous

SANDY SILT, gray, moist, very stiff, fine sand, micaceous, slightly elastic

(AL) SILTY SAND-SANDY SILT, gray, wet, medium dense -stiff, micaceous

ELEVATION

LEGEND OF EARTH MATERIALS

- ⁘ GRAVEL
- ☐ SAND
- ▨ SILT
- ▨ CLAY
- ▨ SANDY CLAY OR CLAYEY SAND
- ▨ SANDY SILT OR SILTY SAND
- ▨ SILTY CLAY
- ▨ CLAYEY SILT
- ▨ PEAT and/or ORGANIC MATTER
- ▨ FILL MATERIAL
- ▦ IGNEOUS ROCK
- ▥ SEDIMENTARY ROCK
- ▥ METAMORPHIC ROCK

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According to the Standard Penetration Test

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20-34	Compact	Very stiff
35-69	Dense	Hard
>70	Very dense	Very hard

NOTE: Classification of earth material as shown on this sheet is based upon field inspection and is not to be construed to imply mechanical analysis.

FIGURE 2

DESIGN OVERSIGHT

SIGN OFF DATE

DRAWN BY	M.A. REICHERT	E.M. SMITH FIELD INVESTIGATOR
CHECKED BY	C.P. POLITO	DATE 7/30/92

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

PROJECT ENGINEER

REGISTERED CIVIL ENGINEER NO.

BRIDGE NO. 55-228

POST MILE 8.9

SAN JUAN CREEK BRIDGE WIDENING (6 OF 7)

LOG OF TEST BORING

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 12104
EA 107221

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)

SHEET OF

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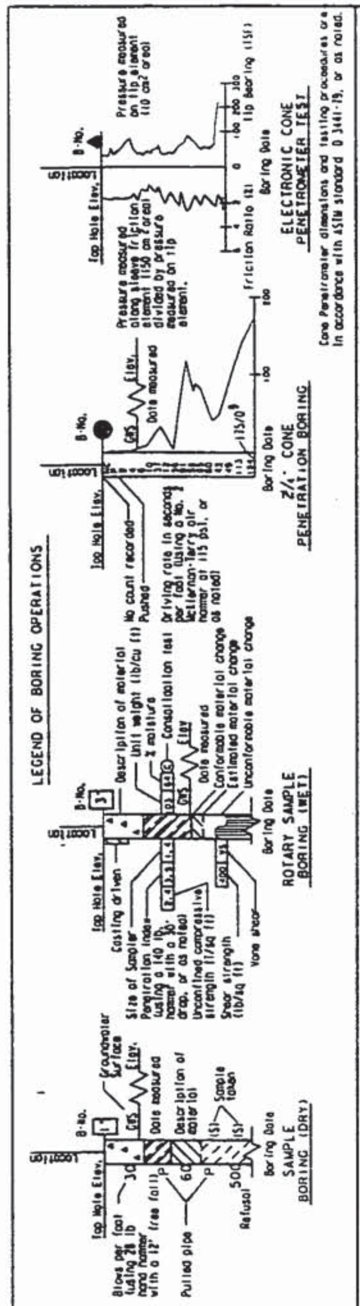

● 2½" CONE PENETROMETER
▭ SAMPLE BORING (DRY)
▭ ROTARY SAMPLE BORING (WET)
▭ AUGER BORING (DRY)
⬚ TEST PIT
◇ DIAMOND CORE BORING
⬚ JET BORING ?
▲ ELECTRONIC CONE PENETROMETER

LEGEND OF EARTH MATERIALS

⁂	GRAVEL	▨	CLAYEY SILT
☐	SAND	▩	PEAT and/or ORGANIC MATTER
▨	SILT	▨	FILL MATERIAL
▨	CLAY	▩	IGNEOUS ROCK
▨	SANDY CLAY OR CLAYEY SAND	▤	SEDIMENTARY ROCK
▨	SANDY SILT OR SILTY SAND	▥	METAMORPHIC ROCK
▨	SILTY CLAY		

CONSISTENCY CLASSIFICATION FOR SOILS

According to the Standard Penetration Test

Penetration Index (Blows / Ft)	Granular	Cohesive
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NOTE: Classification of earth material as shown on this sheet is based upon field inspection and is not to be construed to imply mechanical analysis.

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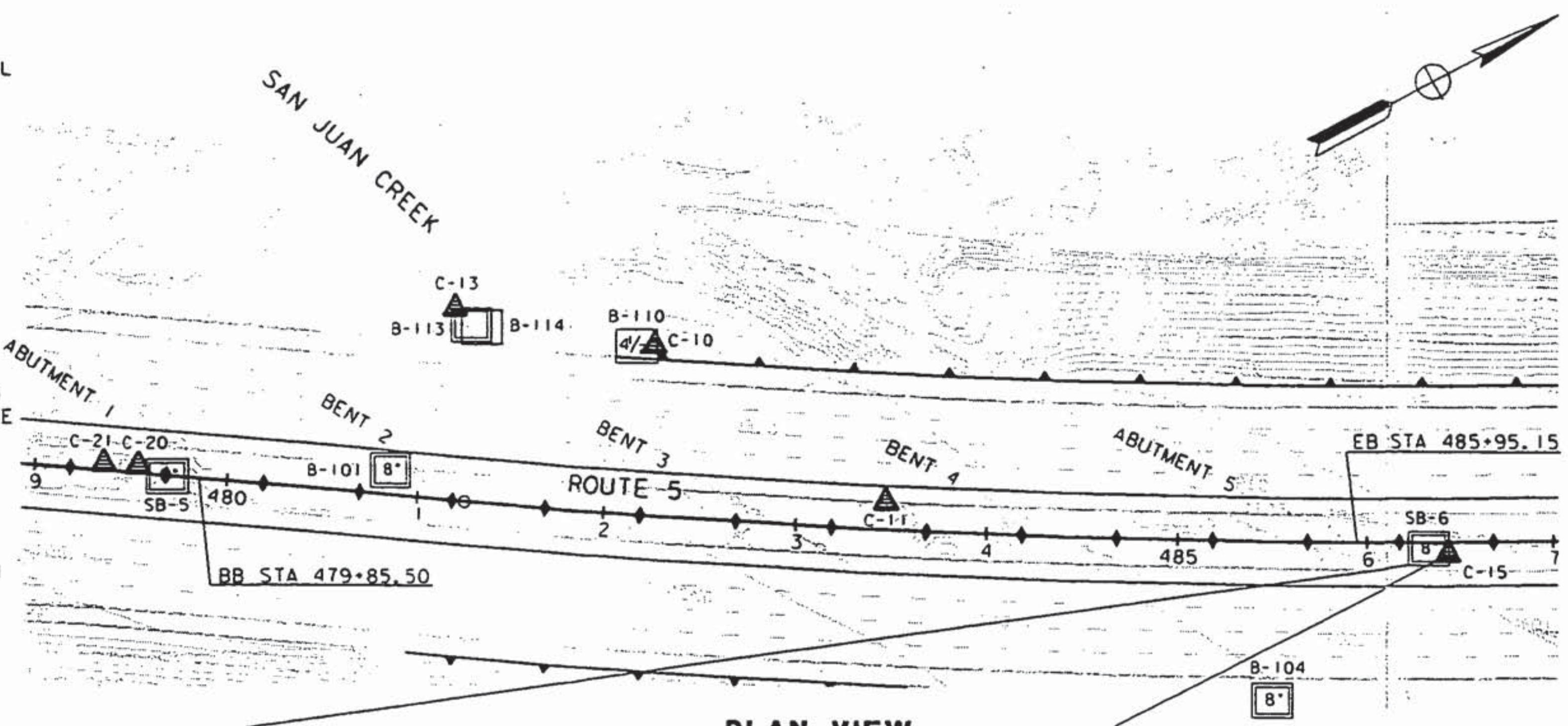
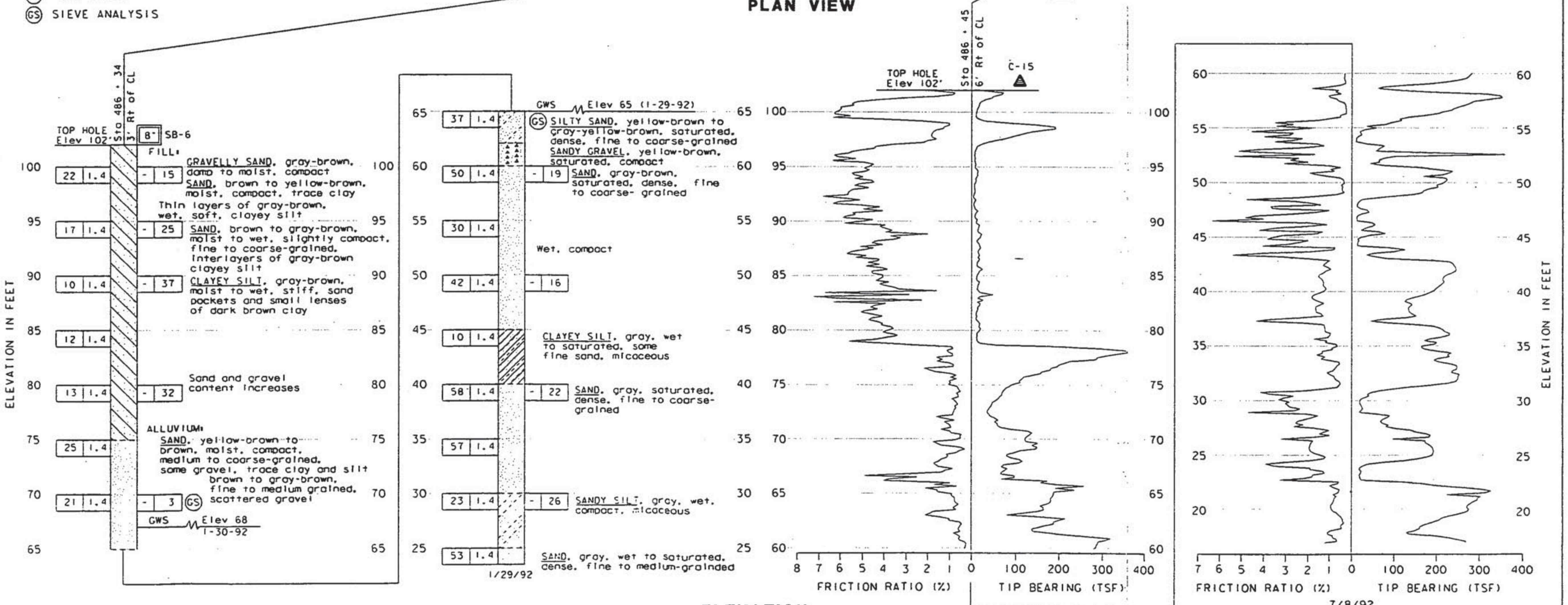
SOIL TEST DESIGNATIONS:

Ⓐ ATTERBERG LIMITS
Ⓦ #200 SIEVE
Ⓖ SIEVE ANALYSIS



PLAN VIEW



ELEVATION

FIGURE 2

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
12	Ora	5	6.7/18.9		

REGISTERED CIVIL ENGINEER

ELIZABETH M. SMITH
No. C-046851
Exp. 06-30-95

PLANS APPROVAL DATE

CH2M HILL
2510 RED HILL AVENUE
SANTA ANA, CA 92705

50 0 50 100
SCALE IN FEET

DESIGN OVERSIGHT
SIGN OFF DATE

DRAWN BY M.A. REICHERT
CHECKED BY C.P. POLITO

E.M. SMITH
FIELD INVESTIGATOR
DATE 7/8/92

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

PROJECT ENGINEER
REGISTERED CIVIL ENGINEER NO.

BRIDGE NO. 55-228
POST MILE 8.9

SAN JUAN CREEK BRIDGE WIDENING (7 OF 7)

LOG OF TEST BORING

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

CU 12104
EA 107221

DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)

SHEET OF

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Appendix D.D

Geotechnical Laboratory Test Results by Others

SAMPLE LOCATION	SAMPLE DEPTH (FT)	DESCRIPTION	PERCENT PASSING NO. 4	PERCENT PASSING NO. 200	USCS (TOTAL SAMPLE)
B-1	10.0-11.5	Poorly Graded SAND with Silt and Gravel	82	6	SP-SM

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 1140-00

Ninyo & Moore

NO. 200 SIEVE ANALYSIS

PROJECT NO.	DATE
207634001	9/09

EASTERN WELLS AND PIPELINE PROJECT
SAN JUAN CAPISTRANO, CALIFORNIA

FIGURE

B-3

SAMPLE LOCATION	SAMPLE DEPTH (FT)	pH [1]	RESISTIVITY [1] (Ohm-cm)	SULFATE CONTENT [2]		CHLORIDE CONTENT [3] (ppm)
				(ppm)	(%)	
B-1	5.0-6.5	7.3	3,000	150	0.015	105

[1] PERFORMED IN GENERAL ACCORDANCE WITH CALIFORNIA TEST METHOD 643

[2] PERFORMED IN GENERAL ACCORDANCE WITH CALIFORNIA TEST METHOD 417

[3] PERFORMED IN GENERAL ACCORDANCE WITH CALIFORNIA TEST METHOD 422

Ninyo & Moore		CORROSIVITY TEST RESULTS	FIGURE
PROJECT NO.	DATE	EASTERN WELLS AND PIPELINE PROJECT SAN JUAN CAPISTRANO, CALIFORNIA	B-6
207634001	9/09		

Table 2
Summary of Laboratory Test Results
San Juan Creek Road Undercrossing
Bridge 55-298

Boring No.	Sample Interval (ft)	Soil Classification (D 2487)[a]	Dry Density (pcf)	Moisture Content (D 2216) (%)	Atterberg Limits (D 4318)			Sieve Analysis D422 and D1140		Undrained Shear Strength (D 2850) (psf)
					LL (%)	PL (%)	PI	% Passing No. 4	% Passing No. 200	
SB-3	10-11.5		92.6	29.3						
SB-3	20-21.5		89.4	31.5						
SB-4	15-16.5	Fat clay (CH)			63	27	36			
SB-4	45-46.5	Silty Sand (SM)						96	29	
SB-4	50-51.5	Well Graded Silty Sand (SW-SM)						85	7	
SB-4	60-61.5	Lean clay (CL)	91.0	31.6	69	29	40			2,200[b]
SB-4	61.5-63	Lean clay (CL)	92.2	30.1	69	29	40			2,600[c]
SB-4	63-64.5	Lean clay (CL)	84.4	34.2	69	29	40			2,500[d]

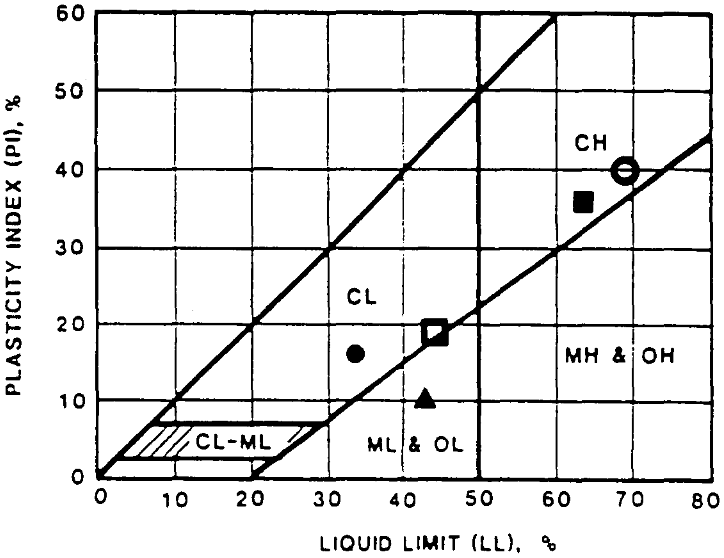
[a] Indicates applicable ASTM designation.
[b] Measured at 5 percent strain at continuing pressure of 1,440 psf.
[c] Measured at 5 percent strain at continuing pressure of 2,880 psf.
[d] Measured at 5 percent strain at continuing pressure of 5,760 psf.

Table 3
Corrosivity Test Results
San Juan Creek Road Undercrossing
Bridge No. 55-298

Boring Number	Depth (ft)	pH[a]	Minimum Electrical Resistivity[a] (ohm-centimeters)	Sulfate[b] (ppm)	Chloride[c] (ppm)
SB-3	5.0-8.0	6.71	253	41	794
SB-4	10.0-13.0	6.71	260	3,960	811
SB-4	31.0-35.0	7.02	260	852	661

[a] Test performed in accordance with California Test Method 643.
[b] Test performed in accordance with California Test Method 417.
[c] Test performed in accordance with California Test Method 422.

SYMBOL	LOCATION	DEPTH (FT.)	% PASSING 200	LL (%)	PL (%)	PI (%)	U.S.C.S.
▲	SB-1	55.0-59.5	-	42	32	10	Siltstone
■	SB-4	15.0-16.5	-	63	27	36	CH
○	SB-4	60.0-64.5	-	69	29	40	Siltstone
●	SB-7	14.0-17.0	-	33	17	16	SC
□	SB-8	20.0-24.5	-	44	25	19	Siltstone



* Entire Sample

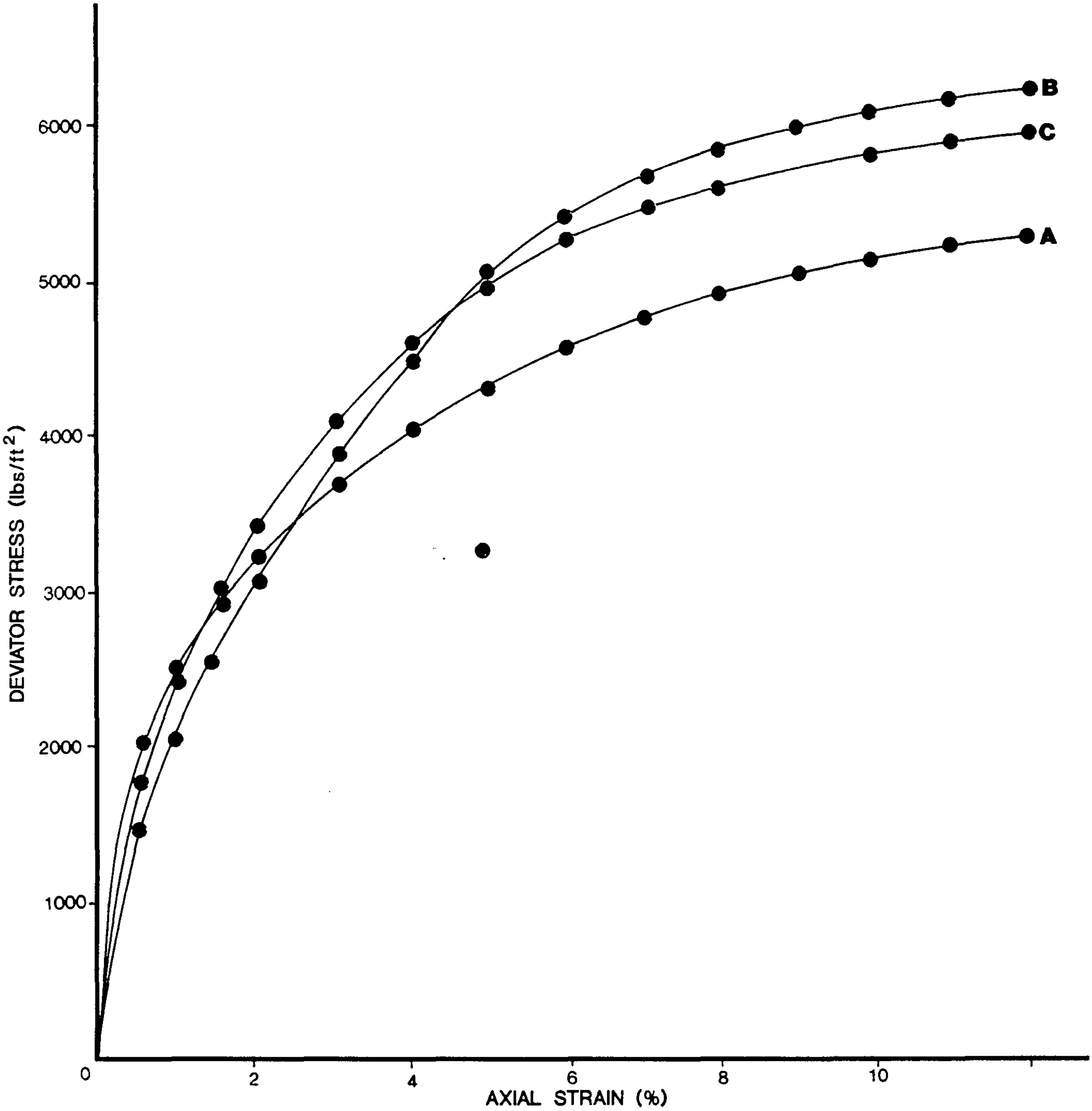
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318-84.

Ninyo & Moore

ATTERBERG LIMITS TEST RESULTS

I-5 Freeway From SR1 to El Toro Road
12-ORA-5PM 6.7/18.9

PROJECT NO.	DATE	FIGURE C-62
200143-01	6/92	



SAMPLE LOCATION: SB-4

SAMPLE: A, B, C

DEPTH: A 60.0-61.5'
B 61.5-63.0'
C 63.5-65.0'

SAMPLE TYPE: SILTSTONE

TEST CONDITIONS: UNDRAINED UNCONSOLIDATED

CONFINING STRESS: A 1440 psf
B 2880 psf
C 5760 psf

STRAIN RATE: A 0.005 in/min
B,C 0.05 in/min

Ninyo & Moore

TRIAXIAL SHEAR TEST RESULTS

I-5 Freeway From SR1 to El Toro Road

12-ORA-5PM 6.7/18.9

PROJECT NO.	DATE	FIGURE C-93
200143-01	6/92	

Table 1
Summary of Laboratory Test Results
San Juan Creek Bridge
Bridge No. 55-228

Sheet 1 of 2

Boring Number	Sample Interval (ft)	Soil Classification (D 2487)[1]	Dry Density (PCF)	Moisture Content (D 2216) (%)	Sieve Analyses (D 422 and D 1140)	
					% Passing No. 4	% Passing No. 200
SB-5	2-3.5			2.9		
SB-5	17-18.5		113.6	3.8		
SB-5	27-28.5	ML			99	93
SB-5	47-48.5	SW-SM			99	8
SB-5	52-53.5	SP-SM		18.1	90	10
SB-5	67-68.5		81.4	38.0		
SB-5	77-78.5		98.1	25.8		
SB-6	2-3.5			15.3		
SB-6	7-8.5			25.2		
SB-6	12-13.5			37.3		
SB-6	22-23.5			32.0		
SB-6	32-33.5	SP-SM		3.1	77	5
SB-6	37-38.5	SP			98	5
SB-6	42-43.5			18.6		
SB-6	52-53.5			15.8		
SB-6	62-63.5			21.5		
SB-6	72-73.5			26.2		

[1] Indicates applicable ASTM designation.

Table 1
Summary of Laboratory Test Results
San Juan Creek Bridge
Bridge No. 55-228

Sheet 2 of 2

Boring No.	Sample Interval (ft)	Soil Classification (D 2487)[1]	Moisture Content (D 2216) (%)	Atterberg Limits (D 4318)			Sieve Analyses (D 422 and D 1140)	
				LL (%)	PL (%)	PI	% Passing No. 4	% Passing No. 200
B-101	25-26.5	ML						65.1
B-101	27.5-29	SM					99.3	46.7
B-101	58.5-60	MH	40.2	50	29	21		92.3
B-101	61-62.5	CL	37.9	46	25	21		93.2
B-104	22.5-24	SM					100.0	48.7
B-104	34-35.5	ML					100.0	75.7
B-104	54-55.5	CL	36.4	38	23	15	100.0	80.8
B-104	63.5-65	ML	35.1	44	27	17		94.4
B-104	73.5-75	SM	63.3	41	27	14		
B-114	20-20.5	CH	31.6	50	28	22		88.5
B-114	21-21.5	ML	48.8	NP	NP	NP		56.0
B-114	60-61	ML	32.5	NP	NP	NP		54.3
B-114	61-61.5	CL	40.4	47	26	21		97.7
B-114	85-86.5	SM					94.7	20.9

TABLE 1
(Continued)

Location	Depth (ft.)	Type[1] of Test	Field Moisture (%)	Field Dry Density (pcf)	Optimum Moisture (%)	Maximum Dry Density (pcf)	Relative Compaction (%)
SB-1	55.0–56.4	ST	19.8	104.7	---	---	---
	56.5–57.8	ST	25.6	99.5	---	---	---
	58.0–59.5	ST	28.6	96.7	---	---	---
SB-2	15.0–16.5	ST	28.1	95.9	---	---	---
	35.0–36.5	ST	26.1	99.1	---	---	---
	55.0–56.5	ST	25.2	99.8	---	---	---
	75.0–76.0	ST	24.3	101.4	---	---	---
SB-3	10.0–11.5	ST	29.3	92.6	---	---	---
	20.0–21.5	ST	31.5	89.4	---	---	---
SB-4	60.0–61.5	ST	31.6	91.0	---	---	---
	61.5–63.0	ST	30.1	92.2	---	---	---
	63.0–64.5	ST	34.2	84.4	---	---	---
SB-5	2.0–3.5	SPT	2.9	---	---	---	---
	17.0–18.5	ST	3.8	113.6	---	---	---
	52.0–53.5	SPT	18.1	---	---	---	---
	67.0–68.5	ST	38.0	81.4	---	---	---
	77.0–78.5	ST	25.8	98.1	---	---	---

(Continued)

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[1] ST = Split Tube Ring Sample, SPT = Standard Penetration Test, B = Bulk Sample

TABLE 1
(Continued)

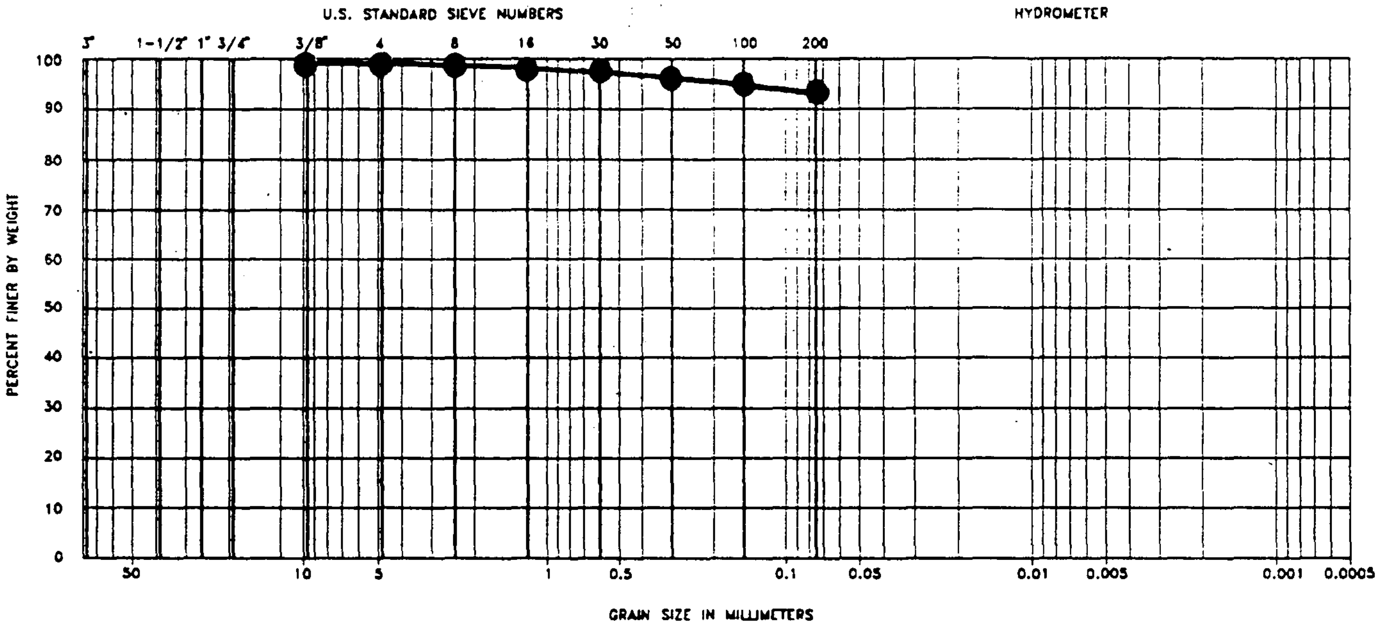
Location	Depth (ft.)	Type[1] of Test	Field Moisture (%)	Field Dry Density (pcf)	Optimum Moisture (%)	Maximum Dry Density (pcf)	Relative Compaction (%)
SB-6	2.0–3.5	SPT	15.3	---	---	---	---
	7.0–8.5	SPT	25.2	---	---	---	---
	12.0–13.5	SPT	37.3	---	---	---	---
	22.0–23.5	SPT	32.0	---	---	---	---
	32.0–33.5	SPT	3.1	---	---	---	---
	42.0–43.5	SPT	18.6	---	---	---	---
	52.0–53.5	SPT	15.8	---	---	---	---
	62.0–63.5	SPT	21.5	---	---	---	---
	72.0–73.5	SPT	26.2	---	---	---	---
SB-8	5.0–6.5	ST	13.8	115.2	---	---	---
	20.0–21.5	ST	26.0	96.0	---	---	---
	21.5–23.0	ST	28.2	94.8	---	---	---
	23.0–24.5	ST	26.6	96.6	---	---	---
	41.5–43.0	ST	20.8	105.6	---	---	---
SB-10	20.0–21.5	ST	15.4	116.7	---	---	---
	27.0–28.3	ST	8.6	---	---	---	---
	32.0–33.5	ST	39.7	79.1	---	---	---
SB-12	15.0–16.5	ST	3.9	135.5	---	---	---
	25.0–26.5	ST	6.1	105.0	---	---	---
	45.0–46.5	ST	40.0	81.6	---	---	---
	49.0–50.5	ST	42.3	79.6	---	---	---
	52.0–53.5	ST	30.8	90.6	---	---	---

(Continued)

---

[1] ST = Split Tube Ring Sample, SPT = Standard Penetration Test, B = Bulk Sample

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay



Symbol	Hole Number	Depth (Feet)	Liquid Limit	Plastic Limit	Plasticity Index	Soil Type
●	SB-5	27.0-28.5	-	-	-	ML

Ninyo & Moore

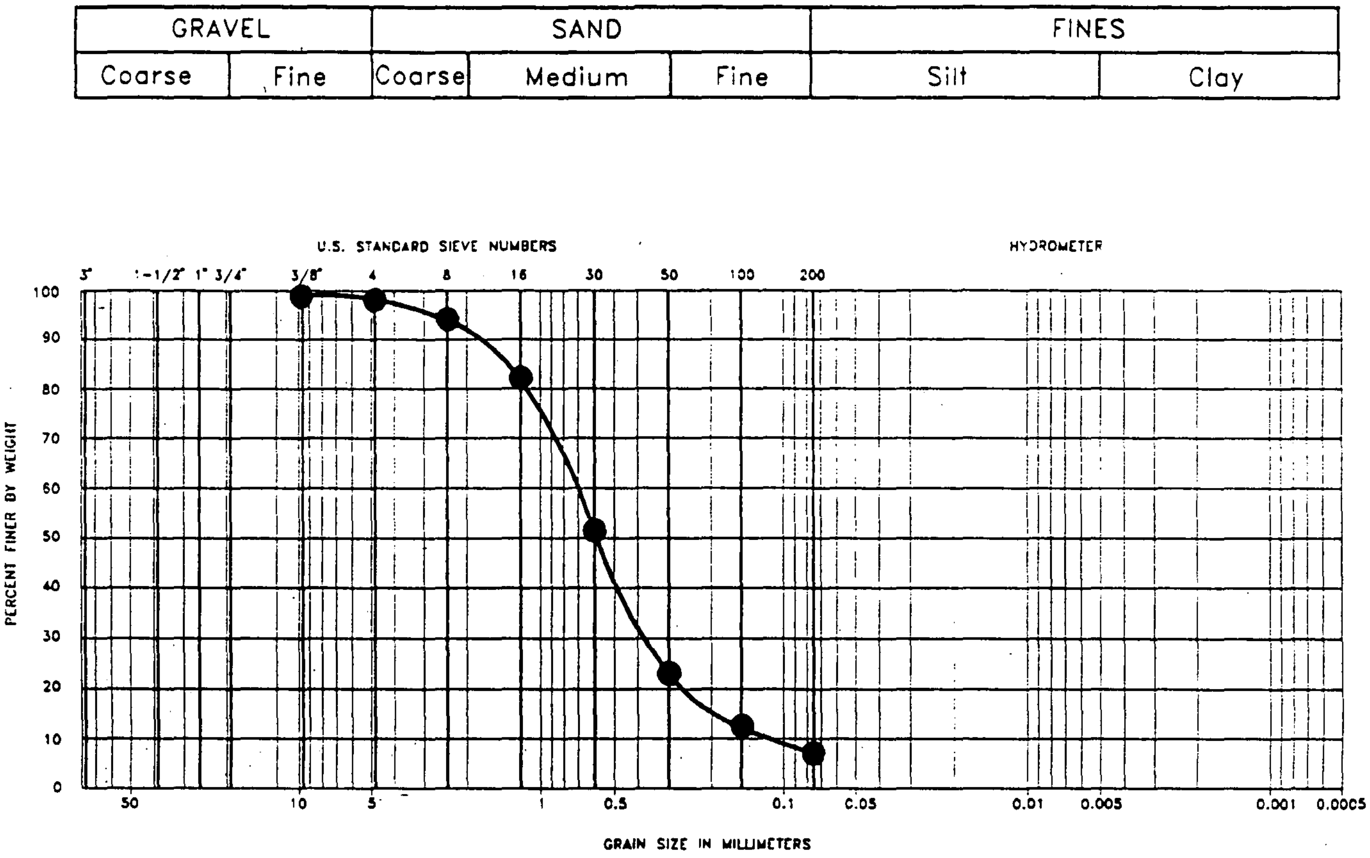
GRADATION TEST RESULTS

I-5 Freeway From SR1 to El Toro Road

12-ORA-5PM 6.7/18.9

PROJECT NO.	DATE	FIGURE C-38
200143-01	6/92	

GRADTEST.DWG



Symbol	Hole Number	Depth (Feet)	Liquid Limit	Plastic Limit	Plasticity Index	Soil Type
●	SB-5	47.0-48.5	-	-	-	SW-SM

Ninyo & Moore

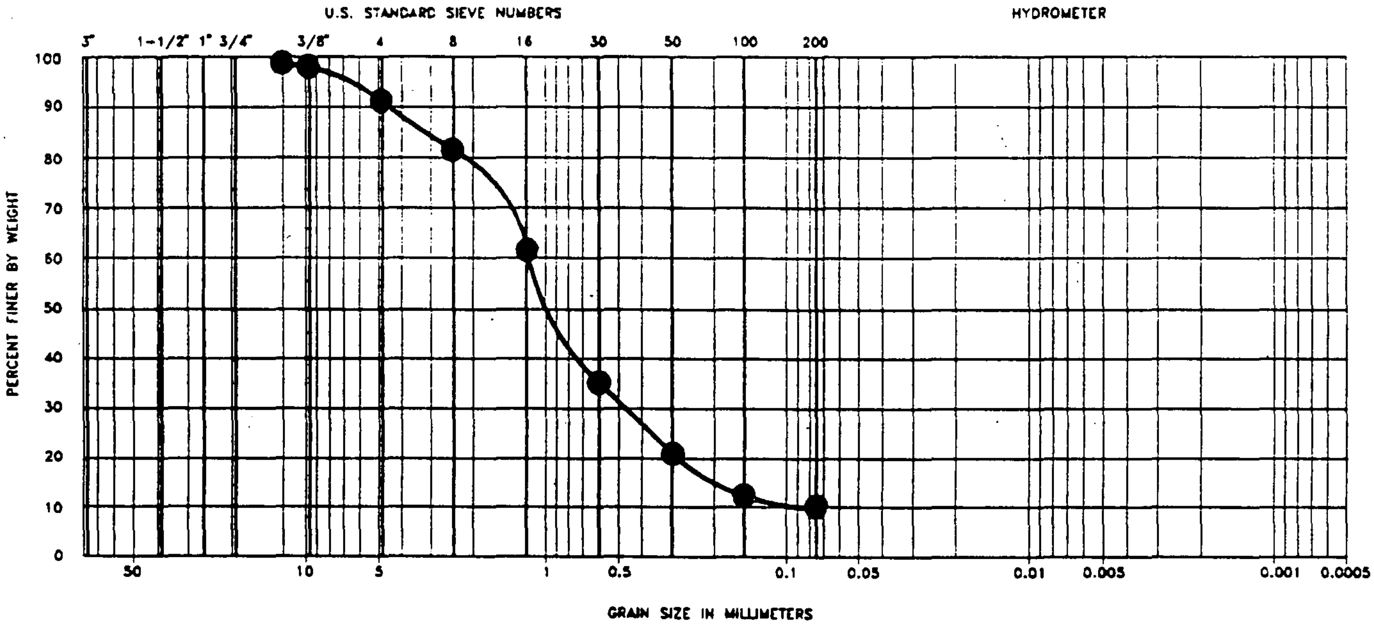
GRADATION TEST RESULTS

I-5 Freeway From SR1 to El Toro Road

12-ORA-5PM 6.7/18.9

PROJECT NO.	DATE	FIGURE C-39
200143-01	6/92	

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay



Symbol	Hole Number	Depth (Feet)	Liquid Limit	Plastic Limit	Plasticity Index	Soil Type
●	SB-5	52.0-53.0	-	-	-	SP-SM

Ninyo & Moore

GRADATION TEST RESULTS

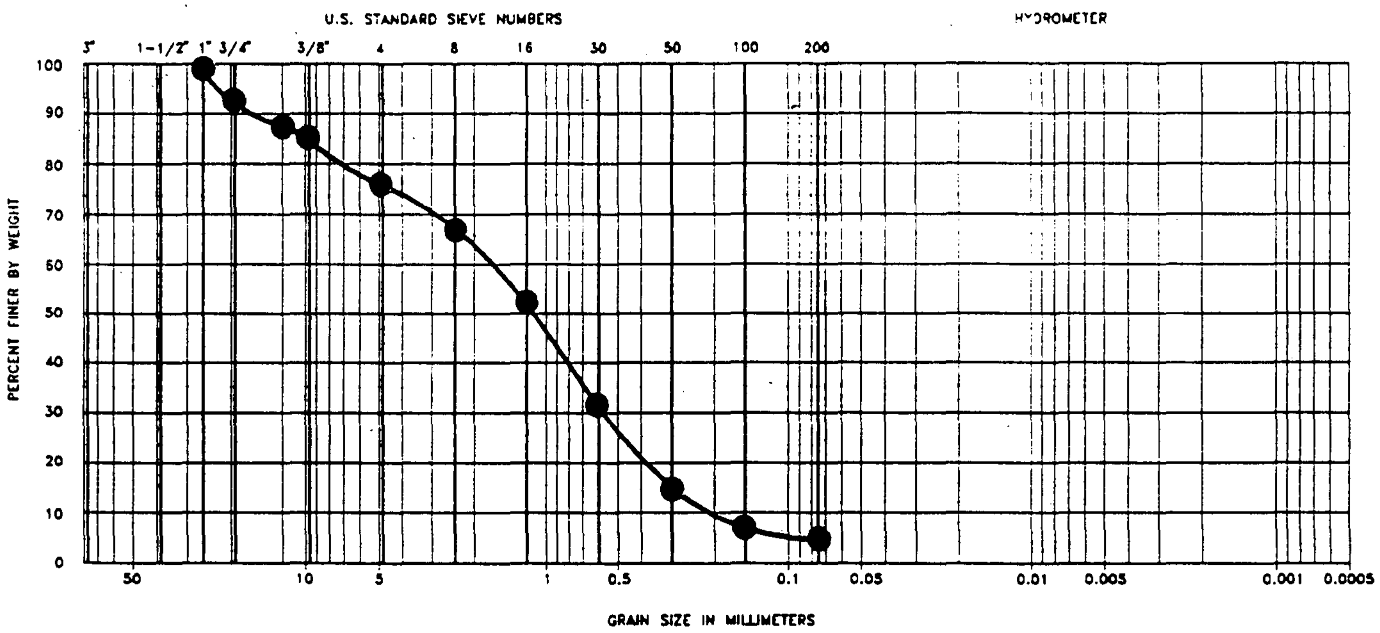
I-5 Freeway From SR1 to El Toro Road

12-ORA-5PM 6.7/18.9

PROJECT NO.	DATE	FIGURE C-40
200143-01	6/92	

GRADTEST.DWG

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay



Symbol	Hole Number	Depth (Feet)	Liquid Limit	Plastic Limit	Plasticity Index	Soil Type
●	SB-6	30.0-33.0	-	-	-	SP-SM

Ninyo & Moore

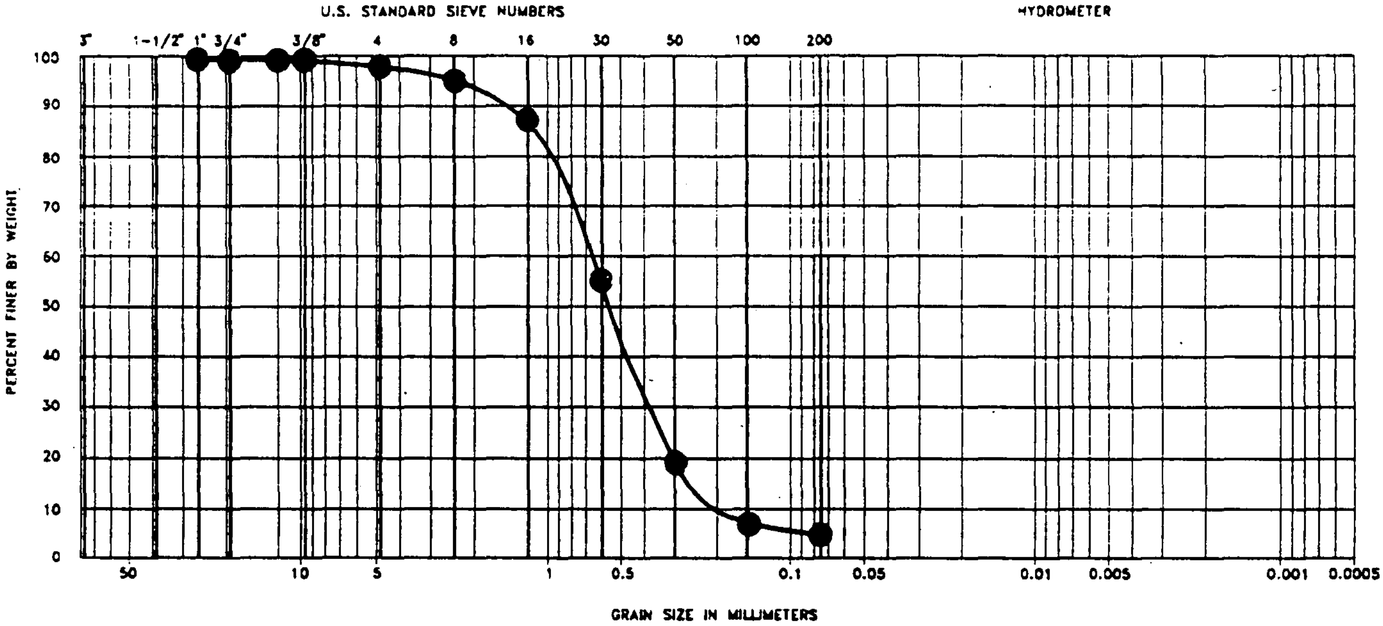
GRADATION TEST RESULTS

I-5 Freeway From SR1 to El Toro Road

12-ORA-5PM 6.7/18.9

PROJECT NO.	DATE	FIGURE C-41
200143-01	6/92	

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay



Symbol	Hole Number	Depth (Feet)	Liquid Limit	Plastic Limit	Plasticity Index	Soil Type
●	SB-6	37.0-38.5	-	-	-	SP

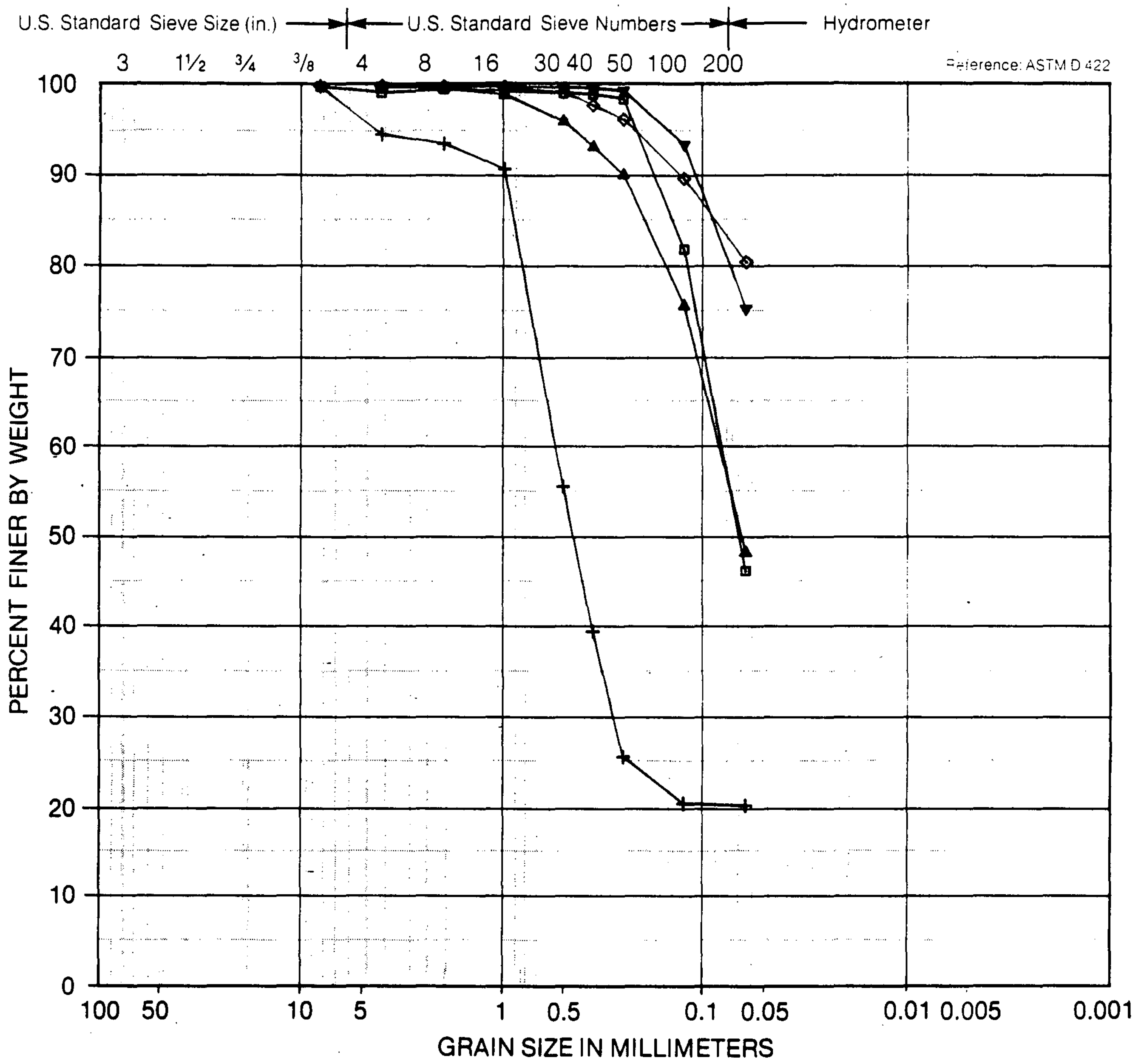
Ninyo & Moore

GRADATION TEST RESULTS

I-5 Freeway From SR1 to El Toro Road

12-ORA-5PM 6.7/18.9

PROJECT NO.	DATE	FIGURE C-42
200143-01	6/92	



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Symbol	Sample Source	Classification
⊡	B-101 @ 27.5 FT	GRAY SILTY SAND (SM)
▲	B-104 @ 22.5 FT	GRAY SILTY SAND (SM)
▼	B-104 @ 34.0 FT	GRAY SILT W/SAND (ML)
◈	B-104 @ 54.0 FT	GRAY LEAN CLAY W/SAND (CL)
+	B-114 @ 85.5 FT	GRAY SILTY SAND (SM)

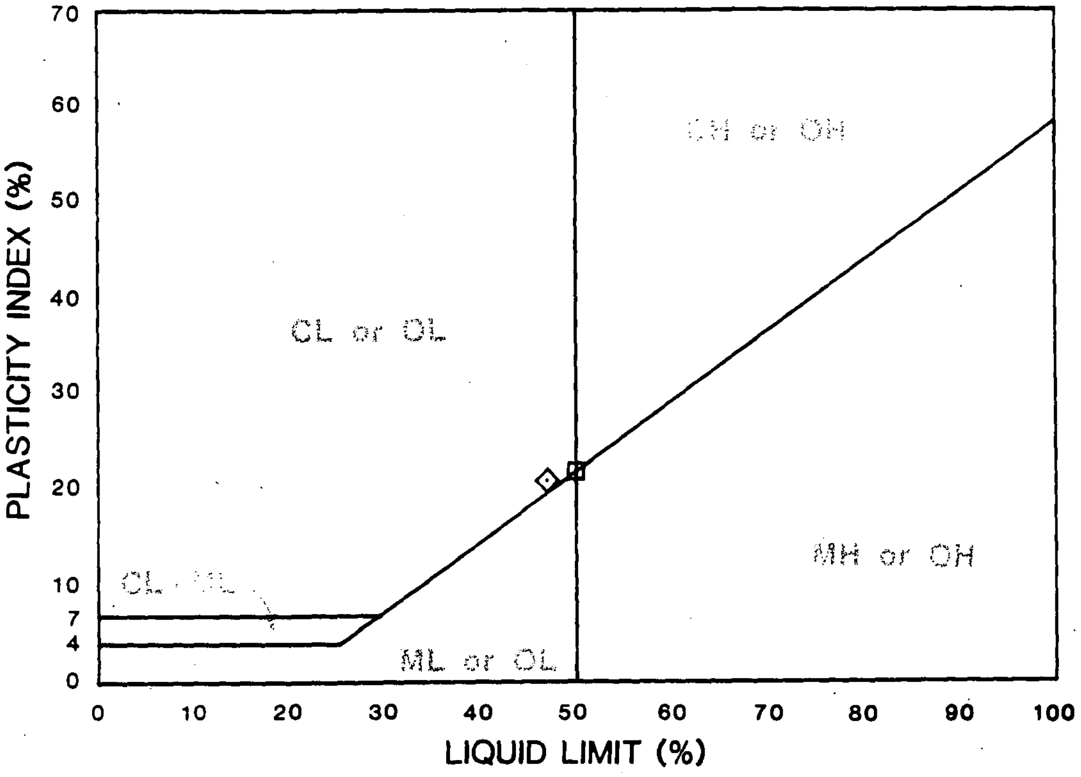
HLA

Harding Lawson Associates
Engineers, Geologists
& Geophysicists

Particle Size Analysis

PLATE

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
	10656-075		08-07-1992		



Reference: ASTM D-4318

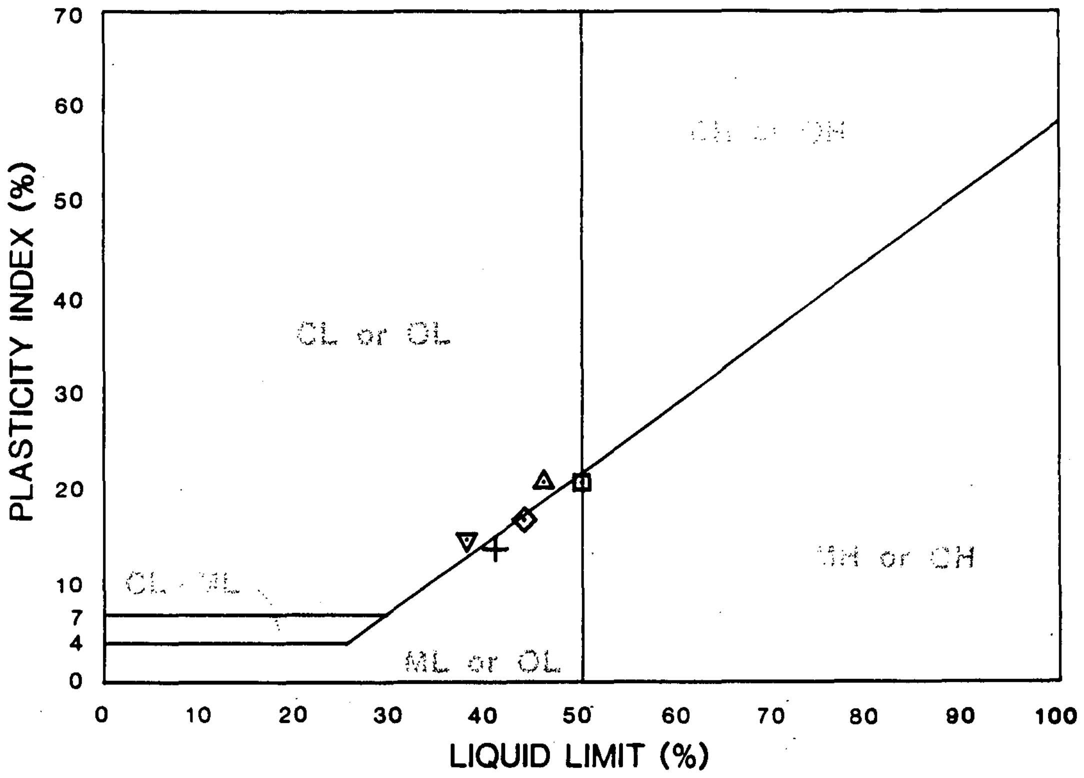
SYMBOL	BORING NUMBER	DEPTH (feet)	CLASSIFICATION	LL (%)	PL (%)	PI (%)	MOISTURE CONTENT (%)
⊡	B-114	20.0	GRAY FAT CLAY (CH)	50	28	22	31.6
△	B-114	21.0	GRAY SANDY SILT (ML)	NP	NP	NP	48.8
▽	B-114	60.0	GRAY SANDY SILT (ML)	NP	NP	NP	32.5
◇	B-114	61.0	GRAY LEAN CLAY (CL)	47	26	21	40.4

Harding Lawson Associates
Engineering and
Environmental Services

Plasticity Chart

PLATE

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
	10656-075	TB	08-12-1992		



Reference: ASTM D-4318

SYMBOL	BORING NUMBER	DEPTH (feet)	CLASSIFICATION	LL (%)	PL (%)	PI (%)	MOISTURE CONTENT (%)
⊡	B-101	58.5	GRAY ELASTIC SILT (MH)	50	29	21	40.2
△	B-101	61.0	GRAY LEAN CLAY (CL)	46	25	21	37.9
▽	B-104	54.0	GRAY LEAN CLAY W/SAND (CL)	38	23	15	36.4
◇	B-104	63.5	GRAY SILT (ML)	44	27	17	35.1
+	B-104	73.5	GRAY SILTY SAND (SM)	41	27	14	63.3

Harding Lawson Associates
Engineering and
Environmental Services

Plasticity Chart

PLATE

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
	10656-075	TKB	08-12-1992		

Minus #200 Test
HLA Testing Services Soils Analysis Results

Project : SAN JUAN CREEK   ID : 10656-075   Test Date : 08-07-1992

Data Entry By : DJM   Data File : TEST0278

Boring Desc.	Depth (ft)	Soil Class	% Passing #200 Sieve
B-101	25.0	(ML)	65.1
B-101	58.5	(MH)	92.3
B-101	61.0	(CL)	93.2
B-104	63.5	(ML)	94.4
B-114	20.0	(CH)	88.5
B-114	21.0	(ML)	56.0
B-114	60.0	(ML)	54.3
B-114	61.0	(CL)	97.7

APPENDIX E
EXISTING BRIDGE SCOUR EVALUATION MEMO

ONE COMPANY
Many Solutions℠

Memo

To:	Aaron Rubio, P.E.		
From:	Vicky Zhang P.E., CFM	Project:	San Juan Creek Bridge
CC:	Mark Seits, P.E. and Brian Doeing, P.E.		
Date:	November 20, 2013	Job No:	215960

Document2

San Juan Creek Bridge Existing Bridge Scour Evaluation

Purpose

The purpose of this memo is to conduct a preliminary bridge scour analysis for the existing San Juan Creek Bridge (Bridge 197.9).

Background

The San Juan Creek Bridge is a railroad bridge along the Los Angeles to San Diego (LOSSAN) rail corridor. It is located in the City of San Juan Capistrano and just downstream of the bridge Camino Capistrano. The existing Bridge 197.9 consists of a 305-foot ballast deck thru-plate girder (TPG) type. It is a three-span superstructure with two concrete piers supported on timber piles. It was built in 1917. The Bridge 197.9 is currently under evaluation of retrofitting or replacement.

Hydrology

The Bridge 197.9 is located in the San Juan Creek watershed. The hydrology used in the modeling is taken from San Juan Creek Watershed Hydrology Study (2008). Per Orange County Flood Control Section staff, this hydrology is the approved hydrology. The 100-year high confidence and expected value hydrology were analyzed. The 1986 Orange County Hydrology Manual (OCHM) yields high confidence peak discharge and volumes that are appropriate for flood control design purpose. Addendum No. 1 to the OCHM requires the use of expected value discharges for mitigation, floodplain delineation, sediment transport and water quality purposes.

Hydraulic Modeling

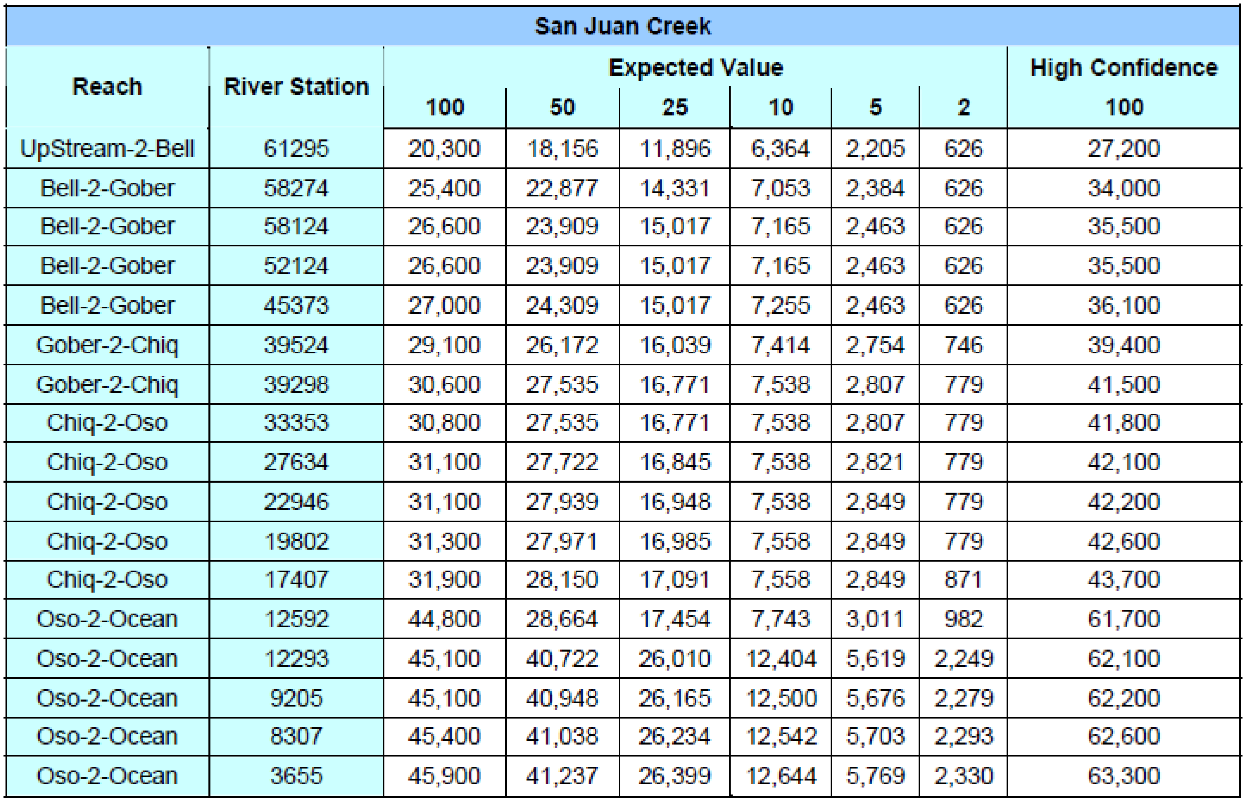
The effective flood insurance study (FIS) model was obtained from Federal Emergency Management Agency (FEMA). However, the effective model does not include the Bridge 197.9. PACE (2010) prepared the San Juan Creek Hydraulic study which includes the Bridge 197.9 hydraulic modeling. It is the best available data, therefore, it was used as a base model to evaluate the bridge scour. The model is prepared with HEC-RAS program version 4.1. Due to limited bridge and channel information, the base model was modified as followings:

- The cross section upstream and downstream of the bridges are skewed in the PACE model. Based on the field measurements and measurement from Google earth, the channel widths were modified to better fit the measurements. Skew was removed from cross sections 13088, 13595, 13772 and 13964 but kept cross section 13427 skewed as in the PACE model.
- The as-built drawing is dated 1917. It shows 3 100-foot bridge spans. The concrete channel is not identified in the plan. The middle span length matches the measurement, but the end spans do not match the measurement. Therefore, it is assumed the concrete channel was placed after the bridge was built.
- Revised the bridge configuration. The center to center pier distance was based on the as-built plan. From the center of pier to the toe of the concrete channel and channel side slope were based on the field measurement.

- Pier dimension was revised based on the as-built plans.
- Copied the bridge upstream configuration to the downstream.
- Revised the low flow bridge modeling approach from Energy only to Highest Energy Answer of Energy, Momentum and Yarnell methods, and selected Pressure and Weir Flow for high flow method.
- Revised top of deck to Elevation 85.3, which considers the steel diaphragm.
- Two feet of debris on each side of the pier were added.

Table 1 shows the discharge for the San Juan Creek, which is taken from the San Juan Creek Baseline Hydraulic Study (2010). The Bridge 197.9 is modeled at River Station 13428, which is within the Chiq-2-Oso reach. The 100-year High Confidence discharge is 43,700 cfs.

Table 1. Discharge Summary Table



San Juan Creek								
Reach	River Station	Expected Value						High Confidence
		100	50	25	10	5	2	100
UpStream-2-Bell	61295	20,300	18,156	11,896	6,364	2,205	626	27,200
Bell-2-Gober	58274	25,400	22,877	14,331	7,053	2,384	626	34,000
Bell-2-Gober	58124	26,600	23,909	15,017	7,165	2,463	626	35,500
Bell-2-Gober	52124	26,600	23,909	15,017	7,165	2,463	626	35,500
Bell-2-Gober	45373	27,000	24,309	15,017	7,255	2,463	626	36,100
Gober-2-Chiq	39524	29,100	26,172	16,039	7,414	2,754	746	39,400
Gober-2-Chiq	39298	30,600	27,535	16,771	7,538	2,807	779	41,500
Chiq-2-Oso	33353	30,800	27,535	16,771	7,538	2,807	779	41,800
Chiq-2-Oso	27634	31,100	27,722	16,845	7,538	2,821	779	42,100
Chiq-2-Oso	22946	31,100	27,939	16,948	7,538	2,849	779	42,200
Chiq-2-Oso	19802	31,300	27,971	16,985	7,558	2,849	779	42,600
Chiq-2-Oso	17407	31,900	28,150	17,091	7,558	2,849	871	43,700
Oso-2-Ocean	12592	44,800	28,664	17,454	7,743	3,011	982	61,700
Oso-2-Ocean	12293	45,100	40,722	26,010	12,404	5,619	2,249	62,100
Oso-2-Ocean	9205	45,100	40,948	26,165	12,500	5,676	2,279	62,200
Oso-2-Ocean	8307	45,400	41,038	26,234	12,542	5,703	2,293	62,600
Oso-2-Ocean	3655	45,900	41,237	26,399	12,644	5,769	2,330	63,300

Bridge Scour

Model Inputs

The existing Bridge 197.9 scour analysis was conducted using the Federal Highway Administration (FHWA) Hydraulic Engineering Circular 18 (HEC-18), Evaluating Scour at Bridges methodology (FHWA 2012). The parameters needed for the scour analysis were obtained from the HEC-RAS model. The parameters are based on the High Confidence discharge.

Additional input required for the scour analysis is soil parameter – D_{50} of the bed material. HDR prepared Preliminary Foundation Study for San Juan Creek Bridge (2013). In this study, it includes the existing geotechnical data prepared by Ninyo & Moore for an adjacent project. Based on the gradation in the Ninyo & Moore and field visit, the D_{50} of 5 mm is estimated for the bed material. After considering other D_{50} sizes it was determined that results are not sensitive to the range of D_{50} sizes that could be assumed for this analysis.

Figure 1 shows a typical bridge pier. The piers are aligned with the existing flow, therefore an approach angle of 0 degrees was assumed. For the 100-year storm event, the bridge deck will be pressurized without overtopping. Localized pier scour was calculated at the pier, based on the depth and velocity at the pier and including floating debris 11 feet wide for the full flow depth at the pier, extending upstream a distance equal to the flow depth. A simple scour analysis was performed considering the pressure flow scour and pier scour. Scour calculations due to the complex pier (considering the pile groups and pile caps) scour might result a deeper scour depth. Live-bed scour which occurs when there is transport of bed materials from the upstream reach into the crossing, is applicable for calculating the contraction scour.

Model Results

Table 2 shows the scour results at the existing Bridge 197.9. Figure 2 shows the scour depth at the pier (elevation needs to be confirmed with survey). It is approximately 7 feet from the ground to the bottom of the pier. Based on the as-built plans, the timber piles are 14.7 feet deep in average. Therefore the total scour depth will be below the piles and result in instability of the bridge structure. Bridge abutments are located at the lined concrete section which is considered protected. Therefore, the abutment scour analysis is not performed. The detailed scour analysis is included in Appendix.

Currently, a timber cribwall around the pier appears to provide a scour countermeasure (Figure 1). The timbers are deteriorated. There is no knowledge of the past performance at the bridge. The scour could have occurred and the sediment filled back into the scour hole.

Table 2: Existing Bridge 197.9 Scour Analysis Results (100-year event)

Scour Type	Scour Depth (ft) HC
Vertical Contraction (Pressure Flow)	10.8
Pier	16.6
Pier + Contraction	27.4

Figure 1 – San Juan Creek Bridge Pier (looking upstream)

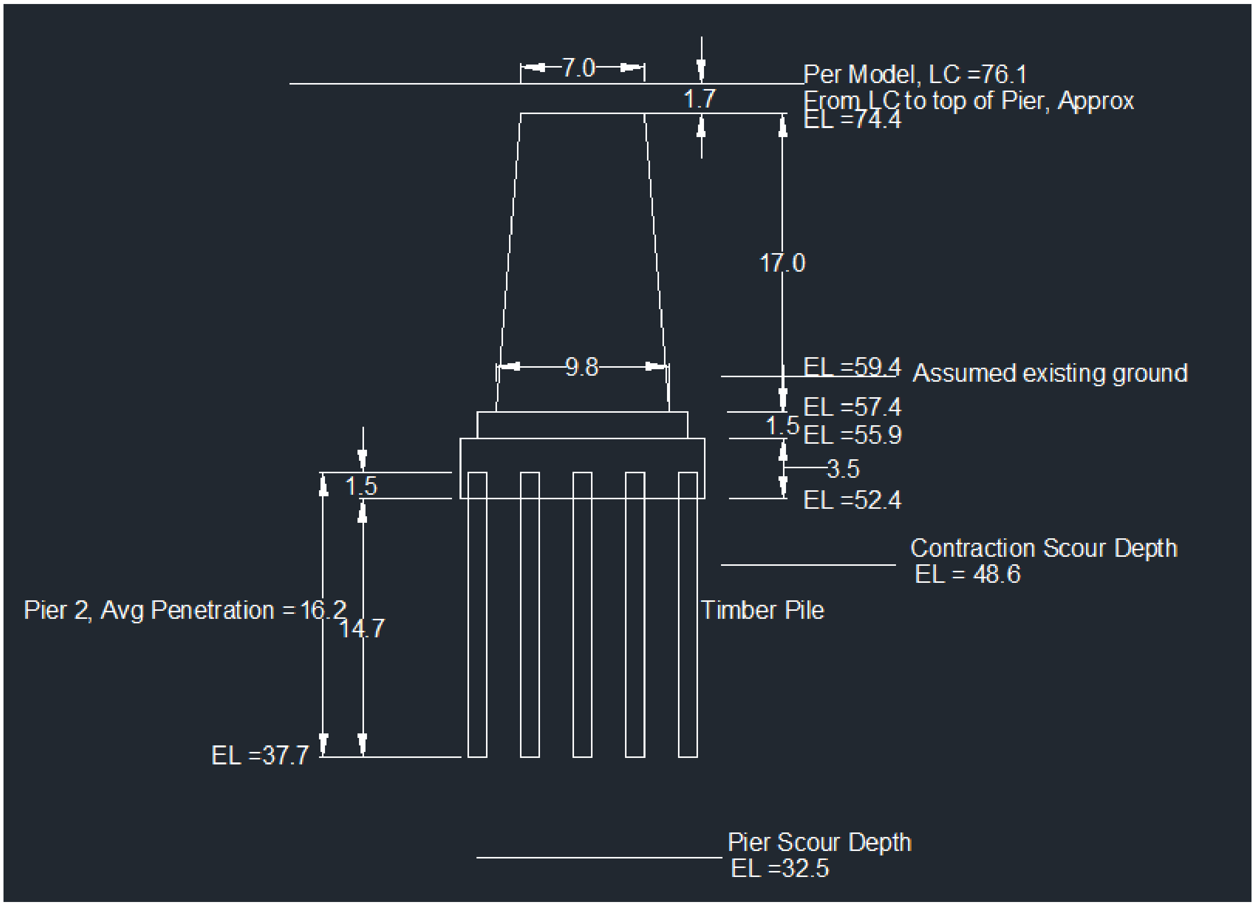


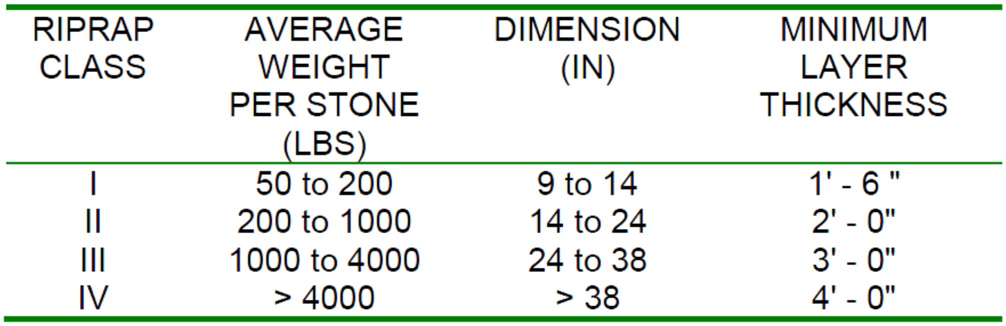
Figure 2 – Scour Depth

Erosion Protection

Rock riprap is recommended to provide erosion protection for the existing piers. According to Federal Highway Administration (FHWA 2009), riprap is flexible and can remain functional as a scour countermeasure even if some individual stones are lost. Riprap can be repaired relatively easily. Properly constructed riprap can provide long-term protection if it is inspected and maintained on a periodic basis as well as after flood events.

Sizing of the rock riprap using FHWA HEC-23 method (FHWA 2009) was conducted. The characteristic riprap D_{50} size was determined to be 1.2 feet. Table 3 shows the standard SCRRA ungrouted riprap classes. Based on the results, SCRRA riprap class II is recommended for San Juan Creek existing bridge erosion protection.

Table 3: SCRRA Ungrouted Riprap Class



RIPRAP CLASS	AVERAGE WEIGHT PER STONE (LBS)	DIMENSION (IN)	MINIMUM LAYER THICKNESS
I	50 to 200	9 to 14	1' - 6 "
II	200 to 1000	14 to 24	2' - 0"
III	1000 to 4000	24 to 38	3' - 0"
IV	> 4000	> 38	4' - 0"

The HEC-23 pier scour countermeasure guidelines recommend a minimum riprap thickness equal to 3 times d_{50}, the depth of contraction scour and long-term degradation, or the depth of bedform trough (sand bed channels), whichever is greatest. The depth of 10.8 feet vertical pressure flow contraction scour is the greatest; therefore it is the preliminary minimum riprap thickness. To avoid deep excavation which might undermine the existing piers, the interior of the riprap apron is 3 times D50 thick and the ends of the apron extend to the 10.8 feet contraction scour depth using a 1.5:1 (H:V) slope extension all around the riprap apron.

SCRRA Standard Specifications, Section 348011 shall be adopted. A geotextile is recommended for the underlying filter. See plan for the detailed riprap limits and configuration.

Conclusion

The existing bridge scour analysis is based on limited best available data. Survey is required to finalize the scour analysis. Based on the preliminary existing Bridge 197.9 scour analysis, the scour depth will be below the existing timber piles for the 100-year High Confidence event. The scour would undermine the stability of the piers and the bridge structure, therefore, the pier scour is determined to be critical. To protect the existing bridge piers from scour, it is recommended to remove the timber cribwall around the piers and to provide pier scour countermeasure protection using rock riprap around the piers according to guidelines in HEC-23 (FHWA 2012).

References:

1. AT&SF, *as-built plans*, 1917
2. HDR, *San Juan Creek Bridge Preliminary Foundation Study*, September 2013
3. PACE, *Baseline Floodplain Hydraulics for San Juan Creek*, April 2010
4. PACE, *San Juan Creek Watershed Hydrology Study*, August 2008
5. U.S. Department of Transportation Federal Highway Administration (FHWA), *HEC-18 - Evaluating Scour at Bridges, Fifth Edition*, April 2012
6. U.S. Department of Transportation Federal Highway Administration (FHWA), *HEC-23 -Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance – Third Edition,* September 2009.

Appendix:

- Appendix 1 – Bridge Scour Analysis