# DESIGN HYDRAULIC STUDY

# TRAVERS CREEK BRIDGE

**AT**

# S. ALTA AVENUE

*Bridge No. 42C0179*

*Prepared for the*

# COUNTY OF FRESNO

November 2015

The Report contained herein has been prepared by or under the direction of the following Registered Person(s):

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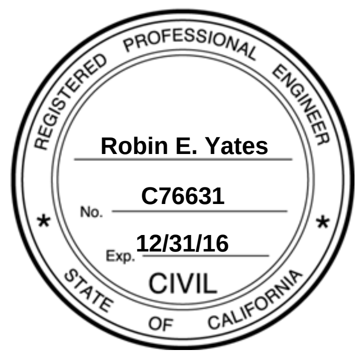
Robin E. Yates, P.E. Date



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**Bridge No. 42C0179**
**Fresno County, California**

## INTRODUCTION

Bridge No. 42C0179 is located over Travers Creek on S. Alta Avenue, approximately 0.3 miles north of South Avenue, near the City of Reedley (see Figure 1). The existing bridge was built in 1971 and consists of a double-barrel cast-in-place reinforced concrete box culvert with a thick asphalt concrete wearing surface. The culvert is approximately 40.5 feet long and 22 feet wide, with two 10' wide by 8' tall barrels. The structure carries two vehicular lanes with 8' wide shoulders which are covered with asphalt concrete. The ADT for Alta Avenue based on a 2010 evaluation is 6,050 vehicles per day, with approximately 10% of the total being trucks. The estimated future ADT for the year 2030 is 10,500 vehicles per day. Based on the Caltrans Structure Inventory and Appraisal sheet dated November 15, 2012, the bridge has a sufficiency rating of 87.6 and is neither Structurally Deficient nor Functionally Obsolete. Therefore, the bridge is not eligible for rehabilitation under the traditional Highway Bridge Program; however, it does qualify for preventive maintenance funds under the Bridge Preventive Maintenance Program. The primary eligible maintenance item for this location includes the repair of existing scour countermeasures and placement of new erosion control measures.

**Downstream Edge of Bridge No. 42C0179**

Travers Creek is a natural creek that has been channelized to a trapezoidal shape. The channel sides and bottom are typically earth-lined with moderate vegetation consisting of small trees and grasses. Adjacent to the culvert, the channel banks are lined with concrete slope paving, extending approximately 25' along the length of the channel, and there are small broken pieces of concrete along the channel bottom near the culvert invert. The creek makes an approximate 90 degree turn within the limits of the structure, which increases the potential for scour at the site. Per the 2012 Caltrans Bridge Inspection Report, there is a scour hole at the upstream end of the culvert and the cutoff wall on the downstream end of the culvert is exposed 4 inches along its entire length. In addition, field observations conducted by TRC in February 2014 revealed that the slope paving at the northeast corner of the culvert is severely cracked and pulling away from the wingwall, with vegetation growing through the cracks. There are also full depth cracks in the slope paving at the northwest corner that are approximately 1.5” wide.

Preventive maintenance work on this structure will include the rehabilitation of cracked slope paving and the complete replacement of the severely damaged slope paving at the northeast corner of the culvert. In addition, vegetation will be cleared from the channel near the culvert to improve hydraulics, and rock slope protection will be placed along the channel bottom along the length of slope paving to prevent further erosion of the channel bottom near the structure. The purpose of this Design Hydraulic Study is to determine the channel velocity for the design of scour countermeasures/erosion control. In addition, an effort will be made to achieve flood neutrality in the design.

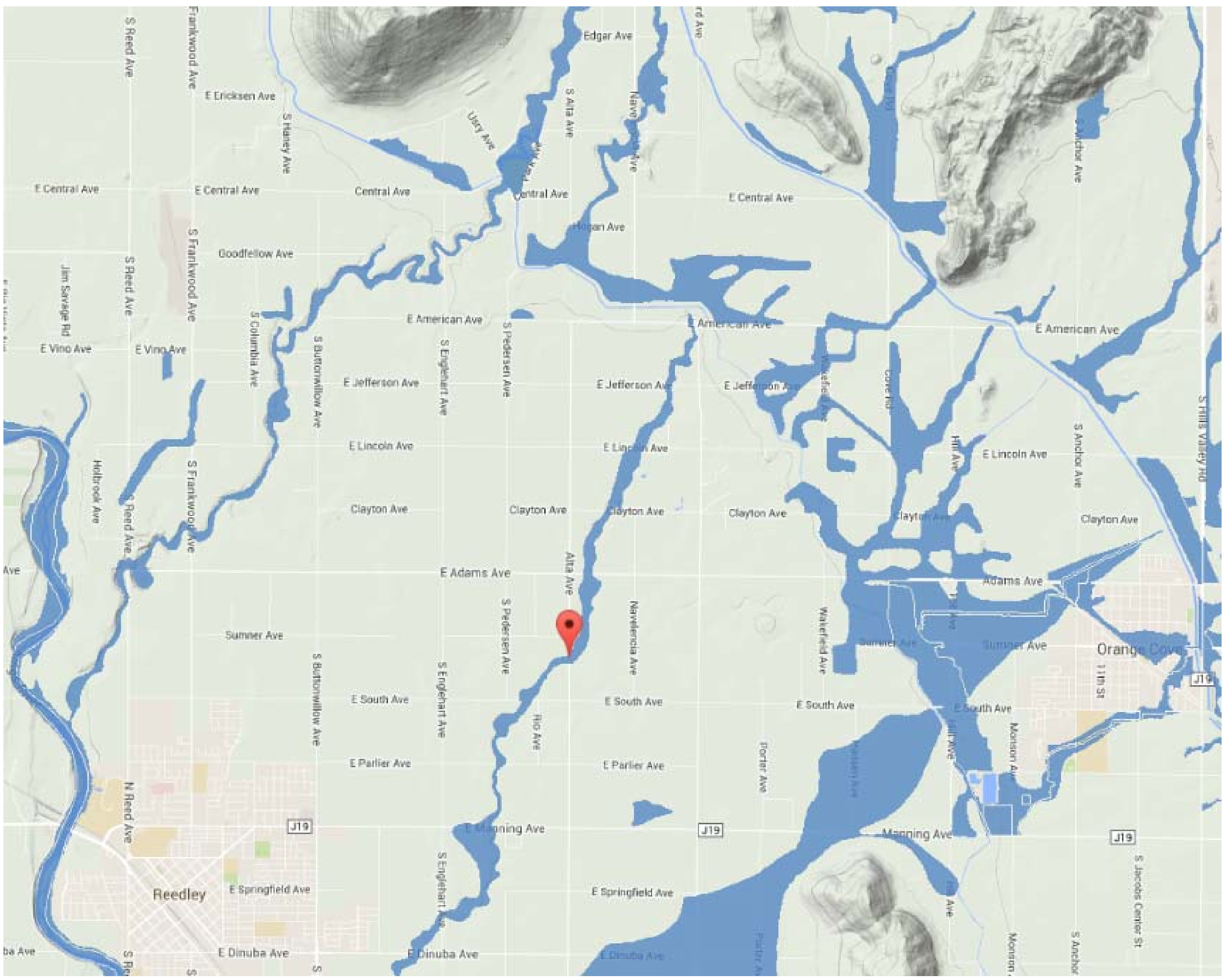



**Figure 1 – Project Location Map**

## STUDY AREA

The study area is located on Travers Creek near Reedley, California. Water flows south into Travers Creek out of Alta Main, which is owned by the Alta Irrigation District (AID). The creek is part of the AID system and is used to deliver irrigation waters to farms in Fresno and Tulare Counties.

The bridge is located in a very rural area consisting of agricultural lands and residential/agricultural structures, and there are established orchards on three of the four quadrants of the bridge (see Figure 2). AID operates check dams and diversion structures along the channel to maintain irrigation flows and discharges. Per TRC's conversations with the AID Superintendent Javier Cavazos, although Travers Creek is operated as a controlled channel during the irrigation season, flood flows govern over irrigation flows and are not controlled or tracked by AID. See further discussion under "Hydrology" below.

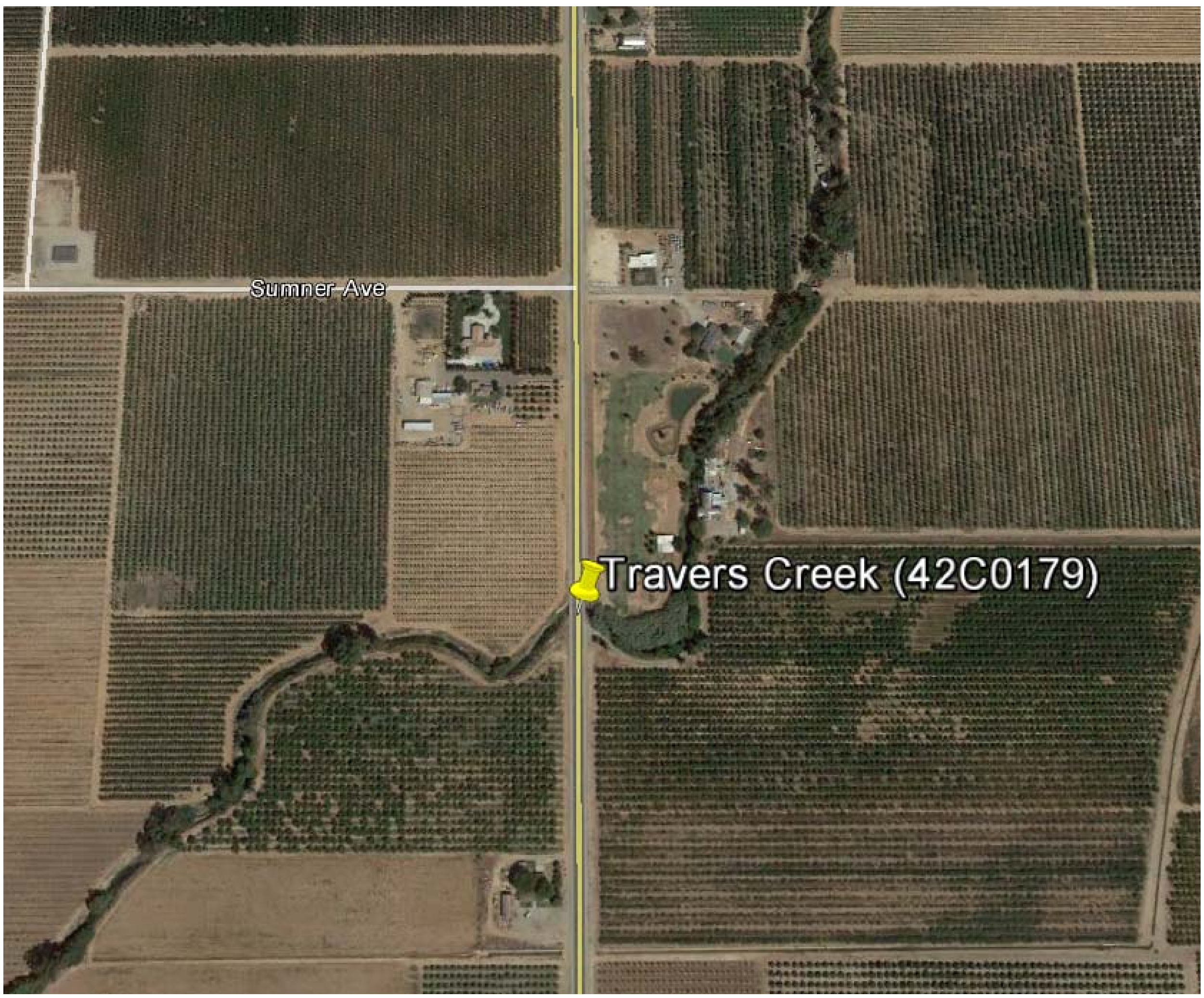



**Figure 2 – Project Aerial**

## HYDROLOGY

Per TRC's conversations with AID, the typical irrigation release in this reach of the channel is 150 cfs, occurring from early April to late August. However, flood flows govern over irrigation flows and are not tracked by AID. An extensive hydrologic study of Travers Creek was performed by Fresno County in 2014 for their replacement of the Manning Avenue Bridge located approximately 2¼ miles downstream of the S. Alta Avenue Bridge (see Figure 3).

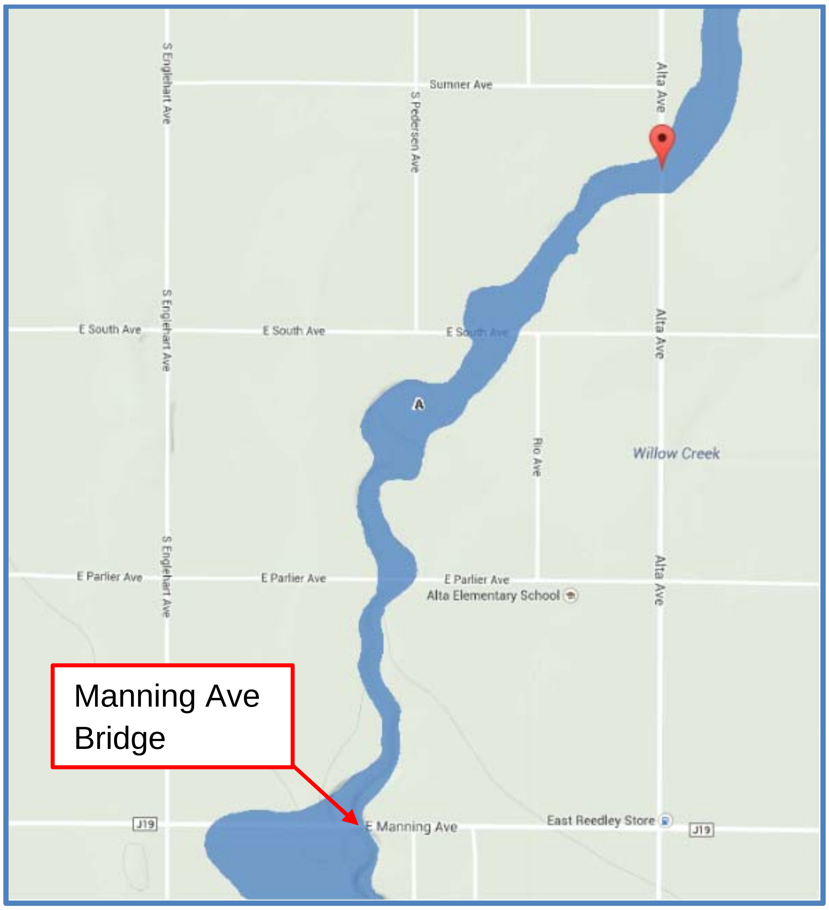



**Figure 3 – Location of Manning Avenue Relative to S. Alta Avenue**

Based on the results of this study, the base and design floods for the Manning Avenue Bridge Replacement Project are 1,340 cfs and 1,090 cfs, respectively (see Appendix A). Because the Manning Avenue Bridge is located downstream of the S. Alta Avenue Bridge, thus having a larger tributary drainage area, it is conservative to use the Manning Avenue flow rates at the S. Alta Avenue location. Therefore, the adopted flow rates for this study will be those given in Table 1 below.

***TABLE 1***
**ADOPTED FLOWS**

| Type of Flow | Travers Canal Flow (cfs) |
|---|---|
| Irrigation Flow | 150 |
| Design (50-year) | 1,090 |
| Base (100-year) | 1,340 |

## HYDRAULIC ANALYSIS

A hydraulic analysis was performed using HEC-RAS software to determine the channel velocities and water surface elevations for the adopted flows given in Table 1. The maximum channel velocity at the structure (due to the 100-year flood event) has been used in the design of scour countermeasures at the bridge (see further discussion under "Scour Analysis" below). To determine the effect of the scour countermeasures on the water surface elevation, two hydraulic models were created to analyze both the existing and proposed conditions. The existing model accounts for the natural earth-lined channel with moderate to heavy vegetation at each end of the culvert. The proposed model accounts for the concrete slope paving at each corner of the culvert and the proposed rock slope protection at the channel bottom along the length of the slope paving (about 25' along the channel at each end of culvert). The rock slope protection will be buried so that the channel thalweg is not raised; however, scour holes on the upstream and downstream ends of the culvert will be filled. Regrading of the channel banks is not anticipated.

Manning's "n" values were used to model the difference in channel friction between the existing and proposed conditions. A value of 0.045 has been assumed throughout the existing model, representing a winding natural stream with weeds and stones. Values of 0.03 and 0.05 have been assumed for the 25' section of slope paving and 10' band of rock slope protection upstream and downstream of the culvert in the proposed model, representing a channel lined with formed concrete sides and jagged rock slope protection bottom, and a channel fully lined with jagged rock slope protection, respectively.

The results of the existing hydraulic model show that both the 50-year and 100-year flood events overflow the channel banks, spilling onto adjacent agricultural lands. Since the main task of this project is to design scour countermeasures for the bridge, it is most important to determine the maximum water velocity. Therefore, the banks were raised (through use of fictitious levees) in both the existing and proposed models to simulate future bank improvements that eliminate overflow. This condition maximizes the flow through the culvert and in turn maximizes the water velocity. Table 2 shows the water velocities for the various investigated flows. The flood events were modeled as free flow conditions (no check dams in place) using the critical depth method. The irrigation flow was modeled with a known downstream water surface elevation (simulating a downstream check dam) that corresponds to a high water mark on the culvert (surveyed as elevation 361.56').

Water surface elevations for the existing and proposed conditions are shown in Table 3. The HEC-RAS results show a slight reduction in water surface elevation due to the proposed channel improvements, therefore flood neutrality is achieved in the design.

***TABLE 2***
**WATER VELOCITY**
**(EXISTING CONDITION)**

| Flow | Discharge Q (cfs) | Velocity V (ft/s) |
|---|---|---|
| Irrigation Flow | 150 | 1.93 |
| Design (50-year) | 1,090 | 7.33 |
| Base (100-year) | 1,340 | 8.30 |

***TABLE 3***
**WATER SURFACE ELEVATIONS**

| Flow | Discharge Q (cfs) | Existing Condition (ft) | Proposed Condition (ft) | Change in WSE (ft) |
|---|---|---|---|---|
| Irrigation Flow | 150 | 361.59 | 361.58 | -0.01 |
| Design (50-year) | 1,090 | 365.65 | 365.56 | -0.09 |
| Base (100-year) | 1,340 | 366.75 | 366.67 | -0.08 |

## SCOUR ANALYSIS

A review of the Caltrans Bridge Maintenance Reports was performed to assess the scour history of the bridge. Noted since 2007 is a scour hole approximately 1.5-2 feet deep and 10 feet in diameter at the upstream end of the culvert. Noted since 2002 is exposure of the downstream cutoff wall for about 4 inches along its full length. These scour conditions are likely due to the increased water velocity caused by the constriction of the flow through the culvert. Additionally, the transition of the flow from a trapezoidal channel to a vertical-walled box and back to a trapezoidal channel may cause eddies to develop at the entrance and exit of the culvert, scouring out finer bed material. Below are the calculations for the total anticipated scour for the site to determine the required toe depth for scour protections.

Contraction Scour

To estimate the anticipated contraction scour at the site, the critical velocity for sediment transport must first be calculated to determine whether it is live-bed or clear-water contraction scour. The critical velocity formula given below is used in combination with the median grain size ($D_{50}$) to calculate the velocity for the beginning of motion of the bed material. A $D_{50}$ value of 0.24 mm (0.01 in) has been provided by Kleinfelder based on field investigation and laboratory testing (see Appendix D for geotechnical memo).

Per HEC-18, equation 6.1:

$$V_c = K_u\, y^{1/6}\, D^{1/3}$$

where:

$V_c$ = critical velocity above which bed material of size D and smaller will be transported, (ft/s)

y = average depth of flow upstream of the bridge, per HEC-RAS (ft)

D = particle size for $V_c$ (ft) = $D_{50}$

$K_u$ = 11.17 (English Units)

Therefore, for the base flood event, the critical velocity is:

$$V_c = (11.17)\,(11.81')^{1/6}\,(0.01''/12)^{1/3} = 1.59 \text{ ft/s}$$

Per the HEC-RAS model of the existing condition, the velocity at the culvert is 8.30 ft/s, which is greater than the calculated critical velocity. Therefore, live-bed scour is expected to occur. According to HEC-18 Figure 6.8, the fall velocity of the bed material (T) based on the $D_{50}$ is 0.035 m/s (0.115 ft/s). The shear velocity in the upstream section is calculated as follows:

$$V^* = (g\, y_1\, S_1)^{1/2}$$

where:

$V^*$ = shear velocity in the upstream section (ft/s)

g = acceleration of gravity (32.2 ft/$s^2$)

$y_1$ = average depth in the upstream main channel, per HEC-RAS (ft)

$S_1$ = slope of energy grade line of main channel, per HEC-RAS (ft/ft)

Therefore, for the base flood event, the shear velocity is:

$$V^* = \{(32.2 \text{ ft/s})\ (7.49')\ (0.0028 \text{ ft/ft})\}^{1/2} = 0.82 \text{ ft/s}$$

The mode of bed material transport is identified by the shear velocity, V*, divided by the fall velocity, T, which is equal to (0.82 ft/s)/(0.115 ft/s) = 7.15. According to HEC-18, Section 6.3 this indicates "Mostly suspended bed material discharge", and yields a $k_1$ value of 0.69. This $k_1$ value is used in the following equation to determine the depth of contraction scour:

$$\frac{y_2}{y_1} = \left(\frac{Q_2}{Q_1}\right)^{\frac{6}{7}} \left(\frac{W_1}{W_2}\right)^{k1}$$

and $y_s = y_2 - y_0$ = average contraction scour depth

where:

$y_1$ = average depth in the upstream main channel, per HEC-RAS (ft)

$y_2$ = average depth in the contracted section (ft)

$y_0$ = existing depth in the contracted section before scour, per HEC-RAS (ft)

$Q_1$ = flow in the upstream main channel transporting sediment, per HEC-RAS (ft$^3$/s)

$Q_2$ = flow in the contracted channel, per HEC-RAS ($ft^3/s$)

$W_1$ = top width of the upstream main channel that is transporting bed material (ft)

$W_2$ = top width of the main channel in contracted section less pier width(s) (ft)

Therefore,

$$\frac{y_2}{7.49} = \left(\frac{1283.10}{1340}\right)^{\frac{6}{7}} \left(\frac{38.73}{20}\right)^{0.69} = 1.52$$

$$y_2 = (7.49') (1.52) = 11.39'$$

$$\text{and} \quad y_s = 11.39' - 8.92' = 2.47'$$

Thus, the anticipated contraction scour due to the base flood event is 2.5'.

Local Scour

Because of its concrete invert slab, the culvert is not susceptible to local pier scour.

Long-term Bed Degradation

Based on available maintenance records, there is no history of long-term bed degradation. Scour conditions observed at the culvert have remained unchanged for several years.

Total Anticipated Scour

The total anticipated scour is the summation of the contraction scour, local scour and long-term bed degradation. Based on the above calculations, the maximum total anticipated scour at the bridge is 2.5' + 0' + 0' = 2.5', which exceeds the existing cutoff wall depths for the concrete slope paving and culvert invert slab. Therefore, to prevent undermining, adequately sized rock slope protection will be placed along the channel bottom at both ends of the culvert. See further discussion under "Scour Countermeasures" below.

## SCOUR COUNTERMEASURES

The existing culvert has concrete slope paving at all four corners with 2' deep cutoff walls placed parallel and perpendicular to the flow. The culvert invert slab has 2' deep cutoff walls at the upstream and downstream ends. The concrete slope paving at the northwest corner of the bridge has full depth cracks, and the slope paving at the northeast corner is severely cracked and pulling away from the wingwall. There are small broken pieces of concrete along the channel bottom at the upstream end of the culvert which appear to have been intentionally placed.

Proposed scour countermeasures for this site include replacement of the failed concrete slope paving at the northeast corner of the bridge, and repair of cracks in the slope paving at the northwest corner of the bridge to prevent water intrusion. In addition, rock slope protection that has been sized for the maximum anticipated water velocity will be placed at the channel bottom along the length of concrete slope paving, and keyed into the channel bottom at its termination. See Figure 4 for the extents of the proposed improvements, and Figure 5 for cross-sections of the improvements.

Design of the rock slope protection is per the California Bank and Shore Rock Slope Protection Design Guide (CABS). To determine the rock slope protection design for the site, the minimum stone weight must first be calculated using CABS Chapter 5, equation 1:

$$W = \frac{0.00002\, V^6\, SG}{(SG-1)^3\, sin^3(r-a)}$$

where:

W = theoretical minimum rock weight which resists forces of flowing water and remains stable on slope of stream or river bank (lbs)

V = velocity to which bank is exposed = 1.33VM for impinging flow

VM = channel velocity, per HEC-RAS Proposed Model (ft/s) = 8.33 ft/s

SG = specific gravity of the rock = 2.65

r = 70° for randomly placed rubble

a = outside slope face angle with horizontal = 33.69° for 1V:1.5H slope

Therefore,

$$W = \frac{0.00002\,(11.07)^6\, 2.65}{(2.65-1)^3\, sin^3(70° - 33.69°)} = 104.38\ lbs$$

Rounding this value up to the nearest standard rock size yields a value of 200 lbs that correlates with the Light RSP-Class (CABS Table 5-1 Guide for Determining RSP-Class of Outside Layer). According to CABS Table 5-2 California Layered RSP, the Light RSP-Class Outside Layer requires Type "A" RSP fabric and no backing material. This is necessary to ensure that underlying layers are retained and the RSP fabric is in contact with the bank soil. According to CABS Table 5-3 Minimum Layer Thickness, the Light RSP-Class Outside Layer shall have a minimum thickness of 2.5 feet and be placed using Method "B".

In summary, the CABS California Layered RSP Design Method recommends a 2.5 feet thick layer of Light RSP-Class (200 lb) over Type "A" RSP fabric placed using Method "B". A typical cross-section of this solution is shown in Figure 4. The bridge General Plan illustrating this configuration is shown in Figure 5.

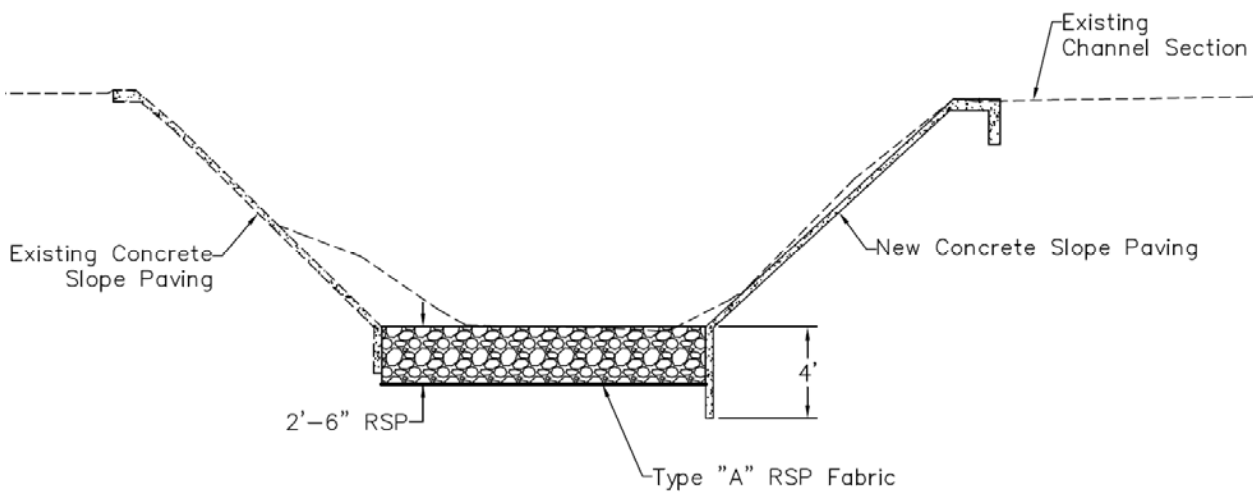



**Figure 4 – Scour Countermeasure Cross-Section**

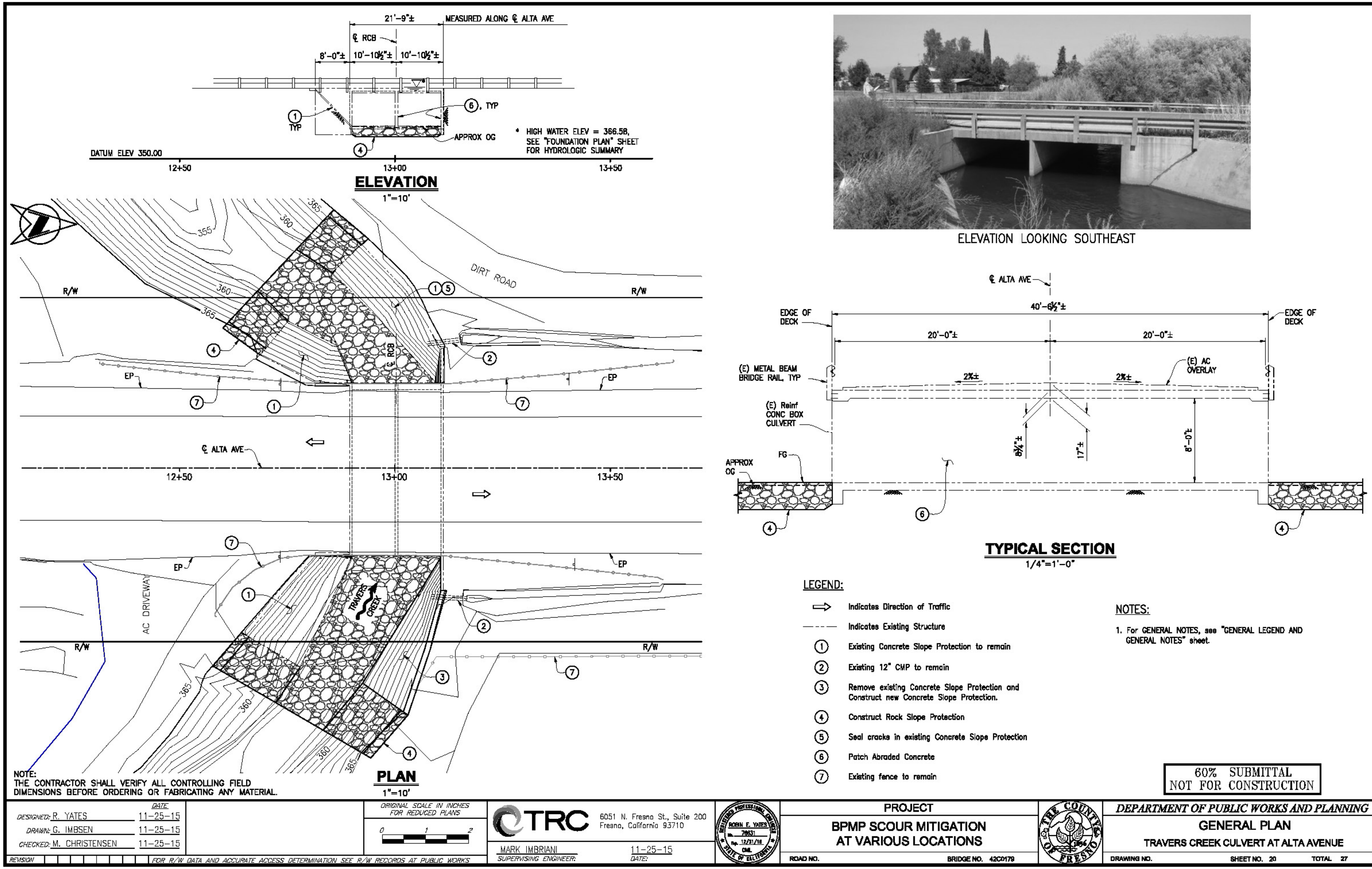



**Figure 5 - Bridge General Plan**

## CONCLUSIONS

The slope paving is shown to be undermined for calculated scour conditions, leaving the culvert vulnerable to structural instability. This project will repair the existing concrete slope paving, and the scour countermeasure includes placing adequately sized rock slope protection at the channel bottom along the length of the slope paving (approx. 25' each end of culvert). The proposed improvements are expected to slightly lower the water surface elevations at the upstream face of the culvert.

The following hydraulic data is required on the project plans:

**Hydrologic Summary**

| Frequency | 50-year | 100-year |
|---|---|---|
| Discharge (cfs) | 1,090 | 1,340 |
| Water Surface Elevation at Upstream face of culvert (ft) | 365.56 | 366.67 |

# REFERENCES

U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-RAS River Analysis System, Davis, California, Version 4.1, January 2010.

U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-RAS River Analysis System User's Manual, Davis, California, January 2010.

State of California, Department of Transportation, Local Assistance Procedures Manual, Chapter 11: Design Standards, page 17-22, January 27, 2012 (revised).

Federal Highway Administration, Office of Research and Development, Publication No. FHWA-HIF-12-003, Hydraulic Engineering Circular No. 18 – Evaluating Scour at Bridges, 5th Edition, Virginia, April 2012.

State of California, Department of Transportation, California Bank and Shore Rock Slope Protection Design Practitioner's Guide and Field Evaluations of Riprap Methods, Third Edition – Internet, October 2000.

State of California, Department of Transportation, Maintenance Records and As-Built Plans for the S. Alta Avenue Bridge over Travers Creek (Br #42C0179), 2012.

Hydrology and Hydraulic Analysis for the Replacement of the Manning Avenue Bridge over Travers Creek, Fresno County, California, Prepared for the County of Fresno, Avila and Associates Consulting Engineers, Inc., October 2014.

# APPENDIX A

# TECHNICAL MEMORANDUM

TITLED

# HYDROLOGY AND HYDRAULIC ANALYSIS FOR THE REPLACEMENT OF THE MANNING AVENUE BRIDGE OVER TRAVERS CREEK

# Technical Memorandum

**To:** Richard Sanguinetti, Biggs Cardosa Associates.

**From:** Cathy Avila, PE, Principal, Avila and Associates


**Date:** October 23, 2014

**RE:** **Hydrology and Hydraulic Analysis for the Replacement of the Manning Avenue Bridge over Travers Creek, Fresno County, California**

This memo presents the preliminary results of the hydraulic analysis for the replacement of the existing Manning Avenue Bridge over the Travers Creek. Biggs Cardosa Associates (BCA) proposed a bridge which is longer than the existing bridge with sloping abutment fills laid back at a 2:1 slope in place of the vertical abutments at the existing bridge. The General Plan for the proposed bridge was provided by BCA and is included as Appendix A. The site is located approximately 1.5 miles east of the City of Reedley, CA. The datum elevation used for this study is NAVD-88[1].

**HYDROLOGY**

Following completion of the draft June 16, 2014 memo, the hydrology was revised by WEST Consultants. This study analyzed the Travers Creek watershed with a FLO-2D model to more accurately estimate the discharge arriving at the bridge taking into account two large water conveyance structures bisecting the watershed (Friant Kern Canal and Alta Irrigation District Canal). This analysis is summarized in Appendix B. To provide a second methodology (per the LAPM) and for reference, the superseded Hydrology memo is outlined in the Travers Creek Hydrology Technical Memorandum included as Appendix C. In addition to the flood discharges, the irrigation discharges were estimated to be a "couple of hundred" cubic feet per second[2]. This discharge was also included in the analysis. The design discharges from the WEST study as shown in Table 1.

Table 1: Discharges used for design

| | Irrigation Season Flow | Channel Capacity | Design | Base |
|---|---|---|---|---|
| Frequency (Years) | | 1969 FOR | 50 | 100 |
| Discharge (Cubic feet per second) | 300 | 1,130 | 1,090 | 1,340 |

[1] E-mail from Anthony Boyes, Project Engineer, Drake Haglan and Associates, to Cathy Avila, Project Manager, Avila and Associates Consulting Engineers dated 3/27/14.
[2] Personal Conversation between Chris Kapheim, General Manager Alta Irrigation District and Cathy Avila, Project Manager, Avila and Associates Consulting Engineers dated 2/13/14.

### Hydraulics

Hydraulic parameters (water surface elevations and velocity) were obtained from the U.S. Army Corps of Engineers HEC-RAS (Hydraulic Engineering Center River Analysis System) version 4.1.0 model, based on: 1) survey information supplied by ESP Surveying on January 24, 2014, 2) as-built data provided by BCA, and 3) a field investigation conducted by Avila and Associates on February 13, 2014. Cross-sections surveyed for the HEC-RAS model are shown Figure 1:

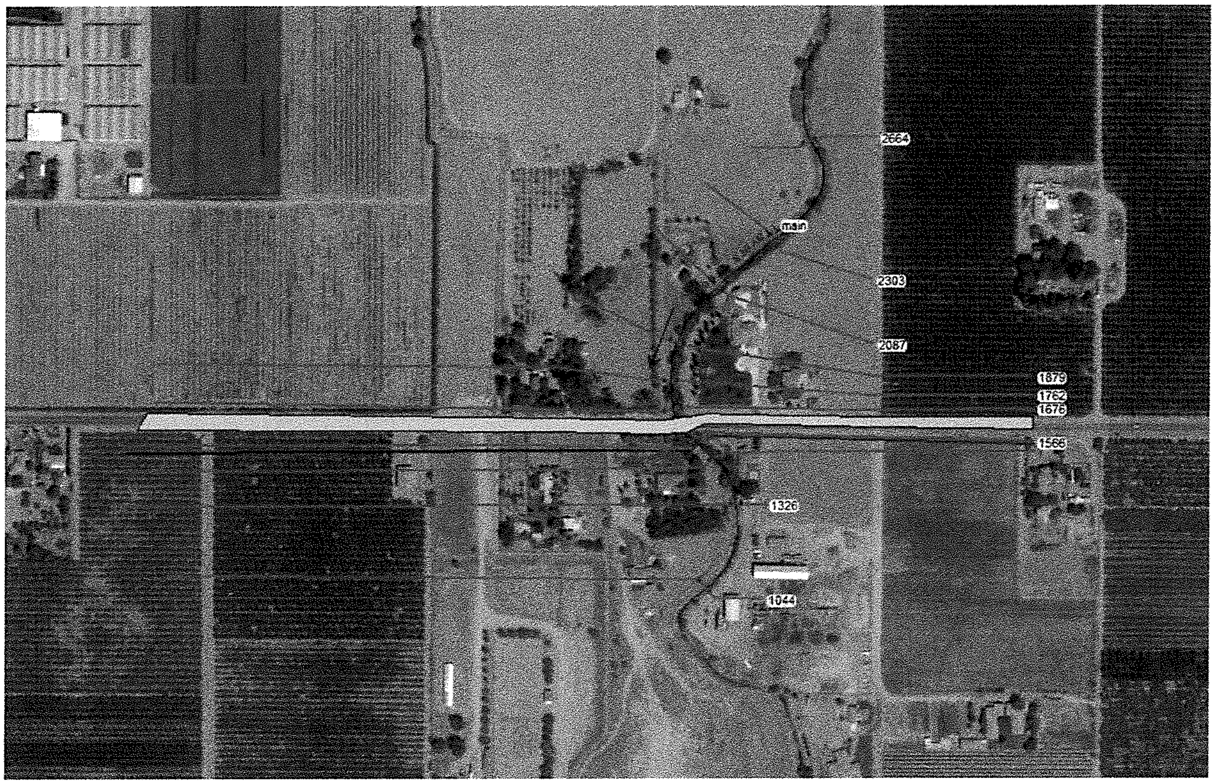



*Figure 1: Plan view of HEC-RAS cross section*

*Existing Conditions*

The Manning "n" values of 0.035 for the channel and overbanks at 0.04 were used in the model. These are consistent with the field reviews by Avila and Associates as shown in Figure 2.

The existing bridge was input into the HEC-RAS model with vertical abutments as shown in Figure 3 and Figure 4. Although the bridge currently "kinks" in the direction of flow due to a bridge widening project, HEC-RAS is unable to recreate this complex geometry and was modeled as a straight channel. The HEC-RAS model confirmed that the estimated 1969 flood of record of 1,130 (MBK, 1971) is contained in the channel but the 100-year discharge places the bridge under pressure flow.

*Figure 2: Looking downstream at the existing bridge. The channel is sparsely vegetated*

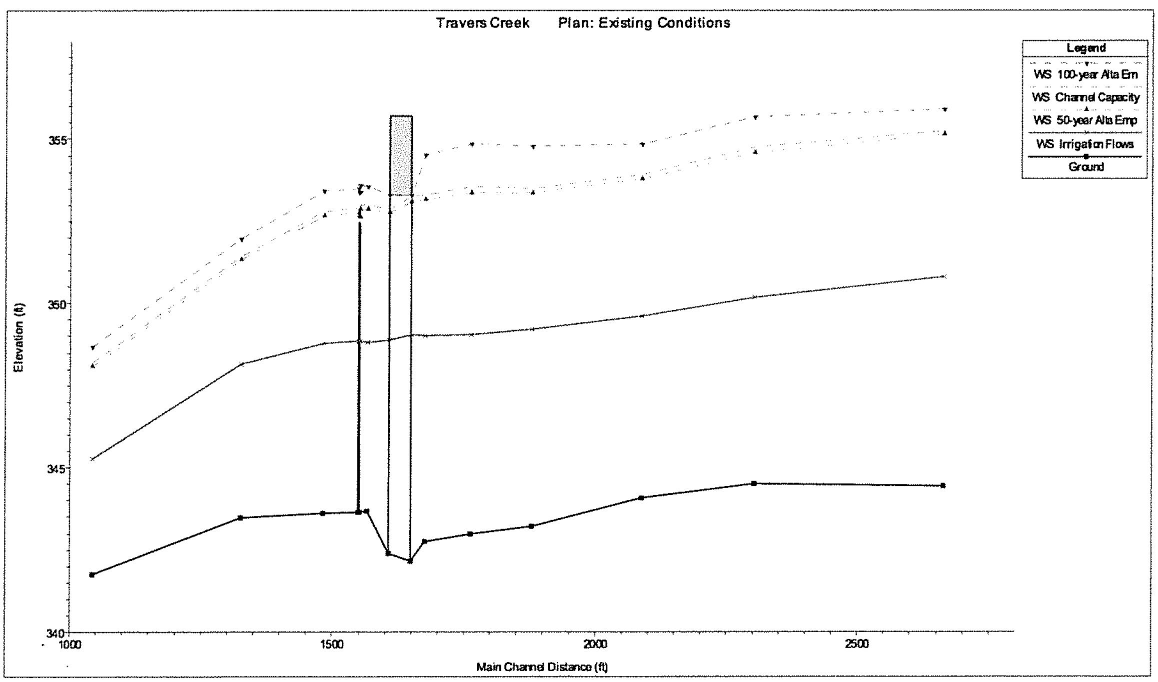



*Figure 3: Longitudinal profile of Existing Condition from HEC-RAS model*

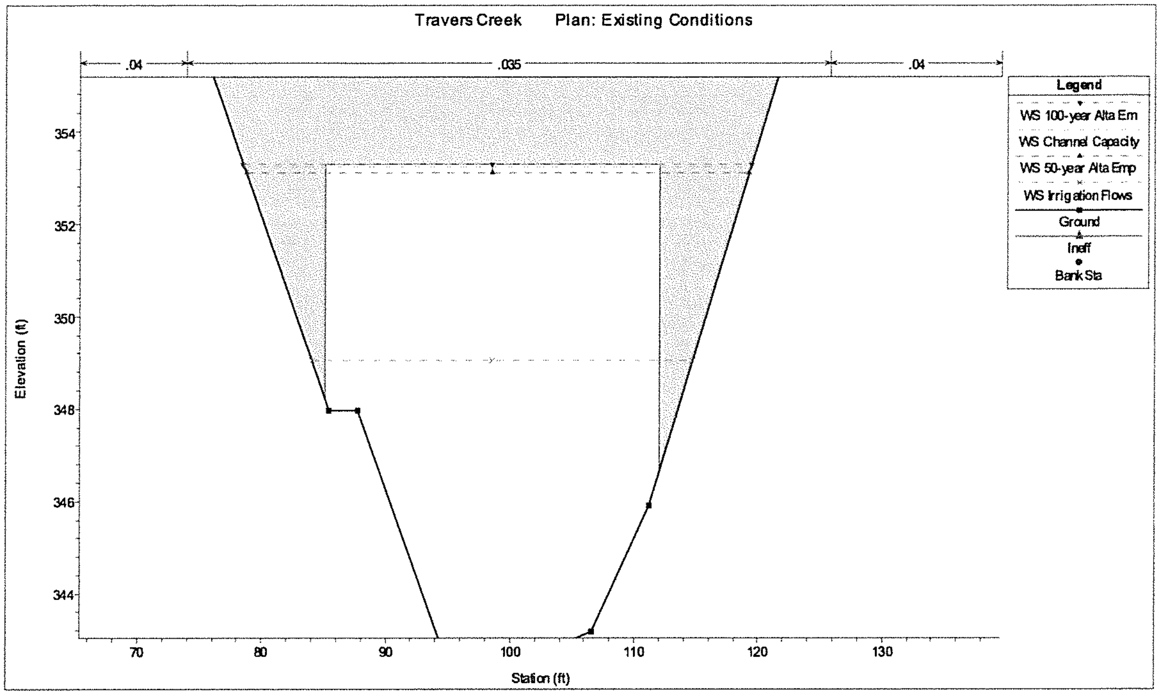



*Figure 4: Cross Section of Existing Condition from HEC-RAS model*

The HEC-RAS model was re-run by replacing the existing bridge in the model with the proposed bridge, a 60-foot long precast pre-stressed voided slab bridge as shown in Figure 5**Error! Reference source not found.**.

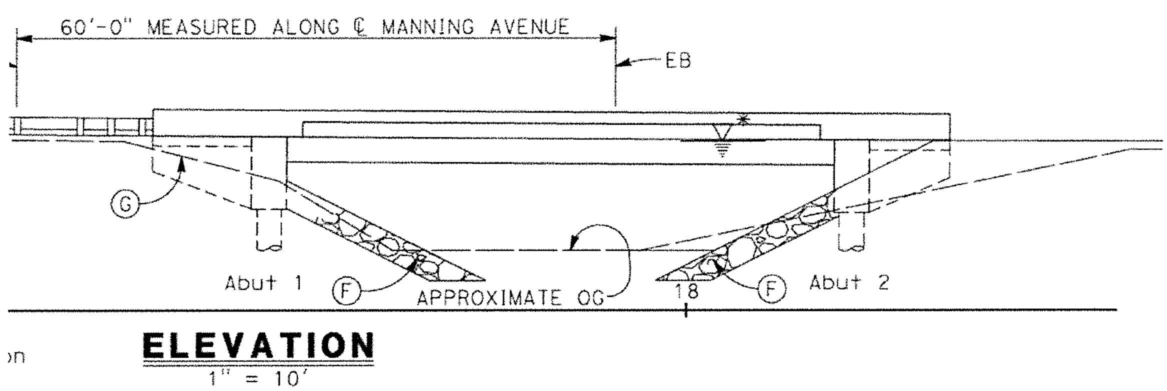



*Figure 5: Proposed bridge elevation*

The proposed bridge has sloping abutment fills as shown in Figure 6.

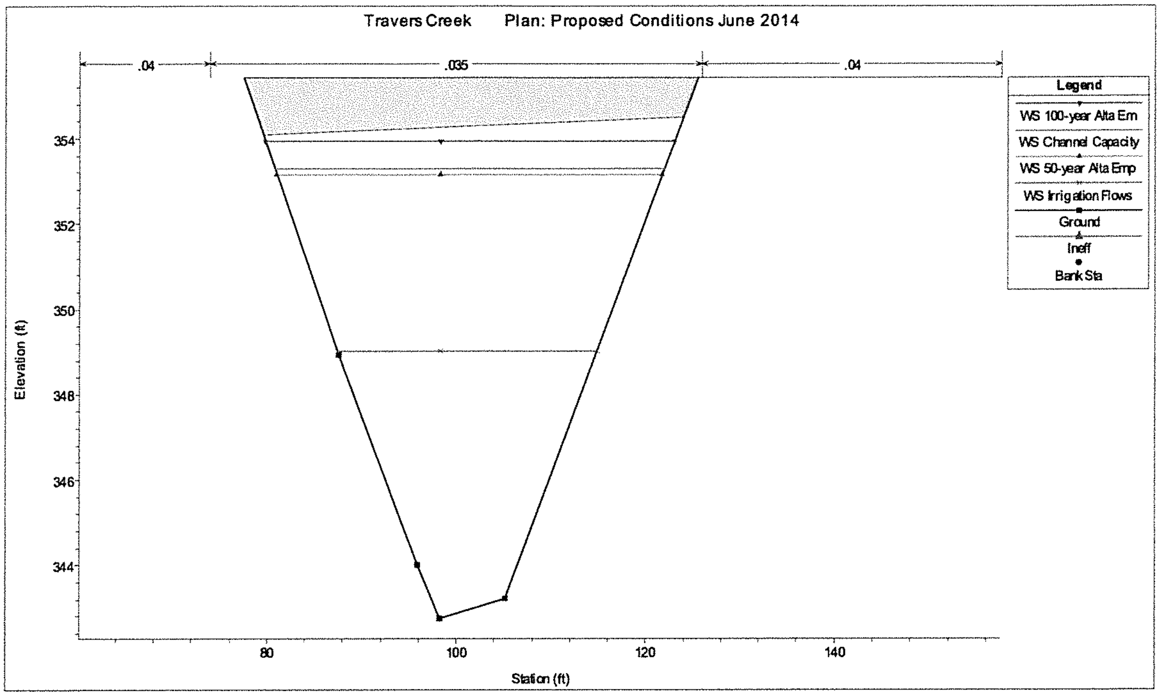



*Figure 6: Proposed Condition from HEC-RAS model*

As shown in Figure 7 and close up in Figure 8, except for a small localized area immediately downstream of the proposed bridge, the water surface elevation for the 100-year discharge is decreased by the proposed bridge and is almost unchanged for the 50-year, Flood of Record and Irrigation flows. This is due to the increase in the soffit elevation and the increase in the available channel area caused by laying back the slopes in lieu of vertical abutments.

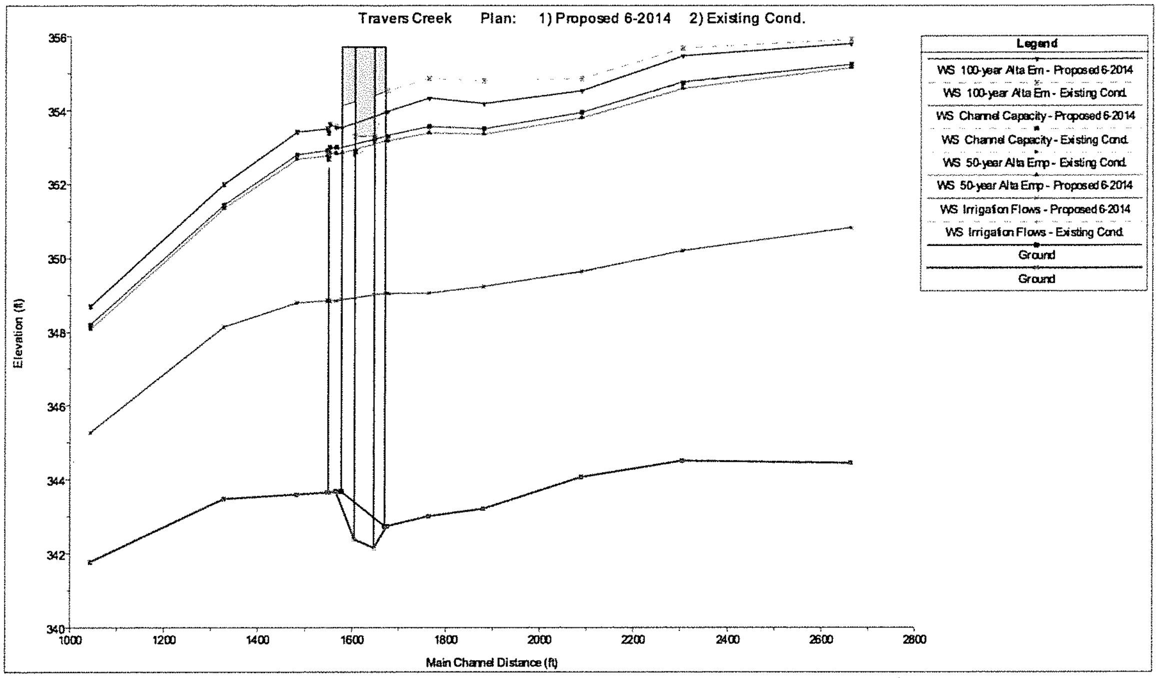



*Figure 7: Water surface elevation comparison existing vs. proposed*

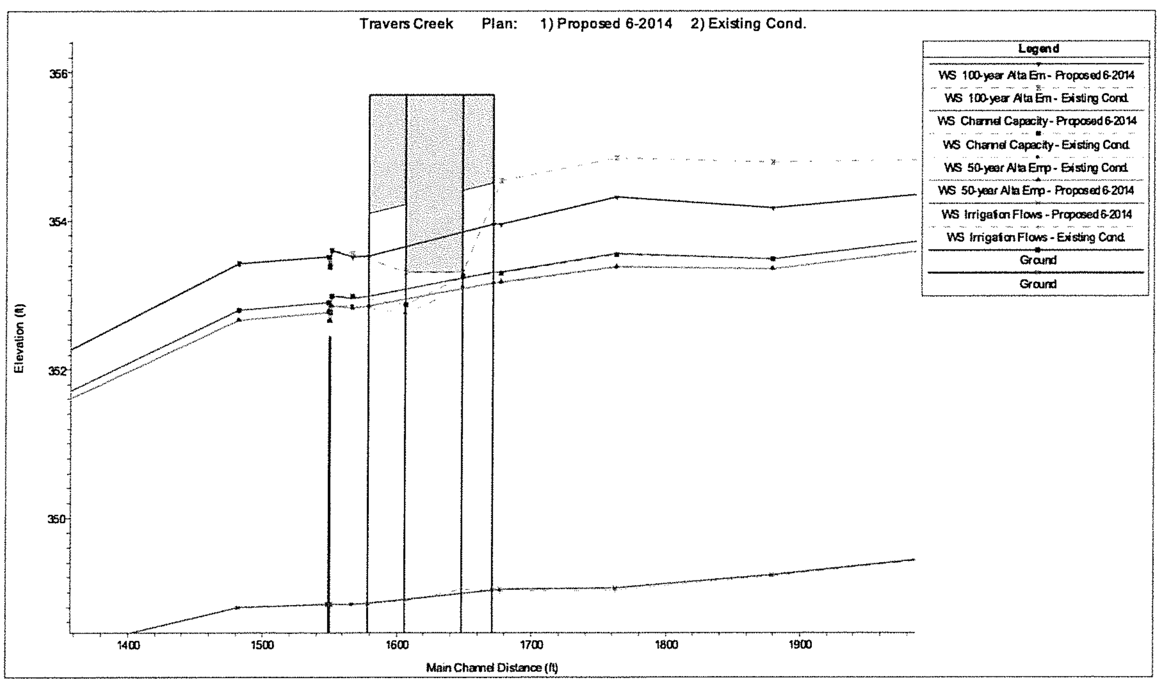



*Figure 8: Water surface elevation comparison existing vs. proposed*

As shown in Table 2, the water surface elevation decreases between existing and proposed conditions. The decrease continues upstream of the upstream limits of the model for the 100-year discharge.

Table 2: Water Surface Elevation change for 100-year discharge

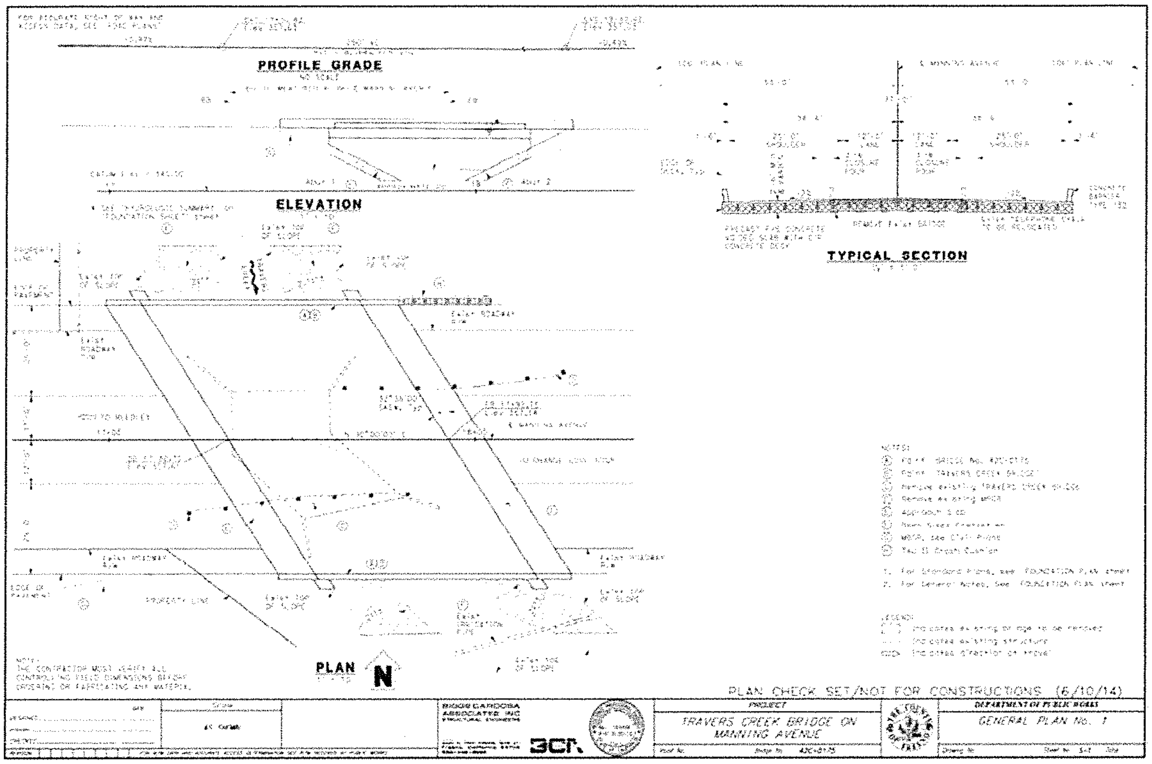
| Station | Existing WSE (ft) | Proposed WSE (ft) | Difference (ft) |
|---|---|---|---|
| 1551 | 353.6 | 353.6 | 0.0 |
| 1566 | 353.6 | 353.5 | 0.0 |
| d/s proposed 1578 | | 353.5 | |
| d/s existing 1606 | 353.3 | | |
| u/s existing 1648 | 353.3 | | |
| u/s proposed 1671 | | 354.0 | |
| 1676 | 354.5 | 354.0 | -0.6 |
| 1762 | 354.8 | 354.3 | -0.5 |
| 1879 | 354.8 | 354.2 | -0.6 |
| 2087 | 354.8 | 354.5 | -0.3 |
| 2303 | 355.7 | 355.5 | -0.2 |
| 2664 | 355.9 | 355.8 | -0.1 |

This Technical Memorandum has been prepared for the sole purpose of analyzing bridge design alternatives. Although potentially useful for other purposes, this analysis has not been prepared for any other purpose. Reuse of information contained in this report for purposes other than for which Avila and Associates Consulting Engineers, Inc. (Avila and Associates) intended and without their written authorization is not endorsed or encouraged and is at the sole risk of the entity reusing the information.

REFERENCES


1. Alta Irrigation District, 1972 "Flood Study of Drainage East of Friant Kern Canal"
2. California Department of Transportation (Caltrans), February, 1998 "Local Assistance Procedures Manual, Processing Procedures for Implementing Federal and/or State Funded local Public Transportation Projects"
3. California Department of Transportation (Caltrans), May, 2001 "Highway Design Manual Chapter 800".
4. California Department of Transportation (Caltrans), Maintenance Records and As-Built Plans for the E. Manning Avenue Bridge over Travers Creek (Br #42C0175), 2010.
5. Murry, Burns and Kienlan, Consulting Engineers Sacramento, CA, June 1971 "Flood Control Master Plan, for the County of Tulare, California".

## APPENDIX A – GENERAL PLANS



# APPENDIX B

# HEC-RAS SUMMARY FILE – EXISTING CONDITION

HEC-RAS Plan: Plan 01 River: Travers Creek Reach: Approx Creek CL

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| Approx Creek CL | 1700 | Design (50 Yr) | 1090.00 | 356.22 | 367.14 | 361.25 | 367.35 | 0.001232 | 3.65 | 298.66 | 41.82 | 0.24 |
| Approx Creek CL | 1700 | Base (100 Yr) | 1340.00 | 356.22 | 368.22 | 361.86 | 368.46 | 0.001229 | 3.90 | 343.71 | 41.82 | 0.24 |
| Approx Creek CL | 1700 | Typ Annual Irrig | 150.00 | 356.22 | 361.87 | 357.88 | 361.90 | 0.000278 | 1.29 | 116.14 | 27.73 | 0.11 |
| | | | | | | | | | | | | |
| Approx Creek CL | 1600 | Design (50 Yr) | 1090.00 | 355.14 | 367.12 | 359.68 | 367.24 | 0.000597 | 2.81 | 387.90 | 49.99 | 0.18 |
| Approx Creek CL | 1600 | Base (100 Yr) | 1340.00 | 355.14 | 368.20 | 360.26 | 368.34 | 0.000612 | 3.03 | 442.00 | 49.99 | 0.18 |
| Approx Creek CL | 1600 | Typ Annual Irrig | 150.00 | 355.14 | 361.86 | 356.55 | 361.88 | 0.000103 | 0.91 | 165.29 | 31.99 | 0.07 |
| | | | | | | | | | | | | |
| Approx Creek CL | 1500 | Design (50 Yr) | 1090.00 | 356.23 | 366.89 | 362.15 | 367.13 | 0.002123 | 3.89 | 280.48 | 61.28 | 0.32 |
| Approx Creek CL | 1500 | Base (100 Yr) | 1340.00 | 356.23 | 368.01 | 362.81 | 368.24 | 0.001615 | 3.84 | 349.04 | 61.28 | 0.28 |
| Approx Creek CL | 1500 | Typ Annual Irrig | 150.00 | 356.23 | 361.81 | 358.33 | 361.85 | 0.000558 | 1.67 | 90.02 | 25.19 | 0.16 |
| | | | | | | | | | | | | |
| Approx Creek CL | 1400 | Design (50 Yr) | 1090.00 | 356.25 | 366.70 | 362.06 | 366.94 | 0.001678 | 3.95 | 275.62 | 48.98 | 0.29 |
| Approx Creek CL | 1400 | Base (100 Yr) | 1340.00 | 356.25 | 367.83 | 362.67 | 368.09 | 0.001462 | 4.03 | 332.27 | 50.11 | 0.28 |
| Approx Creek CL | 1400 | Typ Annual Irrig | 150.00 | 356.25 | 361.76 | 358.31 | 361.80 | 0.000543 | 1.61 | 93.20 | 27.39 | 0.15 |
| | | | | | | | | | | | | |
| Approx Creek CL | 1300 | Design (50 Yr) | 1090.00 | 355.50 | 366.54 | 361.27 | 366.78 | 0.001560 | 3.87 | 281.57 | 47.63 | 0.28 |
| Approx Creek CL | 1300 | Base (100 Yr) | 1340.00 | 355.50 | 367.70 | 361.89 | 367.94 | 0.001374 | 3.98 | 336.52 | 47.63 | 0.26 |
| Approx Creek CL | 1300 | Typ Annual Irrig | 150.00 | 355.50 | 361.72 | 357.58 | 361.75 | 0.000308 | 1.35 | 111.23 | 27.48 | 0.12 |
| | | | | | | | | | | | | |
| Approx Creek CL | 1200 | Design (50 Yr) | 1090.00 | 355.62 | 366.33 | 362.02 | 366.60 | 0.001863 | 4.16 | 261.91 | 46.01 | 0.31 |
| Approx Creek CL | 1200 | Base (100 Yr) | 1340.00 | 355.62 | 367.51 | 362.63 | 367.79 | 0.001594 | 4.24 | 316.20 | 46.01 | 0.28 |
| Approx Creek CL | 1200 | Typ Annual Irrig | 150.00 | 355.62 | 361.67 | 357.98 | 361.71 | 0.000569 | 1.63 | 92.02 | 27.09 | 0.16 |
| | | | | | | | | | | | | |
| Approx Creek CL | 1100 | Design (50 Yr) | 1090.00 | 355.38 | 366.10 | 361.50 | 366.41 | 0.001949 | 4.47 | 243.90 | 38.73 | 0.31 |
| Approx Creek CL | 1100 | Base (100 Yr) | 1340.00 | 355.38 | 367.29 | 362.15 | 367.62 | 0.001771 | 4.62 | 289.99 | 38.73 | 0.30 |
| Approx Creek CL | 1100 | Typ Annual Irrig | 150.00 | 355.38 | 361.63 | 357.62 | 361.66 | 0.000387 | 1.49 | 100.71 | 25.35 | 0.13 |
| | | | | | | | | | | | | |
| Approx Creek CL | 1064 | Design (50 Yr) | 1090.00 | 357.03 | 365.65 | 361.97 | 366.27 | 0.004743 | 6.34 | 171.85 | 21.88 | 0.40 |
| Approx Creek CL | 1064 | Base (100 Yr) | 1340.00 | 357.03 | 366.75 | 362.61 | 367.48 | 0.004985 | 6.83 | 196.17 | 22.00 | 0.40 |
| Approx Creek CL | 1064 | Typ Annual Irrig | 150.00 | 357.03 | 361.59 | 358.74 | 361.64 | 0.000692 | 1.78 | 84.31 | 21.29 | 0.16 |
| | | | | | | | | | | | | |
| Approx Creek CL | 1063.57 | | Culvert | | | | | | | | | |
| | | | | | | | | | | | | |
| Approx Creek CL | 1022 | Design (50 Yr) | 1090.00 | 357.24 | 365.06 | 361.91 | 365.77 | 0.005641 | 6.76 | 161.17 | 22.24 | 0.44 |
| Approx Creek CL | 1022 | Base (100 Yr) | 1340.00 | 357.24 | 365.91 | 362.56 | 366.77 | 0.006278 | 7.45 | 179.98 | 22.48 | 0.46 |
| Approx Creek CL | 1022 | Typ Annual Irrig | 150.00 | 357.24 | 361.56 | 358.68 | 361.61 | 0.000675 | 1.77 | 84.91 | 21.35 | 0.16 |
| | | | | | | | | | | | | |
| Approx Creek CL | 1000 | Design (50 Yr) | 1090.00 | 356.59 | 365.00 | 362.43 | 365.64 | 0.004923 | 6.38 | 170.72 | 31.30 | 0.48 |
| Approx Creek CL | 1000 | Base (100 Yr) | 1340.00 | 356.59 | 365.90 | 363.06 | 366.59 | 0.004944 | 6.71 | 199.66 | 34.00 | 0.49 |
| Approx Creek CL | 1000 | Typ Annual Irrig | 150.00 | 356.59 | 361.53 | 358.86 | 361.59 | 0.000876 | 1.97 | 76.16 | 23.16 | 0.19 |
| | | | | | | | | | | | | |
| Approx Creek CL | 900 | Design (50 Yr) | 1090.00 | 354.55 | 364.83 | 360.88 | 365.21 | 0.002603 | 5.00 | 218.17 | 36.42 | 0.36 |
| Approx Creek CL | 900 | Base (100 Yr) | 1340.00 | 354.55 | 365.72 | 361.55 | 366.17 | 0.002620 | 5.33 | 251.38 | 37.14 | 0.36 |
| Approx Creek CL | 900 | Typ Annual Irrig | 150.00 | 354.55 | 361.51 | 356.83 | 361.53 | 0.000285 | 1.32 | 113.29 | 26.70 | 0.11 |
| | | | | | | | | | | | | |
| Approx Creek CL | 800 | Design (50 Yr) | 1090.00 | 353.70 | 364.66 | 360.27 | 364.95 | 0.002104 | 4.37 | 249.23 | 44.40 | 0.33 |
| Approx Creek CL | 800 | Base (100 Yr) | 1340.00 | 353.70 | 365.57 | 360.98 | 365.90 | 0.002037 | 4.60 | 291.07 | 45.90 | 0.32 |
| Approx Creek CL | 800 | Typ Annual Irrig | 150.00 | 353.70 | 361.49 | 356.13 | 361.51 | 0.000211 | 1.15 | 130.10 | 30.15 | 0.10 |
| | | | | | | | | | | | | |
| Approx Creek CL | 700 | Design (50 Yr) | 1090.00 | 355.68 | 364.30 | 360.83 | 364.70 | 0.002892 | 5.07 | 215.09 | 39.47 | 0.38 |
| Approx Creek CL | 700 | Base (100 Yr) | 1340.00 | 355.68 | 365.22 | 361.44 | 365.65 | 0.002820 | 5.30 | 252.89 | 41.95 | 0.38 |
| Approx Creek CL | 700 | Typ Annual Irrig | 150.00 | 355.68 | 361.46 | 357.33 | 361.48 | 0.000268 | 1.27 | 118.42 | 29.48 | 0.11 |
| | | | | | | | | | | | | |
| Approx Creek CL | 600 | Design (50 Yr) | 1090.00 | 354.00 | 364.25 | 359.03 | 364.46 | 0.001230 | 3.68 | 296.01 | 45.64 | 0.25 |
| Approx Creek CL | 600 | Base (100 Yr) | 1340.00 | 354.00 | 365.17 | 359.61 | 365.41 | 0.001260 | 3.96 | 338.51 | 46.70 | 0.26 |
| Approx Creek CL | 600 | Typ Annual Irrig | 150.00 | 354.00 | 361.45 | 355.91 | 361.47 | 0.000085 | 0.82 | 182.56 | 36.48 | 0.06 |
| | | | | | | | | | | | | |
| Approx Creek CL | 500 | Design (50 Yr) | 1090.00 | 354.81 | 363.75 | 360.67 | 364.24 | 0.003634 | 5.57 | 195.54 | 36.55 | 0.42 |
| Approx Creek CL | 500 | Base (100 Yr) | 1340.00 | 354.81 | 364.65 | 361.30 | 365.17 | 0.004389 | 5.78 | 231.93 | 48.31 | 0.46 |
| Approx Creek CL | 500 | Typ Annual Irrig | 150.00 | 354.81 | 361.43 | 357.05 | 361.45 | 0.000252 | 1.25 | 120.08 | 28.85 | 0.11 |
| | | | | | | | | | | | | |
| Approx Creek CL | 400 | Design (50 Yr) | 1090.00 | 355.21 | 363.25 | 360.72 | 363.82 | 0.004609 | 6.08 | 179.26 | 35.41 | 0.48 |
| Approx Creek CL | 400 | Base (100 Yr) | 1340.00 | 355.21 | 364.05 | 361.34 | 364.68 | 0.005171 | 6.41 | 209.05 | 42.03 | 0.51 |
| Approx Creek CL | 400 | Typ Annual Irrig | 150.00 | 355.21 | 361.40 | 357.25 | 361.42 | 0.000261 | 1.25 | 119.69 | 29.67 | 0.11 |

# Culvert Only Output File

HEC-RAS Plan: Plan 01 River: Travers Creek Reach: Approx Creek CL

| Reach | River Sta | Profile | E.G. US. | W.S. US. | E.G. IC | E.G. OC | Min El Weir Flow | Q Culv Group | Q Weir | Delta WS | Culv Vel US | Culv Vel DS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (ft) | (ft) | (ft) | (ft) | (ft) | (cfs) | (cfs) | (ft) | (ft/s) | (ft/s) |
| Approx Creek CL | 1063.57 Culvert #1 | Design (50 Yr) | 366.27 | 365.65 | 364.95 | 366.27 | 366.38 | 1090.00 | | 0.58 | 7.33 | 7.33 |
| Approx Creek CL | 1063.57 Culvert #1 | Base (100 Yr) | 367.48 | 366.75 | 366.07 | 367.48 | 366.38 | 1283.10 | 56.90 | 0.85 | 8.30 | 8.30 |
| Approx Creek CL | 1063.57 Culvert #1 | Typ Annual Irrig | 361.64 | 361.59 | 359.54 | 361.64 | 366.38 | 150.00 | | 0.03 | 1.93 | 1.91 |

# APPENDIX C

# HEC-RAS SUMMARY FILE – PROPOSED CONDITION

HEC-RAS Plan: Plan 01 River: Travers Creek Reach: Approx Creek CL

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| Approx Creek CL | 1500 | Design (50 Yr) | 1090.00 | 356.23 | 366.91 | 362.15 | 367.15 | 0.002094 | 3.87 | 281.72 | 61.28 | 0.32 |
| Approx Creek CL | 1500 | Base (100 Yr) | 1340.00 | 356.23 | 368.04 | 362.81 | 368.26 | 0.001596 | 3.82 | 350.42 | 61.28 | 0.28 |
| Approx Creek CL | 1500 | Typ Annual Irrig | 150.00 | 356.23 | 361.83 | 358.33 | 361.88 | 0.000548 | 1.66 | 90.62 | 25.27 | 0.15 |
| | | | | | | | | | | | | |
| Approx Creek CL | 1400 | Design (50 Yr) | 1090.00 | 356.25 | 366.72 | 362.07 | 366.96 | 0.001658 | 3.94 | 276.73 | 49.02 | 0.29 |
| Approx Creek CL | 1400 | Base (100 Yr) | 1340.00 | 356.25 | 367.86 | 362.67 | 368.11 | 0.001446 | 4.02 | 333.49 | 50.11 | 0.27 |
| Approx Creek CL | 1400 | Typ Annual Irrig | 150.00 | 356.25 | 361.78 | 358.30 | 361.82 | 0.000533 | 1.60 | 93.88 | 27.48 | 0.15 |
| | | | | | | | | | | | | |
| Approx Creek CL | 1300 | Design (50 Yr) | 1090.00 | 355.50 | 366.57 | 361.25 | 366.80 | 0.001540 | 3.86 | 282.73 | 47.63 | 0.28 |
| Approx Creek CL | 1300 | Base (100 Yr) | 1340.00 | 355.50 | 367.72 | 361.90 | 367.97 | 0.001359 | 3.97 | 337.75 | 47.63 | 0.26 |
| Approx Creek CL | 1300 | Typ Annual Irrig | 150.00 | 355.50 | 361.75 | 357.58 | 361.78 | 0.000302 | 1.34 | 111.93 | 27.55 | 0.12 |
| | | | | | | | | | | | | |
| Approx Creek CL | 1200 | Design (50 Yr) | 1090.00 | 355.62 | 366.36 | 362.02 | 366.63 | 0.001836 | 4.14 | 263.18 | 46.01 | 0.31 |
| Approx Creek CL | 1200 | Base (100 Yr) | 1340.00 | 355.62 | 367.54 | 362.63 | 367.82 | 0.001574 | 4.22 | 317.49 | 46.01 | 0.28 |
| Approx Creek CL | 1200 | Typ Annual Irrig | 150.00 | 355.62 | 361.70 | 357.98 | 361.74 | 0.000557 | 1.62 | 92.73 | 27.19 | 0.15 |
| | | | | | | | | | | | | |
| Approx Creek CL | 1100 | Design (50 Yr) | 1090.00 | 355.38 | 366.13 | 361.50 | 366.43 | 0.001922 | 4.45 | 245.07 | 38.73 | 0.31 |
| Approx Creek CL | 1100 | Base (100 Yr) | 1340.00 | 355.38 | 367.32 | 362.15 | 367.65 | 0.001750 | 4.60 | 291.16 | 38.73 | 0.30 |
| Approx Creek CL | 1100 | Typ Annual Irrig | 150.00 | 355.38 | 361.66 | 357.62 | 361.69 | 0.000380 | 1.48 | 101.40 | 25.42 | 0.13 |
| | | | | | | | | | | | | |
| Approx Creek CL | 1098.57* | Design (50 Yr) | 1090.00 | 355.47 | 366.11 | 361.70 | 366.43 | 0.002481 | 4.53 | 240.86 | 38.07 | 0.32 |
| Approx Creek CL | 1098.57* | Base (100 Yr) | 1340.00 | 355.47 | 367.30 | 362.34 | 367.64 | 0.002262 | 4.68 | 286.12 | 38.07 | 0.30 |
| Approx Creek CL | 1098.57* | Typ Annual Irrig | 150.00 | 355.47 | 361.65 | 357.90 | 361.69 | 0.000540 | 1.55 | 97.08 | 25.50 | 0.14 |
| | | | | | | | | | | | | |
| Approx Creek CL | 1088.57 | Design (50 Yr) | 1090.00 | 356.11 | 365.96 | 362.80 | 366.40 | 0.001492 | 5.33 | 204.59 | 33.42 | 0.38 |
| Approx Creek CL | 1088.57 | Base (100 Yr) | 1340.00 | 356.11 | 367.15 | 363.40 | 367.61 | 0.001340 | 5.49 | 244.23 | 33.42 | 0.36 |
| Approx Creek CL | 1088.57 | Typ Annual Irrig | 150.00 | 356.11 | 361.61 | 358.54 | 361.68 | 0.000602 | 2.14 | 70.17 | 24.70 | 0.22 |
| | | | | | | | | | | | | |
| Approx Creek CL | 1064 | Design (50 Yr) | 1090.00 | 357.67 | 365.56 | 362.08 | 366.22 | 0.002250 | 6.50 | 167.67 | 21.87 | 0.41 |
| Approx Creek CL | 1064 | Base (100 Yr) | 1340.00 | 357.67 | 366.67 | 362.73 | 367.43 | 0.002339 | 6.98 | 192.09 | 22.00 | 0.42 |
| Approx Creek CL | 1064 | Typ Annual Irrig | 150.00 | 357.67 | 361.58 | 358.85 | 361.63 | 0.000336 | 1.83 | 81.76 | 21.28 | 0.16 |
| | | | | | | | | | | | | |
| Approx Creek CL | 1063.57 | | Culvert | | | | | | | | | |
| | | | | | | | | | | | | |
| Approx Creek CL | 1022 | Design (50 Yr) | 1090.00 | 357.63 | 364.98 | 362.04 | 365.73 | 0.002706 | 6.95 | 156.81 | 22.22 | 0.46 |
| Approx Creek CL | 1022 | Base (100 Yr) | 1340.00 | 357.63 | 365.85 | 362.68 | 366.75 | 0.002963 | 7.61 | 176.07 | 22.47 | 0.48 |
| Approx Creek CL | 1022 | Typ Annual Irrig | 150.00 | 357.63 | 361.55 | 358.81 | 361.60 | 0.000331 | 1.83 | 82.15 | 21.35 | 0.16 |
| | | | | | | | | | | | | |
| Approx Creek CL | 1000 | Design (50 Yr) | 1090.00 | 356.59 | 365.02 | 362.43 | 365.65 | 0.002174 | 6.37 | 171.12 | 31.33 | 0.48 |
| Approx Creek CL | 1000 | Base (100 Yr) | 1340.00 | 356.59 | 365.93 | 363.06 | 366.62 | 0.002219 | 6.67 | 201.01 | 34.98 | 0.49 |
| Approx Creek CL | 1000 | Typ Annual Irrig | 150.00 | 356.59 | 361.53 | 358.86 | 361.59 | 0.000388 | 1.97 | 76.25 | 23.17 | 0.19 |
| | | | | | | | | | | | | |
| Approx Creek CL | 997.56 | Design (50 Yr) | 1090.00 | 356.54 | 365.01 | 362.40 | 365.64 | 0.005980 | 6.35 | 171.75 | 31.44 | 0.48 |
| Approx Creek CL | 997.56 | Base (100 Yr) | 1340.00 | 356.54 | 365.93 | 363.05 | 366.62 | 0.006198 | 6.64 | 201.82 | 35.64 | 0.49 |
| Approx Creek CL | 997.56 | Typ Annual Irrig | 150.00 | 356.54 | 361.53 | 358.85 | 361.59 | 0.001063 | 1.96 | 76.63 | 23.26 | 0.19 |
| | | | | | | | | | | | | |
| Approx Creek CL | 987.558* | Design (50 Yr) | 1090.00 | 356.34 | 364.97 | 362.34 | 365.58 | 0.004706 | 6.27 | 173.79 | 31.91 | 0.47 |
| Approx Creek CL | 987.558* | Base (100 Yr) | 1340.00 | 356.34 | 365.89 | 362.96 | 366.55 | 0.005415 | 6.53 | 205.07 | 40.21 | 0.51 |
| Approx Creek CL | 987.558* | Typ Annual Irrig | 150.00 | 356.34 | 361.52 | 358.79 | 361.58 | 0.000813 | 1.92 | 78.23 | 23.60 | 0.19 |
| | | | | | | | | | | | | |
| Approx Creek CL | 900 | Design (50 Yr) | 1090.00 | 354.55 | 364.83 | 360.88 | 365.21 | 0.002603 | 5.00 | 218.17 | 36.42 | 0.36 |
| Approx Creek CL | 900 | Base (100 Yr) | 1340.00 | 354.55 | 365.72 | 361.55 | 366.17 | 0.002620 | 5.33 | 251.38 | 37.14 | 0.36 |
| Approx Creek CL | 900 | Typ Annual Irrig | 150.00 | 354.55 | 361.51 | 356.83 | 361.53 | 0.000285 | 1.32 | 113.29 | 26.70 | 0.11 |
| | | | | | | | | | | | | |
| Approx Creek CL | 800 | Design (50 Yr) | 1090.00 | 353.70 | 364.66 | 360.27 | 364.95 | 0.002104 | 4.37 | 249.23 | 44.40 | 0.33 |
| Approx Creek CL | 800 | Base (100 Yr) | 1340.00 | 353.70 | 365.57 | 360.98 | 365.90 | 0.002037 | 4.60 | 291.07 | 45.90 | 0.32 |
| Approx Creek CL | 800 | Typ Annual Irrig | 150.00 | 353.70 | 361.49 | 356.13 | 361.51 | 0.000211 | 1.15 | 130.10 | 30.15 | 0.10 |
| | | | | | | | | | | | | |
| Approx Creek CL | 700 | Design (50 Yr) | 1090.00 | 355.68 | 364.30 | 360.83 | 364.70 | 0.002892 | 5.07 | 215.09 | 39.47 | 0.38 |
| Approx Creek CL | 700 | Base (100 Yr) | 1340.00 | 355.68 | 365.22 | 361.44 | 365.65 | 0.002820 | 5.30 | 252.89 | 41.95 | 0.38 |
| Approx Creek CL | 700 | Typ Annual Irrig | 150.00 | 355.68 | 361.46 | 357.33 | 361.48 | 0.000268 | 1.27 | 118.42 | 29.48 | 0.11 |
| | | | | | | | | | | | | |
| Approx Creek CL | 600 | Design (50 Yr) | 1090.00 | 354.00 | 364.25 | 359.03 | 364.46 | 0.001230 | 3.68 | 296.01 | 45.64 | 0.25 |
| Approx Creek CL | 600 | Base (100 Yr) | 1340.00 | 354.00 | 365.17 | 359.61 | 365.41 | 0.001260 | 3.96 | 338.51 | 46.70 | 0.26 |
| Approx Creek CL | 600 | Typ Annual Irrig | 150.00 | 354.00 | 361.45 | 355.91 | 361.47 | 0.000085 | 0.82 | 182.56 | 36.48 | 0.06 |

# Culvert Only Output Table

HEC-RAS Plan: Plan 01 River: Travers Creek Reach: Approx Creek CL

| Reach | River Sta | Profile | E.G. US. | W.S. US. | E.G. IC | E.G. OC | Min El Weir Flow | Q Culv Group | Q Weir | Delta WS | Culv Vel US | Culv Vel DS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (ft) | (ft) | (ft) | (ft) | (ft) | (cfs) | (cfs) | (ft) | (ft/s) | (ft/s) |
| Approx Creek CL | 1063.57 Culvert #1 | Design (50 Yr) | 366.22 | 365.56 | 364.95 | 366.22 | 366.38 | 1090.00 | | 0.58 | 7.41 | 7.41 |
| Approx Creek CL | 1063.57 Culvert #1 | Base (100 Yr) | 367.43 | 366.67 | 366.07 | 367.43 | 366.38 | 1287.13 | 52.87 | 0.83 | 8.33 | 8.33 |
| Approx Creek CL | 1063.57 Culvert #1 | Typ Annual Irrig | 361.63 | 361.58 | 359.54 | 361.63 | 366.38 | 150.00 | | 0.03 | 1.93 | 1.91 |

# APPENDIX D

# GEOTECHNICAL DESIGN MEMORANDUM

February 16, 2015
File No. 20152738

Ms. Robin Yates
**TRC Engineers Inc.**
6051 N. Fresno Street, Suite 200
Fresno, California 93710

**SUBJECT: Geotechnical Design Memorandum
Fresno BPMP Scour Countermeasure Project
Alta Avenue at Travers Creek (Bridge No. 42C0179)
Fresno County, California**

Dear Ms. Yates:

This letter presents the results of the geotechnical investigation for the proposed Fresno BPMP Scour Countermeasure project for the subject location in Fresno County, California. This letter describes the study, findings, conclusions, and recommendations for use in project design.

Kleinfelder appreciates the opportunity to provide geotechnical engineering services during the design phase of this project. If there are any questions concerning the information presented in this letter, please contact this office at your convenience.

## PROJECT DESCRIPTION

Understanding of the project is based upon discussions with representatives of TRC Engineers Inc. It is understood the project will consist of a scour evaluation at the Alta Avenue at Travers Creek bridge (Bridge No. 42C0179) location.

## FIELD EXPLORATION

Field exploration included one (1) hand auger boring at the bridge site, which was performed on September 26, 2014. The boring was advanced to a depth of 3 feet below the existing creek bed.

The soil encountered in the hand auger boring was visually classified in the field and a continuous log was recorded. A bulk sample was obtained from the auger cuttings at the obtained depth. Upon completion, the exploration location was backfilled with soil cuttings. The bulk sample was transported back to our Fresno Lab for testing.



5125 North Gates Avenue, Suite 102, Fresno, CA 3722 **p|** 559-486-0750 **f|** 559-442-5081

## LABORATORY TESTING

Kleinfelder performed laboratory tests on the selected sample to evaluate certain physical characteristics that will be necessary to assist TRC in their analysis. The laboratory test performed was a grain-size distribution. Results are shown on Figure 6.

## SITE CONDITIONS AND SUBSURFACE SOILS ENCOUNTERED

The banks and bottom of the creek supported dense vegetation, with rip rap on the west and lined with concrete adjacent to the bridge.

The following description provides a general summary of the subsurface soil conditions encountered during the field exploration and further verified by the laboratory testing program. For a more thorough description of the actual conditions encountered at the specific boring location, refer to the boring log presented in Figure 5. All soils have been classified in general accordance with the Unified Soil Classification System (ASTM D2487).

The earth material at the site generally consists of silty sand (SM) to the maximum exploration depth of 3 feet. The exploration was terminated at a depth of 3 feet due to practical auger refusal.

## SCOUR POTENTIAL

The mean grain size ($D_{50}$) and 90% passing grain size ($D_{90}$) of the soil anticipated to be exposed in the channel is about 0.24 mm and 2.0 mm, respectively.

Should the scour exceed the expected limits, mitigation measures, such as rip rap, may be used.

## LIMITATIONS

Recommendations contained in this letter are based on the field observations and subsurface explorations, laboratory tests, and present knowledge of the proposed project. It is possible that soil conditions could vary between or beyond the points explored. Additional soil exploration may be necessary if better definition of any conditions is desired. If the scope of the proposed improvements changes from that described in this letter, the recommendations provided should also be reviewed.

This letter has been prepared in substantial accordance with the generally accepted geotechnical engineering practice, as it exists in the general area at the time of the study. No warranty, express or implied, is provided or intended. The preliminary recommendations provided in this letter are based on the assumption that Kleinfelder will conduct an adequate program of tests and observations during additional phases of the project in order to evaluate compliance with the recommendations.

This letter may be used only by Fresno County, TRC Engineers Inc., other project subconsultants and reviewing regulatory agencies and only for the purposes stated within a

February 16, 2015
File No. 20152738

Ms. Robin Yates
**TRC Engineers Inc.**
6051 N. Fresno Street, Suite 200
Fresno, California 93710

**SUBJECT: Geotechnical Design Memorandum**
**Fresno BPMP Scour Countermeasure Project**
**Alta Avenue at Travers Creek (Bridge No. 42C0179)**
**Fresno County, California**

Dear Ms. Yates:

This letter presents the results of the geotechnical investigation for the proposed Fresno BPMP Scour Countermeasure project for the subject location in Fresno County, California. This letter describes the study, findings, conclusions, and recommendations for use in project design.

Kleinfelder appreciates the opportunity to provide geotechnical engineering services during the design phase of this project. If there are any questions concerning the information presented in this letter, please contact this office at your convenience.

## PROJECT DESCRIPTION

Understanding of the project is based upon discussions with representatives of TRC Engineers Inc. It is understood the project will consist of a scour evaluation at the Alta Avenue at Travers Creek bridge (Bridge No. 42C0179) location.

## FIELD EXPLORATION

Field exploration included one (1) hand auger boring at the bridge site, which was performed on September 26, 2014. The boring was advanced to a depth of 3 feet below the existing creek bed.

The soil encountered in the hand auger boring was visually classified in the field and a continuous log was recorded. A bulk sample was obtained from the auger cuttings at the obtained depth. Upon completion, the exploration location was backfilled with soil cuttings. The bulk sample was transported back to our Fresno Lab for testing.



5125 North Gates Avenue, Suite 102, Fresno, CA 3722 **p|** 559-486-0750 **f|** 559-442-5081

## LABORATORY TESTING

Kleinfelder performed laboratory tests on the selected sample to evaluate certain physical characteristics that will be necessary to assist TRC in their analysis. The laboratory test performed was a grain-size distribution. Results are shown on Figure 6.

## SITE CONDITIONS AND SUBSURFACE SOILS ENCOUNTERED

The banks and bottom of the creek supported dense vegetation, with rip rap on the west and lined with concrete adjacent to the bridge.

The following description provides a general summary of the subsurface soil conditions encountered during the field exploration and further verified by the laboratory testing program. For a more thorough description of the actual conditions encountered at the specific boring location, refer to the boring log presented in Figure 5. All soils have been classified in general accordance with the Unified Soil Classification System (ASTM D2487).

The earth material at the site generally consists of silty sand (SM) to the maximum exploration depth of 3 feet. The exploration was terminated at a depth of 3 feet due to practical auger refusal.

## SCOUR POTENTIAL

The mean grain size ($D_{50}$) and 90% passing grain size ($D_{90}$) of the soil anticipated to be exposed in the channel is about 0.24 mm and 2.0 mm, respectively.

Should the scour exceed the expected limits, mitigation measures, such as rip rap, may be used.

## LIMITATIONS

Recommendations contained in this letter are based on the field observations and subsurface explorations, laboratory tests, and present knowledge of the proposed project. It is possible that soil conditions could vary between or beyond the points explored. Additional soil exploration may be necessary if better definition of any conditions is desired. If the scope of the proposed improvements changes from that described in this letter, the recommendations provided should also be reviewed.

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This letter may be used only by Fresno County, TRC Engineers Inc., other project subconsultants and reviewing regulatory agencies and only for the purposes stated within a reasonable time from its issuance. Land use, site conditions or other factors may change over time, and additional work may be required with the passage of time. Any other party who wishes to use this letter shall notify Kleinfelder of such intended use. Based on the intended use of the letter, Kleinfelder may require that additional work be performed and that an updated letter be issued. Non-compliance with any of these requirements by the client or anyone else will release Kleinfelder from any liability resulting from the misuse of this letter by any unauthorized party.

**CLOSING**

We appreciate the opportunity to provide geotechnical engineering services to TRC Engineers Inc. and Fresno County. We trust this information meets your current needs. If there are any questions concerning the information presented in this letter, please contact this office at your convenience.

Respectfully Submitted,

**KLEINFELDER, INC.**

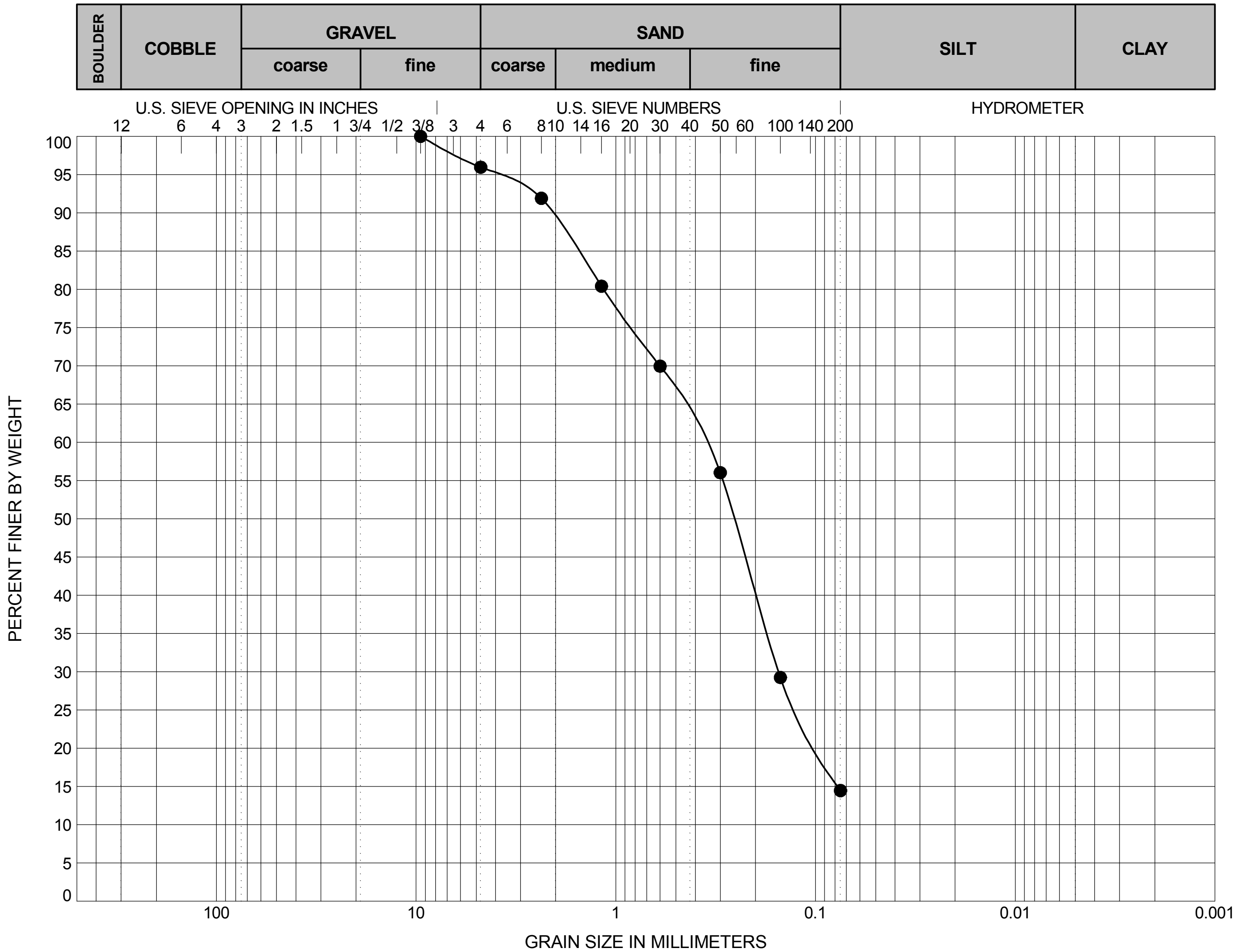
Steven Linton, EIT
Staff Engineer

Neva M. Popenoe, PE, GE
Project Manager

REGISTERED PROFESSIONAL ENGINEER
NEVA M. POPENOE
No. 3024
Exp. 06/30/15
GEOTECHNICAL
STATE OF CALIFORNIA

Attachments

| | |
|---|---|
| Figure 1 | Site Vicinity Map |
| Figure 2 | Boring Location Map |
| Figure 3 | Graphics Key |
| Figure 4 | Soil Description Key |
| Figure 5 | Boring Log B-9 |
| Figure 6 | Grain-Size Distribution |




| | Exploration ID | Depth (ft.) | Sample Description | LL | PL | PI |
|---|---|---|---|---|---|---|
| ● | B-9 | 2 - 3 | SILTY SAND (SM) | NM | NM | NM |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

| | Exploration ID | Depth (ft.) | $D_{100}$ | $D_{60}$ | $D_{30}$ | $D_{10}$ | Cc | Cu | Passing 3/4" | Passing #4 | Passing #200 | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | B-9 | 2 - 3 | 9.5 | 0.366 | 0.153 | NM | NM | NM | | 96 | 14 | NM | NM |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

Sieve Analysis and Hydrometer Analysis testing performed in general accordance with ASTM D422.
NP = Nonplastic
NM = Not Measured

Coefficients of Uniformity - $C_u = D_{60} / D_{10}$
Coefficients of Curvature - $C_C = (D_{30})^2 / D_{60} D_{10}$
$D_{60}$ = Grain diameter at 60% passing
$D_{30}$ = Grain diameter at 30% passing
$D_{10}$ = Grain diameter at 10% passing

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| | | | |
|---|---|---|---|
| PROJECT NO.: 20152738 | SIEVE ANALYSIS | FIGURE |
| DRAWN BY: SL | | |
| CHECKED BY: TD | Fresno County Bridge BPMP Phase 2<br>Fresno County, CA | 6 |
| DATE: 9/30/2014 | | |
| REVISED: - | | |



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reasonable time from its issuance. Land use, site conditions or other factors may change over time, and additional work may be required with the passage of time. Any other party who wishes to use this letter shall notify Kleinfelder of such intended use. Based on the intended use of the letter, Kleinfelder may require that additional work be performed and that an updated letter be issued. Non-compliance with any of these requirements by the client or anyone else will release Kleinfelder from any liability resulting from the misuse of this letter by any unauthorized party.

## CLOSING

We appreciate the opportunity to provide geotechnical engineering services to TRC Engineers Inc. and Fresno County. We trust this information meets your current needs. If there are any questions concerning the information presented in this letter, please contact this office at your convenience.

Respectfully Submitted,

**KLEINFELDER, INC.**

Steven Linton, EIT
Staff Engineer

Neva M. Popenoe, PE, GE
Project Manager


Attachments

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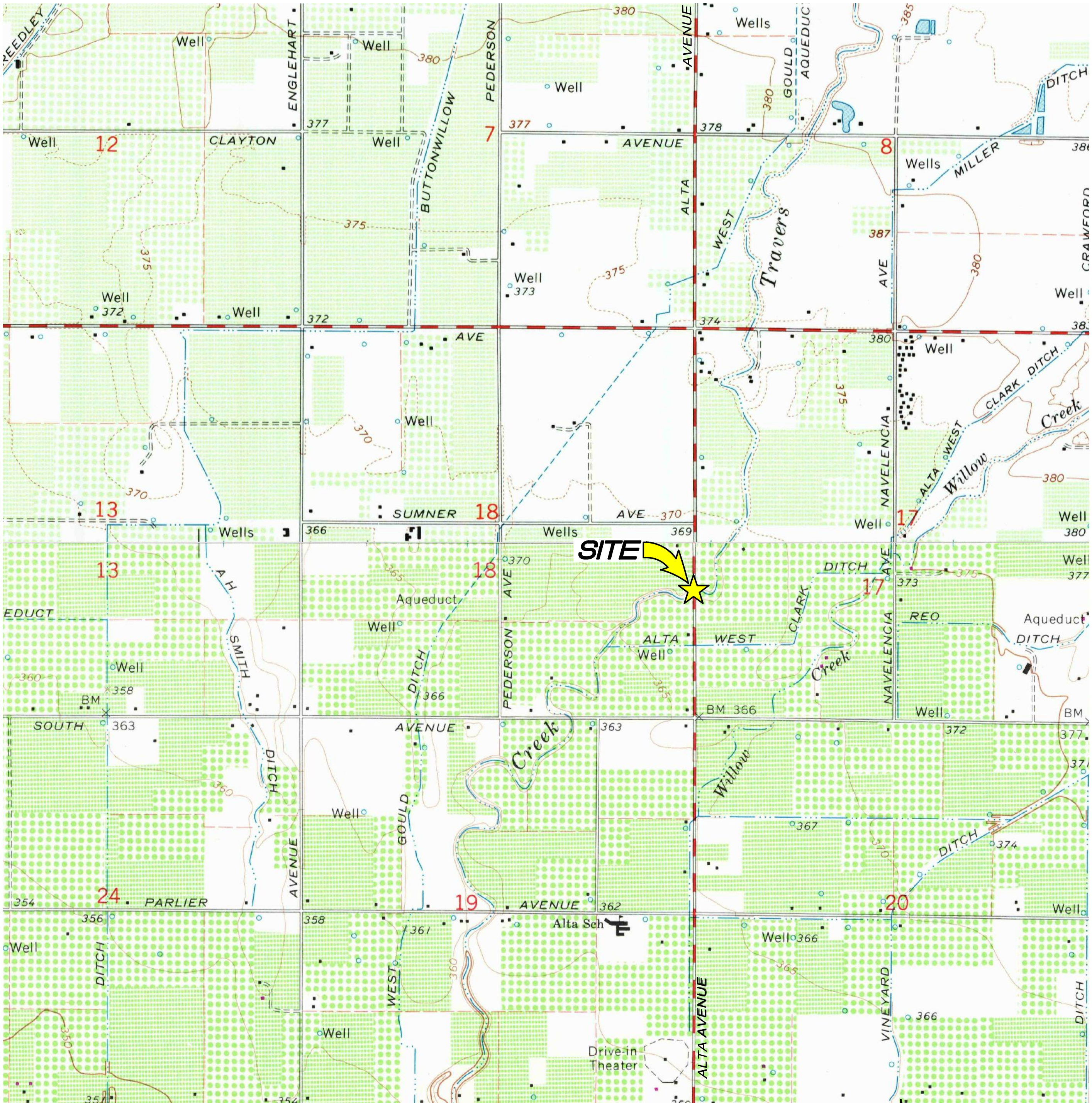
| Figure 5 | Boring Log B-9 |
| Figure 6 | Grain-Size Distribution |

# ATTACHMENTS




SOURCE: U.S.G.S. 7.5' Topographic series, Reedley and Wahtoke, California Quadrangle Dated 1966.

N

2,000 1,000 0 2,000

APPROXIMATE SCALE (feet)



PLOTTED: 10 Jan 2015, 2:38pm, MGriffin

CAD FILE: L:CADD\2015\20152738\FresnoBridge-BPMP_01-2015\9_AltaAve\ LAYOUT: 9

ATTACHED IMAGES: Images: USGS_Reedley-CA_1966_Quad.jpg Images: USGS_Wahtoke-CA_1966_Quad.jpg

ATTACHED XREFS:

LONG BEACH, CA

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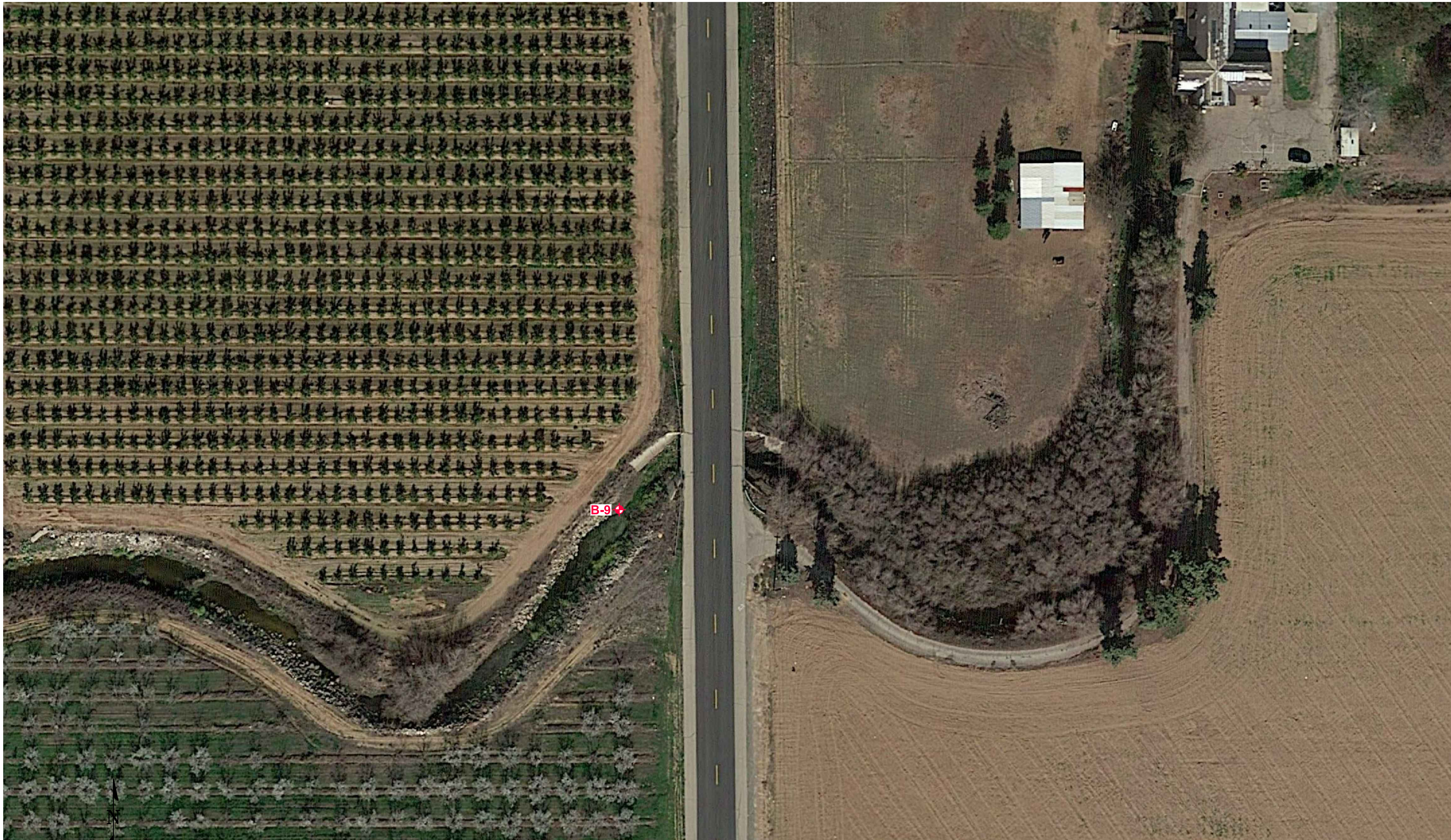
| | |
|---|---|
| PROJECT NO. | 20152738 |
| DRAWN: | 1/2015 |
| DRAWN BY: | MRG |
| CHECKED BY: | NP |
| FILE NAME: | 20152738-fig1_SVM_9.dwg |

## SITE VICINITY MAP

ALTA AVENUE AT TRAVERS CREEK
(BRIDGE NO. 42C0179)
FRESNO COUNTY BRIDGE BPMP, PHASE 2
FRESNO COUNTY, CA

FIGURE

1




60 30 0 60

APPROXIMATE SCALE (feet)



EXPLANATION

B-9 APPROXIMATE BORING LOCATION

SOURCE: GOOGLE EARTH PRO 2015, IMAGE DATE 2/20/14.

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| | |
|---|---|
| PROJECT NO. | 20152738 |
| DRAWN: | 1/2015 |
| DRAWN BY: | MRG |
| CHECKED BY: | NP |
| FILE NAME: | 20152738-fig2_BLM_9.dwg |

BORING LOCATION MAP

ALTA AVENUE AT TRAVERS CREEK
(BRIDGE NO. 42C0179)
FRESNO COUNTY BRIDGE BPMP, PHASE 2
FRESNO COUNTY, CA

FIGURE

2

ATTACHED IMAGES: Images: Aerial-Image_Site-9_AltaAve_100_2-20-14.jpg
ATTACHED XREFS:
LONG BEACH, CA
CAD FILE: L:CADD\2015\20152738\FresnoBridge-BPMP_01-2015\9_AltaAve\ LAYOUT: 9 PLOTTED: 10 Jan 2015, 5:43pm, MGriffin

## SAMPLE/SAMPLER TYPE GRAPHICS

BULK SAMPLE

## GROUND WATER GRAPHICS

- WATER LEVEL (level where first observed)
- WATER LEVEL (level after exploration completion)
- WATER LEVEL (additional levels after exploration)
- OBSERVED SEEPAGE

## NOTES

- The report and graphics key are an integral part of these logs. All data and interpretations in this log are subject to the explanations and limitations stated in the report.
- Lines separating strata on the logs represent approximate boundaries only. Actual transitions may be gradual or differ from those shown.
- No warranty is provided as to the continuity of soil or rock conditions between individual sample locations.
- Logs represent general soil or rock conditions observed at the point of exploration on the date indicated.
- In general, Unified Soil Classification System designations presented on the logs were based on visual classification in the field and were modified where appropriate based on gradation and index property testing.
- Fine grained soils that plot within the hatched area on the Plasticity Chart, and coarse grained soils with between 5% and 12% passing the No. 200 sieve require dual USCS symbols, ie., GW-GM, GP-GM, GW-GC, GP-GC, GC-GM, SW-SM, SP-SM, SW-SC, SP-SC, SC-SM.
- If sampler is not able to be driven at least 6 inches then 50/X indicates number of blows required to drive the identified sampler X inches with a 140 pound hammer falling 30 inches.

## UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D 2487)

| | | | | | |
|---|---|---|---|---|---|
| COARSE GRAINED SOILS (More than half of material is larger than the #200 sieve) | GRAVELS (More than half of coarse fraction is larger than the #4 sieve) | CLEAN GRAVEL WITH <5% FINES | Cu≥4 and 1≤Cc≤3 | GW | WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES |
| | | | Cu<4 and/ or 1>Cc>3 | GP | POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES |
| | | GRAVELS WITH 5% TO 12% FINES | Cu≥4 and 1≤Cc≤3 | GW-GM | WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE FINES |
| | | | | GW-GC | WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE CLAY FINES |
| | | | Cu<4 and/ or 1>Cc>3 | GP-GM | POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE FINES |
| | | | | GP-GC | POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE CLAY FINES |
| | | GRAVELS WITH > 12% FINES | | GM | SILTY GRAVELS, GRAVEL-SILT-SAND MIXTURES |
| | | | | GC | CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES |
| | | | | GC-GM | CLAYEY GRAVELS, GRAVEL-SAND-CLAY-SILT MIXTURES |
| | SANDS (More than half of coarse fraction is smaller than the #4 sieve) | CLEAN SANDS WITH <5% FINES | Cu≥6 and 1≤Cc≤3 | SW | WELL-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES |
| | | | Cu<6 and/ or 1>Cc>3 | SP | POORLY GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES |
| | | SANDS WITH 5% TO 12% FINES | Cu≥6 and 1≤Cc≤3 | SW-SM | WELL-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE FINES |
| | | | | SW-SC | WELL-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE CLAY FINES |
| | | | Cu<6 and/ or 1>Cc>3 | SP-SM | POORLY GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE FINES |
| | | | | SP-SC | POORLY GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE CLAY FINES |
| | | SANDS WITH > 12% FINES | | SM | SILTY SANDS, SAND-GRAVEL-SILT MIXTURES |
| | | | | SC | CLAYEY SANDS, SAND-GRAVEL-CLAY MIXTURES |
| | | | | SC-SM | CLAYEY SANDS, SAND-SILT-CLAY MIXTURES |

| | | | |
|---|---|---|---|
| FINE GRAINED SOILS (More than half of material is smaller than the #200 sieve) | SILTS AND CLAYS (Liquid Limit less than 50) | ML | INORGANIC SILTS AND VERY FINE SANDS, SILTY OR CLAYEY FINE SANDS, SILTS WITH SLIGHT PLASTICITY |
| | | CL | INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS |
| | | CL-ML | INORGANIC CLAYS-SILTS OF LOW PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS |
| | | OL | ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PLASTICITY |
| | SILTS AND CLAYS (Liquid Limit greater than 50) | MH | INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILT |
| | | CH | INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS |
| | | OH | ORGANIC CLAYS & ORGANIC SILTS OF MEDIUM-TO-HIGH PLASTICITY |

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| | |
|---|---|
| PROJECT NO.: | 20152738 |
| DRAWN BY: | SL |
| CHECKED BY: | NMP |
| DATE: | 1/29/2015 |
| REVISED: | - |

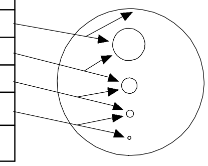
GRAPHICS KEY

Fresno County Bridge BPMP Phase 2
Fresno County, CA

FIGURE
3

## GRAIN SIZE

| DESCRIPTION | | SIEVE SIZE | GRAIN SIZE | APPROXIMATE SIZE |
|---|---|---|---|---|
| Boulders | | >12 in. (304.8 mm.) | >12 in. (304.8 mm.) | Larger than basketball-sized |
| Cobbles | | 3 - 12 in. (76.2 - 304.8 mm.) | 3 - 12 in. (76.2 - 304.8 mm.) | Fist-sized to basketball-sized |
| Gravel | coarse | 3/4 -3 in. (19 - 76.2 mm.) | 3/4 -3 in. (19 - 76.2 mm.) | Thumb-sized to fist-sized |
| | fine | #4 - 3/4 in. (#4 - 19 mm.) | 0.19 - 0.75 in. (4.8 - 19 mm.) | Pea-sized to thumb-sized |
| Sand | coarse | #10 - #4 | 0.079 - 0.19 in. (2 - 4.9 mm.) | Rock salt-sized to pea-sized |
| | medium | #40 - #10 | 0.017 - 0.079 in. (0.43 - 2 mm.) | Sugar-sized to rock salt-sized |
| | fine | #200 - #10 | 0.0029 - 0.017 in. (0.07 - 0.43 mm.) | Flour-sized to sugar-sized |
| Fines | | Passing #200 | <0.0029 in. (<0.07 mm.) | Flour-sized and smaller |

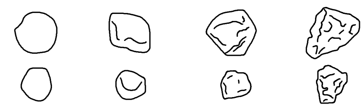


## Munsell Color

| NAME | ABBR |
|---|---|
| Red | R |
| Yellow Red | YR |
| Yellow | Y |
| Green Yellow | GY |
| Green | G |
| Blue Green | BG |
| Blue | B |
| Purple Blue | PB |
| Purple | P |
| Red Purple | RP |
| Black | N |

## ANGULARITY

| DESCRIPTION | CRITERIA |
|---|---|
| Angular | Particles have sharp edges and relatively plane sides with unpolished surfaces |
| Subangular | Particles are similar to angular description but have rounded edges |
| Subrounded | Particles have nearly plane sides but have well-rounded corners and edges |
| Rounded | Particles have smoothly curved sides and no edges |



Rounded Subrounded Subangular Angular

## Particles Present

| Amount | Percentage |
|---|---|
| trace | <5 |
| few | 5-10 |
| little | 15-25 |
| some | 30-45 |
| and | 50 |
| mostly | 50-100 |

## PLASTICITY

| DESCRIPTION | LL | FIELD TEST |
|---|---|---|
| Non-plastic | NP | A 1/8-in. (3 mm.) thread cannot be rolled at any water content. |
| Low (L) | < 30 | The thread can barely be rolled and the lump or thread cannot be formed when drier than the plastic limit. |
| Medium (M) | 30 - 50 | The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump or thread crumbles when drier than the plastic limit |
| High (H) | > 50 | It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump or thread can be formed without crumbling when drier than the plastic limit |

## MOISTURE CONTENT

| DESCRIPTION | FIELD TEST |
|---|---|
| Dry | Absence of moisture, dusty, dry to the touch |
| Moist | Damp but no visible water |
| Wet | Visible free water, usually soil is below water table |

## REACTION WITH HYDROCHLORIC ACID

| DESCRIPTION | FIELD TEST |
|---|---|
| None | No visible reaction |
| Weak | Some reaction, with bubbles forming slowly |
| Strong | Violent reaction, with bubbles forming immediately |

## APPARENT / RELATIVE DENSITY - COARSE-GRAINED SOIL

| APPARENT DENSITY | SPT-$N_{60}$ (# blows/ft) | MODIFIED CA SAMPLER (# blows/ft) | CALIFORNIA SAMPLER (# blows/ft) | RELATIVE DENSITY (%) |
|---|---|---|---|---|
| Very Loose | <4 | <4 | <5 | 0 - 15 |
| Loose | 4 - 10 | 5 - 12 | 5 - 15 | 15 - 35 |
| Medium Dense | 10 - 30 | 12 - 35 | 15 - 40 | 35 - 65 |
| Dense | 30 - 50 | 35 - 60 | 40 - 70 | 65 - 85 |
| Very Dense | >50 | >60 | >70 | 85 - 100 |

NOTE: AFTER TERZAGHI AND PECK, 1948

## CONSISTENCY - FINE-GRAINED SOIL

| CONSISTENCY | UNCONFINED COMPRESSIVE STRENGTH ($q_u$)(psf) | CRITERIA |
|---|---|---|
| Very Soft | < 1000 | Thumb will penetrate soil more than 1 in. (25 mm.) |
| Soft | 1000 - 2000 | Thumb will penetrate soil about 1 in. (25 mm.) |
| Firm | 2000 - 4000 | Thumb will indent soil about 1/4-in. (6 mm.) |
| Hard | 4000 - 8000 | Thumb will not indent soil but readily indented with thumbnail |
| Very Hard | > 8000 | Thumbnail will not indent soil |

## STRUCTURE

| DESCRIPTION | CRITERIA |
|---|---|
| Stratified | Alternating layers of varying material or color with layers at least 1/4-in. thick, note thickness |
| Laminated | Alternating layers of varying material or color with the layer less than 1/4-in. thick, note thickness |
| Fissured | Breaks along definite planes of fracture with little resistance to fracturing |
| Slickensided | Fracture planes appear polished or glossy, sometimes striated |
| Blocky | Cohesive soil that can be broken down into small angular lumps which resist further breakdown |
| Lensed | Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness |
| Homogeneous | Same color and appearance throughout |

## CEMENTATION

| DESCRIPTION | FIELD TEST |
|---|---|
| Weakly | Crumbles or breaks with handling or slight finger pressure |
| Moderately | Crumbles or breaks with considerable finger pressure |
| Strongly | Will not crumble or break with finger pressure |



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| | | | |
|---|---|---|---|
| PROJECT NO.: 20152738 | | SOIL DESCRIPTION KEY | FIGURE |
| DRAWN BY: | SL | | |
| CHECKED BY: | NMP | Fresno County Bridge BPMP Phase 2<br>Fresno County, CA | 4 |
| DATE: | 1/29/2015 | | |
| REVISED: | - | | |

PLOTTED: 01/29/2015 06:18 PM BY: npopenoe

| Date Begin - End: | 9/26/2014 | Drilling Company: | Kleinfelder |
|---|---|---|---|
| Logged By: | T. DeSouza | Drill Crew: | T. DeSouza |
| Hor.-Vert. Datum: | Not Available | Drilling Equipment: | Hand Auger |
| Plunge: | -90 degrees | Drilling Method: | Hand Auger |
| Weather: | Sunny/warm | Exploration Diameter: | 4 in. O.D. |

**BORING LOG B-9**

| Depth (feet) | Graphical Log | FIELD EXPLORATION: Surface Condition: Stream bed / Lithologic Description | Sample Type | Blow Counts(BC)= Uncorr. Blows/6 in. | Recovery (NR=No Recovery) | LABORATORY RESULTS: USCS Symbol | Water Content (%) | Dry Unit Wt. (pcf) | Passing #4 (%) | Passing #200 (%) | Liquid Limit | Plasticity Index (NP=NonPlastic) | Additional Tests/ Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Silty SAND (SM)**: fine to medium grained, non-plastic, dark brown, moist to wet, with subangular gravel up to 3 inches, trace fines | | | | | | | | | | | Limited access, creek partially filled with water |
| | | | | | | SM | | | 96 | 14 | | | |
| 5 | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | |

The boring was terminated because of practical auger refusal (↑) at approximately 3 ft. below ground surface. The exploration was backfilled with auger cuttings on September 26, 2014.

GROUNDWATER LEVEL INFORMATION:
Groundwater was not encountered during drilling or after completion.
GENERAL NOTES:

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| PROJECT NO.: | 20152738 |
|---|---|
| DRAWN BY: | SL |
| CHECKED BY: | TD |
| DATE: | 9/30/2014 |
| REVISED: | - |

BORING LOG B-9

Fresno County Bridge BPMP Phase 2
Fresno County, CA

FIGURE 5



gINT FILE: L:\drafting\2014\20152738\20152738.gpj
gINT TEMPLATE: PROJECTWISE: KLF_STANDARD_GINT_LIBRARY_2015.GLB [KLF_BORING/TEST PIT SOIL LOG]

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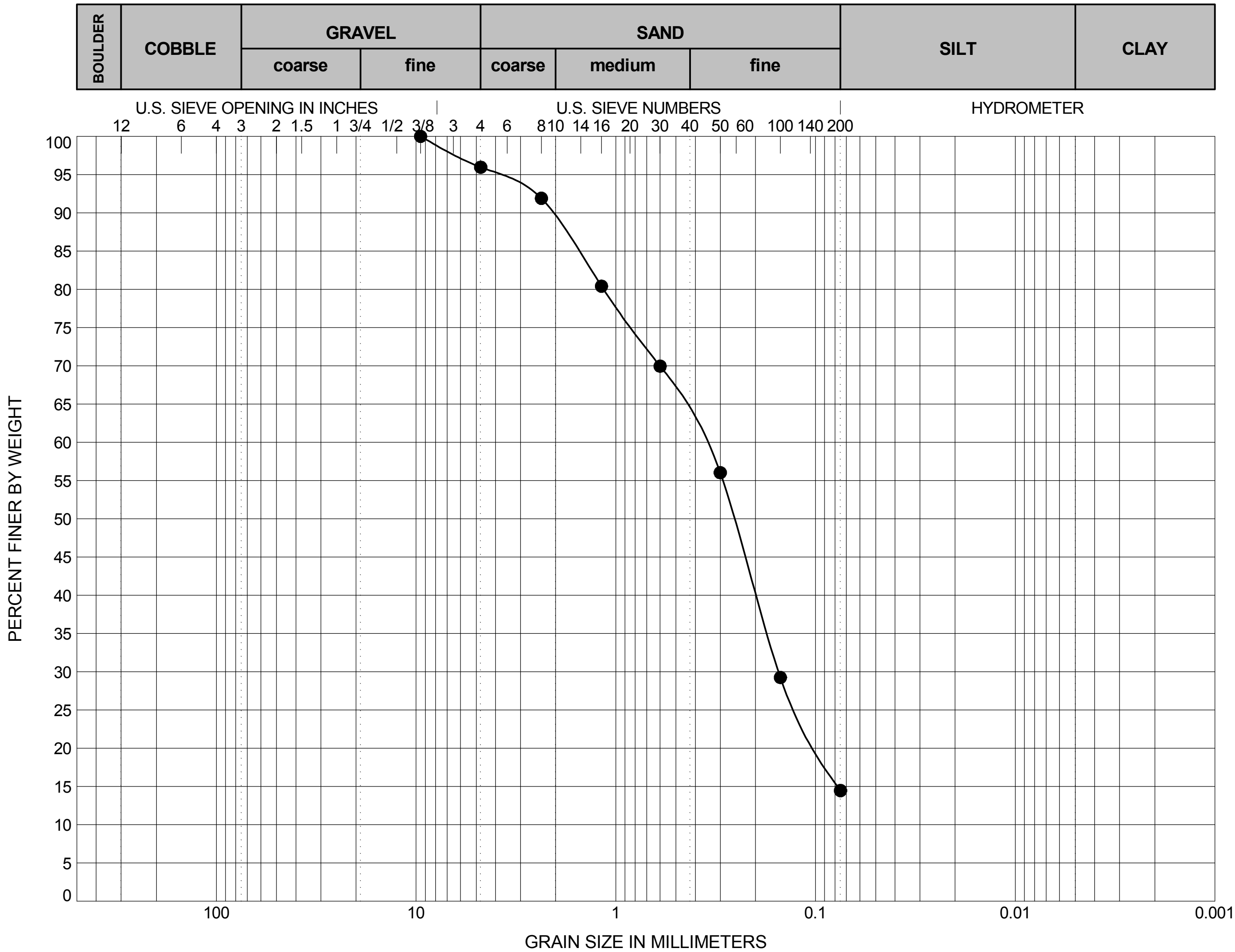


| Exploration ID | | Depth (ft.) | Sample Description | LL | PL | PI |
|---|---|---|---|---|---|---|
| ● | B-9 | 2 - 3 | SILTY SAND (SM) | NM | NM | NM |

| Exploration ID | | Depth (ft.) | $D_{100}$ | $D_{60}$ | $D_{30}$ | $D_{10}$ | Cc | Cu | Passing 3/4" | Passing #4 | Passing #200 | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | B-9 | 2 - 3 | 9.5 | 0.366 | 0.153 | NM | NM | NM | | 96 | 14 | NM | NM |

Sieve Analysis and Hydrometer Analysis testing performed in general accordance with ASTM D422.
NP = Nonplastic
NM = Not Measured

Coefficients of Uniformity - $C_u = D_{60} / D_{10}$
Coefficients of Curvature - $C_C = (D_{30})^2 / D_{60} D_{10}$
$D_{60}$ = Grain diameter at 60% passing
$D_{30}$ = Grain diameter at 30% passing
$D_{10}$ = Grain diameter at 10% passing

KLEINFELDER
Bright People. Right Solutions.

| | |
|---|---|
| PROJECT NO.: | 20152738 |
| DRAWN BY: | SL |
| CHECKED BY: | TD |
| DATE: | 9/30/2014 |
| REVISED: | - |

SIEVE ANALYSIS

Fresno County Bridge BPMP Phase 2
Fresno County, CA

FIGURE
6