DESIGN HYDRAULIC STUDY

MANNING AVENUE BRIDGES AT JAMES BYPASS

Bridge Numbers 42C0066 and 42C0067

FRESNO COUNTY, CALIFORNIA

AVILA & ASSOCIATES

Design Hydraulic Study

MANNING AVENUE BRIDGES AT JAMES BYPASS

Fresno County, CALIFORNIA

Bridges #42C0066 and #42C0067

DECEMBER 28, 2020

PREPARED FOR:

CORNERSTONE STRUCTURAL ENGINEERING GROUP AND FRESNO COUNTY DEPARTMENT OF PUBLIC WORKS

Prepared by:

AVILA AND ASSOCIATES
CONSULTING ENGINEERS, INC.

REGISTERED PROFESSIONAL ENGINEER
CATHERINE M.C. AVILA
No. C 048947
Exp. 09/22
CIVIL
STATE OF CALIFORNIA

Catherine M.C. Avila, P.E

TABLE OF CONTENTS

Table Of Contents ..... *ii*
List of Figures ..... *iii*
List of Tables ..... *iii*
Executive Summary *1*
General *2*
Hydrology *6*
Hydraulics *8*
Scour *18*
Summary Tables *22*
References *23*

LIST OF FIGURES

Figure 1. Location Map 4
Figure 2. Detail of Project Vicinity 4
Figure 3: Proposed west bridge profile view 5
Figure 4: Proposed east bridge profile view 5
Figure 5: Plan view of HEC-RAS cross section (downstream sections based on LiDAR data not shown) 8
Figure 6: East branch looking upstream at existing access road and culvert 9
Figure 7: East branch looking downstream at existing access road crossing channel 9
Figure 8: Profile of access road and culvert upstream from east bridge 10
Figure 9: Profile of existing access road crossing channel downstream from east bridge 10
Figure 10: Starting Water Surface Elevation 11
Figure 11: Cross Section at Station 6393 12
Figure 12: Profile of proposed bridge – West Branch (42C0066) 12
Figure 13: Profile of proposed bridge – East Branch (42C0067) 13
Figure 14: Water surface elevation for existing and proposed for the West Branch 14
Figure 15: Water surface elevation for existing and proposed for the West Branch (zoomed in) 14
Figure 16: Water surface elevation for existing and proposed for the East Branch. 15
Figure 17: Water surface elevation for existing and proposed for the East Branch (zoomed in). 15
Figure 18: Cross sections taken at the West Branch (42C0066) bridge over time (from Caltrans Maintenance Reports) 19
Figure 19: Cross sections taken at the East Branch (42C0067) bridge over time (from Caltrans Maintenance Reports) 19

LIST OF TABLES

Table 1: Estimated discharges and water surface elevations for the West Bridge design 1
Table 2: Estimated discharges and water surface elevations for the East Bridge design 1
Table 3: Discharges used for design 6
Table 4: Bridge information from nearby bridges on the reach 6
Table 5: Calculated flow distributions 16
Table 6. Water Surface Elevation comparison existing vs. proposed for West Bridge 17
Table 7. Water Surface Elevation comparison existing vs. proposed for East Bridge 17
Table 8. Resulting freeboard at West and East Bridge 17
Table 9. Total scour depths and elevations for the West Bridge assuming a thalweg elevation of 156 ft. 20
Table 10. Scour Summary Table for the West Bridge 20
Table 11. Total scour depths and elevations for the East Bridge assuming a thalweg elevation of 170 ft. 21
Table 12. Scour Summary Table for the East Bridge 21

EXECUTIVE SUMMARY

The Manning Avenue Bridges (bridges) at James Bypass in Fresno County, California are proposed for replacement by the County of Fresno. The proposed west branch bridge (west bridge) will be a 3-span precast prestressed voided slab bridge and will replace an existing 6-span precast reinforced concrete inverted U-girder deck bridge. The proposed east branch bridge (east bridge) will be a single span precast prestressed voided slab bridge and will replace an existing 3-span precast reinforced concrete inverted U-girder deck bridge. The west bridge will be approximately 173 feet long and the east bridge approximately 65 feet long. Both will accommodate two 12-ft travel lanes with two 8-ft 3-in wide shoulders as shown in the attached General Plans (Appendix A). The superstructure of both bridges will be supported by reinforced concrete abutments on 4 feet diameter cast in drilled hole piles and, in the case of the west bridge, cast in place prestressed pier caps on 4 feet diameter cast in drilled hole piles.

James Bypass (also known as the Fresno Slough Bypass) is operated by the James Irrigation District (JID) and was constructed to convey overflow from the Kings River to the San Joaquin River. James Bypass flows northwesterly through the project area and through the central part of Fresno County. James Bypass is made up of two channels; the main channel which runs along the western edge of the bypass (the west branch) and a smaller channel that runs along the eastern edge (the east branch). The discharges and a summary of the hydraulic results used for the bridge hydraulic analysis are shown in Table 1 for the West Bridge and Table 2 for the East Bridge.

Table 1: Estimated discharges and water surface elevations for the West Bridge design

	Design	Base	Overtopping
Frequency (years)	100	>100	>>100
Discharge (cubic feet per second)	4,750	8,500	>8,500
Water Surface (elevation in feet at upstream face of Bridge)	173.1	175.3	~182.0
Freeboard (feet)*	7.1	4.9	n/a
*Minimum soffit elevation at the upstream face of the bridge is 180.2 feet.			

Table 2: Estimated discharges and water surface elevations for the East Bridge design

	Design	Base	Overtopping
Frequency (years)	100	>100	>>100
Discharge (cubic feet per second)	4,750	8,500	>8,500
Water Surface (elevation in feet at upstream face of Bridge)	176.7	177.3	~182.0
Freeboard (feet)*	3.6	3.0	n/a
*Minimum soffit elevation at the upstream face of the bridge is 180.3 feet.			

The US Army Corps of Engineers HEC-RAS[1] Version 5.0.7 model was used to estimate the water surface elevation (WSE) for the existing and proposed bridges. Both of the proposed bridges are shorter than the existing bridges, but due to the combination of higher soffit elevations and reduction

[1] US Army Corps of Engineers Hydraulic Engineering Center River Analysis System which backwater hydraulic model designed to perform one-dimensional hydraulic calculations for a full network of natural and constructed channels.

of piers in the channel, the water surface elevation at the upstream face of the proposed bridges decreased compared to the existing conditions.

This report follows the California Department of Transportation (Caltrans) Final Hydraulic Report Format and has been prepared in accordance with the Caltrans Local Assistance Program Guidelines (Caltrans 2020) and Memos to Designers 16-1 [2].

GENERAL

This design hydraulic study has been prepared for the sole purpose of meeting the requirements of the Caltrans "Local Assistance Program Guidelines." 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.

Avila and Associates was retained to complete the bridge hydrology, hydraulics, and scour analysis for the bridges. The following scope of work has been completed to develop this report.

1. Gather information and field review the bridge reach
2. Obtain design discharges
3. Develop a HEC-RAS model.
4. Estimate scour and provide Rock Slope Protection
5. Prepare Draft and Final Hydraulic Report
6. Complete Location Hydraulic Study and Summary Floodplain Encroachment Report
7. Coordinate with the Central Valley Flood Protection Board (CVFPB)

[2] Caltrans Memo to Designers 16-1 December 2017 (http://www.dot.ca.gov/des/techpubs/manuals/bridge-memo-to-designer/page/section-16/MTD_16-1-attach1.pdf)

The existing bridges are located approximately 21 miles southwest from the city of Fresno and 3 miles east of the city of San Joaquin in Fresno County, CA as shown in

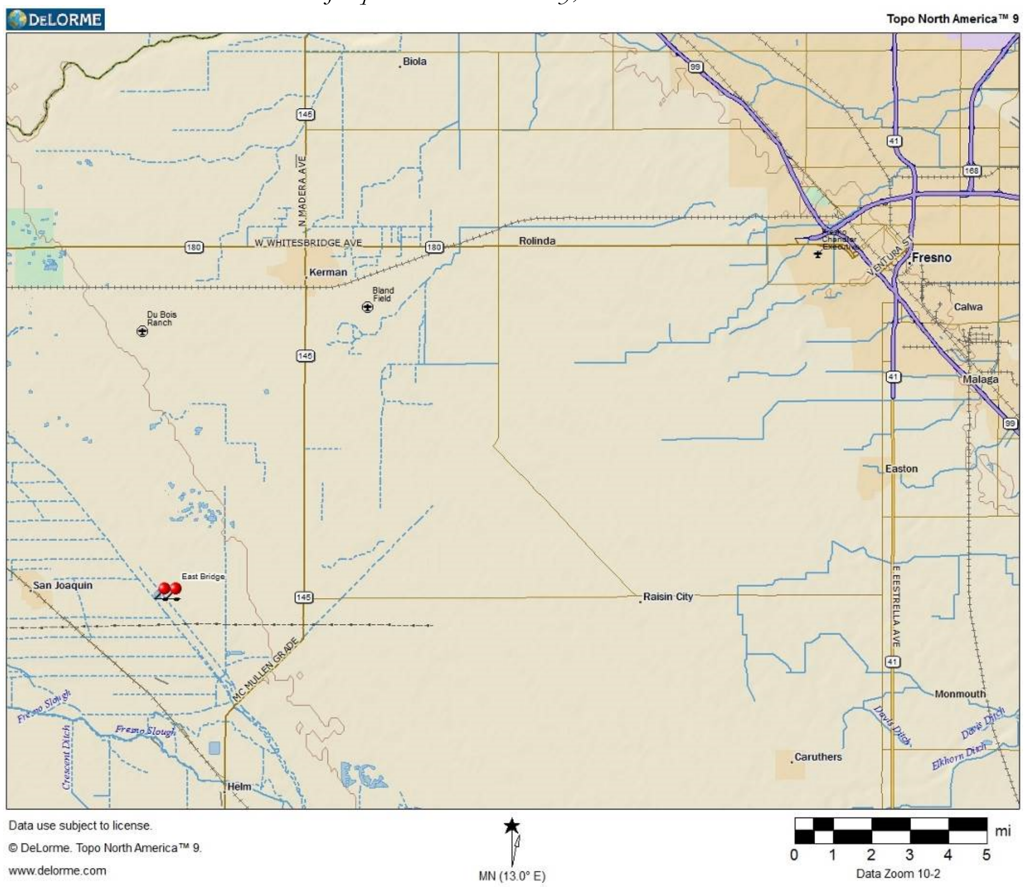


Figure 1 and Figure 2. The existing bridges were constructed in 1957. The west bridge is a 6-span precast reinforced concrete inverted U-girder deck bridge supported by reinforced concrete abutments and reinforced concrete 5-column bents all on driven reinforced concrete filled tapered steel shell piles. The east bridge is identical to the west bridge but with only 3 spans. As of 2014, both bridges had a sufficiency rating of 62.2 and are structurally deficient. The County of Fresno proposes to replace the existing bridges with a new bridges crossing James Bypass using Highway Bridge Program (HBP) funding. The datum elevation used for this study is NGVD-29[3].

[3] Electronic Mail from Mark Meyer, PLS, Chief of Surveys, Construction Management Division, Fresno County Public Works, to Edmund Amobi, Design Division, Fresno County Public Works on August 13, 2015.

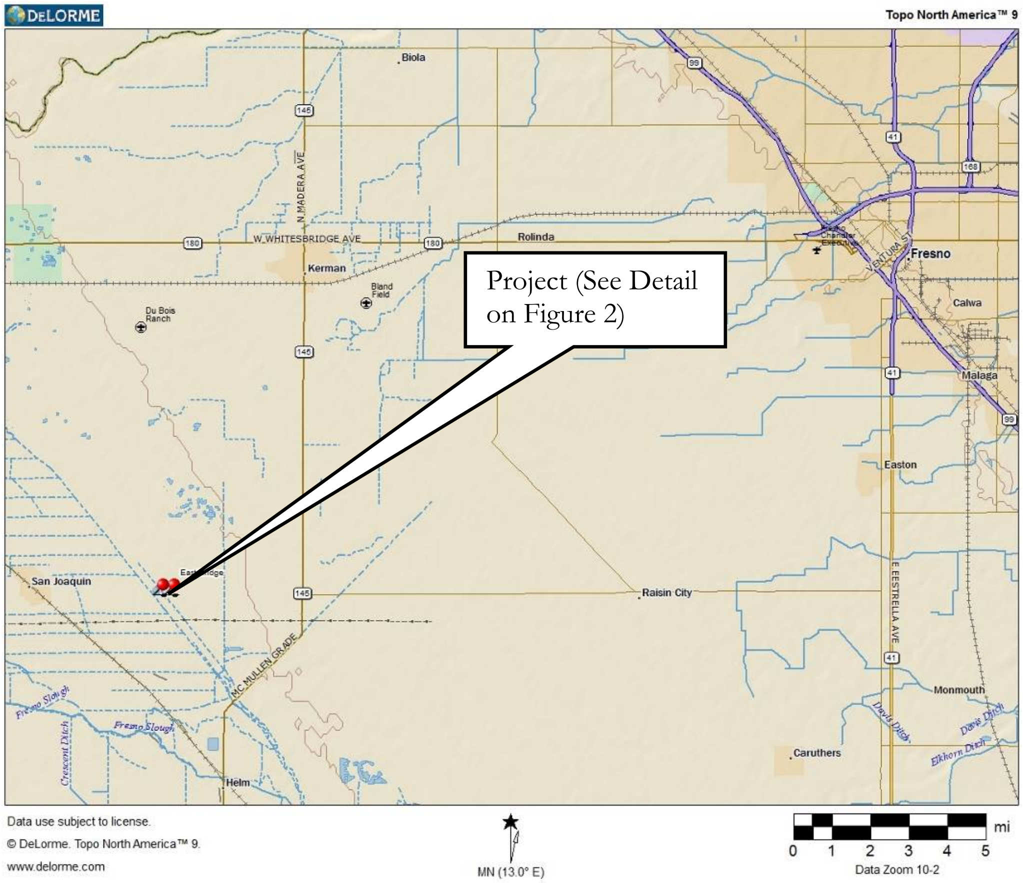


Figure 1. Location Map

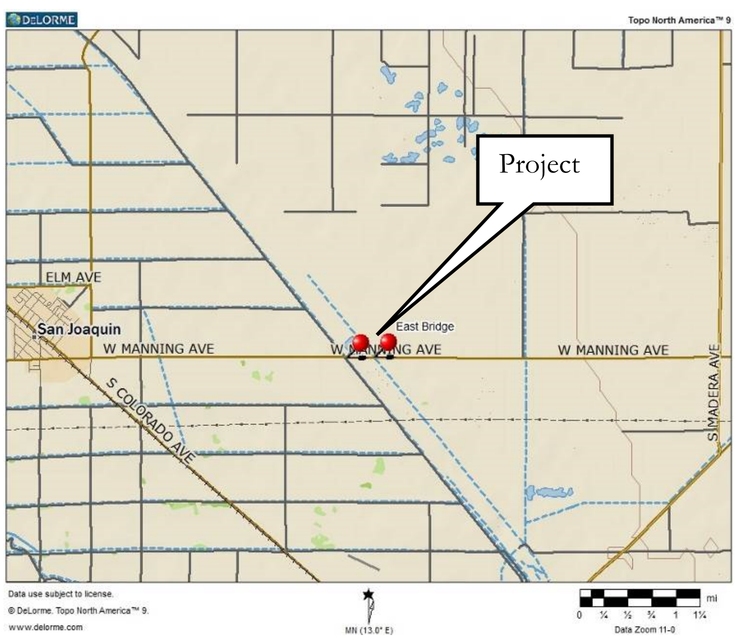


Figure 2. Detail of Project Vicinity

The proposed west branch bridge (west bridge) will be a 3-span precast prestressed voided slab bridge approximately 173 feet long. The proposed east branch bridge (east bridge) will be identical to the west bridge but with only a single span and approximately 65 feet long. Both will accommodate two travel lanes with two 8-ft 7-in wide shoulders as shown in

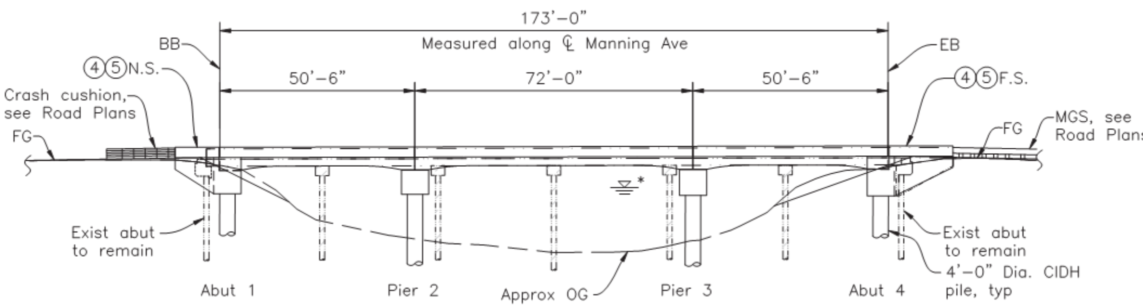


Figure 3, Figure 4, and in the attached General Plan (Appendix A).

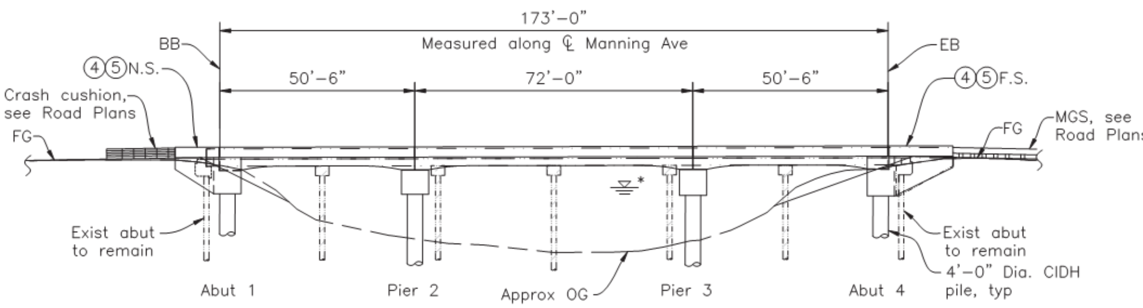


Figure 3: Proposed west bridge profile view

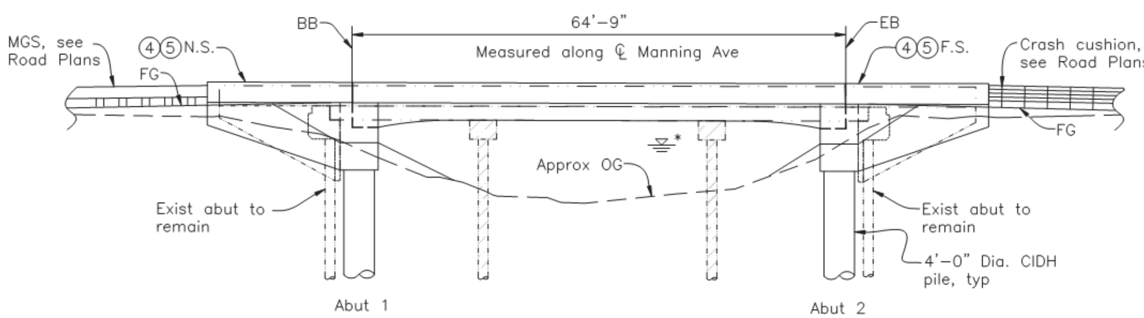


Figure 4: Proposed east bridge profile view

HYDROLOGY

The hydrology for the bridge replacements was provided by Steve Stadler, Assistant Manager at the James Irrigation District. According to Mr. Stadler:

Please use 4,750 cfs for the design flow rate of the James Bypass, which is also known as the Fresno Slough Bypass. The 4,750 cfs value can be assumed to be the 100-year number and I can discuss the basis for that assumption tomorrow. Please also evaluate the structure for 6,000 cfs. The floodway can over-perform the design value by a considerable margin and it is important to preserve that capability. Understand that at high flows, there is debris in the channel and the analysis should include an appropriate amount of debris loading.

The discharges used for design are shown in Table 3. The bridge was evaluated for 8,500 cfs to ensure the bridges could pass discharges larger than the design value when bulked with debris.

Table 3: Discharges used for design

	Design	Base
Frequency (Years)	100	--
Discharge (Cubic feet per second)	4,750	8,500

Avila and Associates reviewed relevant bridge maintenance records for the two bridges being replaced on the James Bypass (Caltrans, 2014) to discern the typical impacts. The relevant information is summarized in Table 4.

Table 4: Bridge information from nearby bridges on the reach

	Manning Avenue (West)	Manning Avenue (East)
Bridge Number	42C0066	42C0067
Bridge Length (ft)	184	74
Span Lengths (ft)	6 @ 30	20/30/20
Bridge Type	6-span PC/RC inverted U-girder on RC abutments on driven piles.	3-span PC/RC inverted U-girder on RC abutments on driven piles.
Debris Challenges	None noted.	None noted.
Cross Sections Available for	1972, 1993, 2005, 2009, 2011, 2014[4]	1972, 1993, 2005, 2011
NBIS Item 113 (scour) code	3	5
ELI Flag 361 Condition State	3	1
Pier Type	RC pile extension	RC pile extension
Year Built	1957	1957
Year Widened	N/A	N/A

[4] A channel cross section was taken during this inspection and is included with this report. The cross section was compared with the previous cross section taken on 12/21/2011. Other than the apparent error in the vertical dimension at both abutments in 2011, there have been no significant changes to the channel profile. The vertical dimension recorded in 2011 was 0.0 m, which would mean that the soil along the edge of the channel came up to the top of the outside of the bridge rail. Photos taken during that inspection do not show any material piled up against the bridge rail and flush with the top of the rail.

Scour Challenges	1972[5], 1974[6], 1976[7], 1982[8], 1984[9], 1997[10], 1999[11], 2001[12], 2010[13], 2011[14], 2014[15]	1972[16], 1974[17], 1976[18], 1984[19], 1986[20], 1993[21], 1994[22], 1999[23], 2001[24]

[5] The bank at Abutment 1 is not protected and the right side of the abutment is being undermined . Erosion has also occurred at bents 3-6 but not serious enough to endanger the structure (1' to 3' of corrugated metal pipe shell is exposed). The left side of Abutment 7 is also undermined by erosion, the bottom of the footing being about 1' above the ground line.

[6] Erosion continues at the right side of Abutment #1. The footing is eroded 1' below and l' back under for a length of 4'. Bents #3, #4, and #5 have up to 3' of pile shell exposed and Bent #6 has 5' exposed.

[7] There is up to 5' of metal pile shell exposed at Bents 3, 4 & 5, as previously reported.

[8] The pile shells are exposed about 6' maximum at Bent 3 to 6. The channel continues to degrade.

[9] The channel continues to degrade. The pile shells at Bent 5 are exposed up to 8 feet. The bottom of the diaphragm at Abutment 7 is exposed.

[10] The bottom of the diaphragm is exposed over approximately half its length at Abutment 7, and most of the original embankment slope between Bent 6 and Abutment 7 is gone.

[11] Abutment 1 is exposed and undermined for about 3m with a void that goes 500mm back and 200mm deep. At bent 6, three of the five piles have exposed steel shells.

[12] Same as 1999.

[13] The result of a Structure Hydraulics Branch investigation in October 2009 is described, in part, as such: since construction of the bridge in 1957 there has been significant channel degradation and pile exposure. Additionally, there has been a chronic erosion problem at the abutments, with some undermining of the curtain walls. There is scour protection in Spans 3-6 consisting mostly of concrete rip-rap ranging from fist size up to 1/4 ton. The rip·rap is distributed in a haphazard manner with uneven gradation and is mounded up under the bridge, creating a 0.6- to-0.9 m (2 to 3 ft) high obstruction in the channel bed in Spans 3-6. There is little to no scour protection in Spans 1 and 2, and the bank is eroded there. At Bent 2, the pile splice is exposed at column 4 and the corrugated steel pile shell is exposed 0.9 m (3 ft) at column 5. No other pile shells are exposed at this time.

[14] There was channel work done to regrade the channel and embankment slopes under and beyond the bridge. There was an effort to rearrange the previously reported haphazard rip-rap placement that created obstructions in the channel bed. The concrete rip-rap was pushed along the bents and under Spans 1 and 2. The previously reported exposed pile shells along Bent 2 were covered.

[15] Since construction of the bridge in 1957 there has been significant channel degradation and pile exposure. Additionally, there has been a chronic erosion problem at the abutments, with some undermining of the curtain walls . There is scour protection in Spans 3-6 consisting mostly of concrete rip-rap ranging from fist size up to 1/4 ton. Piles are the Raymond step-taper type with steel reinforcement extending 12 ft below the pile-to-column splice. The previously exposed pile shells at the bents have been encased in concrete. But, based on the original ground profile and on 2009 measurements of pile shell encasement heights and channel bed elevations, termination of the reinforcement is estimated to be at elevation 160 ft (+/-) at Bents 2 through 5 and 168 ft at Bent 6, whereas the elevation of the channel is currently 158ft (+/-), 2 feet below the reinforcement. Since calculated scour is below the reinforcement in the piles, all of the bents are potentially unstable.

[16] There is some erosion at Bent 2, but not serious.

[17] There is 1' to 2' of pile shell exposed at Bent #2 and the right side of Bent #3.

[18] Same as 1974.

[19] There is a minor erosion in the embankment on the left side of Abutment 4.

[20] The pile shells are exposed 2 feet.

[21] No detrimental scour found, but pile cans exposed at Bents 2 and 3. The exposure ranges to nearly 2 feet for Pile No. 3 of Bent 2.

[22] Piles 4 and 5 of Bent 3 and all piles of Bent 2 remain minimally exposed.

[23] Same as 1994.

[24] Same as 1999.

Hydraulic parameters (water surface elevations and velocity) were modeled with the U.S. Army Corps of Engineers HEC-RAS (Hydraulic Engineering Center River Analysis System) version 4.1.0 model[25], based on: 1) cross-section survey data supplied by Fresno County on May 20, 2015, 2) LiDAR data provided by JID[26] received June 25, 2015, and 3) as-built data provided by CSEG. Cross-sections surveyed for the HEC-RAS model are shown on Figure 5.

The HEC-RAS model was constructed with separate reaches for the west and east branch of the James Bypass. The two reaches combine into one reach at a junction downstream from the bridges as shown in Figure 5. The east branch has hydraulic limitations due to the following:

- smaller channel section compared to the west branch
- an existing access road crosses the channel upstream from the bridge with an 80-inch diameter culvert as shown in Figure 6
- an existing access road crosses the channel downstream from the bridge with no culvert as shown in Figure 7

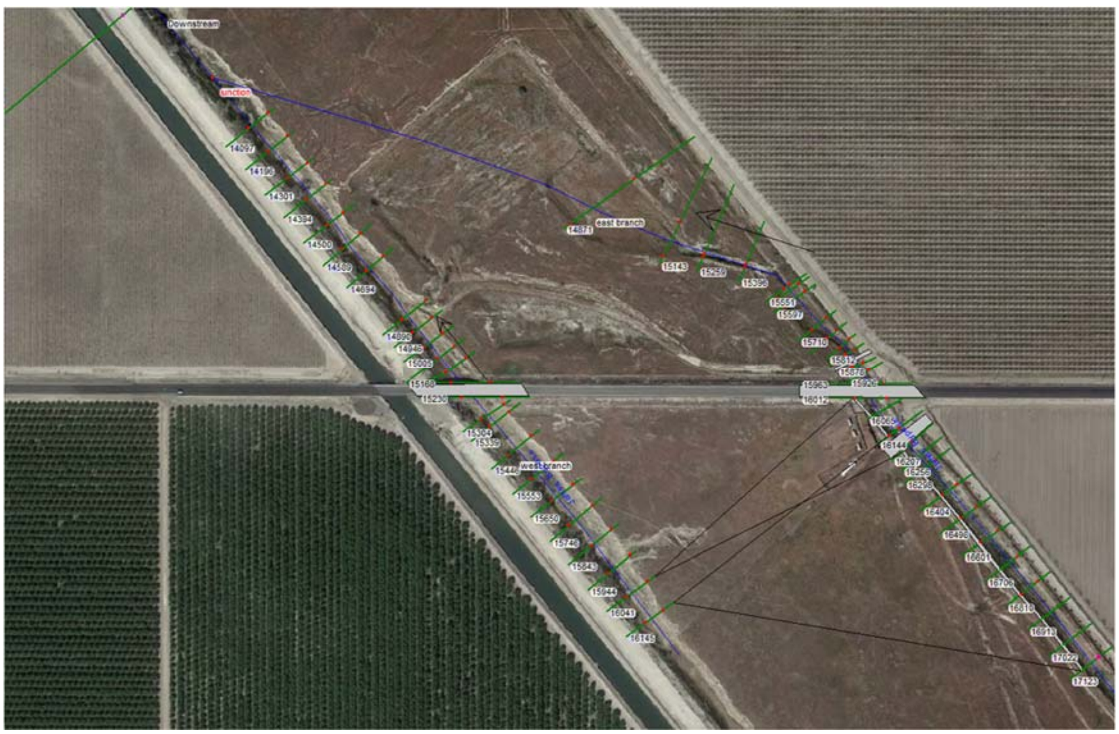


Figure 5: Plan view of HEC-RAS cross section (downstream sections based on LiDAR data not shown)

---

[25] US Army Corps of Engineers Hydraulic Engineering Center River Analysis System which backwater hydraulic model designed to perform one-dimensional hydraulic calculations for a full network of natural and constructed channels.

[26] LiDAR data from JID was in NAD 83, GRS 80, Transverse Mercator Coordinate System, Survey Feet and NAVD 88, feet. This data was first converted to NAD83, California State Plane, Zone 4 and NAVD88 feet and then converted to NGVD-29 (vertical conversion of -2.61 feet per VERTCON, National Geodetic Survey) by Avila and Associates.

Figure 6: East branch looking upstream at existing access road and culvert

Figure 7: East branch looking downstream at existing access road crossing channel

The access road upstream from the east bridge was modeled as a bridge with culvert as shown in Figure 8 and the access road downstream was modeled as an in-line weir structure as shown in Figure 9.

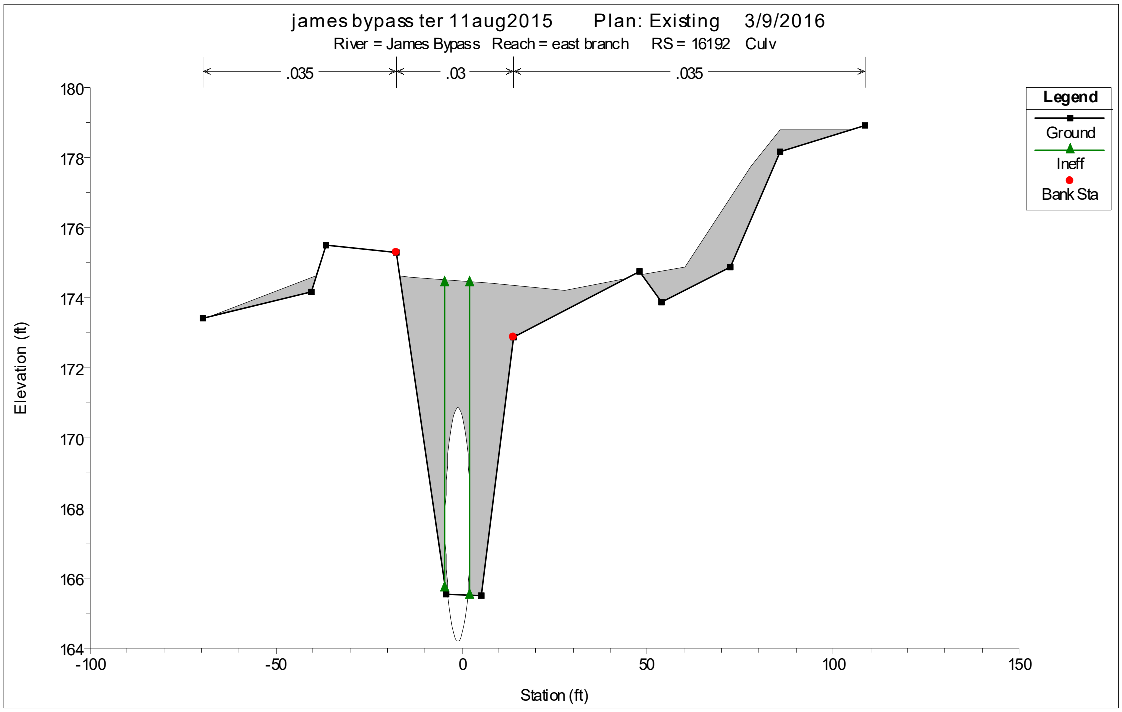


Figure 8: Profile of access road and culvert upstream from east bridge

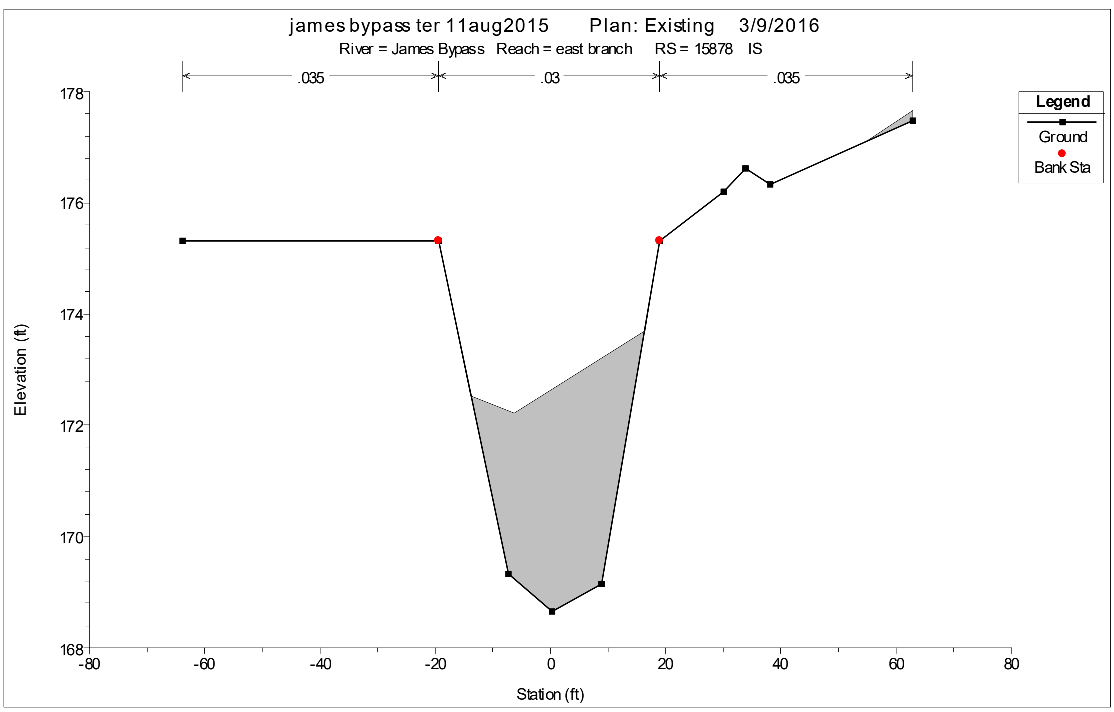


Figure 9: Profile of existing access road crossing channel downstream from east bridge

The amount of flow that passes through the east bridge is governed by the three hydraulic limitations listed above. Lateral weir structures were modeled along the western edge of the east branch to allow flow in excess of the hydraulic capacity of the system to overtop and join flows in the west branch. The lateral weir structures are equivalent to the top of bank areas shown in Figure 6.

For the 100-yr discharge of 4,750 cfs provided by JID, the initial split of flow between the east and west branch was modeled as 1,000 cfs / 3,750 cfs (east / west). Similarly, for the >100-yr discharge of 8,500 cfs, the initial split modeled was 2,000 cfs / 6,500 cfs (east / west).

Existing Conditions

Manning's n values of 0.03 for the channel and 0.035 to 0.045 for the overbanks were used in the model.

The starting water surface elevation was determined by examining the water surface elevation at station 6393 (approximately 1.7 miles downstream from the project) that resulted from various starting water surface elevations as shown in Figure 10. When the water surface elevation reaches the maximum levee elevation of 172.5 at station 6393, it will overtop the levee and utilize overland flow as shown in Figure 11.

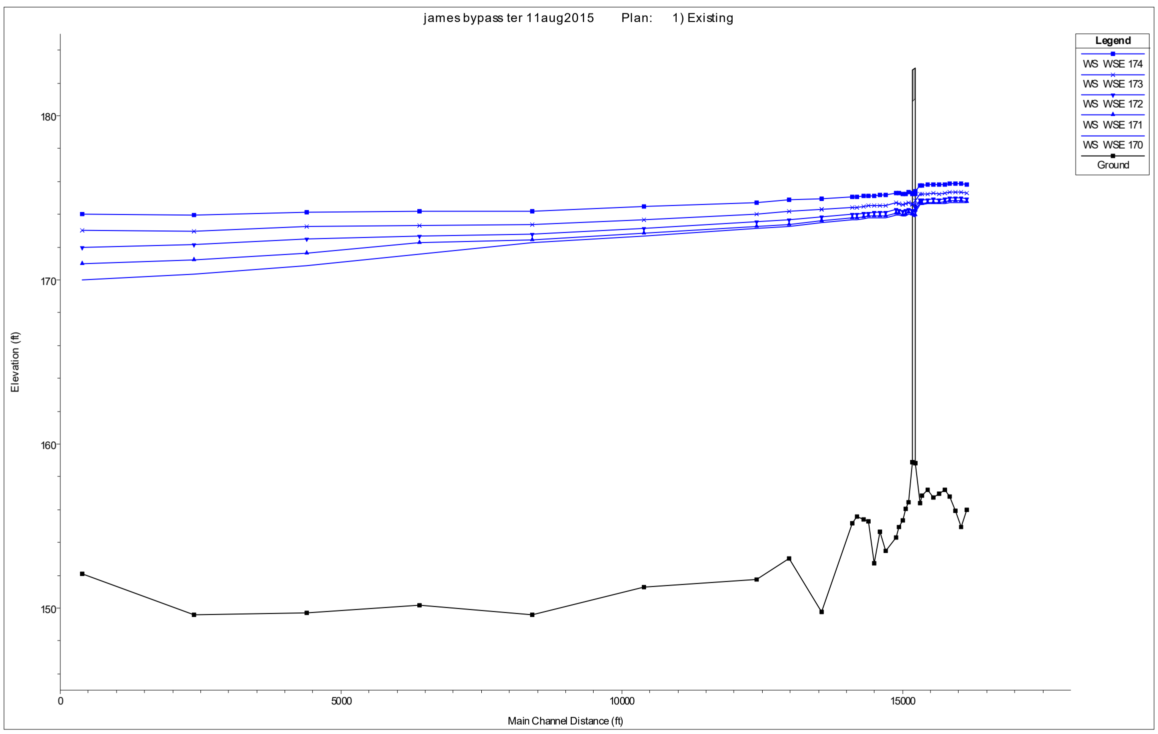


Figure 10: Starting Water Surface Elevation

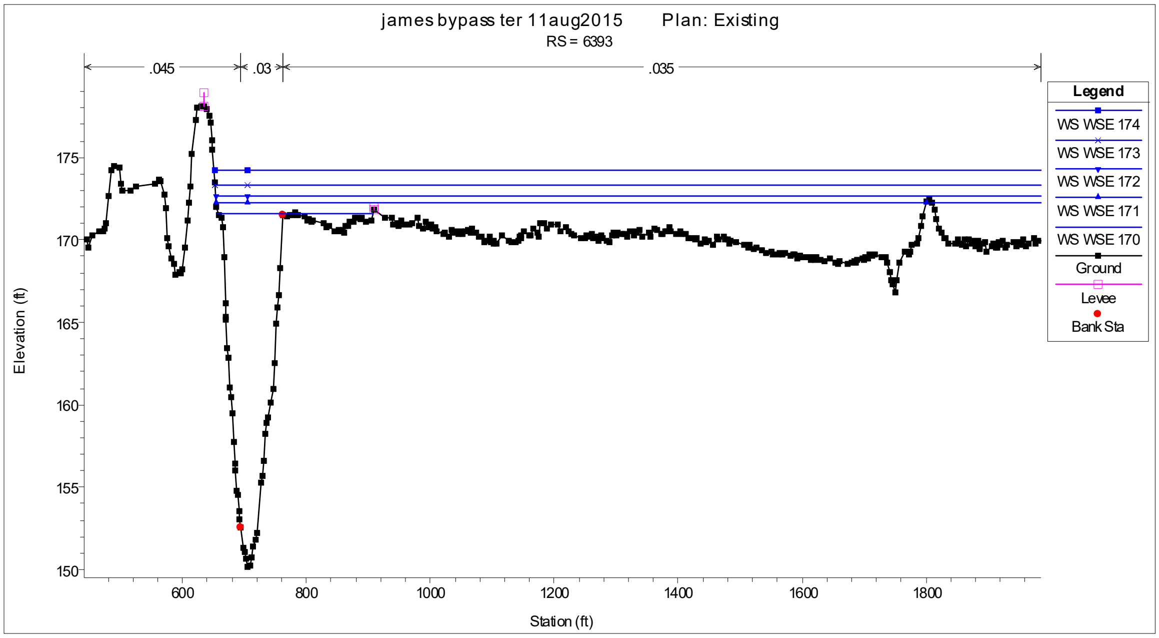


Figure 11: Cross Section at Station 6393

Proposed Bridge Model

The HEC-RAS model was re-run by replacing the existing bridges in the model with the proposed bridge alternatives. Profiles of the proposed bridges are shown in Figure 12 and Figure 13.

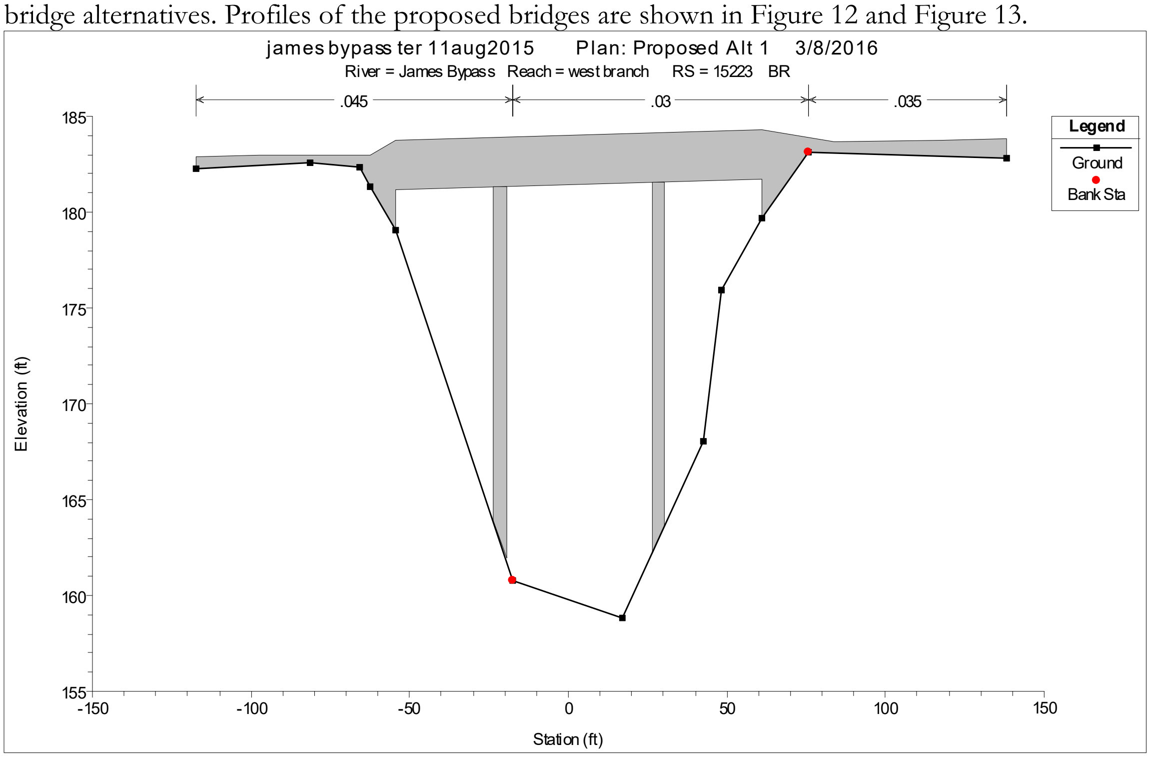


Figure 12: Profile of proposed bridge – West Branch (42C0066)

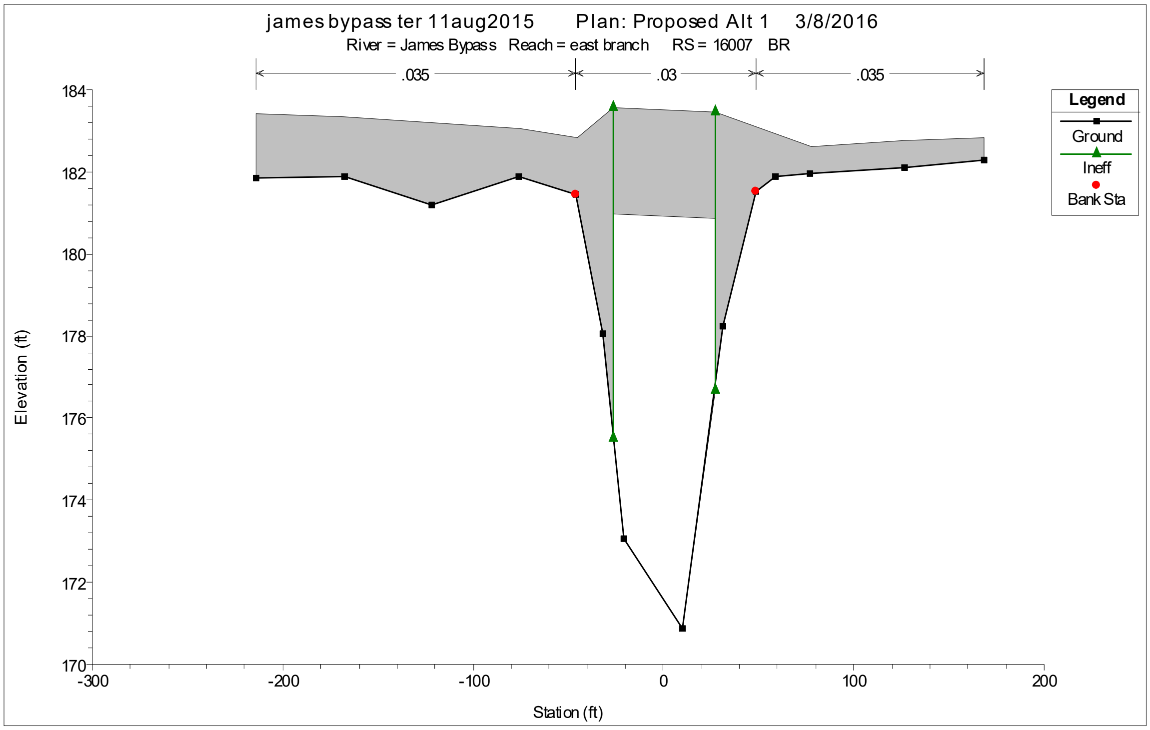


Figure 13: Profile of proposed bridge – East Branch (42C0067)

A downstream starting water surface elevation of 172-feet was utilized in each of the models. Each of the proposed bridges was input into the HEC-RAS model to determine the impact to the water surface elevation and velocity. As shown in Figure 14 through Figure 17, the water surface elevation upstream from the bridge for the 8,500 cfs and 4,750 cfs (100-year discharge) is decreased by each of the proposed bridges. The final distribution of flows between the west and east branch, as calculated by HEC-RAS, is shown in Table 5 for both the existing and proposed condition.

For the proposed condition, less flow is diverted from the east branch to the west branch due to the increased hydraulic capacity of the proposed east bridge. This results in a slightly higher water surface elevation profile downstream from the east bridge due to the geometry of the channel, but primarily due to the higher flow overtopping the existing access road downstream. The water surface elevation profile downstream from the west bridge is unchanged for the proposed condition.

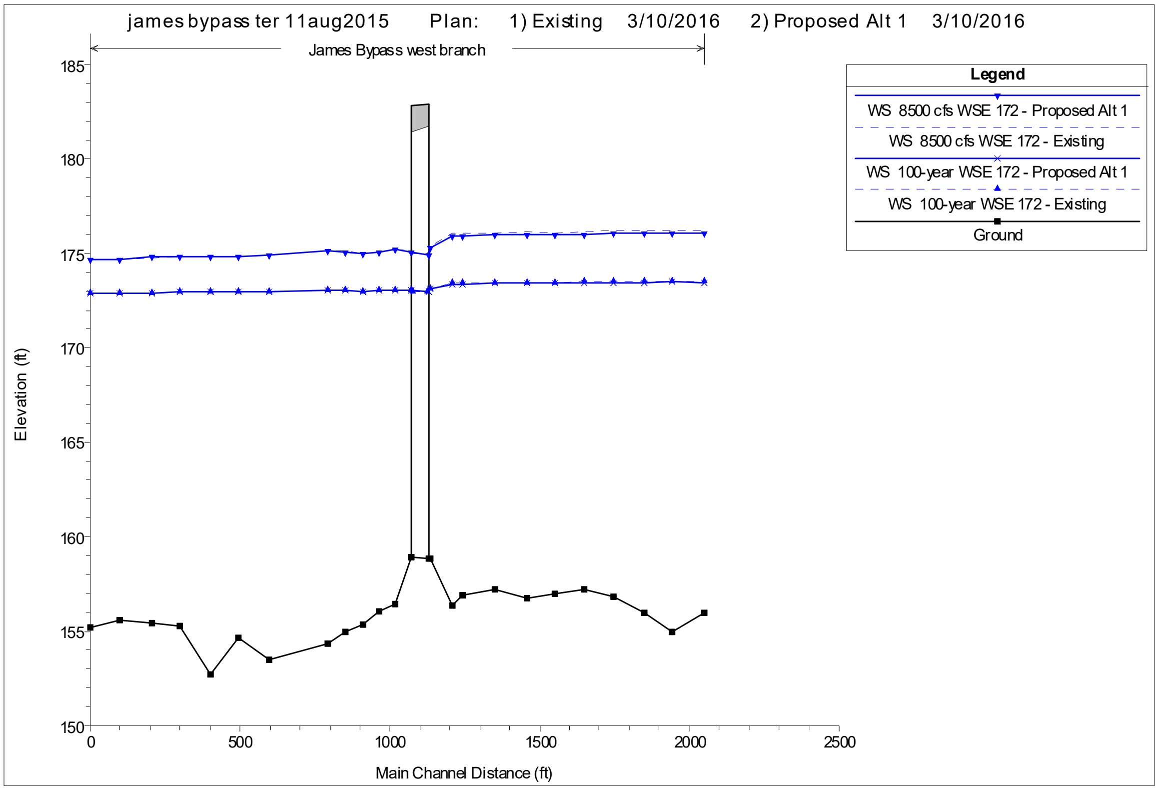


Figure 14: Water surface elevation for existing and proposed for the West Branch

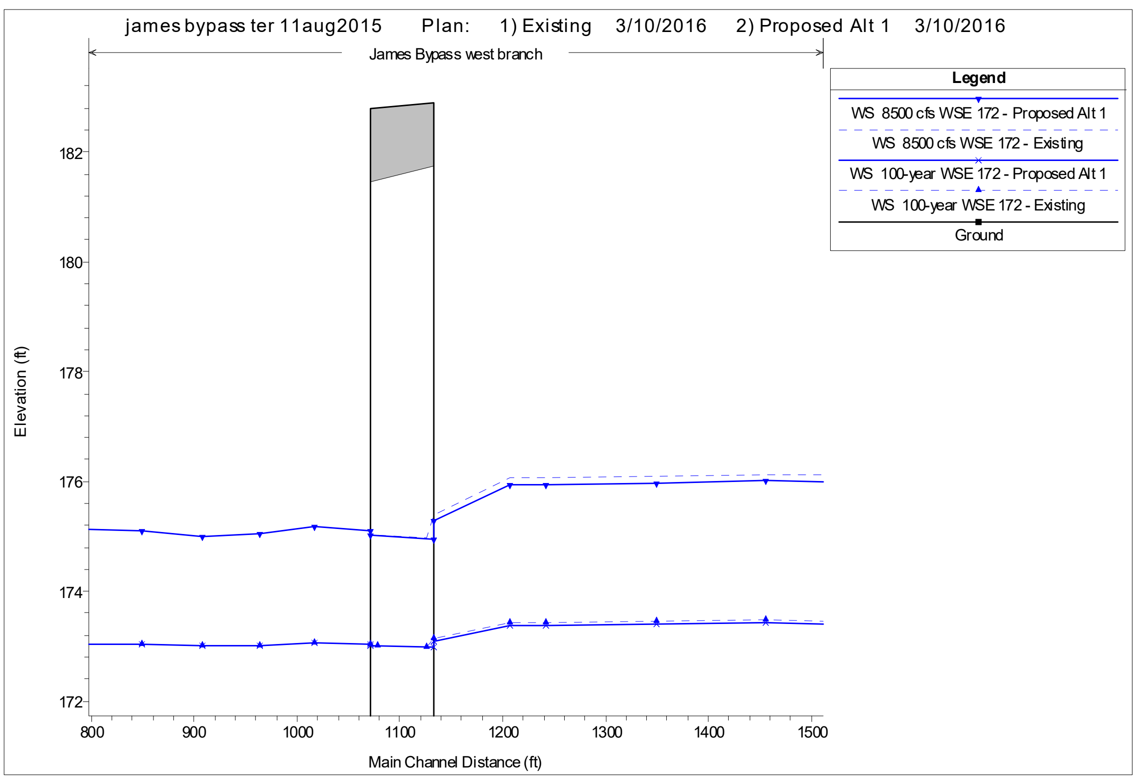


Figure 15: Water surface elevation for existing and proposed for the West Branch (zoomed in)

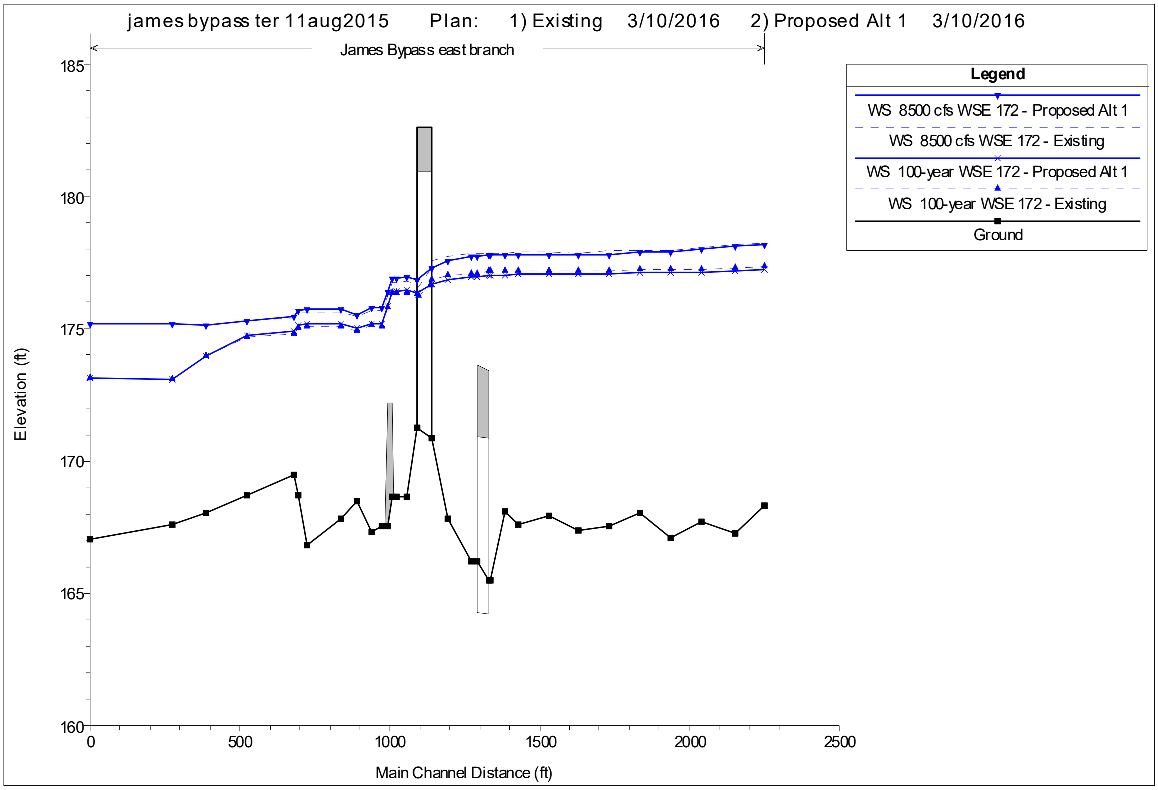


Figure 16: Water surface elevation for existing and proposed for the East Branch.

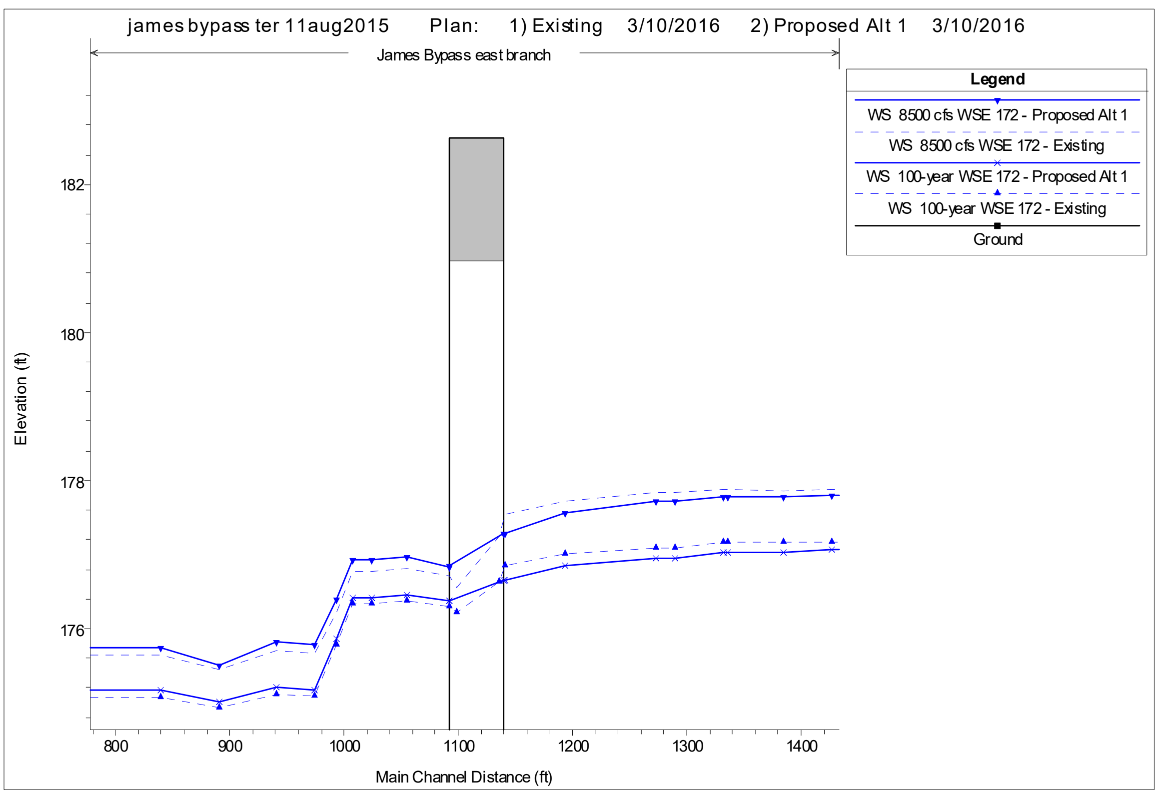


Figure 17: Water surface elevation for existing and proposed for the East Branch (zoomed in).

Table 5: Calculated flow distributions

Discharge	Branch	Initial Split	Flow diverted from east branch to west branch	Final Distribution
		(cfs)	(cfs)	(cfs)
>100-yr	East	2,000	889	1,111
	West	6,500		7,389
	Total	*8,500*		*8,500*
100-yr	East	1,000	185	815
	West	3,750		3935
	Total	*4,750*		*4,750*

As Figure 14 through Figure 17 illustrate, and as shown by the data in Table 6 and Table 7, both of the proposed bridges will cause a decrease in water surface elevation upstream. Table 8 shows the resulting freeboard available at each of the bridges for both discharges.

Table 6. Water Surface Elevation comparison existing vs. proposed for West Bridge

River Station	100-yr			>100-yr		
	Exist	Proposed	Diff.	Exist	Proposed	Diff.
15114	173.1	173.1	0.0	175.2	175.2	0.0
15168	173.0	173.0	0.0	175.1	175.1	0.0
U/S Face of Bridge						
15230	173.2	173.1	-0.1	175.4	175.3	-0.1
15304	173.4	173.4	0.0	176.1	175.9	-0.2
15339	173.4	173.4	0.0	176.1	175.9	-0.2
15446	173.5	173.4	-0.1	176.1	176.0	-0.1

Table 7. Water Surface Elevation comparison existing vs. proposed for East Bridge

River Station	100-yr			>100-yr		
	Exist	Proposed	Diff.	Exist	Proposed	Diff.
15926	176.4	176.5	0.1	176.8	177.0	0.2
15963	176.3	176.4	0.1	176.7	176.8	0.1
U/S Face of Bridge						
16012	176.9	176.7	-0.2	177.6	177.3	-0.3
16065	177.0	176.9	-0.1	177.7	177.6	-0.1
16144	177.1	177.0	-0.1	177.8	177.7	-0.1
16207	177.2	177.0	-0.2	177.9	177.8	-0.1

Table 8. Resulting freeboard at West and East Bridge

Bridge		100-yr		> 100-yr	
	Minimum Soffit Elevation	**WSE** (at upstream face)	**Freeboard** (ft)	**WSE** (at upstream face)	**Freeboard** (ft)
West					
Existing	180.6	173.2	7.4	175.4	5.2
Proposed	180.2	173.1	7.1	175.3	4.9
East					
Existing	180.2	176.9	3.3	177.6	2.6
Proposed	180.3	176.7	3.6	177.3	3.0

HYDRAULIC CRITERIA

Chapter 820 of the Caltrans Highway Design Manual (HDM) delineates the hydraulic design criteria for bridges (Caltrans, 2020). The basic HDM rule for hydraulic design is that bridges should be designed to pass the Q_{50} with sufficient freeboard and convey the Q_{100} without freeboard. Exceptions may be granted if the bridge designer can provide sufficient evidence that less freeboard is needed. The HDM notes that 2 feet of freeboard is often assumed to be appropriate for preliminary bridge designs, but leaves the recommendation for freeboard to the judgment of the hydraulic engineer based primarily upon the debris anticipated at the bridge.

Since the minimum soffit elevation under proposed conditions is 180.2 feet for the west bridge and 180.3 feet for East Bridge, 7.1 feet of freeboard will be provided above the 100-year water surface elevation for the West Bridge and 3.6 feet for the east bridge which meets the HDM criteria.

The Central Valley Flood Protection Board (CVFPB), however, has jurisdiction over this river (California Code of Regulations Title 23, Article 8, Section 112) and requires 3 feet of freeboard on the 100-year discharge. The proposed bridges will meet this criterion so no variance will be required.

DRIFT

Avila and Associates researched the available Bridge Maintenance Reports for the existing bridges to determine if floating debris catches on them. There were no instances of debris being caught on either of the bridges noted.

The proposed bridges will improve the hydraulics by providing more available flow area, due to the raised soffit elevations, and removal of existing piers from the channel which will also reduce the potential for drift accumulation.

SCOUR

Avila and Associates reviewed the available channel cross-sections between 1972 and 2014. There has been a maximum of 2.5-ft of thalweg change at the west bridge between 1972 and 2009 as shown in Figure 18. There has been no significant change in thalweg elevation between 1972 and 2011 at the east bridge. The 1993 profile (red) that is plotted below appears to be either an anomaly or utilizing a different datum that was not correctly specified on the cross section form. Future degradation is therefore assumed to be minimal for the proposed bridge on the east side and up to 5-ft of degradation should be assumed for bridge design on the west side.

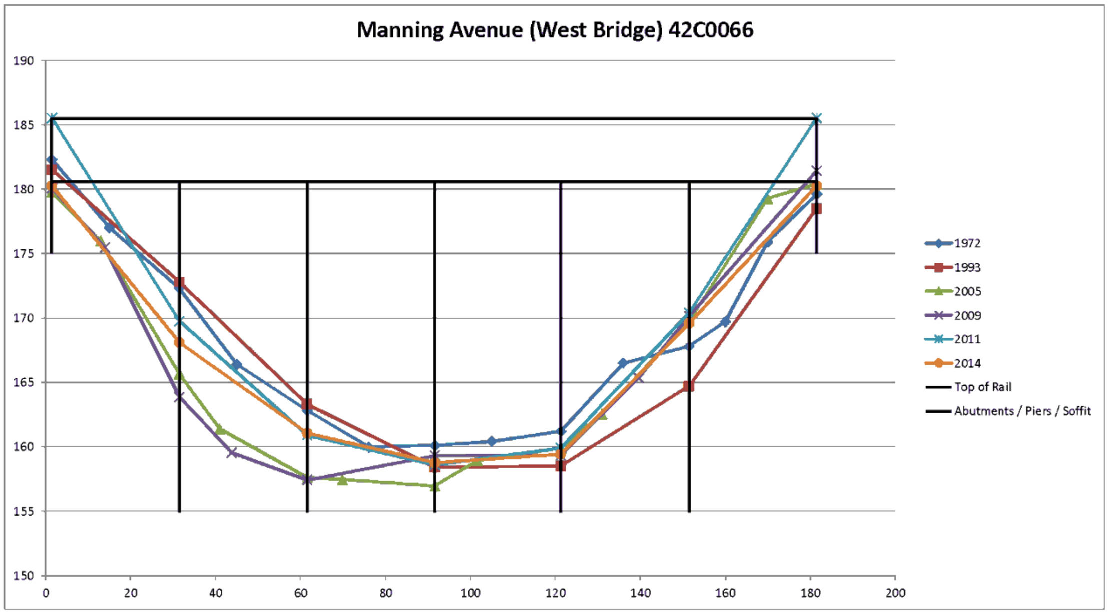


Figure 18: Cross sections taken at the West Branch (42C0066) bridge over time (from Caltrans Maintenance Reports)

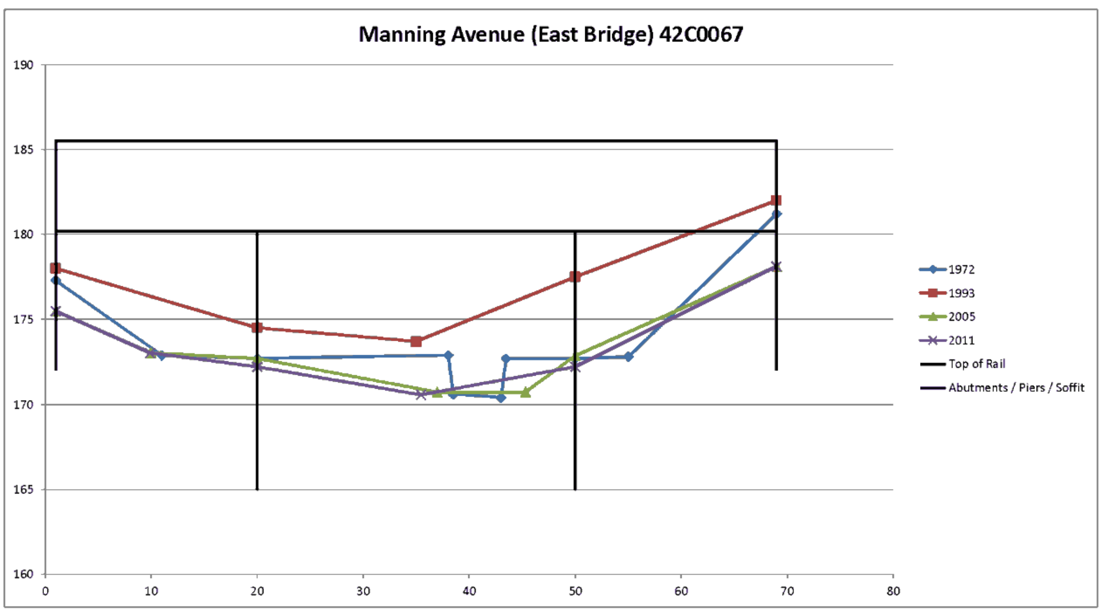


Figure 19: Cross sections taken at the East Branch (42C0067) bridge over time (from Caltrans Maintenance Reports)

All scour calculations were completed following the methodology outlined in HEC-18 (Arneson, 2012).

Contraction Scour

The proposed West bridge does not greatly constrict the channel, however, some of the flow passing in the overbanks upstream passes through the main channel through the bridge reach resulting in approximately 3 feet of contraction scour. The East Bridge constricts the channel from approximately

58 feet upstream to approximately 53 feet through the bridge reach resulting in an estimated contraction scour of 4 feet.

Pier Scour

The proposed West Bridge is anticipated to have 4 ft diameter piers, resulting in an estimated 8 feet of local pier scour. The pier scour elevation should be determined from the channel thalweg of 156 ft for the West Bridge and 170 ft for the East Bridge.

Abutment Scour

Abutment scour was calculated using the equations from NCHRP 24-20 Condition A where the abutments are located near the main channel, resulting in 6 feet of estimated scour at the West Bridge and 10 ft of abutment scour at the East Bridge. These equations are inclusive of contraction scour, thus additional contraction scour should not be added.

Total Scour

According to the Foundation Reports (Kleinfleder, 2017 a and b), scour resistant material bedrock is not present at either the West nor the East bridge. The total scour depths and elevations for the West Bridge are provided in Table 9 and the scour summary table is provided in Table 10. The total scour depths and elevations for the East Bridge are provided in Table 11 and the scour summary table is provided in Table 12.

Table 9. Total scour depths and elevations for the West Bridge assuming a thalweg elevation of 156 ft.

Support	**A1**	**P2**	**P3**	**A4**
Degradation Depth (ft)	5	5	5	5
Contraction Scour Depth (ft)	3	3	3	3
Pier Scour Depth (ft)	n/a	8	8	n/a
Abutment Scour Depth (ft)	6*	n/a	n/a	6*
Total Scour Depth (ft)	11	16	16	11
Total Scour Elevation (ft)	146	141	141	146
Elevation of Scour Resistant Material (ft)	none	none	none	none
Scour Elevation with Geotechnical Considerations (ft)	146	141	141	146

*Abutment scour is inclusive of contraction scour.

Table 10. Scour Summary Table for the West Bridge

Long Term & Short-Term Scour Depths			
Support No.	Degradation Scour Depth (ft)	Contraction Scour Depth (ft)	Short Term (Local) Scour Depth (ft)
A1	n/a	n/a	6
P2	5	3	8
P3	5	3	8
A4	n/a	n/a	6

Table 11. Total scour depths and elevations for the East Bridge assuming a thalweg elevation of 170 ft.

Support	**A1**	**A2**
Degradation Depth (ft)	none	none
Contraction Scour Depth (ft)	4	4
Abutment Scour Depth (ft)	10*	10*
Total Scour Depth (ft)	10	10
Total Scour Elevation (ft)	160	160
Elevation of Scour Resistant Material (ft)	none	none
Scour Elevation with Geotechnical Considerations (ft)	160	160

*Abutment scour is inclusive of contraction scour.

Table 12. Scour Summary Table for the East Bridge

Long Term & Short-Term Scour Depths			
Support No.	Degradation Scour Depth (ft)	Contraction Scour Depth (ft)	Short Term (Local) Scour Depth (ft)
A1	None	n/a	10
A2	none	n/a	10

See Appendix D for detailed scour calculations.

The following Hydrologic Summary Table is provided for your use for placement on the Foundation Plan:

West Bridge:

Drainage Area: n/a Square miles			
	Design	**Base**	**Overtopping**
Frequency (Years)	100	>100	>>100
Discharge (Cubic feet per second)	4,750	8,500	>8,500
Water Surface (Elevation at u/s face of Bridge)	173.1	175.3	~182.0
Flood plain data are based upon information available when the plans were prepared and are shown to meet Federal requirements. The accuracy of said information is not warranted by the County and interested or affected parties should make their own investigation.			

East Bridge:

Drainage Area: n/a Square miles			
	Design	**Base**	**Overtopping**
Frequency (Years)	100	>100	>>100
Discharge (Cubic feet per second)	4,750	8,500	>8,500
Water Surface (Elevation at u/s face of Bridge)	176.7	177.3	~182.0
Flood plain data are based upon information available when the plans were prepared and are shown to meet Federal requirements. The accuracy of said information is not warranted by the County and interested or affected parties should make their own investigation.			

The following Scour Data Table is provided for placement on the West Bridge Foundation Plan, assuming a thalweg elevation of 156 ft:

Support No.	Long Term (Degradation and Contraction) Scour Elevation (ft)	Short Term (Local) Scour Depth (ft)
A1	n/a	6
P2	148	8
P3	148	8
A4	n/a	6

The following Scour Data Table is provided for placement on the East Bridge Foundation Plan, assuming a thalweg elevation of 170 ft:

Support No.	Long Term (Degradation and Contraction) Scour Elevation (ft)	Short Term (Local) Scour Depth (ft)
A1	n/a	10
A2	n/a	10

REFERENCES

Arneson, L.A., Zevenbergen, L.W., Lagasse, P.F., Clopper, P.E., 2012, "Evaluating Scour at Bridges," Hydraulic Engineering Circular 18 Fifth Edition, FHWA NHI-01-001, Washington, D.C.

California Department of Transportation (Caltrans). 2020. "Local Assistance Procedures Manual, Processing Procedures for Implementing Federal and/or State Funded local Public Transportation Projects." January.

California Department of Transportation (Caltrans). 2020. "Highway Design Manual Chapter 820." March.

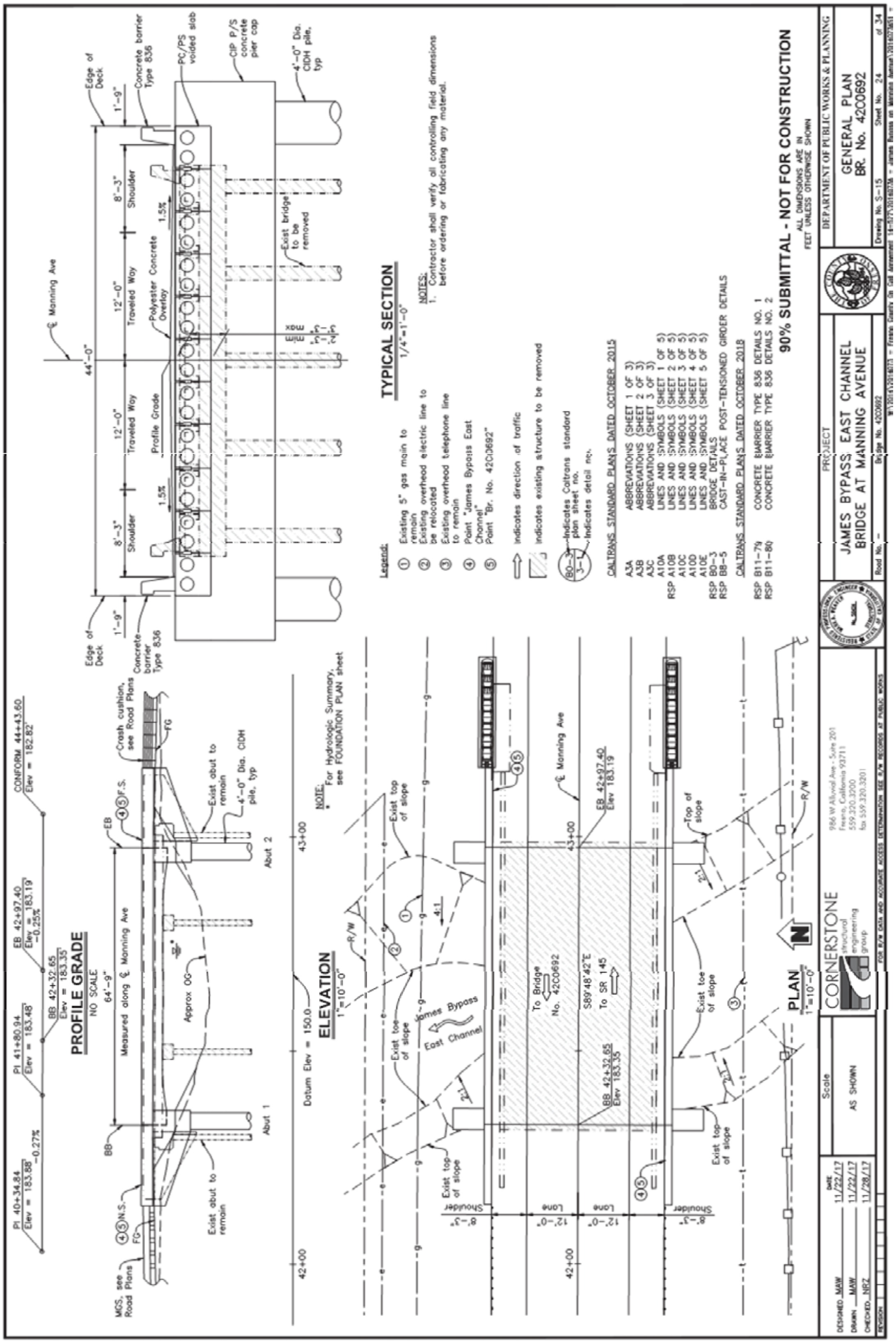
California Department of Transportation (Caltrans). 2014. *Maintenance Records and As-Built Plans for Bridges (Br #42C0066 and 42C0067).*

Kleinfelder, 2017a. "Foundation Report W Manning Avenue over James Bypass East Channel Bridge No. 42C0692 San Joaquin, Fresno County, California." August.

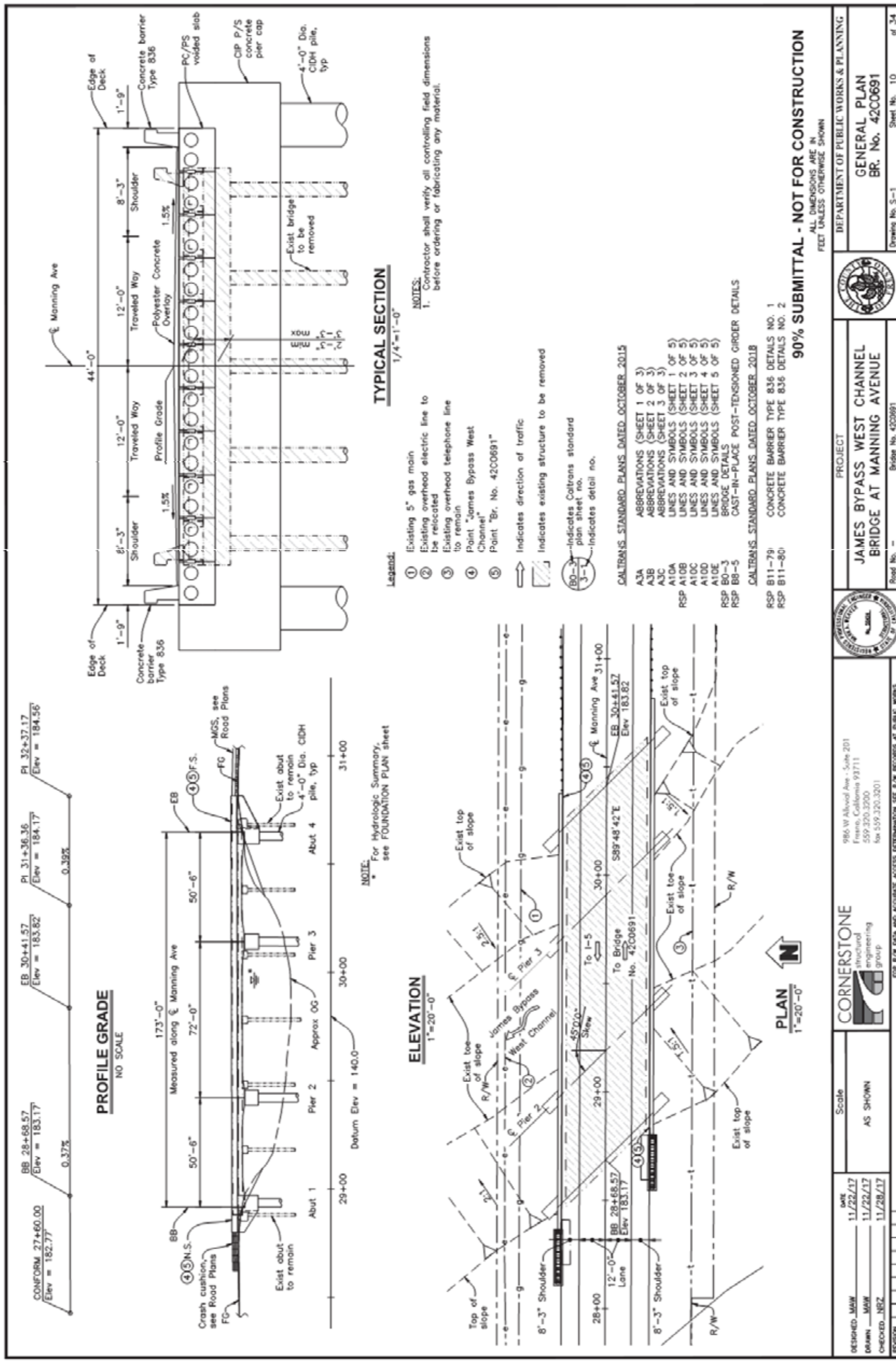
Kleinfelder, 2017b. "Foundation Report W Manning Avenue over James Bypass West Channel Bridge No. 42C0691 San Joaquin, Fresno County, California." August.

APPENDIX A – GENERAL PLANS

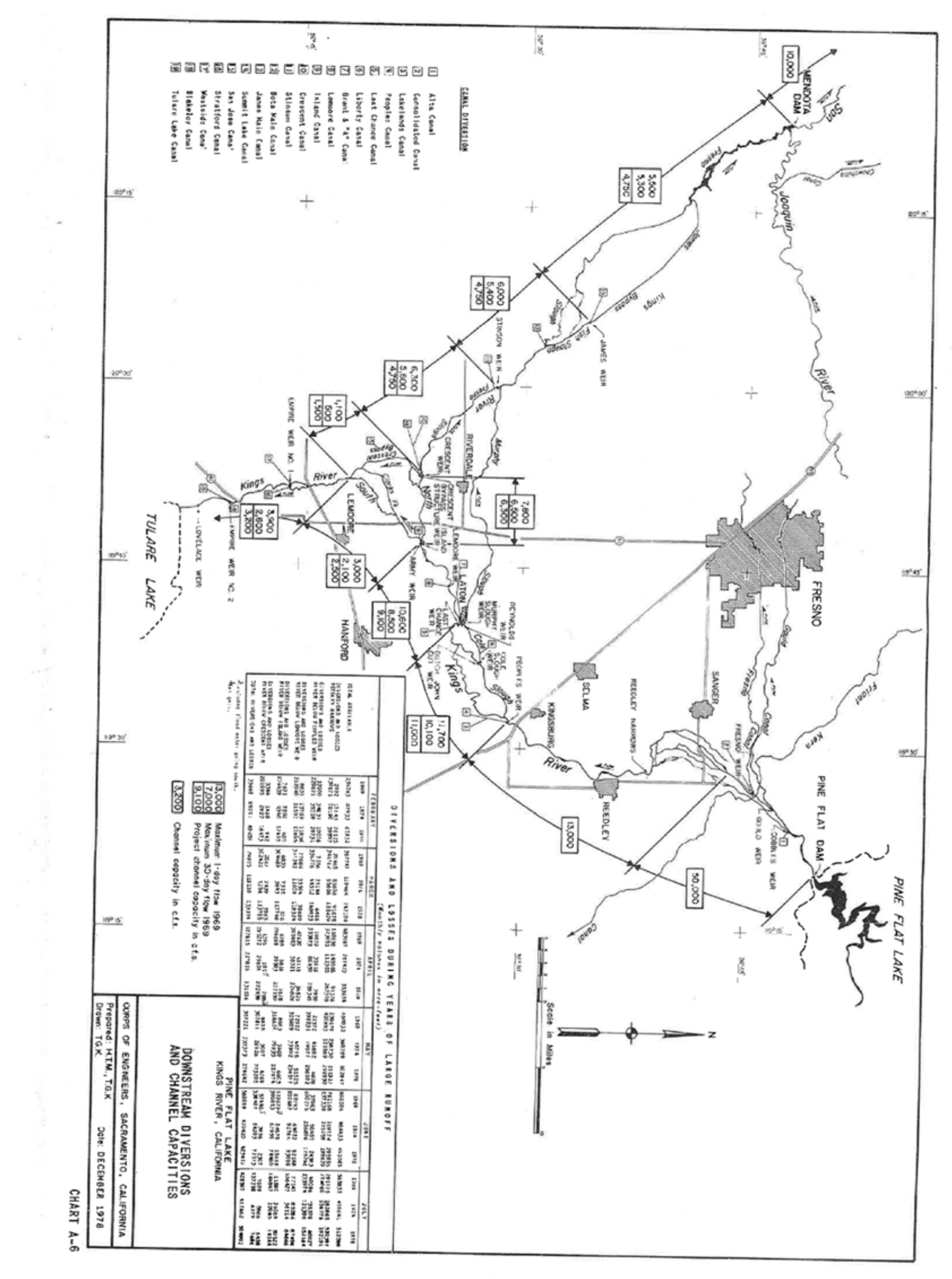
West Bridge


PROFILE GRADE
ELEVATION
PLAN
TYPICAL SECTION
90% SUBMITTAL - NOT FOR CONSTRUCTION
JAMES BYPASS EAST CHANNEL
BRIDGE AT MANNING AVENUE
GENERAL PLAN
BR. No. 42C0692
DEPARTMENT OF PUBLIC WORKS & PLANNING
CORNERSTONE structural engineering group

East Bridge



PROFILE GRADE
NO SCALE
ELEVATION
1"=20'-0"
PLAN
1"=20'-0"
TYPICAL SECTION
1/4"=1'-0"
90% SUBMITTAL - NOT FOR CONSTRUCTION
CORNERSTONE
PROJECT
JAMES BYPASS WEST CHANNEL
BRIDGE AT MANNING AVENUE
DEPARTMENT OF PUBLIC WORKS & PLANNING
GENERAL PLAN
BR. No. 42C0691


CANAL DIVERSIONS
Alta Canal
Consolidated Canal
Lakelands Canal
Peoples Canal
Last Chance Canal
Liberty Canal
Lemoore Canal
Island Canal
Crescent Canal
Stinson Canal
Jacob Main Canal
Summit Lake Canal
San Jose Canal
Westside Canal
Stratford Canal
Tulare Lake Canal
PINE FLAT LAKE
PINE FLAT DAM
FRESNO
SANGER
REEDLEY
SELMA
KINGSBURG
HANFORD
LEMOORE
RIVERDALE
LATON
MENDOTA DAM
TULARE LAKE
Kings River
San Joaquin River
Fresno Slough
James Bypass
JAMES WEIR
STINSON WEIR
EMPIRE WEIR NO. 1
EMPIRE WEIR NO. 2
PEOPLES WEIR
REYNOLDS WEIR
FRESNO WEIR
GOULD WEIR
COBBLES WEIR
ARMY WEIR
10,000
5,500
5,300
4,750
6,000
5,400
4,750
6,300
5,600
4,750
1,100
500
1,500
7,800
6,500
6,300
5,900
2,800
3,200
3,000
2,100
2,200
10,600
8,600
9,100
11,700
10,100
11,000
13,000
50,000
Scale in Miles
N
DIVERSIONS AND LOSSES DURING YEARS OF LARGE RUNOFF
13,000 Maximum 1-day flow 1969
7,000 Maximum 30-day flow 1969
9,100 Project channel capacity in c.f.s.
3,200 Channel capacity in c.f.s.
PINE FLAT LAKE
KINGS RIVER, CALIFORNIA
DOWNSTREAM DIVERSIONS
AND CHANNEL CAPACITIES
CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: H.T.M., T.G.K.
Drawn: T.G.K.
Date: DECEMBER 1978
CHART A-6

Catherine M. C. Avila

From:	sstadler@jamesid.org
Sent:	Tuesday, June 16, 2015 5:12 PM
To:	Catherine M. C. Avila
Cc:	Neil Storey
Subject:	RE: data for James Bypass on Manning Avenue
Attachments:	Kings River Design Flows.pdf; Kings River Below Stinson Weir - 1968-69.pdf

Cathy and Neil –

Attached are some reference documents for your project. Please use 4,750 cfs for the design flow rate of the James Bypass, which is also known as the Fresno Slough Bypass. The 4,750 cfs value can be assumed to be the 100-year number and I can discuss the basis for that assumption tomorrow. Please also evaluate the structure for 6,000 cfs. The floodway can over-perform the design value by a considerable margin and it is important to preserve that capability. Understand that at high flows, there is debris in the channel and the analysis should include an appropriate amount of debris loading.

Regarding the LIDAR data, the entire dataset is 121 GB and includes imagery. I am not sure if it will upload in a reasonable time but will try tomorrow. I am not sure if the data set is thumb drive size.

Steven Stadler, P.E.
Assistant Manager
James Irrigation District
8749 9th Street / P.O. Box 757
San Joaquin, California 93660
(559) 693-4356 x110 (phone)
(559) 693-4357 (fax)
(559) 554-4293 (mobile)
sstadler@jamesid.org

West Branch

HEC-RAS River: James Bypass Reach: west branch

Reach	River Sta	Profile	Plan	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)	
west branch	14097	8500 cfs WSE 172	Existing	7388.67	155.18	174.70		175.11	0.000319	5.30	1547.22	115.57	0.23
west branch	14097	8500 cfs WSE 172	Proposed Alt 1	7255.90	155.18	174.71		175.11	0.000307	5.20	1548.79	115.64	0.23
west branch	14097	100-year WSE 172	Existing	3935.36	155.18	172.88		173.03	0.000130	3.20	1345.65	106.25	0.15
west branch	14097	100-year WSE 172	Proposed Alt 1	3878.95	155.18	172.88		173.03	0.000126	3.16	1346.05	106.27	0.15
west branch	14196	8500 cfs WSE 172	Existing	7388.67	155.58	174.69		175.16	0.000418	5.75	1441.96	115.01	0.27
west branch	14196	8500 cfs WSE 172	Proposed Alt 1	7255.90	155.58	174.70		175.16	0.000402	5.64	1443.55	115.07	0.26
west branch	14196	100-year WSE 172	Existing	3935.36	155.58	172.87		173.05	0.000178	3.53	1239.30	108.13	0.17
west branch	14196	100-year WSE 172	Proposed Alt 1	3878.95	155.58	172.88		173.05	0.000173	3.48	1239.72	108.14	0.17
west branch	14301	8500 cfs WSE 172	Existing	7388.67	155.43	174.79		175.20	0.000299	5.26	1529.44	126.89	0.23
west branch	14301	8500 cfs WSE 172	Proposed Alt 1	7255.90	155.43	174.80		175.20	0.000288	5.16	1530.68	127.56	0.22
west branch	14301	100-year WSE 172	Existing	3935.36	155.43	172.92		173.07	0.000124	3.17	1324.63	102.01	0.14
west branch	14301	100-year WSE 172	Proposed Alt 1	3878.95	155.43	172.92		173.07	0.000120	3.13	1324.88	102.02	0.14
west branch	14394	8500 cfs WSE 172	Existing	7388.67	155.27	174.84		175.23	0.000302	5.25	1576.70	127.43	0.23
west branch	14394	8500 cfs WSE 172	Proposed Alt 1	7255.90	155.27	174.84		175.23	0.000291	5.15	1577.71	127.77	0.23
west branch	14394	100-year WSE 172	Existing	3935.36	155.27	172.94		173.08	0.000126	3.18	1365.30	105.77	0.15
west branch	14394	100-year WSE 172	Proposed Alt 1	3878.95	155.27	172.94		173.08	0.000122	3.13	1365.51	105.78	0.14
west branch	14500	8500 cfs WSE 172	Existing	7388.67	152.74	174.85		175.28	0.000308	5.49	1542.84	122.93	0.23
west branch	14500	8500 cfs WSE 172	Proposed Alt 1	7255.90	152.74	174.85		175.27	0.000297	5.39	1543.77	123.51	0.22
west branch	14500	100-year WSE 172	Existing	3935.36	152.74	172.94		173.10	0.000127	3.32	1340.09	103.68	0.15
west branch	14500	100-year WSE 172	Proposed Alt 1	3878.95	152.74	172.94		173.10	0.000123	3.28	1340.29	103.68	0.14
west branch	14589	8500 cfs WSE 172	Existing	7388.67	154.66	174.85		175.31	0.000353	5.60	1449.35	115.69	0.25
west branch	14589	8500 cfs WSE 172	Proposed Alt 1	7255.90	154.66	174.86		175.30	0.000340	5.49	1450.19	116.03	0.24
west branch	14589	100-year WSE 172	Existing	3935.36	154.66	172.94		173.12	0.000146	3.41	1252.87	99.26	0.16
west branch	14589	100-year WSE 172	Proposed Alt 1	3878.95	154.66	172.94		173.11	0.000142	3.36	1253.05	99.27	0.15
west branch	14694	8500 cfs WSE 172	Existing	7388.67	153.49	174.90		175.35	0.000374	5.66	1481.64	143.29	0.25
west branch	14694	8500 cfs WSE 172	Proposed Alt 1	7255.90	153.49	174.91		175.34	0.000361	5.56	1482.41	143.94	0.25
west branch	14694	100-year WSE 172	Existing	3935.36	153.49	172.96		173.13	0.000157	3.47	1274.46	100.67	0.16
west branch	14694	100-year WSE 172	Proposed Alt 1	3878.95	153.49	172.96		173.13	0.000152	3.42	1274.59	100.68	0.16
west branch	14890	8500 cfs WSE 172	Existing	7388.67	154.31	175.12		175.42	0.000224	4.49	1769.68	126.24	0.20
west branch	14890	8500 cfs WSE 172	Proposed Alt 1	7255.90	154.31	175.12		175.41	0.000216	4.41	1769.30	126.23	0.20
west branch	14890	100-year WSE 172	Existing	3935.36	154.31	173.05		173.16	0.000099	2.77	1512.69	121.31	0.13
west branch	14890	100-year WSE 172	Proposed Alt 1	3878.95	154.31	173.05		173.16	0.000097	2.73	1512.54	121.30	0.13
west branch	14946	8500 cfs WSE 172	Existing	7388.67	154.94	175.11		175.45	0.000260	5.01	1788.81	156.00	0.22
west branch	14946	8500 cfs WSE 172	Proposed Alt 1	7255.90	154.94	175.10		175.44	0.000251	4.92	1788.42	155.99	0.21
west branch	14946	100-year WSE 172	Existing	3935.36	154.94	173.03		173.18	0.000125	3.17	1473.08	149.60	0.15
west branch	14946	100-year WSE 172	Proposed Alt 1	3878.95	154.94	173.03		173.17	0.000121	3.12	1472.94	149.60	0.15
west branch	15005	8500 cfs WSE 172	Existing	7388.67	155.35	175.00		175.52	0.000431	6.02	1401.21	152.22	0.27
west branch	15005	8500 cfs WSE 172	Proposed Alt 1	7255.90	155.35	175.00		175.51	0.000416	5.91	1401.44	152.25	0.27
west branch	15005	100-year WSE 172	Existing	3935.36	155.35	173.00		173.20	0.000200	3.74	1163.25	102.85	0.18

HEC-RAS River: James Bypass Reach: west branch (Continued)

Reach	River Sta	Profile	Plan	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)	
west branch	15005	100-year WSE 172	Proposed Alt 1	3878.95	155.35	173.00		173.20	0.000194	3.69	1163.26	102.85	0.18
west branch	15061	8500 cfs WSE 172	Existing	7388.67	156.05	175.05		175.55	0.000491	6.18	1462.82	153.95	0.29
west branch	15061	8500 cfs WSE 172	Proposed Alt 1	7255.90	156.05	175.05		175.53	0.000474	6.07	1462.75	153.95	0.28
west branch	15061	100-year WSE 172	Existing	3935.36	156.05	173.01		173.22	0.000241	3.90	1179.28	116.46	0.20
west branch	15061	100-year WSE 172	Proposed Alt 1	3878.95	156.05	173.01		173.21	0.000234	3.85	1179.24	116.46	0.20
west branch	15114	8500 cfs WSE 172	Existing	7388.67	156.45	175.19		175.59	0.000374	5.43	1626.62	159.61	0.25
west branch	15114	8500 cfs WSE 172	Proposed Alt 1	7255.90	156.45	175.19		175.57	0.000361	5.33	1625.67	159.59	0.25
west branch	15114	100-year WSE 172	Existing	3935.36	156.45	173.07		173.23	0.000185	3.43	1323.60	118.84	0.17
west branch	15114	100-year WSE 172	Proposed Alt 1	3878.95	156.45	173.07		173.23	0.000180	3.39	1323.35	118.83	0.17
west branch	15168	8500 cfs WSE 172	Existing	7388.67	158.90	175.11		175.73	0.000626	6.68	1260.64	104.99	0.32
west branch	15168	8500 cfs WSE 172	Proposed Alt 1	7255.90	158.90	175.10		175.71	0.000604	6.61	1253.99	102.95	0.32
west branch	15168	100-year WSE 172	Existing	3935.36	158.90	173.04		173.29	0.000299	4.24	1049.73	99.72	0.22
west branch	15168	100-year WSE 172	Proposed Alt 1	3878.95	158.90	173.04		173.28	0.000289	4.19	1047.18	98.38	0.21
west branch	15223			Bridge									
west branch	15230	8500 cfs WSE 172	Existing	7388.67	158.84	175.39	168.92	176.26	0.000876	7.76	1070.68	94.17	0.38
west branch	15230	8500 cfs WSE 172	Proposed Alt 1	7255.90	158.84	175.29	168.82	176.13	0.000862	7.66	1066.09	94.61	0.37
west branch	15230	100-year WSE 172	Existing	3935.36	158.84	173.15	166.14	173.52	0.000449	5.04	865.94	88.05	0.27
west branch	15230	100-year WSE 172	Proposed Alt 1	3878.95	158.84	173.10	166.11	173.46	0.000440	4.98	865.75	88.54	0.26
west branch	15304	8500 cfs WSE 172	Existing	7388.67	156.40	176.07		176.34	0.000205	4.44	1951.42	158.01	0.19
west branch	15304	8500 cfs WSE 172	Proposed Alt 1	7255.90	156.40	175.94		176.21	0.000203	4.40	1931.82	157.76	0.19
west branch	15304	100-year WSE 172	Existing	3935.36	156.40	173.43		173.55	0.000110	2.90	1545.23	151.70	0.14
west branch	15304	100-year WSE 172	Proposed Alt 1	3878.95	156.40	173.38		173.50	0.000109	2.87	1537.10	151.54	0.14
west branch	15339	8500 cfs WSE 172	Existing	7388.67	156.87	176.07		176.35	0.000225	4.66	1977.36	173.40	0.20
west branch	15339	8500 cfs WSE 172	Proposed Alt 1	7255.90	156.87	175.94		176.22	0.000223	4.62	1955.75	173.26	0.20
west branch	15339	100-year WSE 172	Existing	3935.36	156.87	173.43		173.56	0.000129	3.14	1523.77	170.30	0.15
west branch	15339	100-year WSE 172	Proposed Alt 1	3878.95	156.87	173.37		173.51	0.000127	3.11	1514.63	170.19	0.15
west branch	15446	8500 cfs WSE 172	Existing	7388.67	157.22	176.10		176.38	0.000204	4.34	1916.20	163.07	0.19
west branch	15446	8500 cfs WSE 172	Proposed Alt 1	7255.90	157.22	175.98		176.25	0.000202	4.30	1895.97	162.87	0.19
west branch	15446	100-year WSE 172	Existing	3935.36	157.22	173.46		173.58	0.000105	2.82	1514.76	123.07	0.13
west branch	15446	100-year WSE 172	Proposed Alt 1	3878.95	157.22	173.41		173.52	0.000103	2.79	1508.14	122.82	0.13
west branch	15553	8500 cfs WSE 172	Existing	7388.67	156.73	176.14		176.40	0.000191	4.29	1993.70	176.10	0.19
west branch	15553	8500 cfs WSE 172	Proposed Alt 1	7255.90	156.73	176.01		176.27	0.000190	4.25	1971.70	175.90	0.19
west branch	15553	100-year WSE 172	Existing	3935.36	156.73	173.48		173.59	0.000102	2.80	1562.74	132.79	0.13
west branch	15553	100-year WSE 172	Proposed Alt 1	3878.95	156.73	173.42		173.53	0.000100	2.77	1555.55	132.65	0.13
west branch	15650	8500 cfs WSE 172	Existing	7388.67	156.97	176.11		176.44	0.000295	4.92	1776.55	168.73	0.23
west branch	15650	8500 cfs WSE 172	Proposed Alt 1	7255.90	156.97	175.98		176.31	0.000294	4.88	1755.50	168.54	0.22
west branch	15650	100-year WSE 172	Existing	3935.36	156.97	173.46		173.61	0.000172	3.30	1349.32	129.71	0.17
west branch	15650	100-year WSE 172	Proposed Alt 1	3878.95	156.97	173.41		173.56	0.000170	3.27	1342.32	129.57	0.17

HEC-RAS River: James Bypass Reach: west branch (Continued)

Reach	River Sta	Profile	Plan	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)	
west branch	15746	8500 cfs WSE 172	Existing	7388.67	157.19	176.14		176.47	0.000310	4.82	1758.87	177.75	0.23
west branch	15746	8500 cfs WSE 172	Proposed Alt 1	7255.90	157.19	176.02		176.34	0.000309	4.78	1736.62	177.51	0.23
west branch	15746	100-year WSE 172	Existing	3935.36	157.19	173.48		173.63	0.000182	3.24	1332.44	131.06	0.17
west branch	15746	100-year WSE 172	Proposed Alt 1	3878.95	157.19	173.42		173.57	0.000180	3.21	1325.34	130.90	0.17
west branch	15843	8500 cfs WSE 172	Existing	7388.67	156.81	176.22		176.50	0.000225	4.61	1953.27	169.17	0.20
west branch	15843	8500 cfs WSE 172	Proposed Alt 1	7255.90	156.81	176.09		176.37	0.000223	4.57	1932.11	168.83	0.20
west branch	15843	100-year WSE 172	Existing	3935.36	156.81	173.52		173.65	0.000126	3.05	1505.41	150.20	0.15
west branch	15843	100-year WSE 172	Proposed Alt 1	3878.95	156.81	173.46		173.59	0.000124	3.02	1497.23	148.68	0.15
west branch	15944	8500 cfs WSE 172	Existing	7388.67	155.95	176.22		176.54	0.000266	4.75	1774.86	154.44	0.21
west branch	15944	8500 cfs WSE 172	Proposed Alt 1	7255.90	155.95	176.09		176.41	0.000264	4.71	1755.63	153.88	0.21
west branch	15944	100-year WSE 172	Existing	3935.36	155.95	173.52		173.67	0.000144	3.13	1386.53	122.12	0.15
west branch	15944	100-year WSE 172	Proposed Alt 1	3878.95	155.95	173.47		173.61	0.000142	3.10	1379.84	121.88	0.15
west branch	16041	8500 cfs WSE 172	Existing	7388.67	154.95	176.22		176.57	0.000276	4.98	1709.79	148.91	0.22
west branch	16041	8500 cfs WSE 172	Proposed Alt 1	7255.90	154.95	176.10		176.44	0.000273	4.93	1691.29	148.37	0.22
west branch	16041	100-year WSE 172	Existing	3935.36	154.95	173.53		173.68	0.000146	3.24	1344.27	112.41	0.16
west branch	16041	100-year WSE 172	Proposed Alt 1	3878.95	154.95	173.48		173.62	0.000144	3.21	1338.10	112.24	0.16
west branch	16145	8500 cfs WSE 172	Existing	6500.00	155.96	176.24		176.61	0.000282	5.06	1492.92	144.39	0.22
west branch	16145	8500 cfs WSE 172	Proposed Alt 1	6500.00	155.96	176.11		176.48	0.000291	5.11	1473.60	144.08	0.23
west branch	16145	100-year WSE 172	Existing	3750.00	155.96	173.53		173.71	0.000169	3.55	1175.51	94.30	0.17
west branch	16145	100-year WSE 172	Proposed Alt 1	3750.00	155.96	173.47		173.65	0.000172	3.57	1170.03	94.15	0.17

East Branch

HEC-RAS River: James Bypass Reach: east branch

Reach	River Sta	Profile	Plan	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)	
east branch	14871	8500 cfs WSE 172	Existing	1111.33	167.04	175.19		175.19	0.000009	0.56	2181.39	490.44	0.04
east branch	14871	8500 cfs WSE 172	Proposed Alt 1	1244.10	167.04	175.19		175.20	0.000011	0.63	2183.79	490.46	0.04
east branch	14871	100-year WSE 172	Existing	814.64	167.04	173.11		173.12	0.000015	0.59	1387.75	325.29	0.05
east branch	14871	100-year WSE 172	Proposed Alt 1	871.05	167.04	173.12		173.12	0.000018	0.64	1388.49	325.59	0.05
east branch	15143	8500 cfs WSE 172	Existing	1111.33	167.57	175.18		175.20	0.000091	1.31	1088.57	351.89	0.11
east branch	15143	8500 cfs WSE 172	Proposed Alt 1	1244.10	167.57	175.18		175.21	0.000114	1.46	1089.83	351.93	0.12
east branch	15143	100-year WSE 172	Existing	814.64	167.57	173.08		173.15	0.000603	2.34	408.32	241.40	0.25
east branch	15143	100-year WSE 172	Proposed Alt 1	871.05	167.57	173.07		173.16	0.000692	2.51	407.51	241.05	0.27
east branch	15259	8500 cfs WSE 172	Existing	1111.33	168.01	175.15		175.25	0.001263	4.01	475.36	266.73	0.31
east branch	15259	8500 cfs WSE 172	Proposed Alt 1	1244.10	168.01	175.14		175.28	0.001597	4.51	473.92	266.54	0.35
east branch	15259	100-year WSE 172	Existing	814.64	168.01	173.95	173.95	174.43	0.006750	7.79	189.95	183.09	0.69
east branch	15259	100-year WSE 172	Proposed Alt 1	871.05	168.01	173.97	173.97	174.50	0.007355	8.16	194.32	186.13	0.72
east branch	15396	8500 cfs WSE 172	Existing	1111.33	168.68	175.29		175.43	0.001144	4.08	408.44	176.00	0.32
east branch	15396	8500 cfs WSE 172	Proposed Alt 1	1244.10	168.68	175.32		175.49	0.001382	4.50	414.06	176.50	0.36
east branch	15396	100-year WSE 172	Existing	814.64	168.68	174.68		174.82	0.001332	4.04	304.16	166.35	0.34
east branch	15396	100-year WSE 172	Proposed Alt 1	871.05	168.68	174.76		174.91	0.001366	4.14	317.53	167.61	0.35
east branch	15551	8500 cfs WSE 172	Existing	1111.33	169.46	175.39		175.67	0.001420	5.34	323.20	130.57	0.42
east branch	15551	8500 cfs WSE 172	Proposed Alt 1	1244.10	169.46	175.45		175.77	0.001677	5.84	330.31	131.14	0.46
east branch	15551	100-year WSE 172	Existing	814.64	169.46	174.81		175.08	0.001518	5.08	249.23	124.44	0.42
east branch	15551	100-year WSE 172	Proposed Alt 1	871.05	169.46	174.89		175.17	0.001562	5.22	259.54	125.31	0.43
east branch	15565	8500 cfs WSE 172	Existing	1111.33	168.68	175.61		175.69	0.000234	2.35	513.94	132.99	0.18
east branch	15565	8500 cfs WSE 172	Proposed Alt 1	1244.10	168.68	175.70		175.80	0.000275	2.58	526.68	133.98	0.19
east branch	15565	100-year WSE 172	Existing	814.64	168.68	175.05		175.11	0.000187	1.96	440.78	127.14	0.15
east branch	15565	100-year WSE 172	Proposed Alt 1	871.05	168.68	175.14		175.20	0.000200	2.05	452.19	128.07	0.16
east branch	15597	8500 cfs WSE 172	Existing	1111.33	166.81	175.65		175.70	0.000101	1.81	672.13	139.92	0.12
east branch	15597	8500 cfs WSE 172	Proposed Alt 1	1244.10	166.81	175.75		175.81	0.000120	1.99	686.62	140.47	0.13
east branch	15597	100-year WSE 172	Existing	814.64	166.81	175.08		175.11	0.000075	1.47	592.88	136.85	0.10
east branch	15597	100-year WSE 172	Proposed Alt 1	871.05	166.81	175.17		175.21	0.000081	1.55	605.48	137.35	0.11
east branch	15710	8500 cfs WSE 172	Existing	1111.33	167.80	175.64		175.73	0.000220	2.47	533.34	137.68	0.17
east branch	15710	8500 cfs WSE 172	Proposed Alt 1	1244.10	167.80	175.74		175.85	0.000258	2.70	547.39	138.15	0.19
east branch	15710	100-year WSE 172	Existing	814.64	167.80	175.07		175.13	0.000176	2.08	455.40	135.07	0.15
east branch	15710	100-year WSE 172	Proposed Alt 1	871.05	167.80	175.16		175.23	0.000188	2.17	467.78	135.49	0.16
east branch	15762	8500 cfs WSE 172	Existing	1111.33	168.48	175.45		175.85	0.001499	5.26	247.63	134.70	0.42
east branch	15762	8500 cfs WSE 172	Proposed Alt 1	1244.10	168.48	175.51		175.99	0.001774	5.77	256.04	134.88	0.46
east branch	15762	100-year WSE 172	Existing	814.64	168.48	174.92		175.22	0.001242	4.47	197.13	59.88	0.38
east branch	15762	100-year WSE 172	Proposed Alt 1	871.05	168.48	175.00		175.33	0.001337	4.68	201.78	60.28	0.39
east branch	15812	8500 cfs WSE 172	Existing	1111.33	167.32	175.70		175.91	0.000607	3.87	346.22	102.14	0.28
east branch	15812	8500 cfs WSE 172	Proposed Alt 1	1244.10	167.32	175.82		176.06	0.000699	4.21	358.19	102.64	0.30
east branch	15812	100-year WSE 172	Existing	814.64	167.32	175.11		175.27	0.000509	3.31	287.07	99.65	0.25

HEC-RAS River: James Bypass Reach: east branch (Continued)

Reach	River Sta	Profile	Plan	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)	
east branch	15812	100-year WSE 172	Proposed Alt 1	871.05	167.32	175.21		175.38	0.000539	3.45	296.73	100.06	0.26
east branch	15845	8500 cfs WSE 172	Existing	1111.33	167.55	175.67		175.96	0.000880	4.71	311.73	112.35	0.33
east branch	15845	8500 cfs WSE 172	Proposed Alt 1	1244.10	167.55	175.78		176.12	0.001007	5.10	324.52	113.19	0.36
east branch	15845	100-year WSE 172	Existing	814.64	167.55	175.08		175.32	0.000752	4.08	248.63	97.83	0.30
east branch	15845	100-year WSE 172	Proposed Alt 1	871.05	167.55	175.18		175.43	0.000802	4.26	257.96	102.87	0.31
east branch	15878			Inl Struct									
east branch	15895	8500 cfs WSE 172	Existing	1111.33	168.64	176.76	173.48	177.04	0.000834	4.42	305.99	111.51	0.32
east branch	15895	8500 cfs WSE 172	Proposed Alt 1	1244.10	168.64	176.93	173.78	177.24	0.000920	4.73	324.99	115.16	0.34
east branch	15895	100-year WSE 172	Existing	814.64	168.64	176.33	172.74	176.53	0.000626	3.64	260.86	95.26	0.27
east branch	15895	100-year WSE 172	Proposed Alt 1	871.05	168.64	176.42	172.89	176.63	0.000669	3.81	269.11	99.21	0.28
east branch	15926	8500 cfs WSE 172	Existing	1111.33	168.63	176.81	172.97	177.07	0.000740	4.12	293.52	95.66	0.30
east branch	15926	8500 cfs WSE 172	Proposed Alt 1	1244.10	168.63	176.97	173.24	177.27	0.000829	4.45	309.47	96.77	0.32
east branch	15926	100-year WSE 172	Existing	814.64	168.63	176.38	172.26	176.55	0.000524	3.32	252.35	77.67	0.25
east branch	15926	100-year WSE 172	Proposed Alt 1	871.05	168.63	176.46	172.41	176.65	0.000570	3.49	257.57	83.51	0.26
east branch	15963	8500 cfs WSE 172	Existing	1111.33	171.24	176.71	175.41	177.27	0.002944	6.01	184.81	53.40	0.57
east branch	15963	8500 cfs WSE 172	Proposed Alt 1	1244.10	171.24	176.84	175.64	177.52	0.003171	6.60	188.47	54.00	0.60
east branch	15963	100-year WSE 172	Existing	814.64	171.24	176.30	174.79	176.69	0.002256	4.97	163.77	51.63	0.49
east branch	15963	100-year WSE 172	Proposed Alt 1	871.05	171.24	176.38	174.92	176.81	0.002321	5.27	165.43	51.95	0.51
east branch	16007			Bridge									
east branch	16012	8500 cfs WSE 172	Existing	1111.33	170.88	177.55	174.97	177.83	0.001109	4.27	259.97	60.09	0.36
east branch	16012	8500 cfs WSE 172	Proposed Alt 1	1244.10	170.88	177.28	175.19	177.70	0.001524	5.18	240.34	58.76	0.43
east branch	16012	100-year WSE 172	Existing	814.64	170.88	176.86	174.43	177.07	0.000961	3.71	219.73	56.63	0.33
east branch	16012	100-year WSE 172	Proposed Alt 1	871.05	170.88	176.66	174.54	176.93	0.001223	4.20	207.20	55.63	0.38
east branch	16065	8500 cfs WSE 172	Existing	1157.33	167.83	177.72	172.37	177.88	0.000370	3.21	385.62	74.03	0.22
east branch	16065	8500 cfs WSE 172	Proposed Alt 1	1271.33	167.83	177.56	172.60	177.76	0.000483	3.63	373.97	73.76	0.25
east branch	16065	100-year WSE 172	Existing	816.49	167.83	177.01	171.62	177.11	0.000266	2.57	333.17	72.80	0.18
east branch	16065	100-year WSE 172	Proposed Alt 1	871.29	167.83	176.86	171.74	176.98	0.000328	2.82	322.36	72.55	0.20
east branch	16143.99			Lat Struct									
east branch	16144	8500 cfs WSE 172	Existing	1268.51	166.22	177.84	174.01	177.92	0.000194	2.62	671.80	155.59	0.16
east branch	16144	8500 cfs WSE 172	Proposed Alt 1	1353.20	166.22	177.72	174.01	177.82	0.000238	2.87	653.54	155.16	0.18
east branch	16144	100-year WSE 172	Existing	825.56	166.22	177.09	174.00	177.14	0.000134	2.04	555.60	152.81	0.13
east branch	16144	100-year WSE 172	Proposed Alt 1	875.16	166.22	176.95	174.00	177.02	0.000165	2.24	535.39	152.32	0.14
east branch	16192			Culvert									
east branch	16207	8500 cfs WSE 172	Existing	1268.51	165.51	177.87	174.40	177.94	0.000174	2.57	711.42	154.24	0.15
east branch	16207	8500 cfs WSE 172	Proposed Alt 1	1353.20	165.51	177.78	174.41	177.86	0.000208	2.79	697.57	153.87	0.16
east branch	16207	100-year WSE 172	Existing	825.56	165.51	177.16	173.35	177.20	0.000114	1.98	602.93	151.33	0.12

HEC-RAS River: James Bypass Reach: east branch (Continued)

Reach	River Sta	Profile	Plan	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)	
east branch	16207	100-year WSE 172	Proposed Alt 1	875.16	165.51	177.03	173.66	177.08	0.000140	2.16	583.34	150.80	0.13
east branch	16256	8500 cfs WSE 172	Existing	1460.92	168.08	177.87	172.49	177.96	0.000236	2.69	688.67	153.79	0.18
east branch	16256	8500 cfs WSE 172	Proposed Alt 1	1532.81	168.08	177.78	172.62	177.88	0.000275	2.87	675.13	153.47	0.19
east branch	16256	100-year WSE 172	Existing	924.57	168.08	177.16	171.45	177.21	0.000150	2.00	581.15	151.25	0.14
east branch	16256	100-year WSE 172	Proposed Alt 1	954.23	168.08	177.02	171.52	177.10	0.000215	2.36	458.48	149.49	0.17
east branch	16298	8500 cfs WSE 172	Existing	1547.29	167.57	177.89	172.29	177.97	0.000200	2.57	782.86	172.89	0.17
east branch	16298	8500 cfs WSE 172	Proposed Alt 1	1610.34	167.57	177.80	172.39	177.89	0.000228	2.73	768.45	172.72	0.18
east branch	16298	100-year WSE 172	Existing	940.44	167.57	177.18	171.15	177.22	0.000117	1.84	660.72	171.38	0.12
east branch	16298	100-year WSE 172	Proposed Alt 1	963.12	167.57	177.06	171.19	177.11	0.000133	1.94	641.11	171.14	0.13
east branch	16404	8500 cfs WSE 172	Existing	1773.79	167.93	177.88	173.07	178.01	0.000330	3.24	722.73	184.78	0.21
east branch	16404	8500 cfs WSE 172	Proposed Alt 1	1815.20	167.93	177.80	173.13	177.94	0.000365	3.39	707.65	184.62	0.22
east branch	16404	100-year WSE 172	Existing	988.24	167.93	177.18	171.71	177.24	0.000167	2.16	594.03	183.40	0.15
east branch	16404	100-year WSE 172	Proposed Alt 1	992.73	167.93	177.07	171.72	177.13	0.000184	2.24	573.35	183.17	0.16
east branch	16498	8500 cfs WSE 172	Existing	1848.51	167.38	177.85	173.02	178.08	0.000504	3.90	520.93	162.05	0.26
east branch	16498	8500 cfs WSE 172	Proposed Alt 1	1880.87	167.38	177.77	173.07	178.01	0.000543	4.02	513.03	161.54	0.27
east branch	16498	100-year WSE 172	Existing	1000.00	167.38	177.18	171.61	177.26	0.000209	2.39	455.14	157.71	0.17
east branch	16498	100-year WSE 172	Proposed Alt 1	1000.00	167.38	177.07	171.61	177.16	0.000222	2.44	444.52	157.00	0.17
east branch	16601	8500 cfs WSE 172	Existing	1849.55	167.56	177.97	172.92	178.13	0.000378	3.38	679.12	173.72	0.23
east branch	16601	8500 cfs WSE 172	Proposed Alt 1	1881.10	167.56	177.81	172.97	178.07	0.000573	4.10	462.41	166.83	0.28
east branch	16601	100-year WSE 172	Existing	1000.00	167.56	177.20	171.54	177.29	0.000215	2.40	417.47	132.73	0.17
east branch	16601	100-year WSE 172	Proposed Alt 1	1000.00	167.56	177.09	171.54	177.18	0.000226	2.44	410.33	131.51	0.17
east branch	16706	8500 cfs WSE 172	Existing	1885.33	168.05	177.98	173.44	178.19	0.000519	3.84	575.93	155.79	0.26
east branch	16706	8500 cfs WSE 172	Proposed Alt 1	1906.99	168.05	177.92	173.46	178.14	0.000552	3.93	567.81	154.48	0.27
east branch	16706	100-year WSE 172	Existing	1000.00	168.05	177.21	171.96	177.32	0.000273	2.61	382.42	132.91	0.19
east branch	16706	100-year WSE 172	Proposed Alt 1	1000.00	168.05	177.10	171.96	177.21	0.000287	2.66	375.60	130.44	0.19
east branch	16810	8500 cfs WSE 172	Existing	1894.58	167.10	177.98	173.10	178.27	0.000658	4.34	436.07	121.71	0.29
east branch	16810	8500 cfs WSE 172	Proposed Alt 1	1913.67	167.10	177.92	173.12	178.23	0.000687	4.43	432.37	121.05	0.30
east branch	16810	100-year WSE 172	Existing	1000.00	167.10	177.24	171.51	177.35	0.000249	2.57	389.56	113.18	0.18
east branch	16810	100-year WSE 172	Proposed Alt 1	1000.00	167.10	177.14	171.51	177.24	0.000261	2.61	383.04	111.95	0.18
east branch	16913	8500 cfs WSE 172	Existing	1907.26	167.73	178.08	173.68	178.35	0.000643	4.30	521.58	140.33	0.29
east branch	16913	8500 cfs WSE 172	Proposed Alt 1	1923.48	167.73	178.03	173.69	178.30	0.000675	4.38	514.89	139.94	0.30
east branch	16913	100-year WSE 172	Existing	1000.00	167.73	177.25	172.09	177.38	0.000322	2.86	349.37	109.63	0.20
east branch	16913	100-year WSE 172	Proposed Alt 1	1000.00	167.73	177.15	172.09	177.28	0.000338	2.91	343.46	108.29	0.21
east branch	17022	8500 cfs WSE 172	Existing	1974.25	167.26	178.20	173.47	178.41	0.000528	3.96	616.39	160.09	0.26
east branch	17022	8500 cfs WSE 172	Proposed Alt 1	1980.23	167.26	178.15	173.48	178.37	0.000548	4.01	608.94	159.99	0.27
east branch	17022	100-year WSE 172	Existing	1000.00	167.26	177.31	171.77	177.42	0.000272	2.66	375.54	118.26	0.19
east branch	17022	100-year WSE 172	Proposed Alt 1	1000.00	167.26	177.20	171.77	177.32	0.000284	2.71	369.40	116.96	0.19
east branch	17122.99			Lat Struct									

HEC-RAS River: James Bypass Reach: east branch (Continued)

Reach	River Sta	Profile	Plan	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)	
east branch	17123	8500 cfs WSE 172	Existing	2000.00	168.33	178.22	173.81	178.49	0.000649	4.31	536.85	120.77	0.29
east branch	17123	8500 cfs WSE 172	Proposed Alt 1	2000.00	168.33	178.18	173.81	178.45	0.000666	4.35	531.56	120.69	0.30
east branch	17123	100-year WSE 172	Existing	1000.00	168.33	177.33	172.18	177.45	0.000293	2.74	365.13	94.29	0.19
east branch	17123	100-year WSE 172	Proposed Alt 1	1000.00	168.33	177.23	172.18	177.35	0.000307	2.78	359.14	93.58	0.20

West Bridge

RIVER FOCUS
WATER RESOURCE CONSULTANTS

HEC-18 5th Edition - Scour Calculation Spreadsheet (1D)

Live Bed Contraction Scour

Live Bed Contraction Scour ***: Scour at a contraction when the bed material in the channel upstream of the bridge is moving at the flow causing bridge scour.***

Modified Laursen's Equation (1):

$$\frac{y_2}{y_1} = \left(\frac{Q_2}{Q_1}\right)^{6/7} \left(\frac{W_1}{W_2}\right)^{k_1}$$

Average Contraction Scour Depth:

$$y_s = y_2 - y_o$$

Parameter	Description	Metric Units		US Units		Notes
y_o	Existing Depth in the Contracted Section Before Scour	3.90	(m)	12.80	(ft)	*Flow area of bridge / W_2*
y_1	Average Depth in the Upstream Channel	4.88	(m)	16.02	(ft)	*Data from Chosen Upstream XS*
y_2	Average Depth in the Contraction Section	4.90	(m)	16.07	(ft)	*Modified Laursen's Equation*
Q_1	Flow in the Upstream Channel Transporting Sediment	189.78	(m^3/s)	6701.86	(cfs)	*Flow in the main channel upstream of the bridge, not including overbank flow.*
Q_2	Flow in the Contracted Channel	205.56	(m^3/s)	7259.46	(cfs)	*Flow at the bridge section (through the bridge opening)*
W_1	Bottom Width of the Upstream Main Channel that is Transporting Bed Material	29.65	(m)	97.29	(ft)	*Can be estimated by Upstream Channel Top Width. Data from Chosen Upstream XS*
W_2	Bottom width of the Contracted Section Minus Pier and Debris Width	32.61	(m)	107.00	(ft)	*Effective Bridge Width Calculated Given Bridge, Pier, and Debris Width*
S_1	Slope of EGL of Upstream Channel	0.00	(m/m)	0.00	(ft/ft)	*Data from Chosen Upstream XS*
V*	Shear Velocity in the Upstream Main Channel	0.10	(m/s)	0.32	(ft/s)	*Calculated from data from Chosen Upstream XS(s). ($V^* = (gy_1 S_1)^{0.5}$)*
ω	Fall Velocity of Bed Material based on D50	0.04	(m/s)	0.12	(ft/s)	*See Fall Velocity Tab*
V*/ω	Ratio of Shear Velocity to Fall Velocity	2.697	-	2.697	-	*Determines Mode of Bed Transport and k_1*
k_1	Modified Laursen's Equation Exponent	0.69	-	0.69	-	*See Table 2 to the right.*

Average Live Bed Contraction Scour Depth (y_s)	**3.3**	**(ft)**
	1.0	(m)

Pier Scour

***Pier Scour** is a function of bed material characteristics, bed configuration, flow characteristics, fluid properties, and the geometry of the pier and footing.*

1). HEC-18 5th Edition Pier Scour Equation (based on the CSU Equation)

HEC-18 Equation:

$$\frac{y_s}{y_1} = 2.0\,K_1\,K_2\,K_3\left(\frac{a}{y_1}\right)^{0.65} Fr_1^{0.43}$$

In terms of y_s/a:

$$\frac{y_s}{a} = 2.0\,K_1\,K_2\,K_3\left(\frac{y_1}{a}\right)^{0.35} Fr_1^{0.43}$$

Parameter	Description	Metric Units		US Units		Notes
y_1	Flow depth directly upstream of the pier	3.90	(m)	12.81	(ft)	*Obtained from (BR U) Flow Distribution Table; Bridge Information Macro*
θ	Angle of attack of the flow (skew)	0	(deg)	0	(deg)	*Bridge Skew*
K_1	Correction factor for Pier nose shape	1.0	-	1.0	-	*Use Figure 7.3 and Table 7.1* ***If θ > 5 degrees, K_1 = 1.0***
K_2	Correction factor for angle of attack of flow	1.0	-	1.0		*$K_2 = [(\cos(\theta) + \sin(\theta) * L / A)^{0.65}]$ (where L/A_{max} = 12)*
K_3	Correction factor for bed condition	1.0	-	1.0	-	*Use Table 7.3*
a	Pier Width (including bottom width)	1.2	(m)	4.00	(ft)	*Bottom Pier Width; no floating debris included*
L	Length of Pier	0.0	(m)	0.0	(ft)	*See Figure 7.3 for Guidance*
V_1	Velocity of flow directly upstream of the pier	2.66	(m/s)	8.73	(ft/s)	*Obtained from (BR U) Flow Distribution Table; Bridge Information Macro*
Fr_1	Froude Number directly upstream of the pier	0.43	-	0.43	-	*$Fr_1 = [V_1 / (gy_1)^{1/2}]$*

HEC-18 Equation Maximum Pier Scour Depth (y_s)		
	8.4	**(ft)**
	2.5	(m)

***Note for Round Nose Piers:**

Maximum Scour Depth (y_s) is typically ≤ (2.4 * a) for Fr ≤ 0.8 → 2.4 * a = 9.60

Maximum Scour Depth (y_s) is typically ≤ (3.0 * a) for Fr > 0.8 → 3.0 * a = 12.00

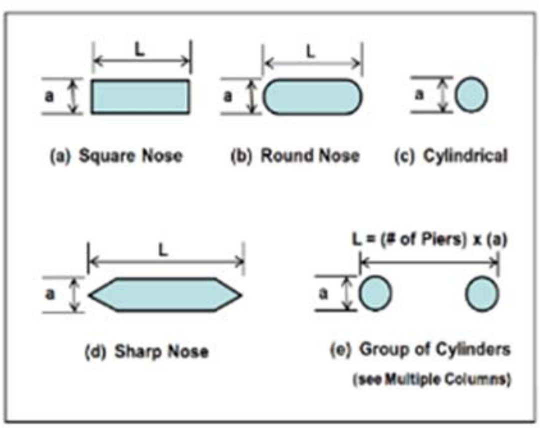
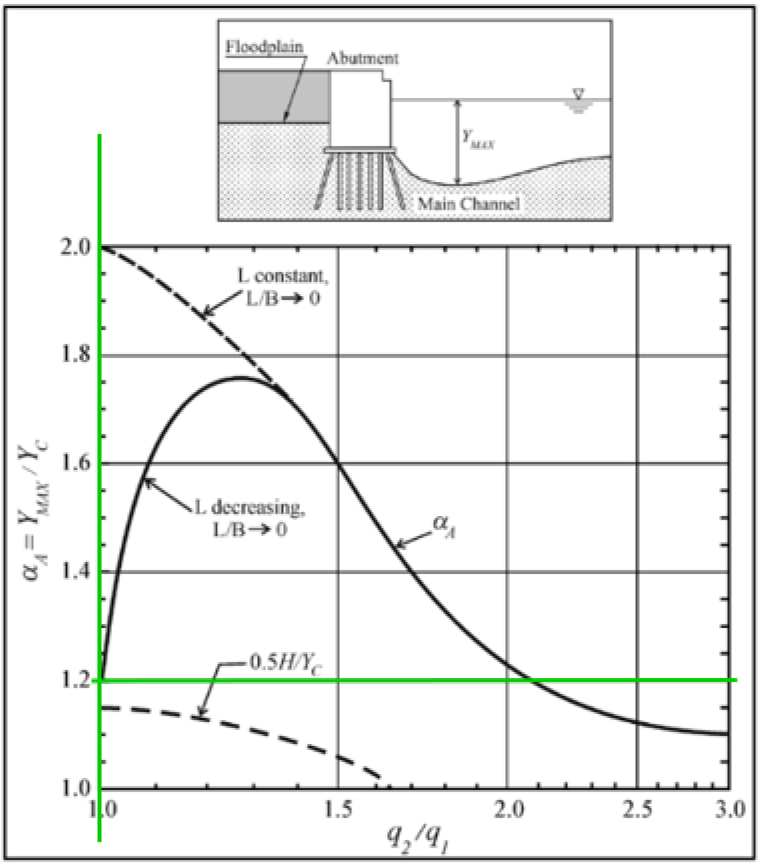


Figure 7.3. Common pier shapes.

Table 7.1. Correction Factor, K_1, for Pier Nose Shape.	
Shape of Pier Nose	K_1
(a) Square nose	1.1
(b) Round nose	1.0
(c) Circular cylinder	1.0
(d) Group of cylinders	1.0
(e) Sharp nose	0.9

Table 7.3. Increase in Equilibrium Pier Scour Depths, K_3, for Bed Condition.

Bed Condition	Dune Height ft	K_3
Clear-Water Scour	N/A	1.1
Plane bed and Antidune flow	N/A	1.1
Small Dunes	10 > H ≥ 2	1.1
Medium Dunes	30 > H ≥ 10	1.2 to 1.1
Large Dunes	H ≥ 30	1.3



2a) Scour occurring when the abutment is in or close to the main channel (Live Bed)

$$y_c = y_1 \left(\frac{q_{2c}}{q_1} \right)^{6/7} \qquad y_{max} = \alpha_A \, y_c \qquad y_s = y_{max} - y_0$$

Parameter	Description	Metric Units		US Units		Notes
y_1	Upstream flow depth	4.88	(m)	16.02	(ft)	*Flow area of bridge / W_2*
y_0	Flow depth prior to scour	3.90	(m)	12.80	(ft)	*Data from chosen upstream XS*
α_a	Amplification factor for live-bed conditions	1.20	-	**1.20**	-	*For spill through abutments: Use Figure 8.9* *For wingwall abutments: Use Figure 8.10*
W_1	Width of the upstream channel	29.65	(m)	97.29	(ft)	*Width of Flow upstream of the bridge section*
Q_1	Flow in the upstream channel	189.78	(m^3/s)	6701.9	(ft^3/s)	*Flow upstream of the bridge section*
q_{2c}	Unit discharge in the constricted opening accounting for non-uniform flow distribution	6.30	(m^2/s)	67.85	(ft^2/s)	*Estimated as the total discharge in the bridge opening divided by the width of the bridge opening: Q_2 / W_2*
q_1	Upstream unit discharge	6.40	(m^2/s)	68.89	(ft^2/s)	*Q_1 / W_1*
q_2/q_1	Ratio of unit discharge	0.98	(m)	0.98	(ft)	*Value used in Figure 8.9 and Figure 8.10 to determine amplification factor*
y_c	Flow depth including live-bed contraction scour	4.82	(m)	15.81	(ft)	*Equation Above*
y_{max}	Max flow depth resulting from abutment scour	5.78	(m)	18.97	(ft)	*Equation Above*

Live Bed Abutment Scour Depth (y_s)	**6.2**	**(ft)**
	1.9	(m)

HEC-18 5th Edition - Scour Calculation Spreadsheet (1D)

Live Bed Contraction Scour

***Live Bed Contraction Scour**: Scour at a contraction when the bed material in the channel upstream of the bridge is moving at the flow causing bridge scour.*

Modified Laursen's Equation (1):

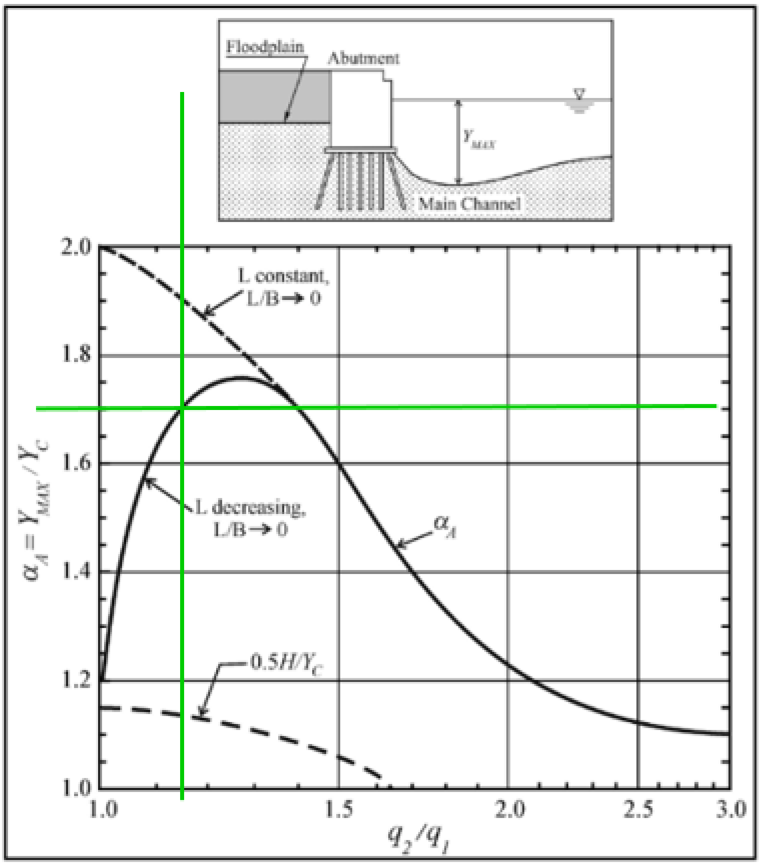
$$\frac{y_2}{y_1} = \left(\frac{Q_2}{Q_1}\right)^{6/7} \left(\frac{W_1}{W_2}\right)^{k_1}$$

Average Contraction Scour Depth:

$$y_s = y_2 - y_o$$

Parameter	Description	Metric Units		US Units		Notes
y_o	Existing Depth in the Contracted Section Before Scour	1.37	(m)	4.50	(ft)	*Flow area of bridge / W_2*
y_1	Average Depth in the Upstream Channel	2.26	(m)	7.42	(ft)	*Data from Chosen Upstream XS*
y_2	Average Depth in the Contraction Section	2.50	(m)	8.20	(ft)	*Modified Laursen's Equation*
Q_1	Flow in the Upstream Channel Transporting Sediment	33.80	(m^3/s)	1193.77	(cfs)	*Flow in the main channel upstream of the bridge, not including overbank flow.*
Q_2	Flow in the Contracted Channel	35.13	(m^3/s)	1240.54	(cfs)	*Flow at the bridge section (through the bridge opening)*
W_1	Bottom Width of the Upstream Main Channel that is Transporting Bed Material	17.93	(m)	58.83	(ft)	*Can be estimated by Upstream Channel Top Width. Data from Chosen Upstream XS*
W_2	Bottom width of the Contracted Section Minus Pier and Debris Width	16.27	(m)	53.39	(ft)	*Effective Bridge Width Calculated Given Bridge, Pier, and Debris Width*
S_1	Slope of EGL of Upstream Channel	0.00	(m/m)	0.00	(ft/ft)	*Data from Chosen Upstream XS*
V*	Shear Velocity in the Upstream Main Channel	0.07	(m/s)	0.23	(ft/s)	*Calculated from data from Chosen Upstream XS(s). [$V^* = (g y_1 S_1)^{0.5}$]*
ω	Fall Velocity of Bed Material based on D50	0.02	(m/s)	0.07	(ft/s)	*See Fall Velocity Tab*
V*/ω	Ratio of Shear Velocity to Fall Velocity	3.302	-	3.302	-	*Determines Mode of Bed Transport and k_1*
k_1	Modified Laursen's Equation Exponent	0.69	-	0.69	-	*See Table 2 to the right.*

Average Live Bed Contraction Scour Depth (y_s)	**3.7**	**(ft)**
	1.1	(m)



2a) Scour occurring when the abutment is in or close to the main channel (Live Bed)

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7} \qquad y_{max} = \alpha_A y_c \qquad y_s = y_{max} - y_0$$

Parameter	Description	Metric Units		US Units		Notes
y_1	Upstream flow depth	2.26	(m)	7.42	(ft)	*Flow area of bridge / W₂*
y_0	Flow depth prior to scour	1.37	(m)	4.50	(ft)	*Data from chosen upstream XS*
α_a	Amplification factor for live-bed conditions	1.70	-	1.70	-	*For spill through abutments: Use Figure 8.9* *For wingwall abutments: Use Figure 8.10*
W_1	Width of the upstream channel	17.93	(m)	58.83	(ft)	*Width of Flow upstream of the bridge section*
Q_1	Flow in the upstream channel	33.80	(m^3/s)	1193.8	(ft^3/s)	*Flow upstream of the bridge section*
q_{2c}	Unit discharge in the constricted opening accounting for non-uniform flow distribution	2.16	(m^2/s)	23.24	(ft^2/s)	*Estimated as the total discharge in the bridge opening divided by the width of the bridge opening: Q_2 / W_2*
q_1	Upstream unit discharge	1.89	(m^2/s)	20.29	(ft^2/s)	*Q_1 / W_1*
q_2/q_1	Ratio of unit discharge	1.15	(m)	1.15	(ft)	*Value used in Figure 8.9 and Figure 8.10 to determine amplification factor*
y_c	Flow depth including live-bed contraction scour	2.54	(m)	8.33	(ft)	*Equation Above*
y_{max}	Max flow depth resulting from abutment scour	4.32	(m)	14.17	(ft)	*Equation Above*

Live Bed Abutment Scour Depth (y_s)	**9.7**	**(ft)**
	2.9	(m)

APPENDIX E – LOCATION HYDRAULIC STUDY

LOCATION HYDRAULIC STUDY FORM

District: 6 Co. Fresno Rte. Manning Ave P.M.
Adv No. ____ Fed Aid No. BRLS-5942(233) Bridge Nos. 42C0066 and 42C0067

Floodplain Description:

Within the project area, James Bypass runs northwesterly through the central part of Fresno County. James Bypass is operated by the James Irrigation District (JID) and was constructed as an overflow channel from Kings River to San Joaquin River. Within the project area, there are two channels within the bypass; one along the western edge and the other along the eastern edge. The western branch is approximately 140 feet from top of bank to top of bank with an approximate depth of 14 feet from top of bank to toe. The eastern branch is approximately 85 feet from top of bank to top of bank with an approximate depth of 12.5 feet from top of bank to toe. Bridge #42C0066 crosses the west branch and bridge # 42C0067 crosses the east branch. Within the project area, James Bypass is bounded by levees on each side. The area surrounding the project site is agricultural. The banks are sparsely vegetated and the channel bed is composed of clayey sand to poorly graded sand (at 42C0066) and silty sand (at 42C0067).

1. Description of Proposal *(include any physical barriers i.e. concrete barriers, soundwalls etc. and design elements to minimize floodplain impacts)*

   Fresno County is proposing to replace two County owned bridges (No. 42C0066 & No. 42C0067) along the Manning Avenue corridor over the James Bypass Overflow. The purpose of the proposed project is to replace these bridges which were revealed to be structurally deficient with a 2011 sufficiency rating of 62.2 for both bridges. Due to the relatively close proximity of the two bridges, they have been programmed for concurrent replacement in order to maximize efficiencies during design and construction. Replacement funding will be provided through the FHWA Highway Bridge Program (HBP).

2. ADT:Current 1,600 (2013) Projected 2,530 (2036)

3. Hydraulic Data: Base Flood $>Q_{100}$= 7,389 cfs at west bridge WSE$_{>100}$= 175.3 ft upstream face of west bridge

   = 1,111 cfs at east bridge WSE$_{>100}$= 177.3 ft upstream face of east bridge

   = 8,500 cfs Total

   The flood of record, if greater than Q_{100}: Q= n/a CFS WSE= n/a

   Overtopping flood Q= $>>Q_{100}$ CFS WSE= approx.182.0 (existing roadway elevation east of site)

   For flows much higher than the base flood, the levee along the east branch overtops first and will eventually overtop Manning Avenue east of the project. The project bridges do not overtop in this scenario.

   Are NFIP maps and studies available? YES ☒ NO ☐

LOCATION HYDRAULIC STUDY FORM cont'd

District: 6 Co. Fresno Rte. Manning Ave P.M.
Adv No. ___ Fed Aid No. BRLS-5942(233) Bridge Nos. 42C0066 and 42C0067

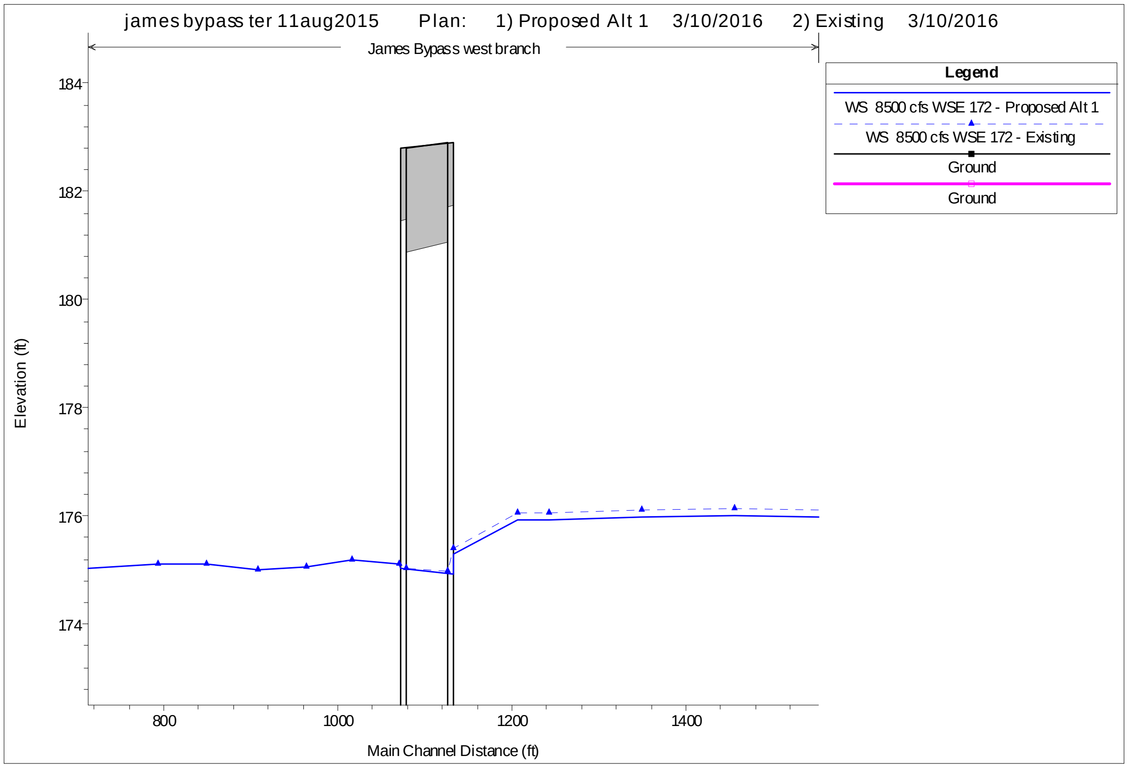


Figure 1: ***Water Surface Profile through the west bridge reach (comparison of existing to proposed)***

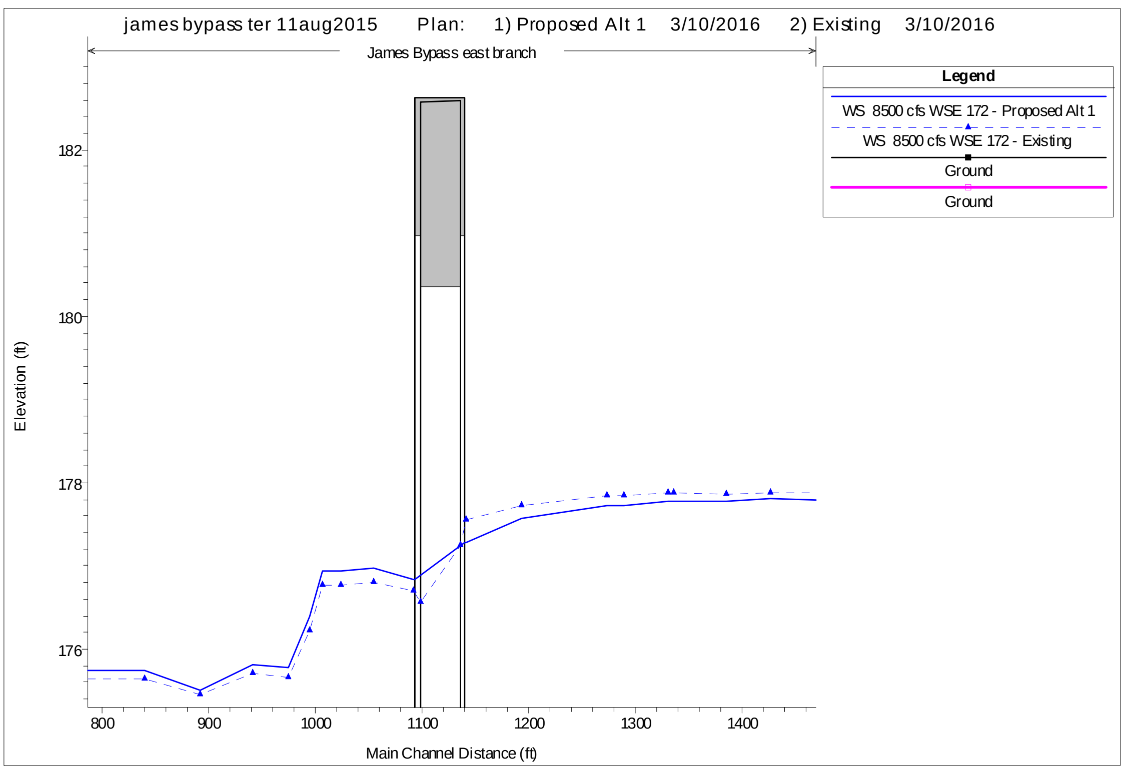


Figure 2. ***Water Surface Profile through the east bridge reach (comparison of existing to proposed)***

District: 6 Co. Fresno Rte. Manning Ave P.M.
Adv No. ___ Fed Aid No. BRLS-5942(233) Bridge Nos. 42C0066 and 42C0067

4. Is the highway location alternative within a regulatory floodway? **YES** ☐ **NO** ☒

The reach is in a Zone A FEMA floodplain without Base Flood Elevations determined as shown in Figure 3 and Figure 4.

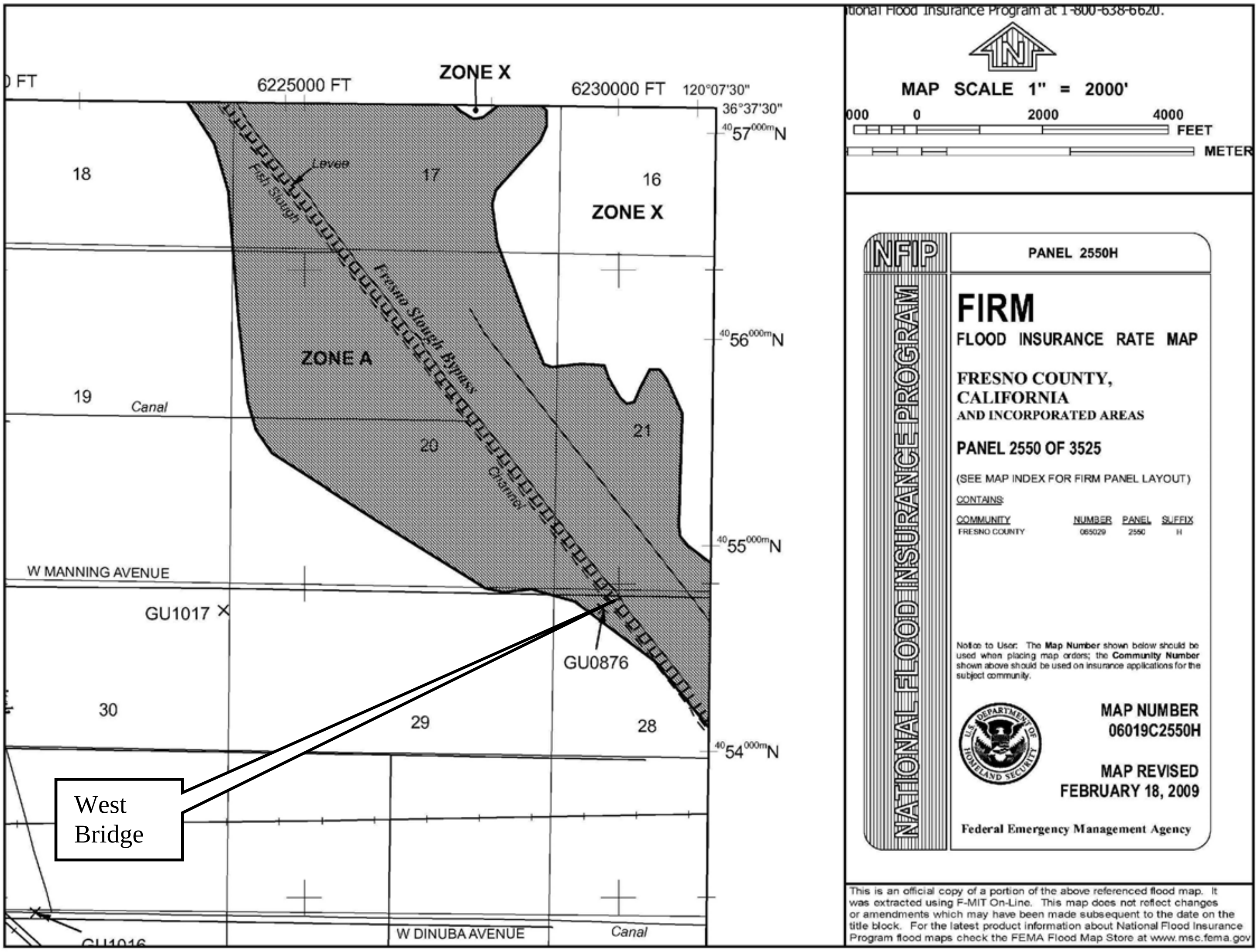


Figure 3. ***FEMA FIS FIRM Panel 2550 of 3525 dated February 18, 2009***

District: 6 Co. Fresno Rte. Manning Ave P.M.
Adv No. ___ Fed Aid No. BRLS-5942(233) Bridge Nos. 42C0066 and 42C0067

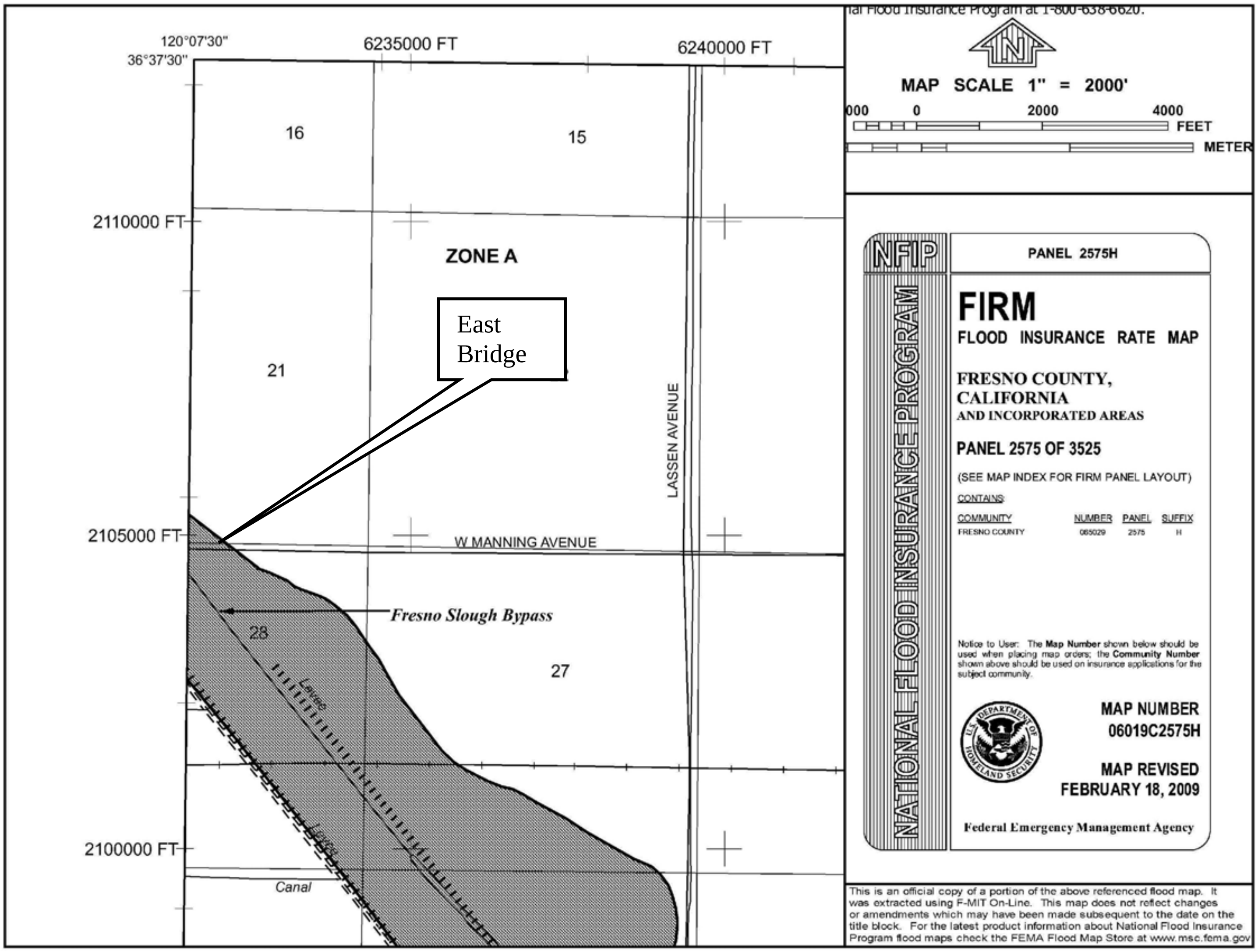


Figure 4. ***FEMA FIS FIRM Panel 2575 of 3525 dated February 18, 2009***

5. Attach map with flood limits outlined showing all buildings or other improvements within the base floodplain. Potential Q_{100} backwater damages: The water surface elevation within the floodplain upstream from the bridges is slightly lowered as a result of the proposed bridges as shown in Figure 1 and Figure 2. Even though the water surface profiles change slightly (approximately 0.2 ft at most), the limits of the floodplain are unchanged as shown in Figure 5.

District: 6 Co. Fresno Rte. Manning Ave P.M.
Adv No. ___ Fed Aid No. BRLS-5942(233) Bridge Nos. 42C0066 and 42C0067

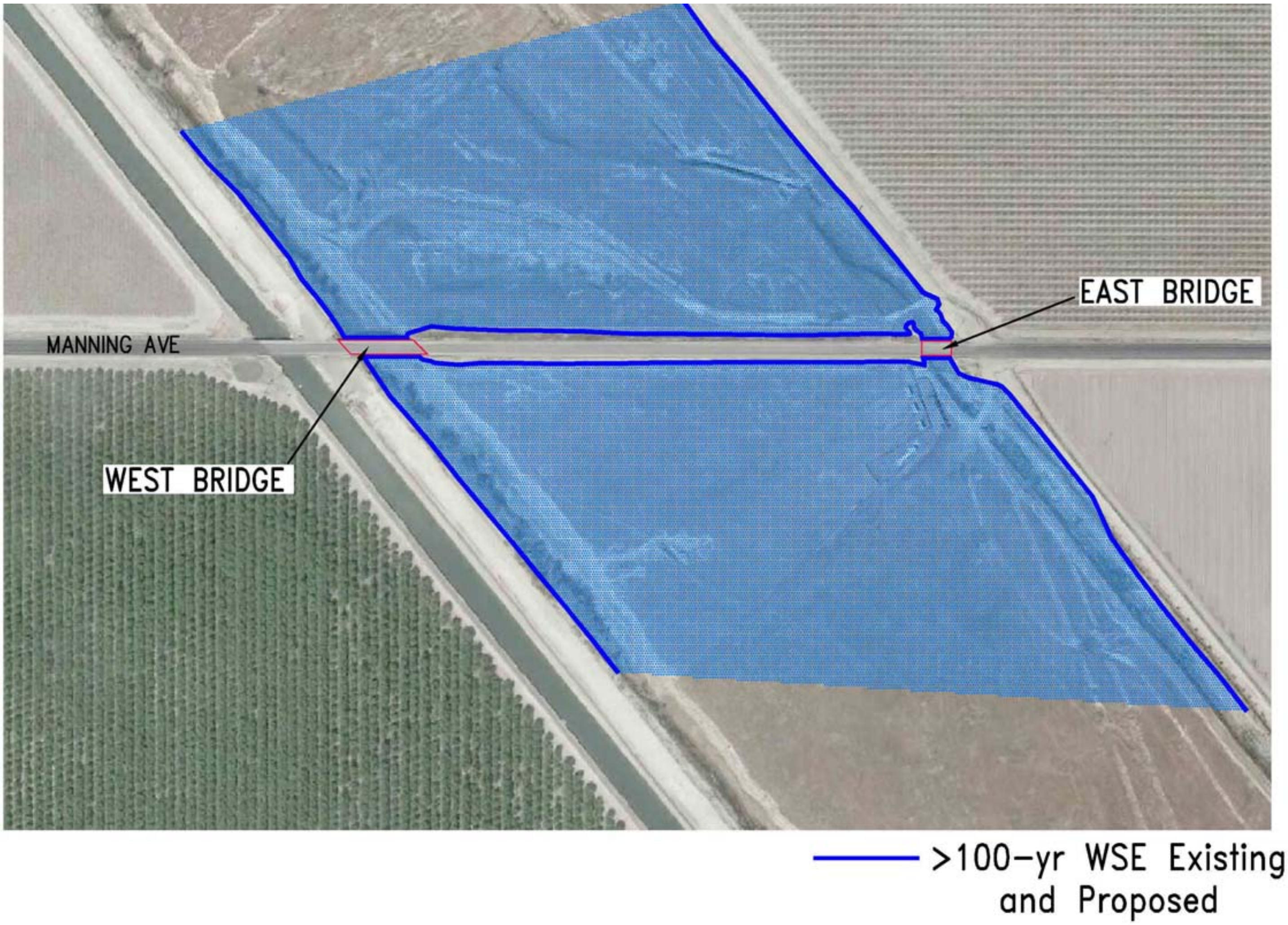


Figure 5. ***100-year water surface elevation delineated on Plan View for Existing and Proposed Conditions***

A. Residences? NO ☒ YES ☐
There are no residences in the vicinity of the proposed bridges as shown in Figure 5.

B. Other Bldgs? NO ☒ YES ☐
There are no buildings in the vicinity of the proposed bridge as shown in Figure 5.

C. Crops? NO ☐ YES ☒
There are crops adjacent to the floodplain upstream and downstream from the proposed bridges as shown in Figure 5. The crops are on the "dry side" of the levee and the floodplain is unchanged, the proposed bridges will have no impact on the crops.

D. Natural and beneficial Floodplain values? NO ☐ YES ☒
Since the floodplain is unchanged, the proposed bridges will have no impact on the floodplain values.

"Natural and beneficial flood-plain values" shall include but are not limited to fish, wildlife, plants, open space, natural beauty, scientific study, outdoor recreation, agriculture, aquaculture, forestry, natural moderation of floods, water quality maintenance and groundwater recharge.

LOCATION HYDRAULIC STUDY FORM cont'd

District: 6 Co. Fresno Rte. Manning Ave P.M.
Adv No. ___ Fed Aid No. BRLS-5942(233) Bridge Nos. 42C0066 and 42C0067

6. Type of Traffic:
   A. Emergency supply or evacuation route? NO ☐ YES ☒
   B. Emergency vehicle access? NO ☐ YES ☒
   C. Practicable detour available? NO ☐ YES ☒
   D. School bus or mail route? NO ☐ YES ☒
7. Estimated duration of traffic interruption for 100-year event (hours): 0
8. Estimated value of Q_{100} flood damages (if any) – moderate risk level.
   A. Roadway $ 0
   B Property $ 0
   Total $ 0
9. Assessment of Level of Risk
   Low ☒
   Moderate ☐
   High ☐

For High Risk projects, during design phase, additional Design Study Risk Analysis may be necessary to determine design alternative.

LOCATION HYDRAULIC STUDY FORM cont'd

District: 6 Co. Fresno Rte. Manning Ave P.M.
Adv No. ___ Fed Aid No. BRLS-5942(233) Bridge Nos. 42C0066 and 42C0067

PREPARED BY:

REGISTERED PROFESSIONAL ENGINEER
CATHERINE M.C. AVILA
No. C 048947
Exp. 09/16
CIVIL
STATE OF CALIFORNIA

Signature – Hydraulic Engineer [signature] Date May 31, 2016
(Item numbers 3, 4, 5, 7, 9) Catherine M.C. Avila, P.E.

Is there any longitudinal encroachment, significant encroachment, or any support of incompatible Floodplain development? No __X__ Yes _____

If yes, provide evaluation and discussion of practicability of alternatives in accordance with 23 CFR 650.113

Information developed to comply with the Federal requirement for the Location Hydraulic Study shall be retained in the project files.

Signature – Project Engineer [signature] Date MAY 31, 2016.
(Item numbers 1, 2, 6, 8)

SUMMARY FLOODPLAIN ENCROACHMENT REPORT*

District: 6 Co. Fresno Rte. Manning Ave P.M. 0.XX
Adv No. __ Fed Aid No. _ Bridge Nos. 42C0066 and 42C0067

Limits:

Fresno County is proposing to replace two County owned bridges (No. 42C0066 & No. 42C0067) along the Manning Avenue corridor over the James Bypass Overflow. The purpose of the proposed project is to replace these bridges which were revealed to be structurally deficient with a 2011 sufficiency rating of 62.2 for both bridges. Due to the relatively close proximity of the two bridges, they have been programmed for concurrent replacement in order to maximize efficiencies during design and construction. The proposed bridges will improve the hydraulics by eliminating some of the existing piers in the channel and maintaining the existing soffit elevation.

Floodplain Description:

The proposed bridge is within an existing FEMA Zone A floodplain without Base Flood Elevations determined.

		No	Yes
1.	Is the proposed action a longitudinal encroachment of the base floodplain? *The proposed bridges are not a longitudinal encroachment.*	☒	☐
2.	Are the risks associated with the implementation of the proposed action significant? *The level of risk to the floodplain of the project site is low.*	☒	☐
3.	Will the proposed action support probable incompatible floodplain development? *The proposed bridge replacement will not support incompatible floodplain development.*	☒	☐
4.	Are there any significant impacts on natural and beneficial floodplain values? *The proposed construction will have only minor impact to the existing riparian habitat in the creek at the bridge site.*	☒	☐
5.	Routine construction procedures are required to minimize impacts on the floodplain. Are there any special mitigation measures necessary to minimize impacts or restore and preserve natural and beneficial floodplain values? If yes, explain. *Best management practices for erosion control measures should be used for proposed construction to minimize temporary impacts to the floodplain during construction.*	☒	☐
6.	Does the proposed action constitute a significant floodplain encroachment as defined in 23 CFR, Section 650.105(q).	☒	☐
7.	Are Location Hydraulic Studies that document the above answers on file? If not explain.	☐	☒

* Same as Figure 804.7B Floodplain Evaluation Report Summary located in Chapter 804 of the *Highway Design Manual*

PREPARED BY:

Signature – Hydraulic Engineer — May 31, 2016
Date

I Concur:

Signature – District Hydraulic Engineer — 6/2/2016
Date

Signature – District Environmental Branch Chief — 6/3/2016
Date

Signature – District Local Assistance Engineer — 6/3/16
Date