Replacement of Market Street Bridge at Santa Ana River

Between Hall Avenue and Rivera Street
In the Cities of Jurupa Valley and Riverside
Project No. C0-0528
Federal Aid No. BRLS-5956(200)

Bridge Design Hydraulic Report

Dated February 2022

Notice regarding this Report:

This document is provided for reference only.

Although this information represents the latest information available, the County of Riverside Transportation Department does not guarantee the accuracy of this data.

Market Street Bridge at Santa Ana River

RIVERSIDE COUNTY, CALIFORNIA
FEDERAL-AID PROJECT NO. BRLS-5956(200)
COUNTY PROJECT NO. C0-0528
EXISTING BRIDGE NO. 56C0024

Bridge Design Hydraulic Report

Prepared for:

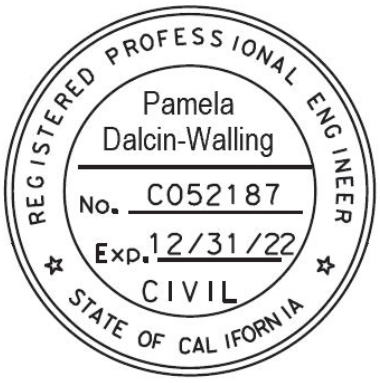
County of Riverside
14th Street Annex
3525 14th Street
Riverside, CA 92501

Prepared by:

Dokken Engineering
110 Blue Ravine Road, Suite 200
Folsom, CA 95630

February 2022

This report has been prepared by or under the supervision of the following Registered Engineer. The Registered Civil Engineer attests to the technical information contained herein and has judged the qualifications of any technical specialists providing engineering data upon which recommendations, conclusions, and decisions are based.



Pamela Dalcin-Walling, P.E.

February 11, 2022

Date

TABLE OF CONTENTS

APPENDICES

1 INTRODUCTION

The County of Riverside (County) is proposing to replace the existing structurally deficient and functionally obsolete two-lane Market Street Bridge over the Santa Ana River with a new four-lane bridge. The project is located in northwestern Riverside County, in the cities of Jurupa Valley and Riverside. See **Appendix A** for a Vicinity Map.

The existing bridge is approximately 34 feet wide and carries two lanes of traffic over the Santa Ana River (one lane in each direction) plus a sidewalk along the north side that is separated by a concrete barrier from the vehicular traffic. The bridge is a 12-span steel plate girder bridge with a total length of 1,195 feet. It is supported on reinforced concrete pier walls. The existing bridge was constructed in two segments. The first segment was completed in 1953, which included piers 7 through 12 and abutment 13. Pier 7 and abutment 13 were founded on driven steel shell filled with concrete piles, and piers 8 through 12 were founded on untreated timber piles as referenced in the as-builts. The second segment was completed in 1957, which included abutment 1 and piers 2 through 6 founded on driven steel shell filled with concrete piles as referenced in the as-builts. The bridge was later retrofitted for seismic safety in 2001. As-builts for the 2001 retrofit are included as **Appendix B**.

The proposed bridge will be approximately 88 feet wide carrying four lanes of traffic and one multi-use path. The bridge replacement is located along the same alignment as the existing bridge where the wider footprint will extend in the upstream direction. The proposed bridge will be a nine-span bridge supported by eight 5.5-foot diameter pier columns constructed in two stages to avoid a full traffic closure along Market Street.

2 REPORT OBJECTIVE

This report documents the temporary and proposed condition hydraulic and scour impacts due to the proposed improvements under various storm events. The conclusions and recommendations of this report will support the bridge design to ensure sufficient freeboard and scour protection is provided.

3 HYDRAULIC ANALYSIS

3.1 Hydraulic Criteria

The hydraulic design of the proposed Market Street Bridge was performed in accordance with the Caltrans design standards. The Caltrans design standards require bridges to pass the 50- and 100-year peak discharges with two and zero feet of freeboard, respectively.

3.2 Hydraulic Model

The hydraulic analysis of the Santa Ana River at the Market Street Bridge was performed using the United States Army Corps of Engineers (USACE) Hydrologic Engineering Center's River Analysis System (HEC-RAS) hydraulic modeling software. The base model was originally developed by the Riverside County Flood Control and Water Conservation District (RCFC&WCD) and has been further developed to analyze the existing, temporary

construction, and proposed conditions. The model was developed based on the following components:

3.2.1 *Peak Flows*

Peak flow rates for the Santa Ana River were extracted from the *USACE Santa Ana River Design Memorandum No. 1 Phase II GDM on the Santa Ana River Mainstem Including Santiago Creek* dated August 1988. These flow rates are shown in Table 1 and represent the future anticipated peak flow rates accounting for the construction of the Seven Oaks Dam. Although these flows are not currently incorporated into Federal Emergency Management Agency (FEMA) reports and maps, it is the most current data available and is recognized by the Riverside County Flood Control and Water Conservation District (RCFC&WCD). See **Appendix C** for an excerpt from the USACE memo summarizing the peak flows utilized for the Market Street Bridge hydraulic analysis.

Table 1: Santa Ana River Peak Flows at Market Street Bridge

Storm Frequency	Peak Flow (cubic feet per second)
50-Year	82,000
100-Year	140,000

3.2.2 *River Geometry*

The hydraulic model provided by RCFC&WCD includes 209 geometric cross sections representing the existing Santa Ana River channel and overbanks. The model spans 86,250 feet along the Santa Ana River from approximately 4,690 feet upstream of the Market Street bridge to the Prado Reservoir. Cross-sections were modeled immediately upstream and downstream of bridges to ensure that the model could adequately capture the losses. The remaining cross-sections are spaced further apart to represent the river upstream, downstream and between the bridges. River geometry was modeled using elevations based on the North American Vertical Datum of 1988 (NAVD88). The existing, temporary, and proposed conditions models all utilized the same river cross-sections. See **Appendix D** for a layout of the cross sections in the hydraulic model.

3.2.3 *Bridge Geometry*

Existing Bridges

A total of eleven bridges were included in the hydraulic model, including the Market Street Bridge. The existing Market Street Bridge structure was modeled based on data from surveys and as-builts. Survey data was collected in May 2017 and supplemented in March 2019, with elevations based on NAVD88. Superstructure elevations that were not surveyed were determined using the geometry indicated in as-builts, which include the 1953 original bridge construction and two retrofit as-builts from 1996 and 2002. The elevations reported in the as-builts had to be converted from the National Geodetic Vertical Datum of 1929 (NGVD29) to NAVD88 to be used in the models.

Piers 1 through 6 in the model (7 through 12 in the as-builts) are skewed 20 degrees relative to the flow while piers 7 through 11 in the model (2 through 6 of the as-builts) are aligned parallel to the flow of the river. Pier widths for piers skewed relative to flow were adjusted to account for the effective obstruction width. Pier widths for piers not skewed relative to flow were adjusted for debris by adding four feet to the constructed widths, assuming debris may extend two feet beyond each end. Piers 3, 4, 11, and 12 have exposed foundations (due to recent scour), and in some cases the underlying piles are exposed. The exposed foundations and piles were modeled as a solid obstruction since it is anticipated that debris will collect between each of the foundation piles. See Table 2 for a summary of the pier numbering and geometry.

Table 2: Existing Market Street Bridge Piers

	Pier Number										
As-Built No.	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**
Model No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Pier Width (ft)	4.9	4.9	4.9	4.9	4.9	4.9	4.5	4.5	4.5	4.5	4.5
Skew Adjusted Pier Width (ft)	12.81	12.81	12.81	12.81	12.81	12.81	N/A	N/A	N/A	N/A	N/A
Foundation Width (ft)	13.0*	13.0*	13.0	13.0	13.0	13.0	9.0	9.0	9.0*	9.0*	9.0
Skew Adjusted Foundation Width (ft)	23.84*	23.84*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

*Indicates an exposed foundation used in the scour analysis.

Proposed Bridge

The proposed bridge replacement is a nine span, 1,216-foot long by 88-foot 5-inch wide, cast-in-place pre-stressed concrete box girder bridge. The bridge will accommodate two 12-foot and two 14-foot lanes, two 8-foot shoulders, a 12-foot multi-use path, a 4-foot center median, and two bridge railings. The bridge will be supported by a total of (32) 66-inch diameter columns over (32) 8-foot cast-in-drilled-hole (CIDH) piles aligned with the flow of the river. The maximum horizontal shift of the roadway will be approximately 39 feet to the northeast, while the maximum vertical profile will increase approximately three feet. Features of the new bridge are summarized in Table 3.

Table 3: Proposed Market Street Bridge Information

Bridge Number	56C0024 (same as existing)
Length	1,216 feet
Clear Width	88 feet 5 inches
Number of Spans	9
Lanes	4
Low Chord Elevation	820.9 feet ± (at abut 10) (NAVD 88)
Bridge Deck Elevation	826.9-830.4 feet ± (NAVD 88)

The alignment is offset to the northeast of the existing roadway centerline by the distance required to allow for one lane of traffic to be open during the first stage of construction while the existing bridge is removed. The remaining construction will take place in Stage 3, with the exception of the closure pour.

The project includes approximately 1,770 feet of roadway approach northwest of the bridge, 1,370 feet of roadway approach southeast of the bridge, and the modification of one driveway due to the revised horizontal and vertical alignment of Market Street.

See **Appendix E** for the Proposed Market Street Bridge General Plan.

Temporary Bridge Conditions

The temporary construction condition was modeled using the existing condition cross-sections and a combination of the existing bridge, the proposed bridge, and temporary falsework structures. The temporary condition analysis was performed to confirm that the combination of structural elements in the channel will not have an adverse hydraulic impact at or upstream of the bridge crossing during construction.

Construction of the new bridge will be staged to allow the roadway to remain open to traffic. Construction will consist of five stages:

- Stage 1 consists of constructing an access road spanning the channel, a temporary bridge structure for construction accessibility, and the Market Street northbound lane improvements including the proposed bridge while traffic continues to utilize the existing bridge. Stage 1 also includes construction of Soundwall No. 1.
- Stage 2 construction is limited to the Via Cerro and Market Street intersection improvements and will not include work within the Santa Ana River.
- Stage 3 will follow the same steps as Stage 1 while constructing the southbound lanes of the proposed bridge and traffic will be shifted to the proposed bridge northbound lanes. Stage 3 also includes a bridge closure to construct the deck closure pour and constructing retaining walls No. 1 and 2.
- Stage 4 construction is limited to the Via Cerro and Market Street intersection and Market Street center lane improvements south of the bridge. Stage 4 will not include work within the Santa Ana River.
- Stage 5 construction is limited to Market Street northbound lane improvements south of the bridge. Stage 5 will not include work within the Santa Ana River.

During Stage 1, a construction access road and temporary bridge will be constructed upstream of the existing bridge to provide a work platform for construction activities. The temporary bridge falsework will extend 3.5 feet below the proposed bridge soffit and will be supported by approximately (45) 14-inch diameter temporary driven piles. The spacing and locations of the existing, proposed, and temporary piers vary, resulting in overlapping obstructions for some piers and no overlap for others. The temporary bridge will be constructed of a timber or steel plate decking spanning the dry weather low water channel. The construction access road and temporary bridge will be removed between Stages 1 and 3. During Stage 3, another construction access road and temporary bridge will be constructed, this time on the downstream side of the existing bridge.

The temporary bridges will be removed during the rainy seasons when the Santa Ana River may experience high flows. The temporary bridge falsework soffit elevations are lower than the existing bridge soffit elevations. As a result, the modeled temporary construction condition includes the proposed bridge with its soffit lowered by 3.5 feet to represent the falsework, the existing and proposed piers, the temporary 14-inch diameter driven piles, and the channel bed raised by 2 feet representing the access road. Due to the temporary access road and the inconsistent alignment of the three sets of piers, the temporary condition increases the channel obstructions. See **Appendix F** for an exhibit depicting the temporary construction obstructions.

3.2.4 Manning's N Values

Manning's roughness coefficients (n values) were used in the hydraulic model to represent the site-specific resistance to channel flow. Several Manning's n values were assigned along each cross section ranging from 0.015 to 0.100. The Manning's n values were verified based on field observations and aerial imagery.

3.2.5 Boundary Conditions

The hydraulic model downstream cross section is located immediately upstream of the Prado Dam. The downstream boundary condition recognized by RCFC&WCD is set to the known water surface elevation of 556.5 feet, which is conservative compared to the FEMA FIRM base flood elevation (BFE). The WSEs documented in the FIS in the vicinity of the downstream model boundary is approximately 552 feet.

3.2.6 Expansion and Contraction Coefficients

Expansion and contraction coefficients were used in the hydraulic model to account for associated energy losses in the channel. The channel segments were assigned an expansion coefficient of 0.3 and a contraction coefficient of 0.1 due to its gradual transitions between most cross-sections. The cross-sections immediately upstream and downstream of the bridges and along the channel that experience abrupt changes of the cross-sectional area were assigned an expansion coefficient of 0.5 and a contraction coefficient of 0.3. The expansion and contraction coefficients were verified based on field observations and aerial imagery.

3.2.7 Hydraulic Results

The hydraulic results were determined by performing a subcritical flow analysis of the modeled channel, structures, and peak flows under existing, temporary, and proposed conditions.

Existing Bridge Condition

The hydraulic analysis indicates the existing bridge meets Caltrans' freeboard criteria by providing over 13 feet of freeboard during a 50-year event and 10 feet of freeboard during a 100-year event. Existing condition freeboards are summarized in Table 4.

Table 4: Existing Condition Market Street Bridge Hydraulic Summary

Flood Frequency (years)	Peak Flow (cfs)	Channel Velocity (ft/s)	Water Surface Elevation* (ft)	Available Freeboard* (ft)	Required Freeboard (ft)
50	82,000	10.1	806.5	13.8	2.0
100	140,000	12.3	809.9	10.4	0.0

* Water surface elevation and available freeboard is based on the upstream bridge face and calculated using a minimum bridge soffit elevation of 820.3 feet (NAVD88).

Temporary Bridge Condition

The temporary bridge condition was evaluated using the same storm flows as that of the existing and proposed condition (i.e. the 50- and 100-year events). Although the temporary condition is unlikely to experience a 50- or 100-year event since the temporary falsework will be removed during the rainy season, the results of this analysis show that impacts to WSE will be significant, but will not compromise freeboard at the bridge or along the upstream channel banks/levee.

During storm conditions, the temporary bridge will meet Caltrans' freeboard criteria by providing over 8 feet of freeboard during a 50-year event and 4 feet of freeboard during a 100-year event. Temporary condition freeboards are summarized in Table 5.

Table 5: Temporary Condition Market Street Bridge Hydraulic Summary

Flood Frequency (years)	Peak Flow (cfs)	Channel Velocity (ft/s)	Water Surface Elevation* (ft)	Available Freeboard* (ft)	Required Freeboard (ft)
50	82,000	9.9	809.0	8.4	2.0
100	140,000	12.1	812.7	4.7	0.0

* Water surface elevation and available freeboard is based on the upstream bridge face and calculated using a minimum existing bridge soffit elevation of 817.4 feet (NAVD88).

During a 100-year storm event, the temporary construction condition hydraulic analysis results in a maximum WSE increase of 2.83 feet at the proposed bridge compared to the existing condition. This increase attenuates over a distance of approximately 4,700 feet in the upstream direction. This increase will not breach the required freeboards along the upstream channel banks/levee due to the naturally high bank and levee elevations along this impacted channel segment. The lowest bank elevation in this reach occurs at cross section 99500, where 8 feet of freeboard is still available during the 100-year storm event in the temporary bridge condition.

Table 6 summarizes the 50- and 100-year WSEs of the Santa Ana River at several cross sections in the vicinity of the Market Street Bridge for the temporary conditions.

Table 6: Temporary Condition Water Surface Elevation Summary

River Station	Description	Water Surface Elevation (NAVD88)					
		50-Year Flow			100-Year Flow		
		Existing	Temporary	Difference	Existing	Temporary	Difference
103000	4,712 Feet Upstream of Bridge	826.34	826.34	0.00	829.03	829.03	0.00
102500	4,212 Feet Upstream of Bridge	823.31	823.31	0.00	825.94	825.95	0.01
10200	3,712 Feet Upstream of Bridge	820.93	820.93	0.00	823.68	823.70	0.02
101500	3,212 Feet Upstream of Bridge	819.34	819.34	0.00	822.21	822.25	0.04
101000	2,712 Feet Upstream of Bridge	817.53	817.53	0.00	820.36	820.46	0.10
100500	2,212 Feet Upstream of Bridge	815.12	815.18	0.06	817.95	818.33	0.38
100000	1,712 Feet Upstream of Bridge	813.04	813.31	0.27	816.22	817.00	0.78
99500	1,212 Feet Upstream of Bridge	811.49	812.06	0.57	814.84	816.02	1.18
99000	712 Feet Upstream of Bridge	809.38	810.78	1.40	812.83	814.84	2.01
98750	462 Feet Upstream of Bridge	808.36	810.32	1.96	812.04	814.43	2.39
98355	5 Feet Upstream of Bridge	807.33	809.90	2.57	811.12	813.95	2.83
98288*	Upstream Face of Proposed Bridge	N/A	809.03	N/A	N/A	812.67	N/A
	Upstream Face of Existing Bridge	806.48	N/A	N/A	809.94	N/A	N/A
	Downstream Face of Existing Bridge	805.81	805.41	-0.40	809.13	808.51	-0.62
	Downstream Face of Proposed Bridge	N/A	N/A	N/A	N/A	N/A	N/A
98250	12 Feet Downstream of Bridge	806.03	806.03	0.00	809.55	809.55	0.00

*The upstream face of the proposed bridge is approximately 45 feet upstream of the existing bridge upstream face. The downstream face of the proposed bridge is approximately 10 feet downstream of the existing bridge downstream face.

Proposed Bridge Condition

The hydraulic analysis indicates the proposed bridge will meet Caltrans' freeboard criteria by providing over 14 feet of freeboard during the 50-year storm and over 10 feet of freeboard during the 100-year storm. Proposed condition freeboards are summarized in Table 7.

Table 7: Proposed Condition Market Street Bridge Hydraulic Summary

Flood Frequency (years)	Peak Flow (cfs)	Channel Velocity (ft/s)	Water Surface Elevation* (ft)	Available Freeboard* (ft)	Required Freeboard (ft)
50	82,000	9.3	806.7	14.2	2.0
100	140,000	11.3	810.3	10.6	0.0

* Water surface elevation and available freeboard is based on the upstream bridge face and calculated using a minimum bridge soffit elevation of 820.9 feet (NAVD88).

The proposed condition hydraulic analysis results in minor decreases to WSEs and minor increases in flow velocity at and upstream of the proposed bridge compared to the existing condition.

Although the project will not substantially increase the erodibility of the channel banks, the disturbed and unlined banks at the proposed abutments will be lined for erosion protection. The project will incorporate grouted rock slope protection with a toe depth down to the total

scour depth (see Section 3.3) at Abutment 1. The grouted rock slope protection will be coordinated and consistent with the Army Corps of Engineers Riverside Levees Rehabilitation Project design.

The existing channel bank at Abutment 10 consists of concrete slope protection from the toe of slope rising half way up the bank to a concrete bike path, and an unlined channel bank from the bike path to the top of bank. Abutment 10 will be constructed by protecting the existing concrete slope and bike path. The channel bank above the bike path will be concrete lined, providing seamless concrete lining at Abutment 10.

See **Appendix G** for detailed results of the hydraulic analysis.

Table 8: Proposed Condition Water Surface Elevation Summary

River Station	Description	Water Surface Elevation (NAVD88)					
		50-Year Flow			100-Year Flow		
		Existing	Proposed	Difference	Existing	Proposed	Difference
100000	1,712 Feet Upstream of Bridge	813.04	813.03	-0.01	816.22	816.19	-0.03
99500	1,212 Feet Upstream of Bridge	811.49	811.47	-0.02	814.84	814.78	-0.06
99000	712 Feet Upstream of Bridge	809.38	809.30	-0.08	812.83	812.70	-0.13
98750	462 Feet Upstream of Bridge	808.36	808.21	-0.15	812.04	811.86	-0.18
98355	5 Feet Upstream of Bridge	807.33	807.09	-0.24	811.12	810.87	-0.25
98288*	Upstream Face of Proposed Bridge	N/A	806.74	N/A	N/A	810.33	N/A
	Upstream Face of Existing Bridge	806.48	N/A	N/A	809.94	N/A	N/A
	Downstream Face of Existing Bridge	805.81	N/A	N/A	809.13	N/A	N/A
	Downstream Face of Proposed Bridge	N/A	805.93	N/A	N/A	809.36	N/A
98250	12 Feet Downstream of Bridge	806.03	806.03	0.00	809.55	809.55	0.00

*The upstream face of the proposed bridge is approximately 45 feet upstream of the existing bridge upstream face. The downstream face of the proposed bridge is approximately 10 feet downstream of the existing bridge downstream face.

3.3 Scour Analysis

Using the results of the hydraulic analysis described above, together with the Federal Highway Administration (FHWA) Hydraulic Engineering Circular No. 18 titled Evaluating Scour at Bridges Fifth Edition (HEC-18), total scour for the existing Market Street Bridge was calculated as a function of the long-term aggradation/degradation, contraction scour, and local (pier/abutment) scour.

3.3.1 Long-Term Scour

The long-term aggradation/degradation was derived from a series of BIR measurements and the 2017 survey of the thalweg in the *Draft Bridge Design Hydraulic Study Report for the Market Street Bridge Replacement at Santa Ana River*, dated August 2018. Based on the thalweg elevation change from 2001 to 2017, the best fit extrapolation over the 75-year design life of the bridge results in bed elevation scour of 7.8 feet.

3.3.2 *Contraction Scour*

Contraction scour was calculated assuming cohesionless bed materials using the live-bed contraction method since the critical velocity of the mean bed material size is less than the mean velocity in the channel. The critical velocity is calculated as follows:

$$V_c = K_u \, y^{1/6} \, D_{50}^{1/3}$$

Where:

V_c = Critical velocity above which the bed material size D_{50} and smaller will be transported (feet per second)
y = Average depth of flow upstream of the bridge (feet)
D_{50} = Median particle size diameter (feet)
K_u = 11.17 (unitless, US customary units)

The live-bed contraction scour was calculated using the modified version of Laursen's 1960 equation per recommendation in HEC-18. The equations used for live-bed contraction scour is as follows:

$$y_2 = y_1 \, (Q_2/Q_1) \, (W_1/W_2)^{k_1}$$

$$V_* = g \, y_1 \, S_1$$

Where:

y_2 = Average depth in the contracted section (feet)
y_1 = Average depth in the upstream main channel (feet)
y_0 = Existing depth in the contracted section before scour (feet)
Q_1 = Flow in the upstream channel transporting sediment (cubic feet per second)
Q_2 = Flow in the upstream channel transporting sediment (cubic feet per second)
W_1 = Bottom width of the upstream main channel that is transporting bed material (feet)
W_2 = Bottom width of main channel in contracted section less pier width(s) (feet)
V_* = Shear velocity in the upstream section (feet per second)
T = Fall velocity of bed material (feet per second, see **Appendix H**)
g = Acceleration of gravity (32.2 feet per second squared)
S_1 = Slope of energy grade line of main channel (feet per feet)
k_1 = Exponent determined by Table 9 (unitless)

Table 9: Contraction Scour Factor k_1

V_*/T	k_1	Mode of Bed Material Transport
<0.50	0.59	Mostly contact bed material discharge
0.50 to 2.0	0.64	Some suspended bed material discharge
>2.0	0.69	Mostly suspended bed material discharge

The median particle size diameters were determined using the sieve analyses performed at each pier in March 2021. The results of the borings indicate median particle size diameters ranging

from 0.08 to 0.80 millimeters. See **Appendix I** for the grain size distribution graphs for each pier location.

The contraction scour calculations resulted in no contraction scour.

3.3.3 Local Scour

Local scour is comprised of pier scour and abutment scour. The abutments do not encroach on the 100-year floodway, resulting in zero abutment scour.

The local pier scour equation is based on the Colorado State University method and is recommended for live-bed pier scour. The equation used to predict maximum pier scour depths is as follows:

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

$$K_2 = \left(\cos\theta + \min\left(\frac{L}{a}, 12\right)\sin\theta\right)^{0.65}$$

$$Fr_1 = \frac{V_1}{\sqrt{g y_1}}$$

Where:

y_s = Scour depth (feet)
y_1 = Flow depth directly upstream of the pier (feet)
K_1 = Correction factor for pier nose shape (unitless)
K_2 = Correction factor for angle of attack of flow (unitless)
K_3 = Correction factor for bed condition (unitless)
θ = Angle of attack of the flow approaching the piers (degrees)
a = Pier width (feet)
L = Length of pier (feet)
Fr_1 = Froude Number directly upstream of the pier (unitless)
V_1 = Mean velocity of flow directly upstream of the pier (feet per second)
g = Acceleration of gravity (32.2 feet per second squared)

The shape of the proposed pier is round, the angle of attack is zero degrees, and the bed condition is clear-water scour, which results in K_1, K_2, and K_3 factors of 1.0, 1.0, and 1.1, respectively per HEC-18 Section 7.2. HEC-RAS utilized the 100-year steady flow hydraulic simulation results with user inputted D_{50} and pier length values to calculate the local pier scour. A summary of the pier scour results is presented in Table 10.

Table 10: Pier Scour Summary

Pier Scour (feet)								
General Plan No.	**Pier 2**	**Pier 3**	**Pier 4**	**Pier 5**	**Pier 6**	**Pier 7**	**Pier 8**	**Pier 9**
Model No.	**Pier 8**	**Pier 7**	**Pier 6**	**Pier 5**	**Pier 4**	**Pier 3**	**Pier 2**	**Pier 1**
100-Year Storm	10.9	12.0	13.2	13.1	11.9	11.2	11.1	11.0

3.3.4 Total Scour

Results of the scour analysis indicate that total scour ranges from a minimum of 18.7 feet to a maximum of 21.0 feet. A summary of the total scour results is presented in Table 11.

Table 11: Total Scour Results

Total Scour (feet)								
General Plan No.	**Pier 2**	**Pier 3**	**Pier 4**	**Pier 5**	**Pier 6**	**Pier 7**	**Pier 8**	**Pier 9**
Model No.	**Pier 8**	**Pier 7**	**Pier 6**	**Pier 5**	**Pier 4**	**Pier 3**	**Pier 2**	**Pier 1**
100-Year Storm	18.7	19.8	21.0	20.9	19.7	19.0	18.9	18.8

Borings show that the material at the maximum predicted scour depths are prone to scour. The scour analysis indicates there is potential for total pier scour from 18.7 feet to 21.0 feet. The pier foundations for the proposed Market Street Bridge are proposed to be constructed to a minimum depth of 68 feet, which is significantly lower than the maximum scour depths.

The detailed scour analysis is presented in **Appendix J**.

4 REFERENCES

American Association of State Highway and Transportation Officials. *AASHTA LRFD Bridge Design Specifications (6th Edition) (2012) with California Amendments.*

American Society of Testing and Materials (ASTM). *ASTM D25 (2012) Standard Specifications for Round Timber Piles.*

California Department of Transportation. (2016b). *Bridge Inspection Report.* Bridge Number: 56C0024. Facility Carried: Market Street. Location: 0.4 mi northwest of SR 60. Inspection Type: Routine, Fracture Critical, Hydraulic, and Scour Evaluation.

California Department of Transportation. (2015). *Bridge Inspection Report.* Bridge Number: 56 0410. Facility Carried: SR 60. Location: 08-RIV-060-10.51-RIV. Inspection Type: Routine.

California Department of Transportation. (1992). *Falsework Design Manual.* Section 7-3 Pile Foundations.

Federal Highway Administration. (2012). Hydraulic Engineering Circular No. 18, *Evaluating Scour at Bridges*, Fifth Edition (HEC-18) (April 2012).

Federal Emergency Management Agency. (March 6, 2018). *Flood Insurance Study for Riverside County, California and Incorporated Areas.* Flood Insurance Study Number 06065CV001D.

Federal Emergency Management Agency. (August 28, 2008). *Flood Insurance Rate Map for Riverside County, California and Incorporated Areas.* Map Number 06065C0045G. Panel 45 of 3805.

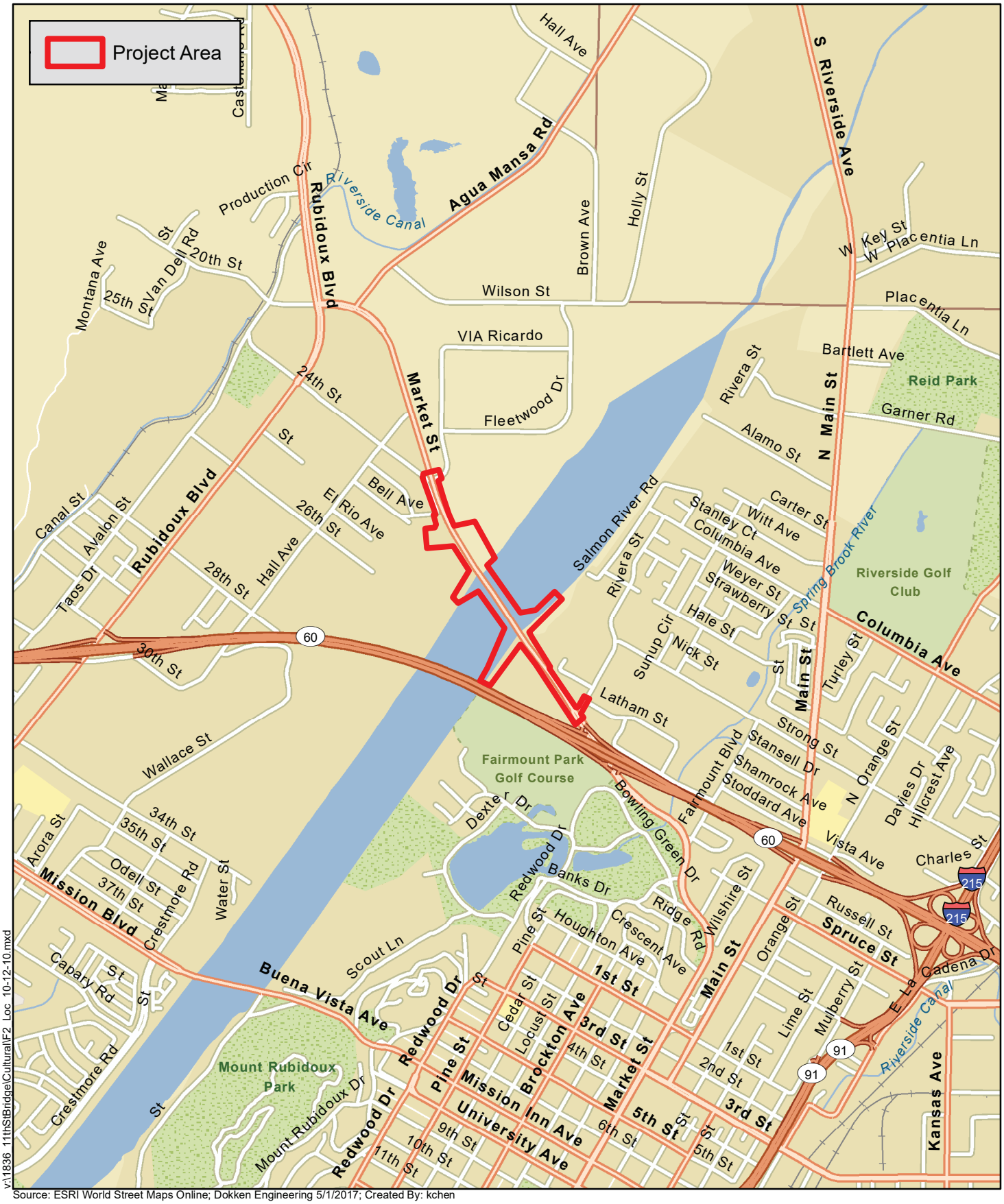
Kleinfelder. (2016). *Preliminary Geotechnical Design Report.* Mission Boulevard Bridge Replacement at Santa Ana River, State Bridge No. 56C0071. Federal Project No. BRLSZ-5956(192). Riverside County, California.

United States Army Corps of Engineers - Hydrologic Engineering Center. (2021). HECRAS River Analysis System. (Version 6.0) [Computer software].

United States Army Corps of Engineers - Hydrologic Engineering Center. (2021). HECRAS River Analysis System Hydraulic Reference Manual. (Version 6.0).

APPENDIX A

Vicinity Map



Source: ESRI World Street Maps Online; Dokken Engineering 5/1/2017; Created By: kchen

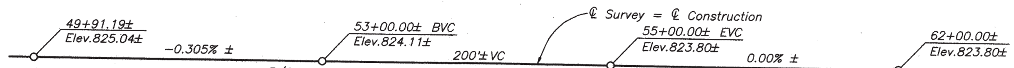
v:\1836 11thStBridge\Cultural\F2 Loc 10-12-10.mxd

0 0.25 0.5 0.75 1 Miles

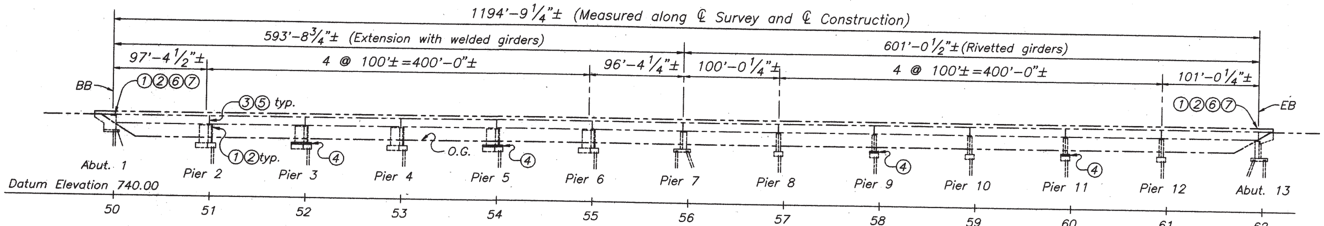
Appendix A
Vicinity Map
Short Term Scour Report
Market Street Bridge
City of Jurupa Valley, California

APPENDIX B

Market Street Bridge As-Builts



PROFILE
No Scale



ELEVATION
1"=60'

RETROFIT LEGEND

1. Replace existing Rocker Bearings.
2. Transverse shear keys.
3. New end cross frames.
4. Retrofit footing.
5. Shear plates.
6. Concrete diaphragm at abutments.
7. Existing conduits, see Road Plans.

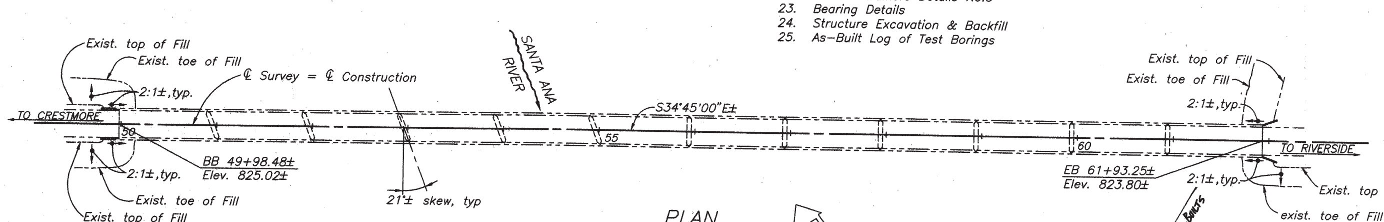
———— Indicates new construction
- - - - - Indicates new construction (hidden)
— - — - Indicates existing

NOTES

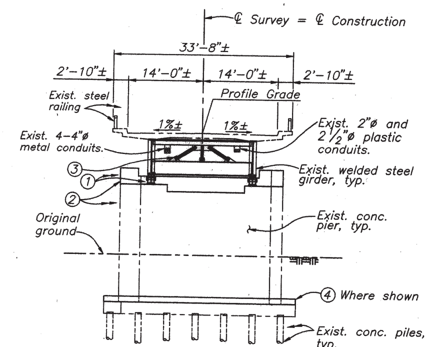
1. The Contractor shall verify all controlling field dimensions prior to ordering or fabricating any material.
2. The Contractor may retrofit in any construction sequence except that no two adjacent piers and abutment shall be retrofitted at the same time.
3. For General Notes see "Abutment 1 Layout" sheet.

INDEX TO PLANS

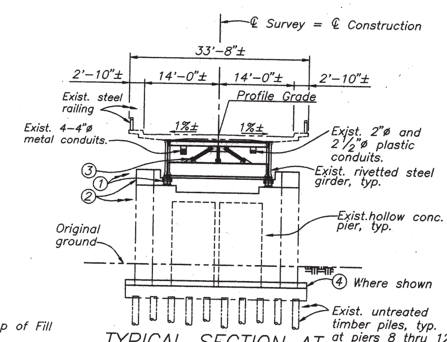
Standard plan sheet no.
Detail no.



PLAN
1"=60'



TYPICAL SECTION AT SPANS 1 THRU 6
No Scale



TYPICAL SECTION AT SPANS 7 THRU 12
No Scale

DIST.	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
08	RIV	FAU-R100		15	39

Mehrdad Harms
REGISTERED STRUCTURAL ENGINEER

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — M.HARMS — No. SE2639 — Exp. 12/31/96 — STRUCTURAL — STATE OF CALIFORNIA

RUTH AND GOING, INC.
1630 ZANKER ROAD
SAN JOSE, CALIFORNIA 95112

MARK THOMAS AND COMPANY, INC.
90 ARCHER STREET
SAN JOSE, CALIFORNIA 95112

VOID SUPERSEDED BY As-BUILTS RJM 10-7-04

DESIGN	BY H.Mistry	CHECKED M. Harms	LOAD FACTOR DESIGN	LIVE LOADING:	HS20-44 AND ALTERNATIVE AND PERMIT DESIGN LOAD	
DETAILS	BY H.Mistry	CHECKED M. Harms	LAYOUT	BY H.Mistry	CHECKED M.Harms	
QUANTITIES	BY H.Mistry	CHECKED M. Harms	SPECIFICATIONS	BY H.Mistry	PLANS AND SPECS COMPARED M.Harms	

ADE BOWALE AKINSANYA
DESIGN OVERSIGHT
SIGN OFF DATE 10/31/96

PREPARED FOR THE
STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

M. HARMS
PROJECT ENGINEER

CU
EA EQC033

BRIDGE NO. 56C-24
POST MILE

EARTHQUAKE RETROFIT PROJECT NO. 33C
SANTA ANA RIVER BRIDGE AT MARKET STREET
GENERAL PLAN

DISREGARD PRINTS BEARING EARLIER REVISION DATES
REVISION DATES (PRELIMINARY STAGE ONLY) 10/10/92 1/19/92 2/19/93 6/2/93 10/6/93 3/10/94
SHEET 2 OF 39

JOB NO. 17820-170
FILENAME SHE019
PLOT DATE 3-10-94

APPENDIX C

Santa Ana River Peak Flow Excerpt

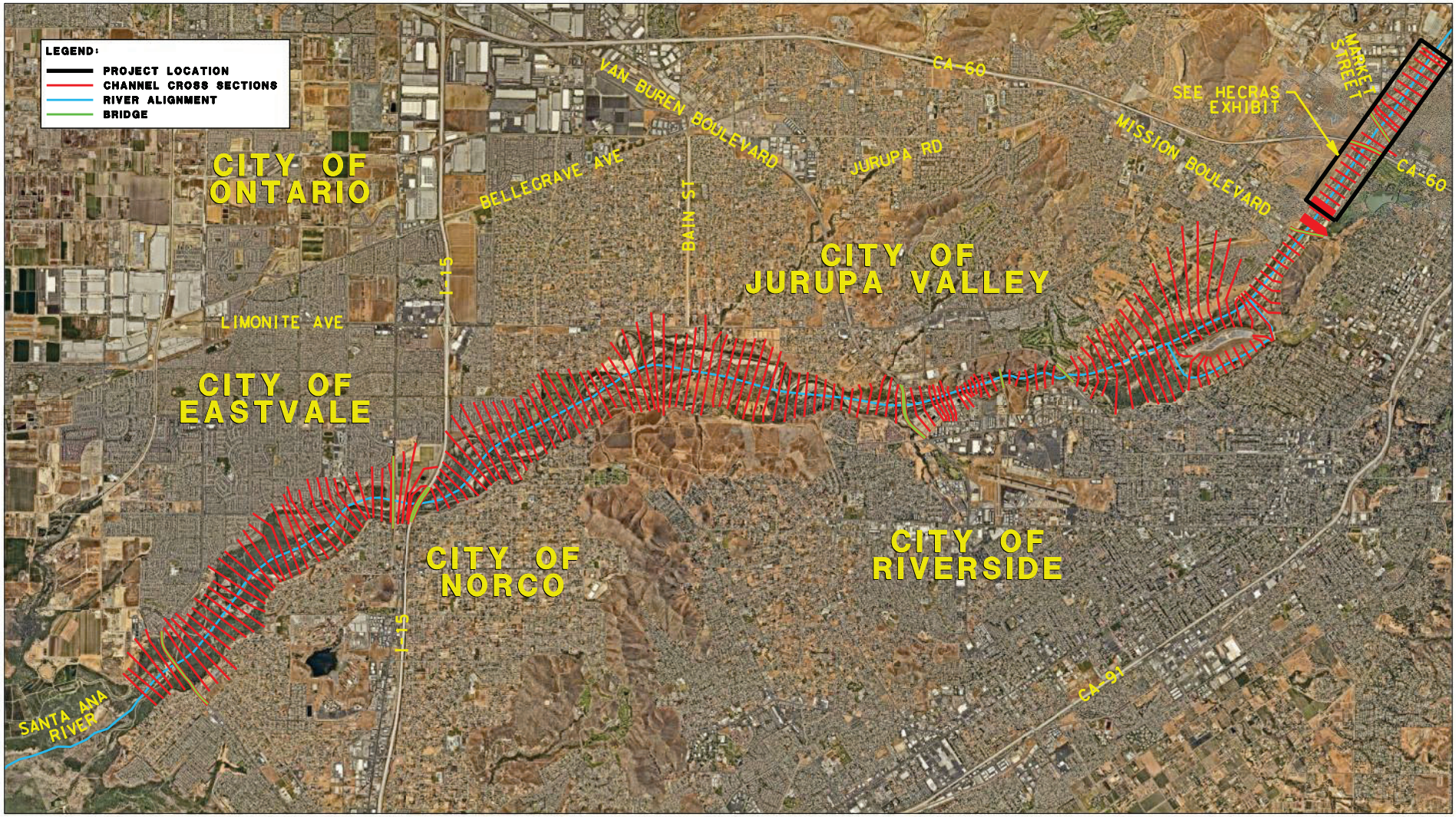
Table 7-10. Santa Ana River Mainstem Discharge-Frequency Values.
(Future Conditions)

Location	Frequency of Peak Discharge (in ft^3/s)						
	200-YR	100-YR	50-YR	25-YR	10-YR	5-YR	2-YR
at Seven Oaks Dam (D.A. = 177 mi^2)							
Inflow							
w/o project and w/project	88,000	58,000	34,000	20,500	8,800	4,300	1,100
Outflow							
w/o project			same as inflow				
w/project	6,900	5,500	4,200	3,150	2,150	2,000	500
D/S of Mill Creek (D.A. = 242 mi^2)							
w/o project	120,000	76,000	45,000	26,000	11,700	5,600	1,400
w/project	37,000	25,000	15,500	9,300	4,300	2,050	760
D/S of City Creek (D.A. = 290 mi^2)							
w/o project	125,000	80,000	48,000	28,000	12,500	5,800	1,400
w/project	50,000	33,000	21,000	13,000	5,600	2,600	800
at E Street (D.A. = 500 mi^2)							
w/o project	170,000	111,000	64,000	36,000	14,500	6,300	1,450
w/project	110,000	70,000	42,000	24,000	9,400	4,000	920
at Riverside Narrows (D.A. = 824 mi^2)							
w/o project	280,000	190,000	115,000	62,000	26,000	11,000	2,200
w/project	220,000	140,000	82,000	47,000	19,000	8,100	1,680
at Prado Dam (D.A. = 2255 mi^2)							
Inflow							
w/o project	380,000	270,000	155,000	85,000	34,000	14,000	3,400
w/project	320,000	230,000	135,000	75,000	30,000	13,000	3,100
Outflow							
w/o project	240,000	115,000	21,000	6,900	6,400	4,700	2,400
w/project	30,000	30,000	30,000	22,000	11,000	6,000	3,200
at Imperial Hwy (D.A. = 2306 mi^2)							
w/o project	240,000	110,000	22,000	7,000	6,500	4,800	2,500
w/project	40,000	36,000	34,000	25,000	13,000	7,200	3,800
at Santa Ana (D.A. = 2447 mi^2)							
w/o project	220,000	90,000	30,000	20,400	13,000	8,400	4,700
w/project	50,000	42,000	37,000	27,500	18,000	11,000	4,700

Note: D.A. = drainage area.

APPENDIX D

Hydraulic Model Layout



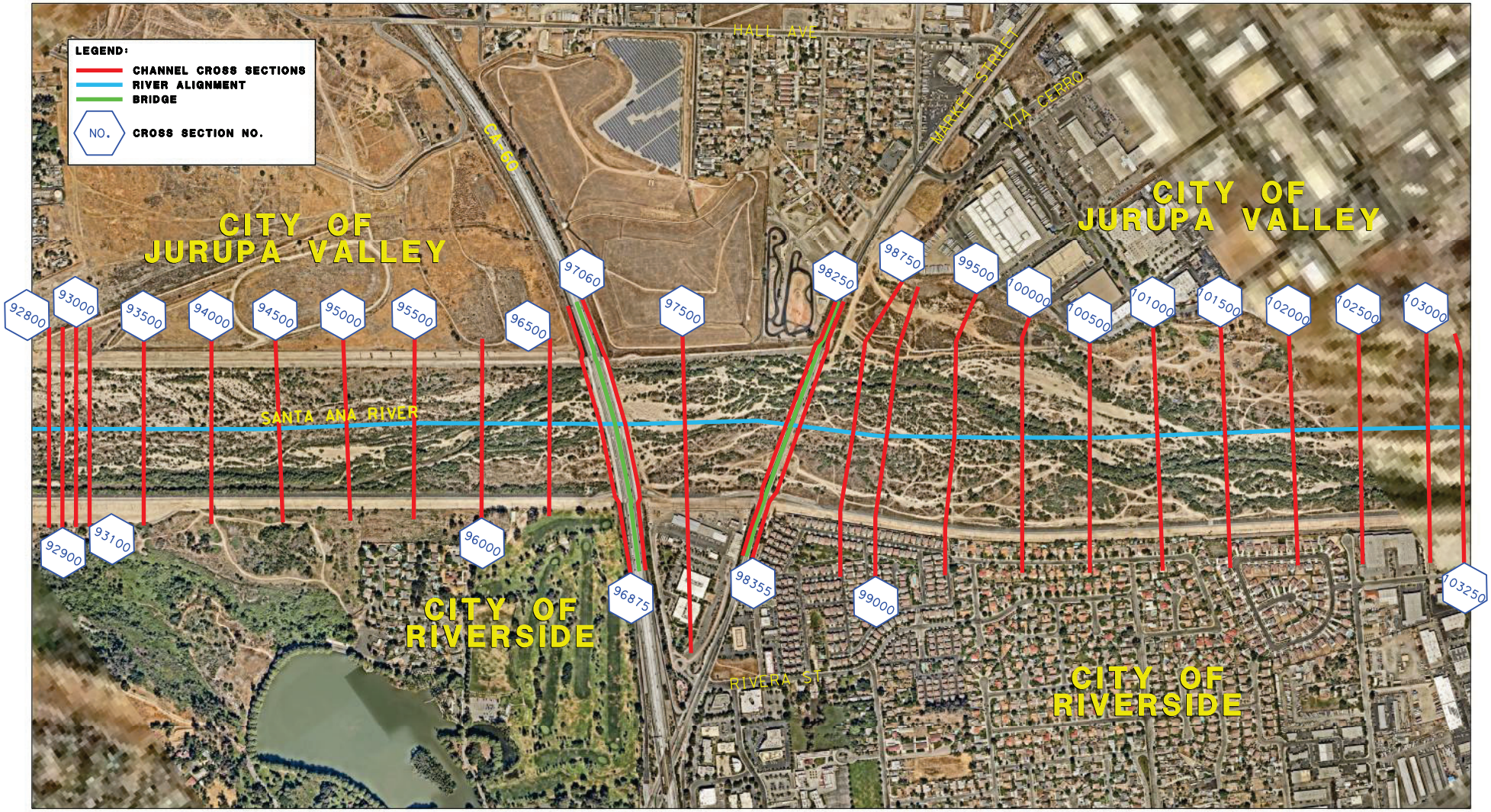
DOKKEN ENGINEERING
110 Blue Ravine Road, Suite 200
Folsom, CA. 95630
(916)858-0642

PROJECT:
REPLACEMENT OF MARKET STREET BRIDGE AT SANTA ANA RIVER

EXHIBIT:
HECRAS OVERVIEW EXHIBIT

JUNE 2021

SCALE: 1"=5250'



GRAPHIC SCALE
0 400 600 800 1200 2000
(IN FEET)
1 INCH = 700 Ft

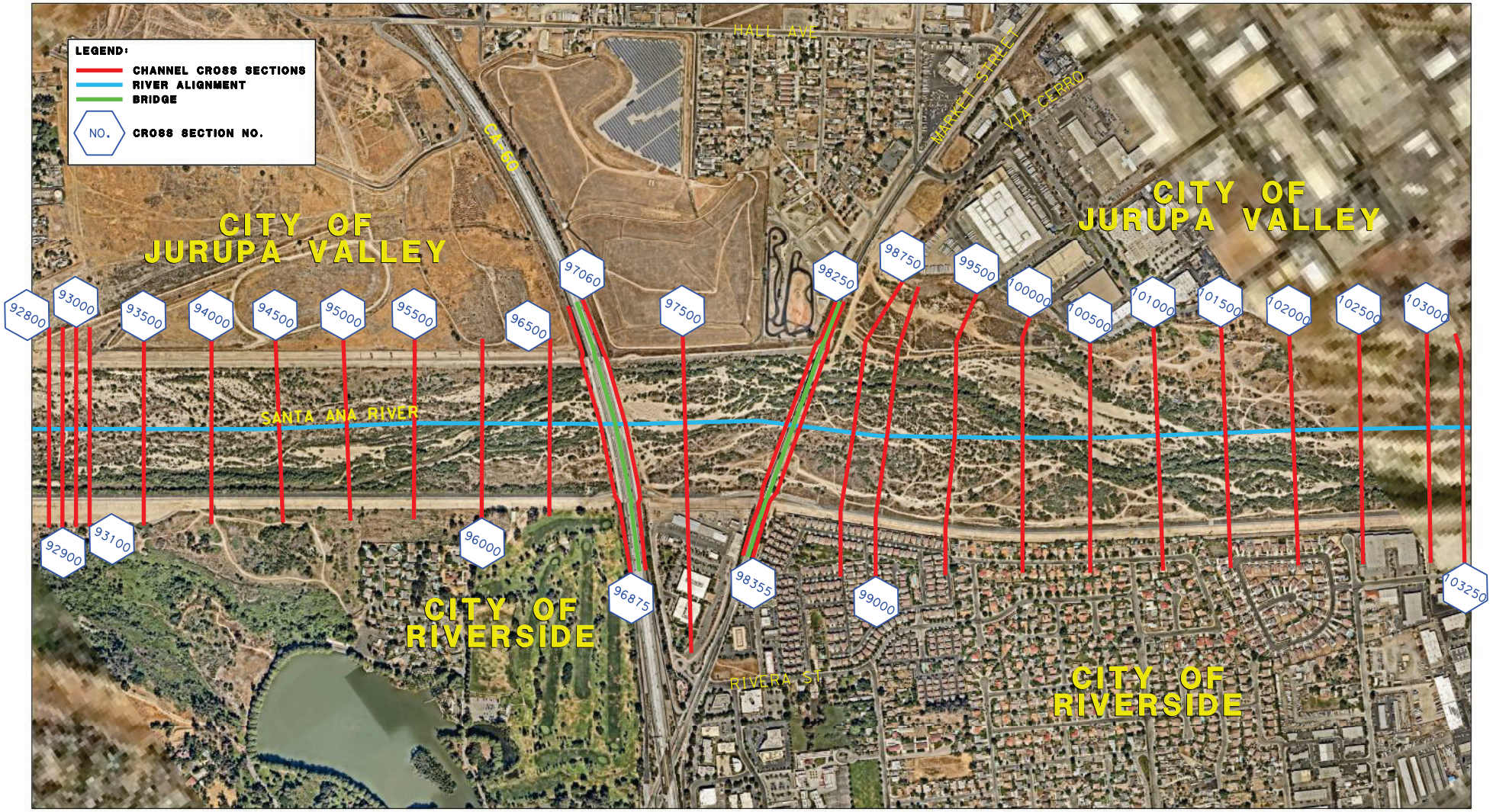
DOKKEN ENGINEERING
110 Blue Ravine Road, Suite 200
Folsom, CA. 95630
(916)858-0642

PROJECT:
REPLACEMENT OF MARKET STREET BRIDGE AT SANTA ANA RIVER

EXHIBIT:
EXISTING HECRAS EXHIBIT

JUNE 2021

SCALE: 1" = 700'



GRAPHIC SCALE
0 400 600 800 1200 2000
(IN FEET)
1 INCH = 700 Ft

DOKKEN ENGINEERING
110 Blue Ravine Road, Suite 200
Folsom, CA. 95630
(916)858-0642

PROJECT:
REPLACEMENT OF MARKET STREET BRIDGE AT SANTA ANA RIVER

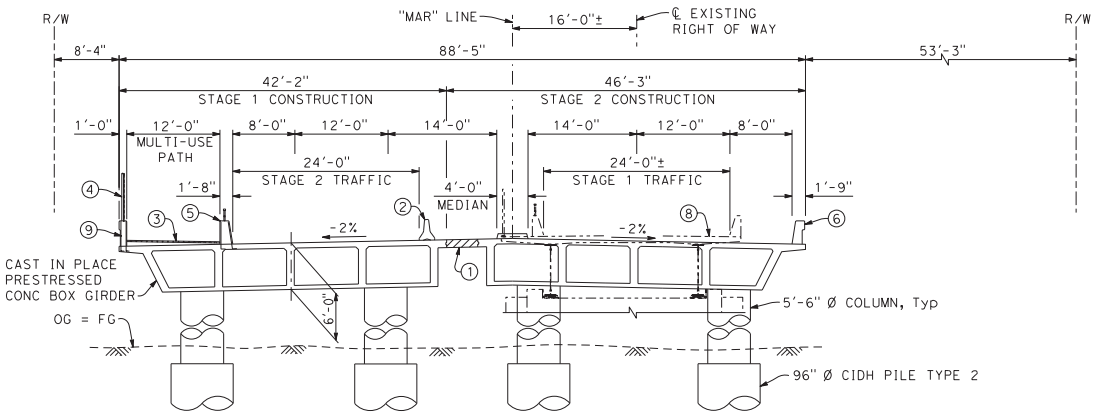
EXHIBIT:
PROPOSED HECRAS EXHIBIT

JUNE 2021

SCALE: 1" = 700'

APPENDIX E

Proposed Market Street Bridge General Plan



TYPICAL SECTION

1/8" = 1'-0"

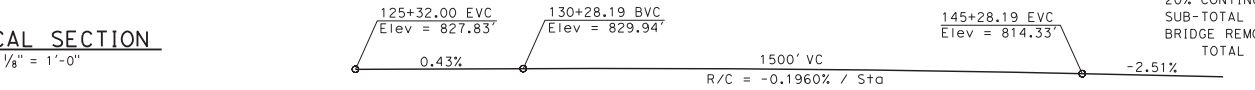
NOTES:

1. Deck Closure Pour.
2. Temporary Railing (Type K).
3. Rubberized HMA (2" thick)
4. Chain Link Railing (Type 7)
5. Concrete Barrier Type 836 (Mod) with Tubular Hand Railing
6. Concrete Barrier Type 836
7. Temporary 8' wide x 10' high falsework opening for bike trail
8. Remove existing bridge after Stage 1 Construction
9. Concrete Barrier Type 732SW (Mod)
10. Concrete Slope Paving
11. Structure Approach Type N (30)
12. Paint "Br. No. 56C-24" & year constructed
13. Paint "SANTA ANA RIVER BRIDGE"

LEGEND

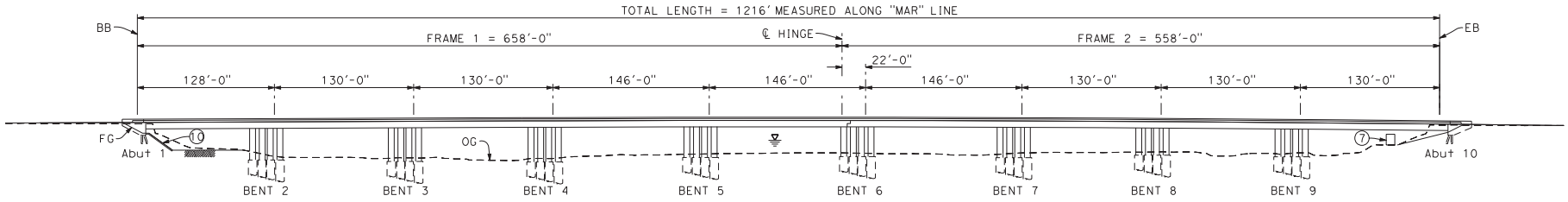
- Direction of Traffic
- Existing Structure
- New Structure
- 4'-0" Closure Pour
- Remove Existing Bridge
- Minimum Vertical Clearance
- Direction of the flow
- 50-year water surface Elevation = 807.6' 100-year water surface Elevation = 811.6'

DATE OF ESTIMATE	=	January 2020
STRUCTURE DEPTH	=	6'-0"
LENGTH	=	1216'
WIDTH	=	88'-5"
AREA	=	107,515 SQFT
COST/ SQ FT INCLUDING 10% mobilization & 20% CONTINGENCY	=	$ 246.57
SUB-TOTAL COST	=	$ 26,510,000
BRIDGE REMOVAL	=	$ 550,000
TOTAL COST	=	$ 27,060,000



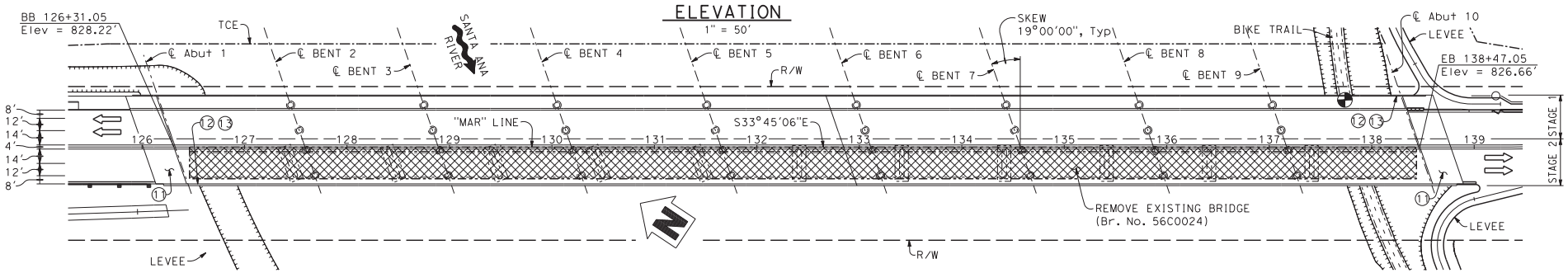
PROFILE GRADE

NO SCALE



ELEVATION

1" = 50'



PLAN

1" = 50'

PREPARED BY	GENERAL PLAN	SHEET No.
PREPARED UNDER THE SUPERVISION OF: M.G. MAECHLER No. 42513 3-31-22 CIVIL STATE OF CALIFORNIA NAME DATE PROJECT MANAGER COUNTY OF RIVERSIDE	**MARKET STREET** REPLACEMENT OF MARKET STREET BRIDGE AT SANTA ANA RIVER **ALTERNATIVE 1 - CIP/PS CONCRETE BOX GIRDER**	SHEET 1 OF 36

DATE PLOTTED => 7/8/2021
TIME PLOTTED => 3:18:34 PM
LAST REVISION 00-00-00

BORDER LAST REVISED 07/21/2015

USERNAME => untitled
DGN FILE => J:\1971_Market_St_Santa_Ana_Rv_BR\517\CIP_BOX_GIRDER\1971-a-GDE.dgn

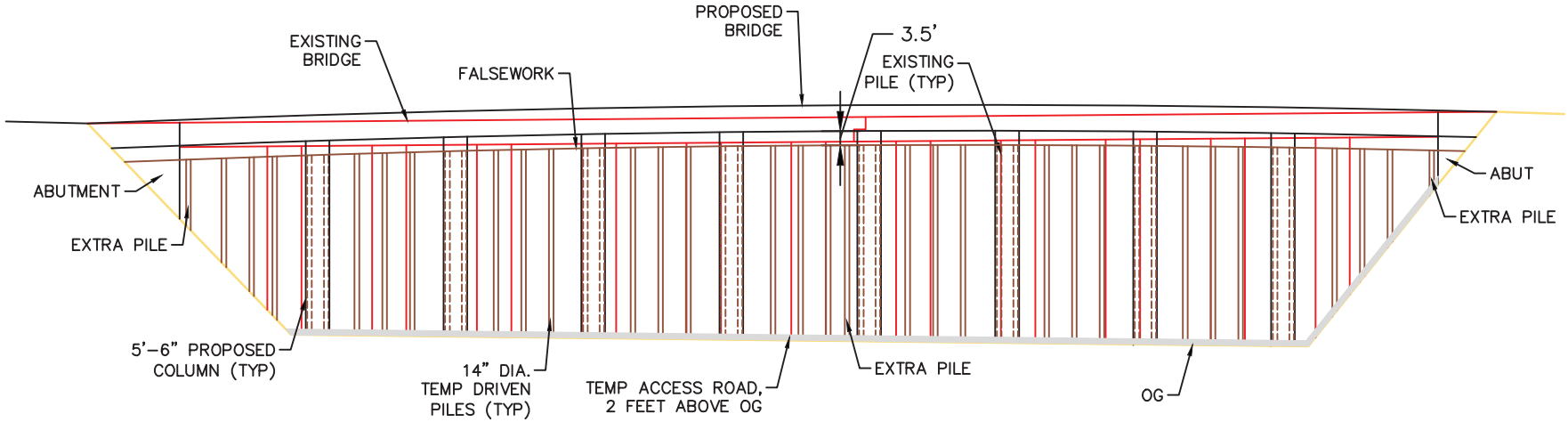
WO XX-XXXX

COUNTY DRAWING NO.

APPENDIX F

Temporary Construction Obstructions

APPENDIX F



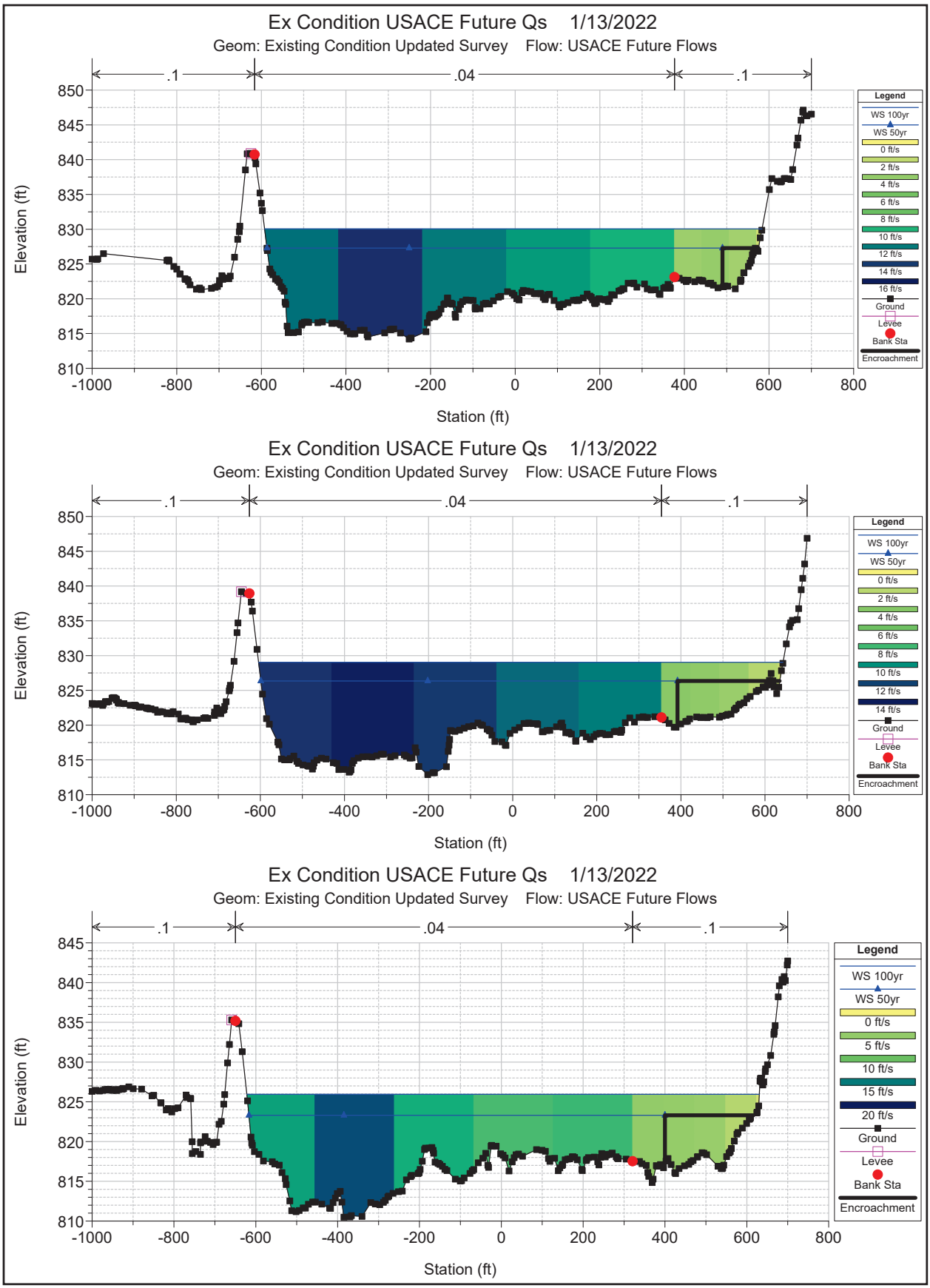
MARKET STREET BRIDGE TEMPORARY CONSTRUCTION OBSTRUCTIONS ELEVATION VIEW

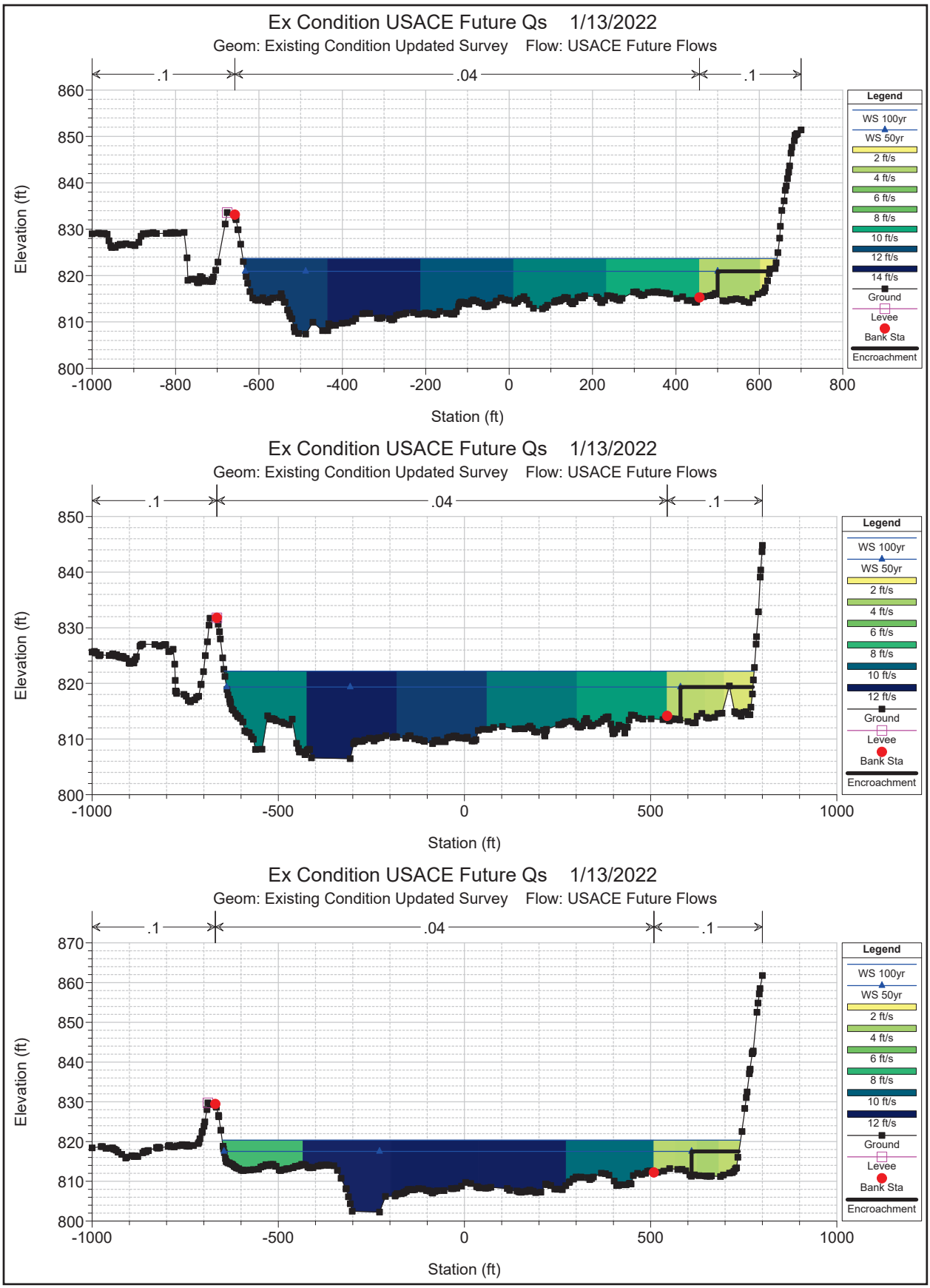
NOT TO SCALE

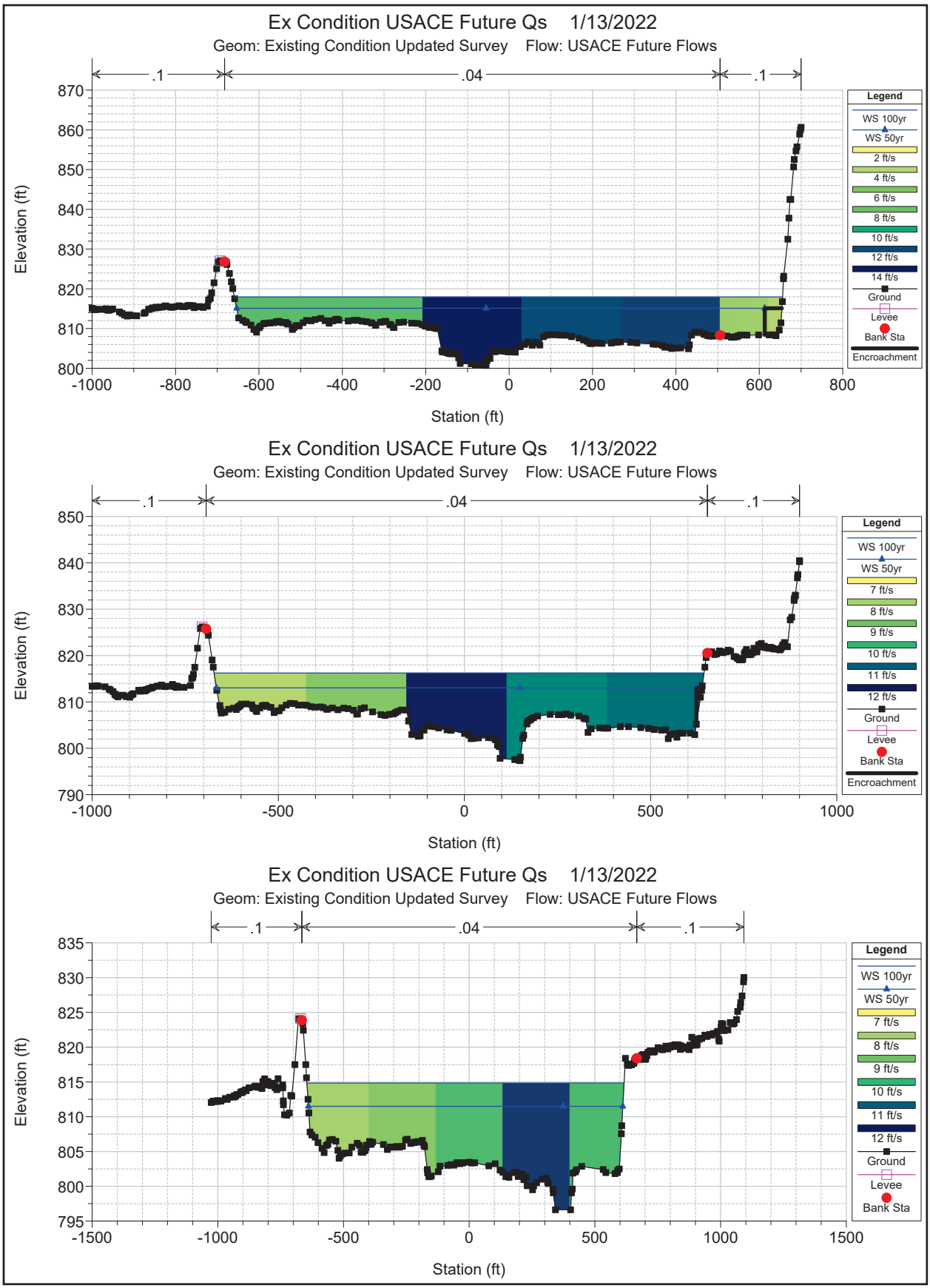
APPENDIX G

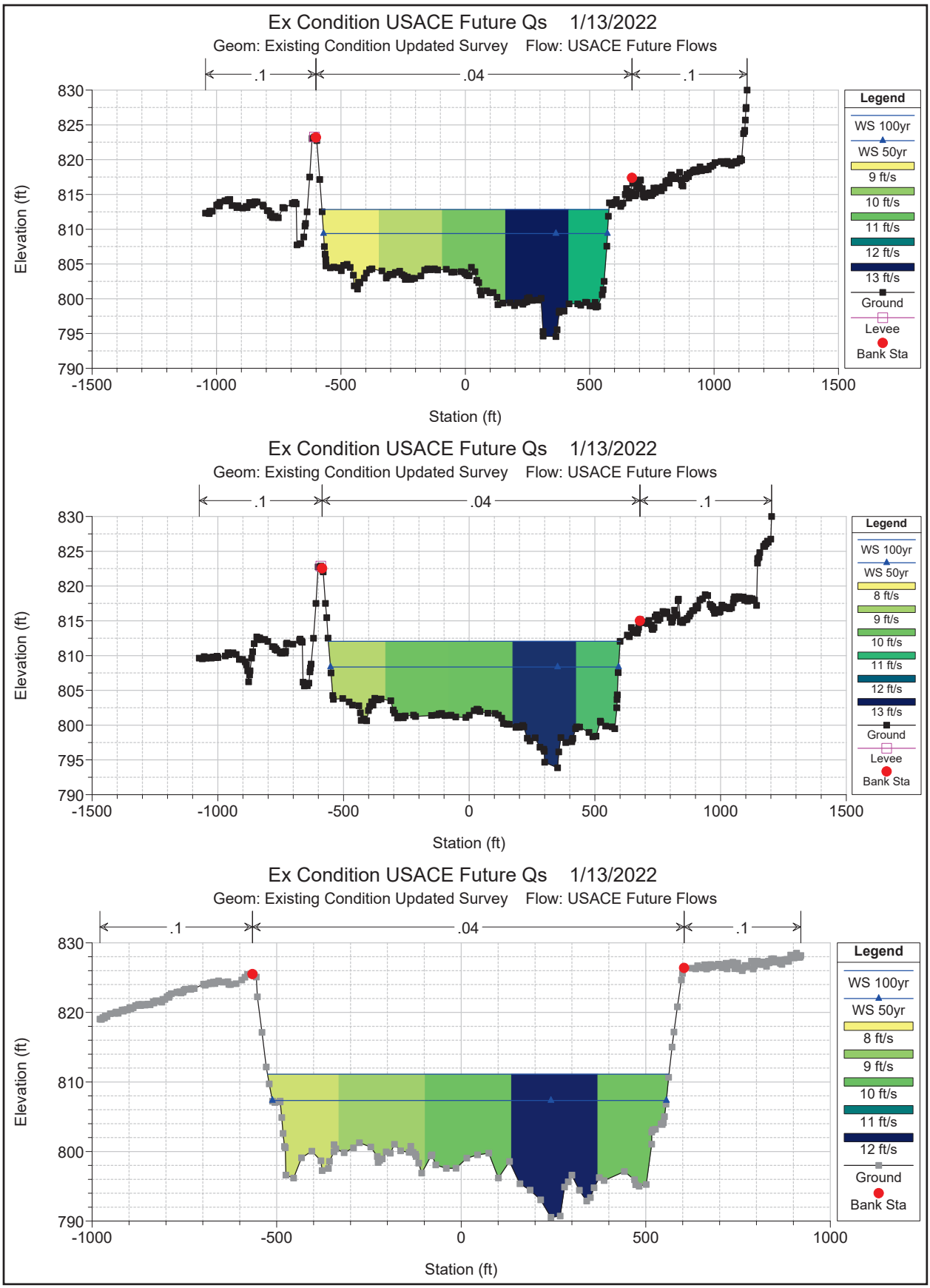
Hydraulic Analyses

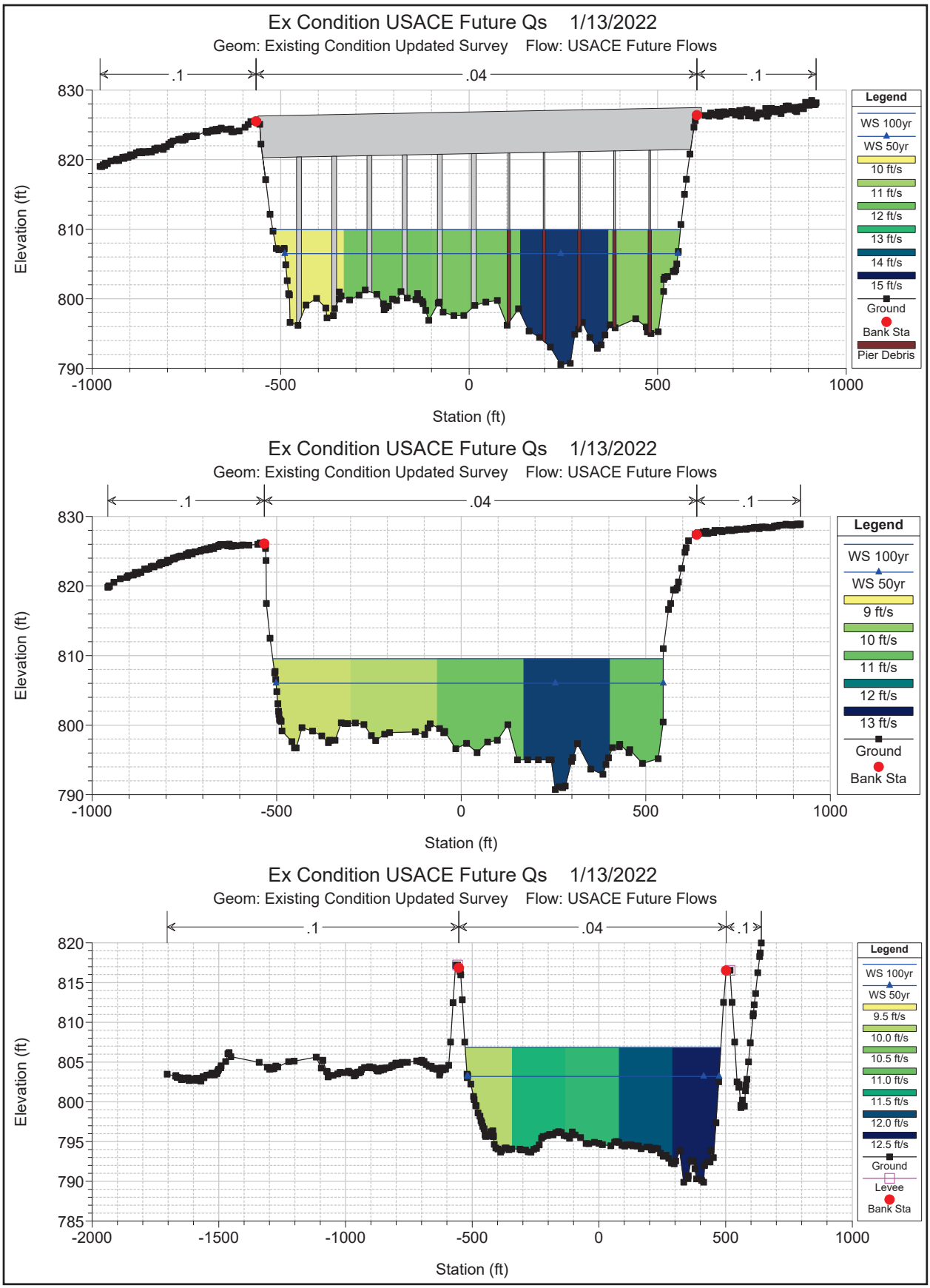
Existing Conditions Hydraulic Analysis

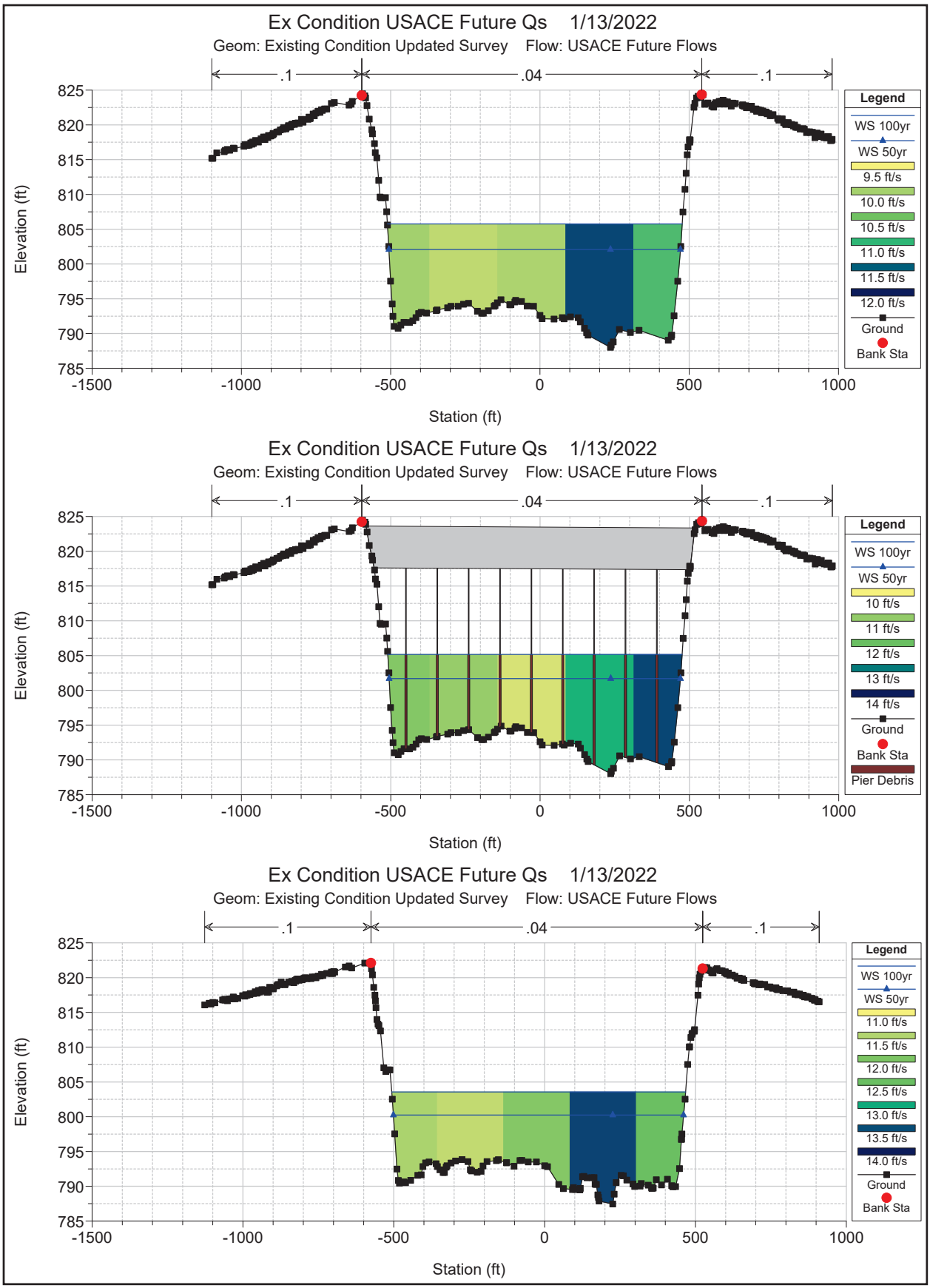

Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
16 ft/s
Ground
Levee
Bank Sta
Encroachment
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Levee
Bank Sta
Encroachment
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
0 ft/s
5 ft/s
10 ft/s
15 ft/s
20 ft/s
Ground
Levee
Bank Sta
Encroachment

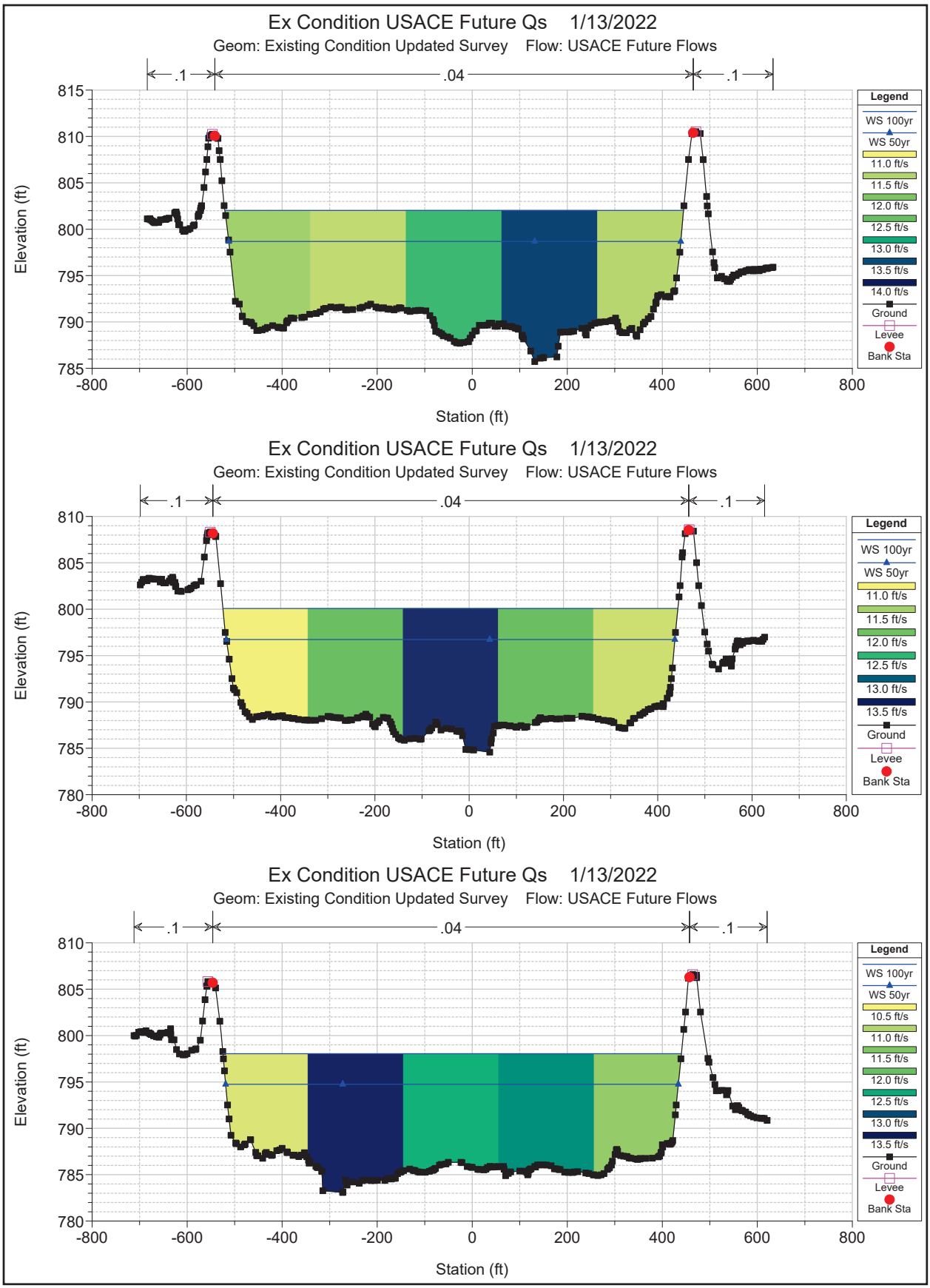

Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Levee
Bank Sta
Encroachment
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
Elevation (ft)
Station (ft)
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
Elevation (ft)
Station (ft)

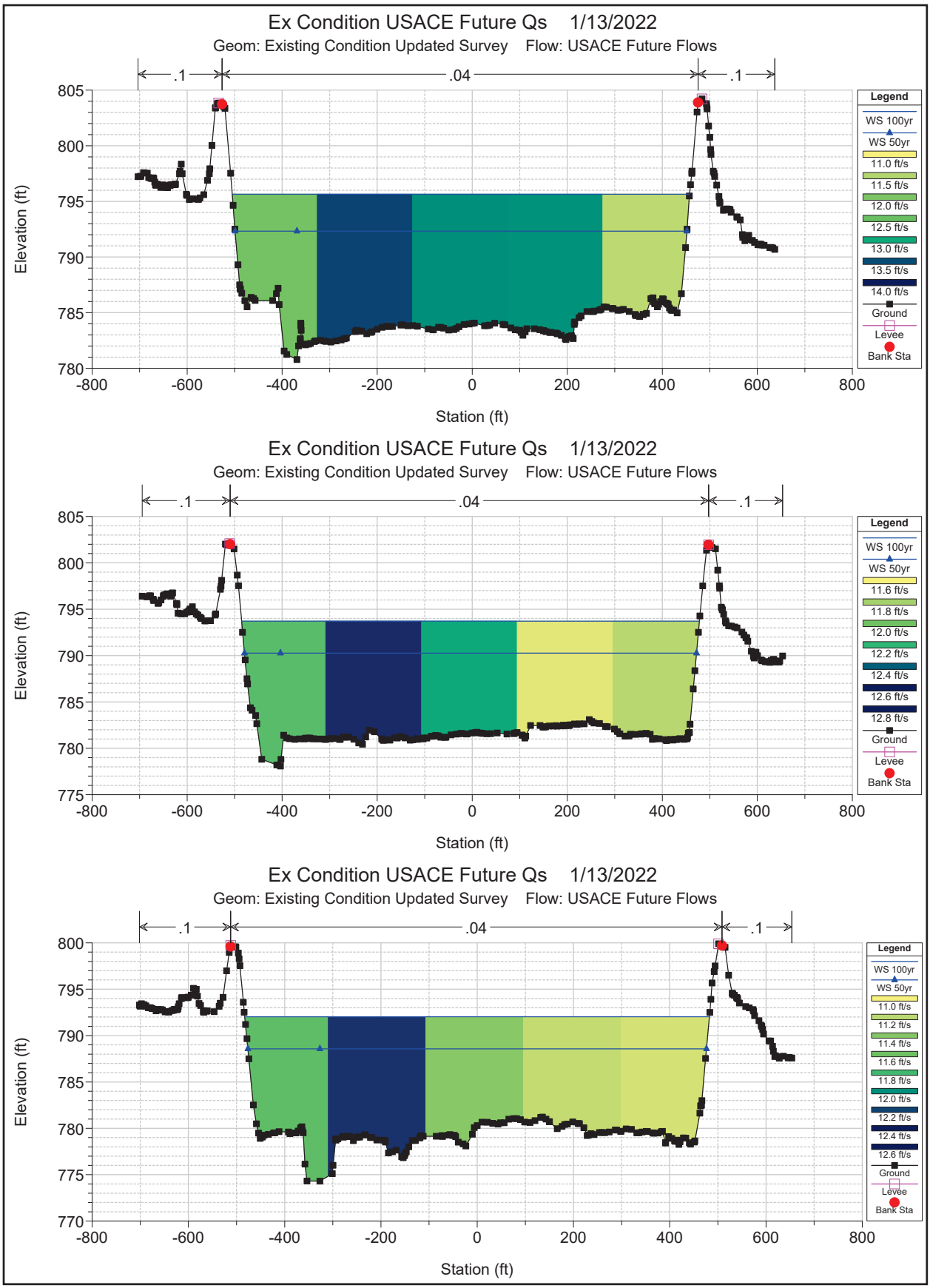

Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Levee
Bank Sta
Encroachment
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
7 ft/s
8 ft/s
9 ft/s
10 ft/s
11 ft/s
12 ft/s
Ground
Levee
Bank Sta
Encroachment
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
7 ft/s
8 ft/s
9 ft/s
10 ft/s
11 ft/s
12 ft/s
Ground
Levee
Bank Sta

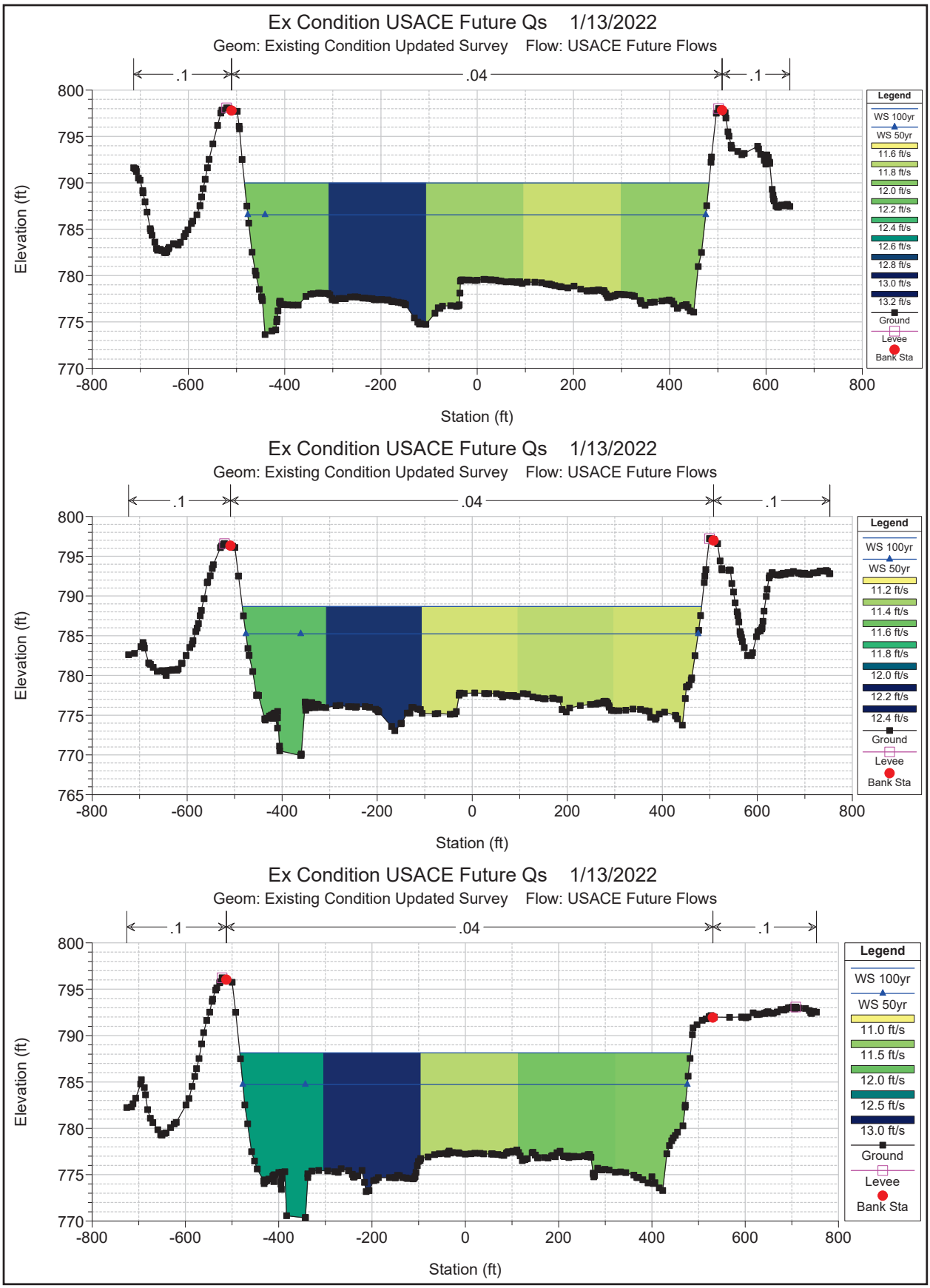


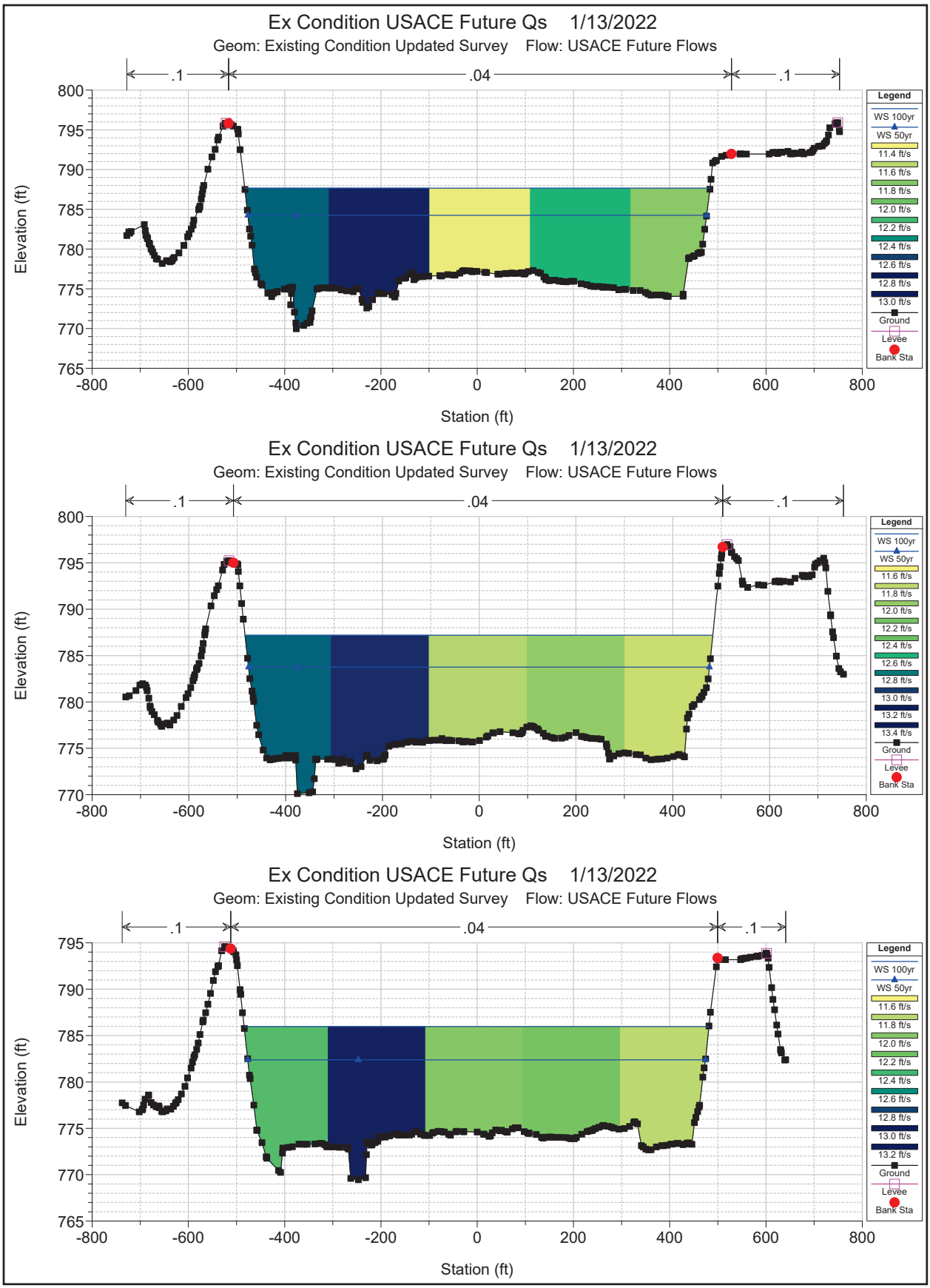

Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
10 ft/s
11 ft/s
12 ft/s
13 ft/s
14 ft/s
15 ft/s
Ground
Bank Sta
Pier Debris
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
9 ft/s
10 ft/s
11 ft/s
12 ft/s
13 ft/s
Ground
Bank Sta
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
9.5 ft/s
10.0 ft/s
10.5 ft/s
11.0 ft/s
11.5 ft/s
12.0 ft/s
12.5 ft/s
Ground
Levee
Bank Sta

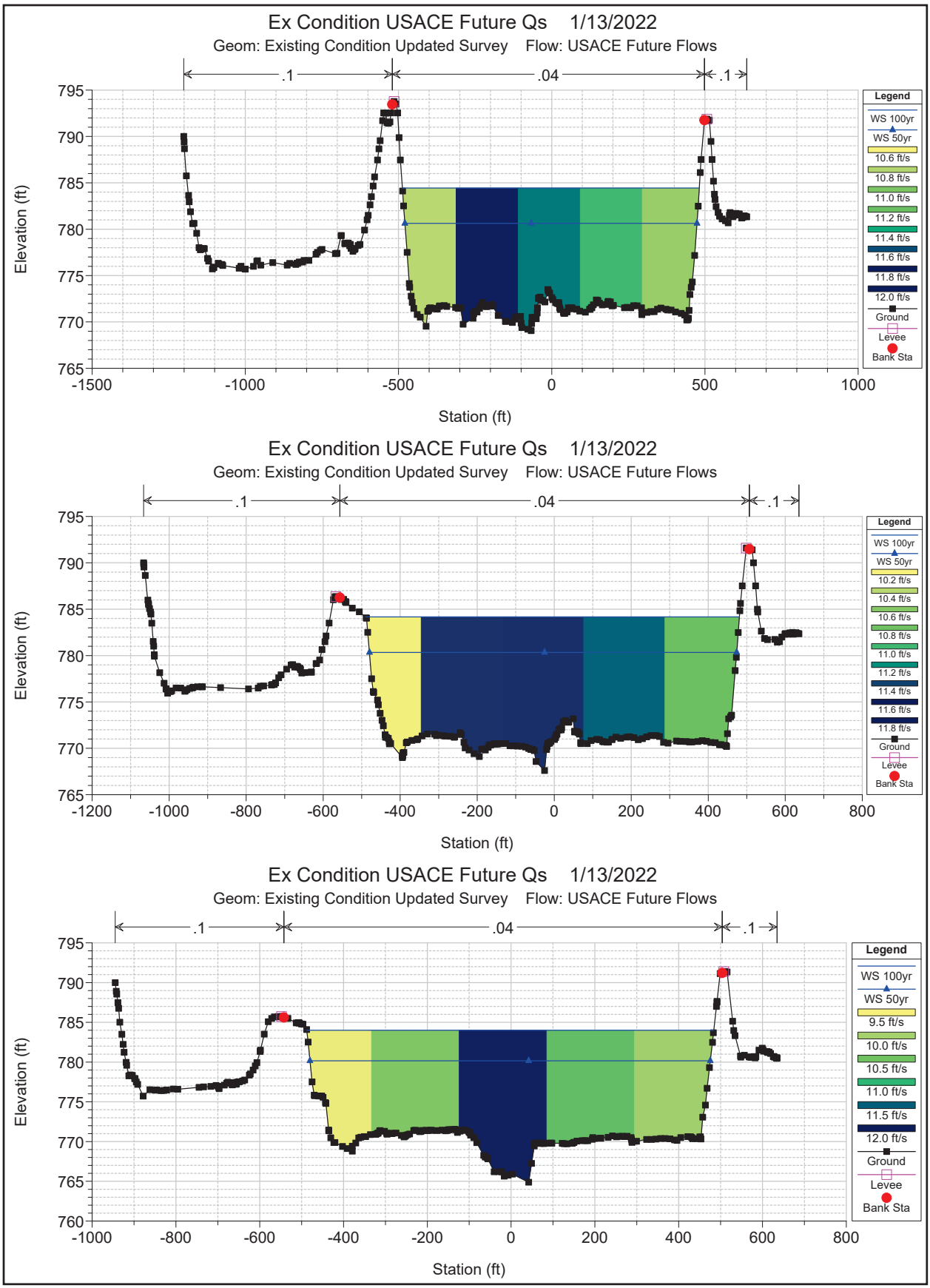

Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
825
820
815
810
805
800
795
790
785
-1500
-1000
-500
0
500
1000
Station (ft)
Legend
WS 100yr
WS 50yr
9.5 ft/s
10.0 ft/s
10.5 ft/s
11.0 ft/s
11.5 ft/s
12.0 ft/s
Ground
Bank Sta
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
825
820
815
810
805
800
795
790
785
-1500
-1000
-500
0
500
1000
Station (ft)
Legend
WS 100yr
WS 50yr
10 ft/s
11 ft/s
12 ft/s
13 ft/s
14 ft/s
Ground
Bank Sta
Pier Debris
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
825
820
815
810
805
800
795
790
785
-1500
-1000
-500
0
500
1000
Station (ft)
Legend
WS 100yr
WS 50yr
11.0 ft/s
11.5 ft/s
12.0 ft/s
12.5 ft/s
13.0 ft/s
13.5 ft/s
14.0 ft/s
Ground
Bank Sta

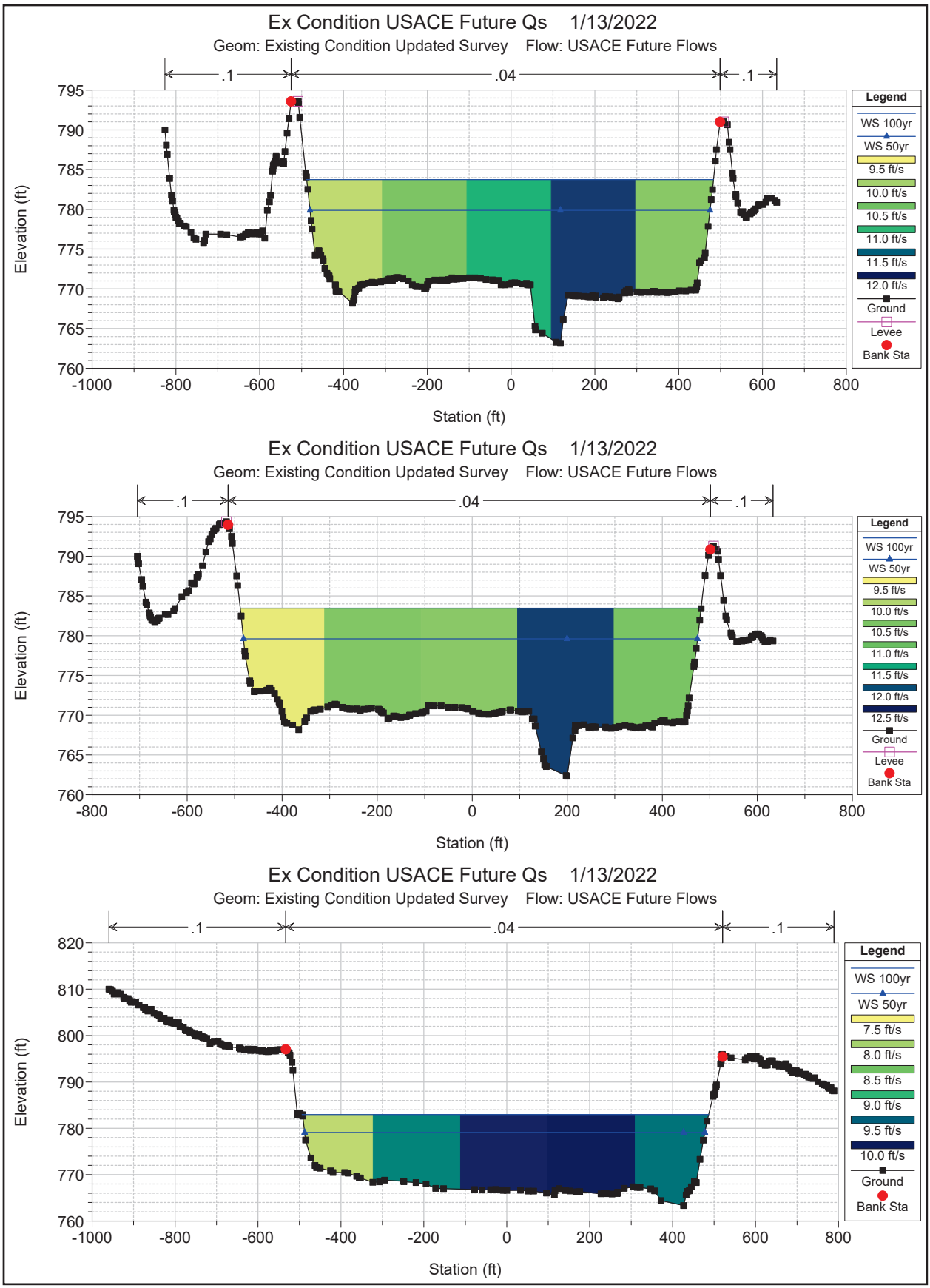

Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
11.0 ft/s
11.5 ft/s
12.0 ft/s
12.5 ft/s
13.0 ft/s
13.5 ft/s
14.0 ft/s
Ground
Levee
Bank Sta
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
11.0 ft/s
11.5 ft/s
12.0 ft/s
12.5 ft/s
13.0 ft/s
13.5 ft/s
Ground
Levee
Bank Sta
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
10.5 ft/s
11.0 ft/s
11.5 ft/s
12.0 ft/s
12.5 ft/s
13.0 ft/s
13.5 ft/s
Ground
Levee
Bank Sta

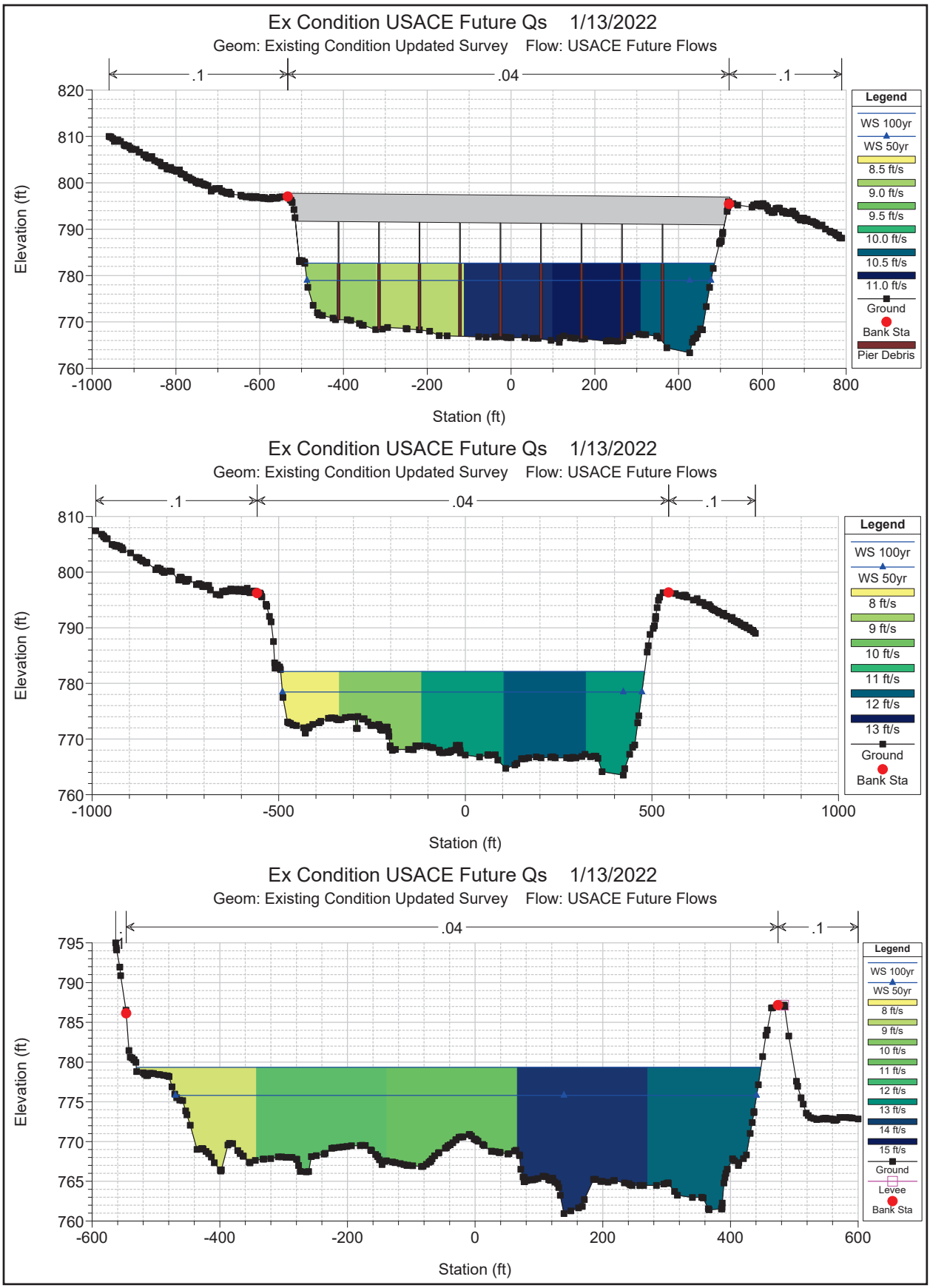

Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
11.0 ft/s
11.5 ft/s
12.0 ft/s
12.5 ft/s
13.0 ft/s
13.5 ft/s
14.0 ft/s
Ground
Levee
Bank Sta
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
11.6 ft/s
11.8 ft/s
12.0 ft/s
12.2 ft/s
12.4 ft/s
12.6 ft/s
12.8 ft/s
Ground
Levee
Bank Sta
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
11.0 ft/s
11.2 ft/s
11.4 ft/s
11.6 ft/s
11.8 ft/s
12.0 ft/s
12.2 ft/s
12.4 ft/s
12.6 ft/s
Ground
Levee
Bank Sta

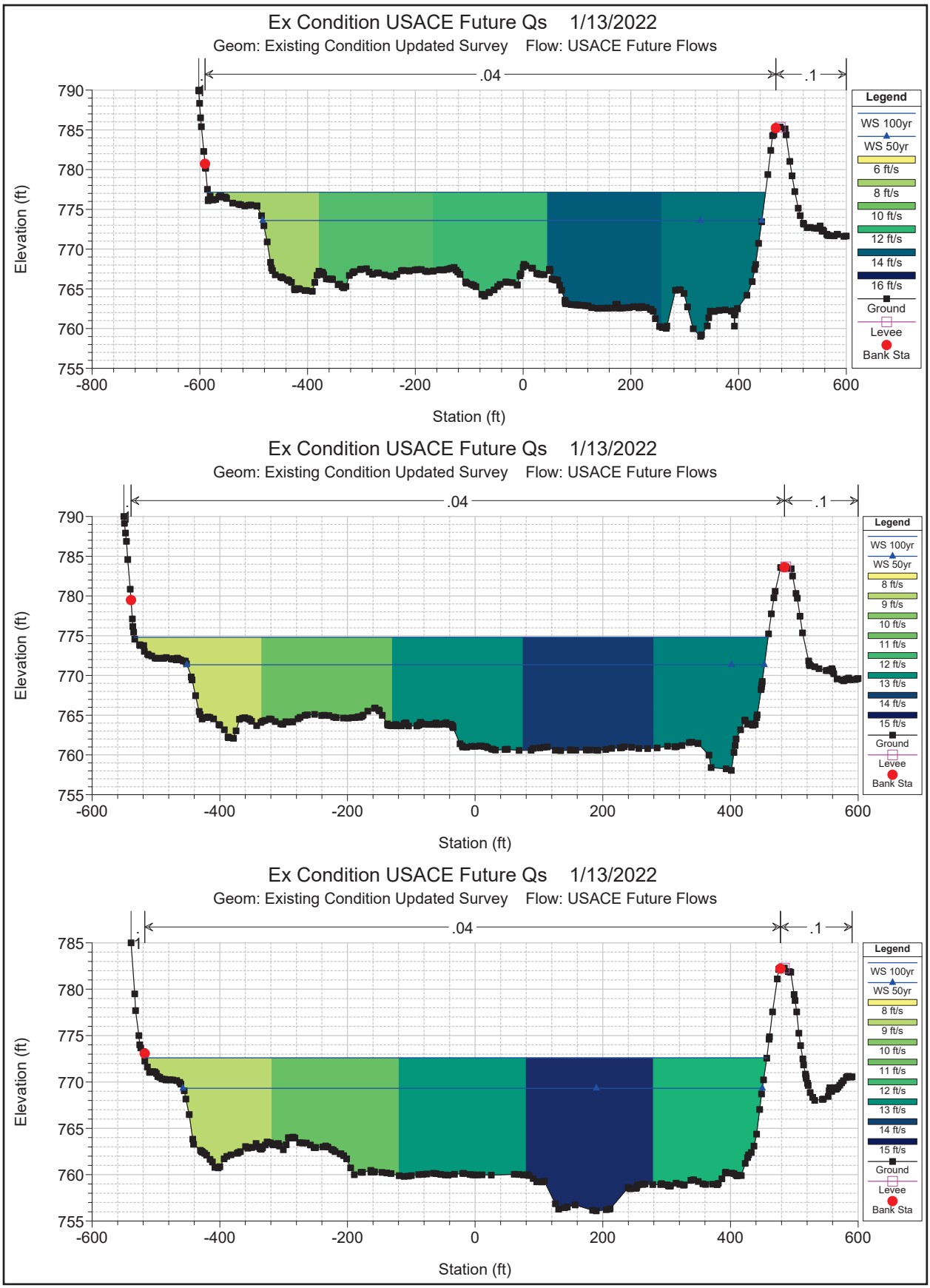

Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
11.6 ft/s
11.8 ft/s
12.0 ft/s
12.2 ft/s
12.4 ft/s
12.6 ft/s
12.8 ft/s
13.0 ft/s
13.2 ft/s
Ground
Levee
Bank Sta
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
11.2 ft/s
11.4 ft/s
11.6 ft/s
11.8 ft/s
12.0 ft/s
12.2 ft/s
12.4 ft/s
Ground
Levee
Bank Sta
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
11.0 ft/s
11.5 ft/s
12.0 ft/s
12.5 ft/s
13.0 ft/s
Ground
Levee
Bank Sta

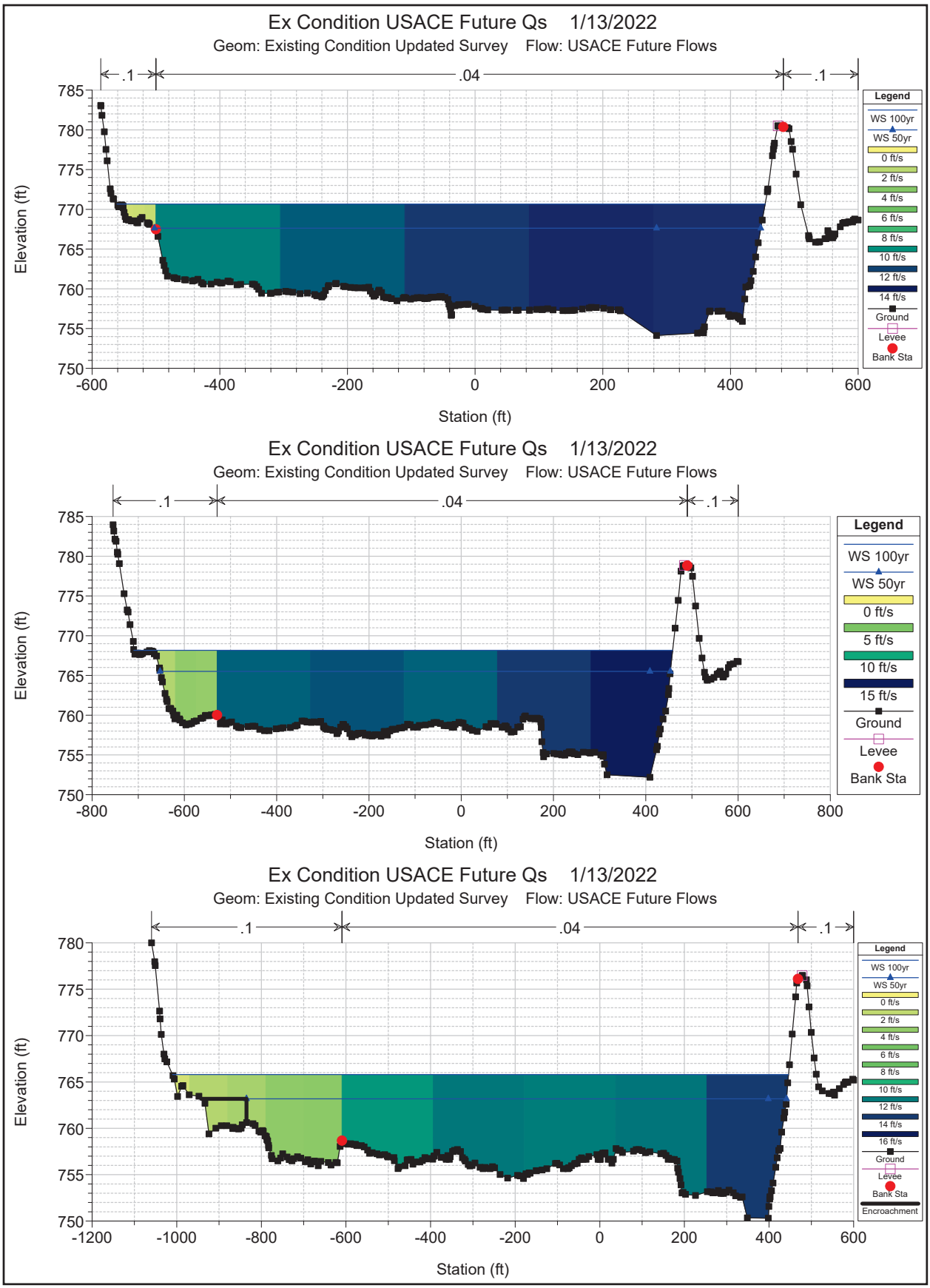

Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
11.4 ft/s
11.6 ft/s
11.8 ft/s
12.0 ft/s
12.2 ft/s
12.4 ft/s
12.6 ft/s
12.8 ft/s
13.0 ft/s
Ground
Levee
Bank Sta
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
11.6 ft/s
11.8 ft/s
12.0 ft/s
12.2 ft/s
12.4 ft/s
12.6 ft/s
12.8 ft/s
13.0 ft/s
13.2 ft/s
13.4 ft/s
Ground
Levee
Bank Sta
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
11.6 ft/s
11.8 ft/s
12.0 ft/s
12.2 ft/s
12.4 ft/s
12.6 ft/s
12.8 ft/s
13.0 ft/s
13.2 ft/s
Ground
Levee
Bank Sta

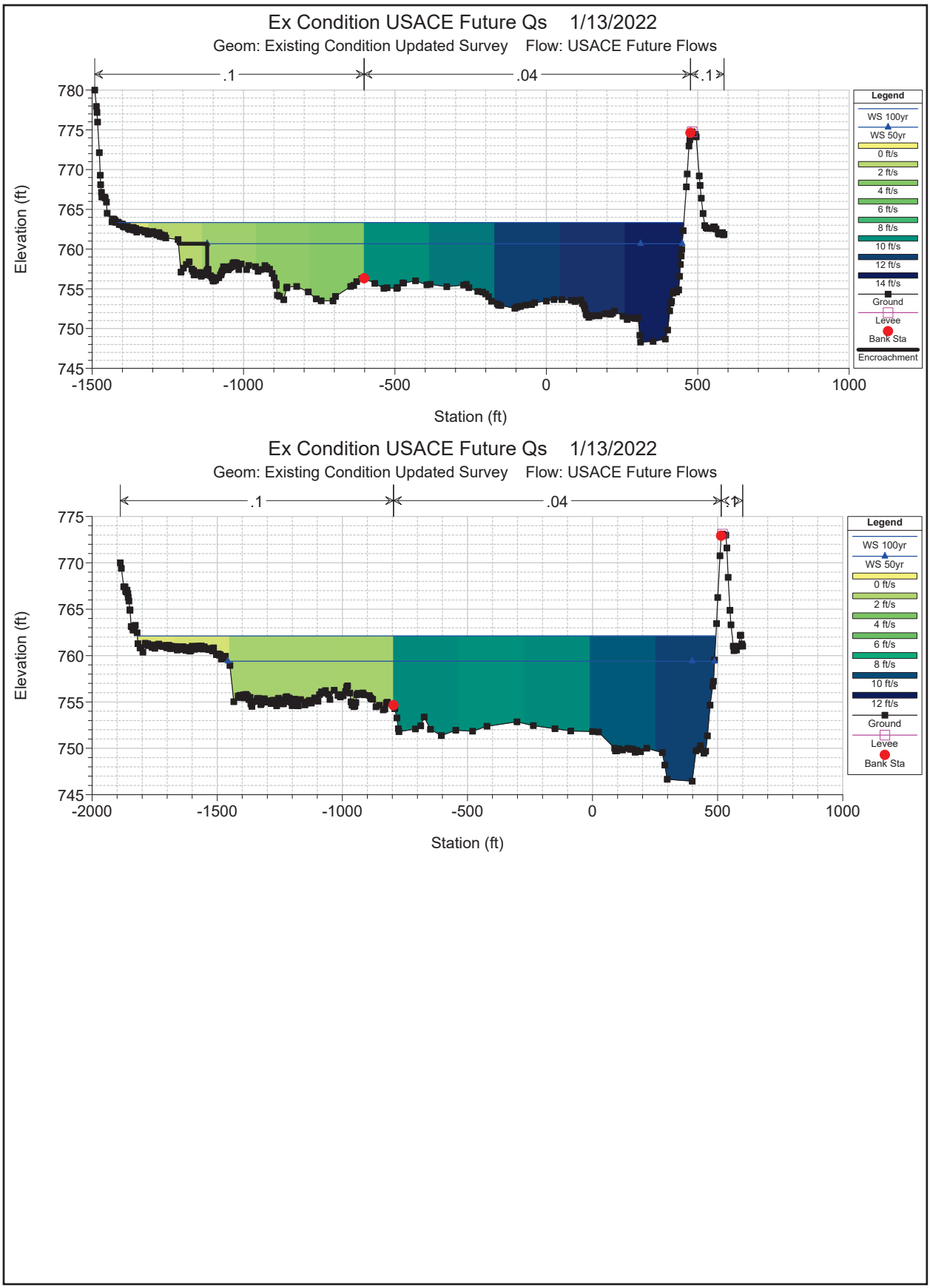

Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
795
790
785
780
775
770
765
-1500
-1000
-500
0
500
1000
Station (ft)
Legend
WS 100yr
WS 50yr
10.6 ft/s
10.8 ft/s
11.0 ft/s
11.2 ft/s
11.4 ft/s
11.6 ft/s
11.8 ft/s
12.0 ft/s
Ground
Levee
Bank Sta
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
795
790
785
780
775
770
765
-1200
-1000
-800
-600
-400
-200
0
200
400
600
800
Station (ft)
Legend
WS 100yr
WS 50yr
10.2 ft/s
10.4 ft/s
10.6 ft/s
10.8 ft/s
11.0 ft/s
11.2 ft/s
11.4 ft/s
11.6 ft/s
11.8 ft/s
Ground
Levee
Bank Sta
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
795
790
785
780
775
770
765
760
-1000
-800
-600
-400
-200
0
200
400
600
800
Station (ft)
Legend
WS 100yr
WS 50yr
9.5 ft/s
10.0 ft/s
10.5 ft/s
11.0 ft/s
11.5 ft/s
12.0 ft/s
Ground
Levee
Bank Sta

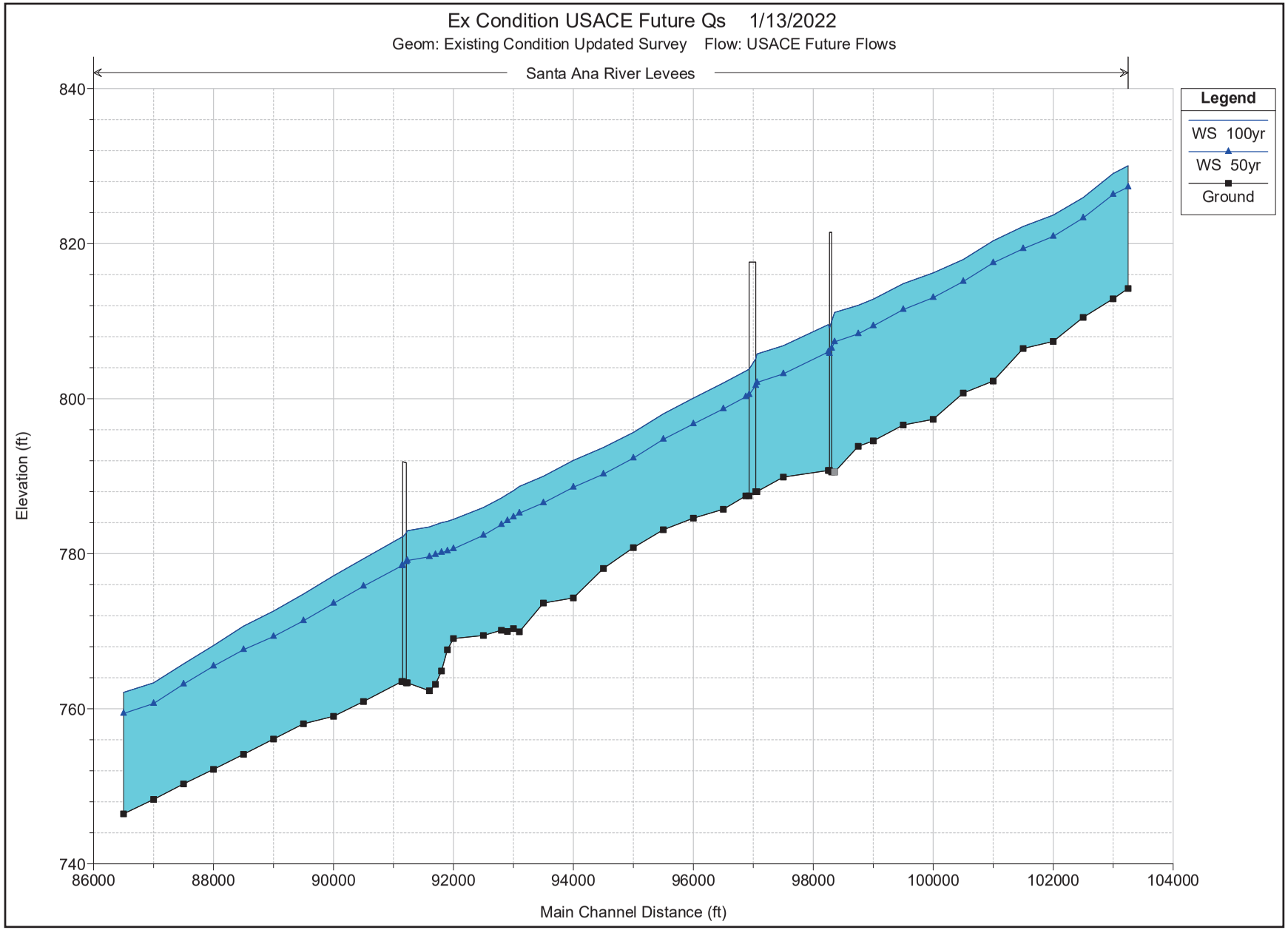

Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
795
790
785
780
775
770
765
760
-1000
-800
-600
-400
-200
0
200
400
600
800
Station (ft)
Legend
WS 100yr
WS 50yr
9.5 ft/s
10.0 ft/s
10.5 ft/s
11.0 ft/s
11.5 ft/s
12.0 ft/s
Ground
Levee
Bank Sta
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
795
790
785
780
775
770
765
760
-800
-600
-400
-200
0
200
400
600
800
Station (ft)
Legend
WS 100yr
WS 50yr
9.5 ft/s
10.0 ft/s
10.5 ft/s
11.0 ft/s
11.5 ft/s
12.0 ft/s
12.5 ft/s
Ground
Levee
Bank Sta
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
820
810
800
790
780
770
760
-1000
-800
-600
-400
-200
0
200
400
600
800
Station (ft)
Legend
WS 100yr
WS 50yr
7.5 ft/s
8.0 ft/s
8.5 ft/s
9.0 ft/s
9.5 ft/s
10.0 ft/s
Ground
Bank Sta


Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
820
810
800
790
780
770
760
-1000
-800
-600
-400
-200
0
200
400
600
800
Station (ft)
Legend
WS 100yr
WS 50yr
8.5 ft/s
9.0 ft/s
9.5 ft/s
10.0 ft/s
10.5 ft/s
11.0 ft/s
Ground
Bank Sta
Pier Debris
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
810
800
790
780
770
760
-1000
-500
0
500
1000
Station (ft)
Legend
WS 100yr
WS 50yr
8 ft/s
9 ft/s
10 ft/s
11 ft/s
12 ft/s
13 ft/s
Ground
Bank Sta
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.04
.1
Elevation (ft)
795
790
785
780
775
770
765
760
-600
-400
-200
0
200
400
600
Station (ft)
Legend
WS 100yr
WS 50yr
8 ft/s
9 ft/s
10 ft/s
11 ft/s
12 ft/s
13 ft/s
14 ft/s
15 ft/s
Ground
Levee
Bank Sta


Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.04
.1
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
16 ft/s
Ground
Levee
Bank Sta
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.04
.1
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
8 ft/s
9 ft/s
10 ft/s
11 ft/s
12 ft/s
13 ft/s
14 ft/s
15 ft/s
Ground
Levee
Bank Sta
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.04
.1
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
8 ft/s
9 ft/s
10 ft/s
11 ft/s
12 ft/s
13 ft/s
14 ft/s
15 ft/s
Ground
Levee
Bank Sta


Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Levee
Bank Sta
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
0 ft/s
5 ft/s
10 ft/s
15 ft/s
Ground
Levee
Bank Sta
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
16 ft/s
Ground
Levee
Bank Sta
Encroachment


Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
780
775
770
765
760
755
750
745
-1500
-1000
-500
0
500
1000
Station (ft)
Legend
WS 100yr
WS 50yr
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Levee
Bank Sta
Encroachment
Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
775
770
765
760
755
750
745
-2000
-1500
-1000
-500
0
500
1000
Station (ft)
Legend
WS 100yr
WS 50yr
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Levee
Bank Sta


Ex Condition USACE Future Qs 1/13/2022
Geom: Existing Condition Updated Survey Flow: USACE Future Flows
Santa Ana River Levees
Legend
WS 100yr
WS 50yr
Ground
Elevation (ft)
840
820
800
780
760
740
86000
88000
90000
92000
94000
96000
98000
100000
102000
104000
Main Channel Distance (ft)

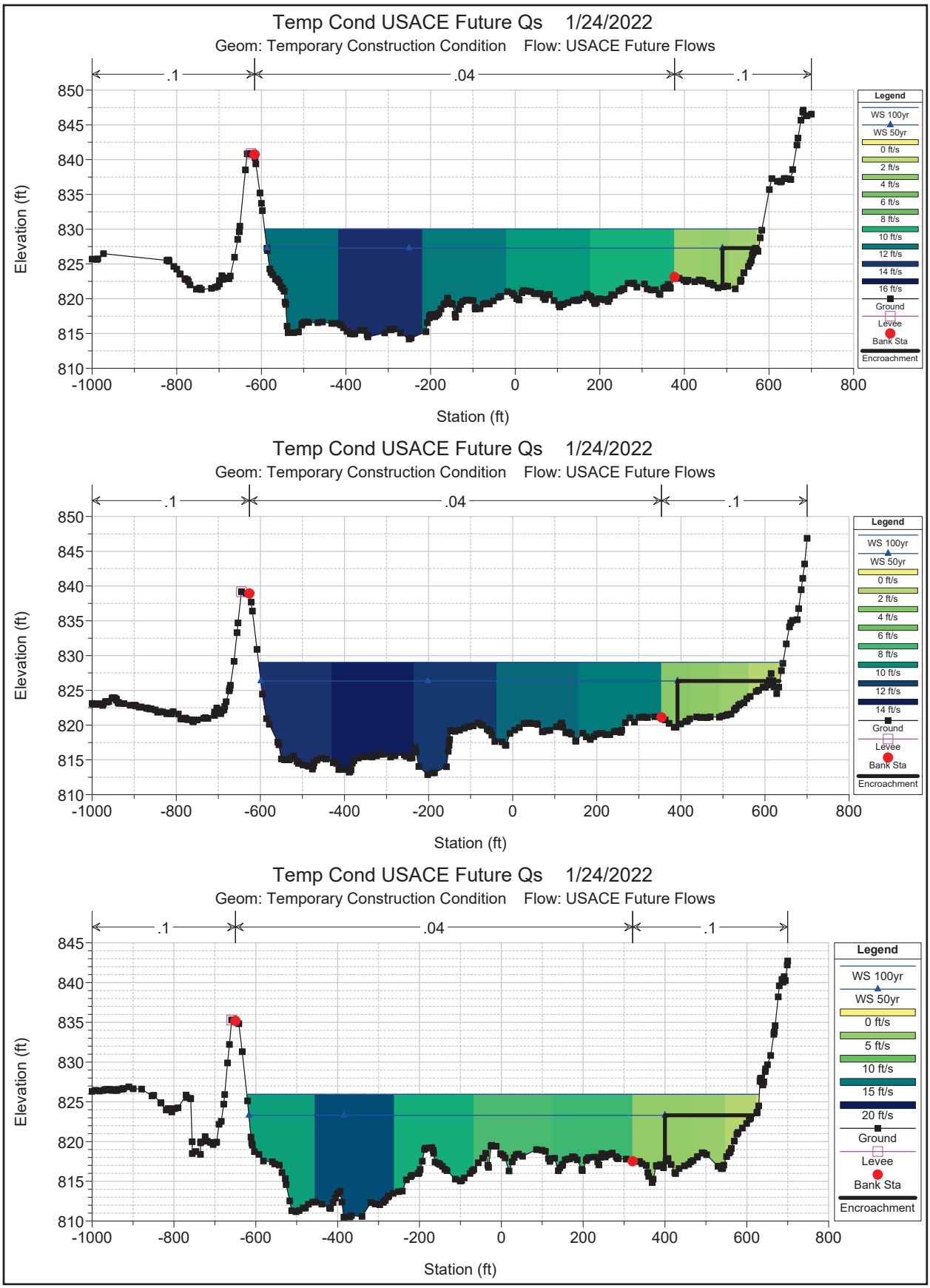
HEC-RAS Plan: ExCondJul2021FutureQs River: Santa Ana River Reach: Levees

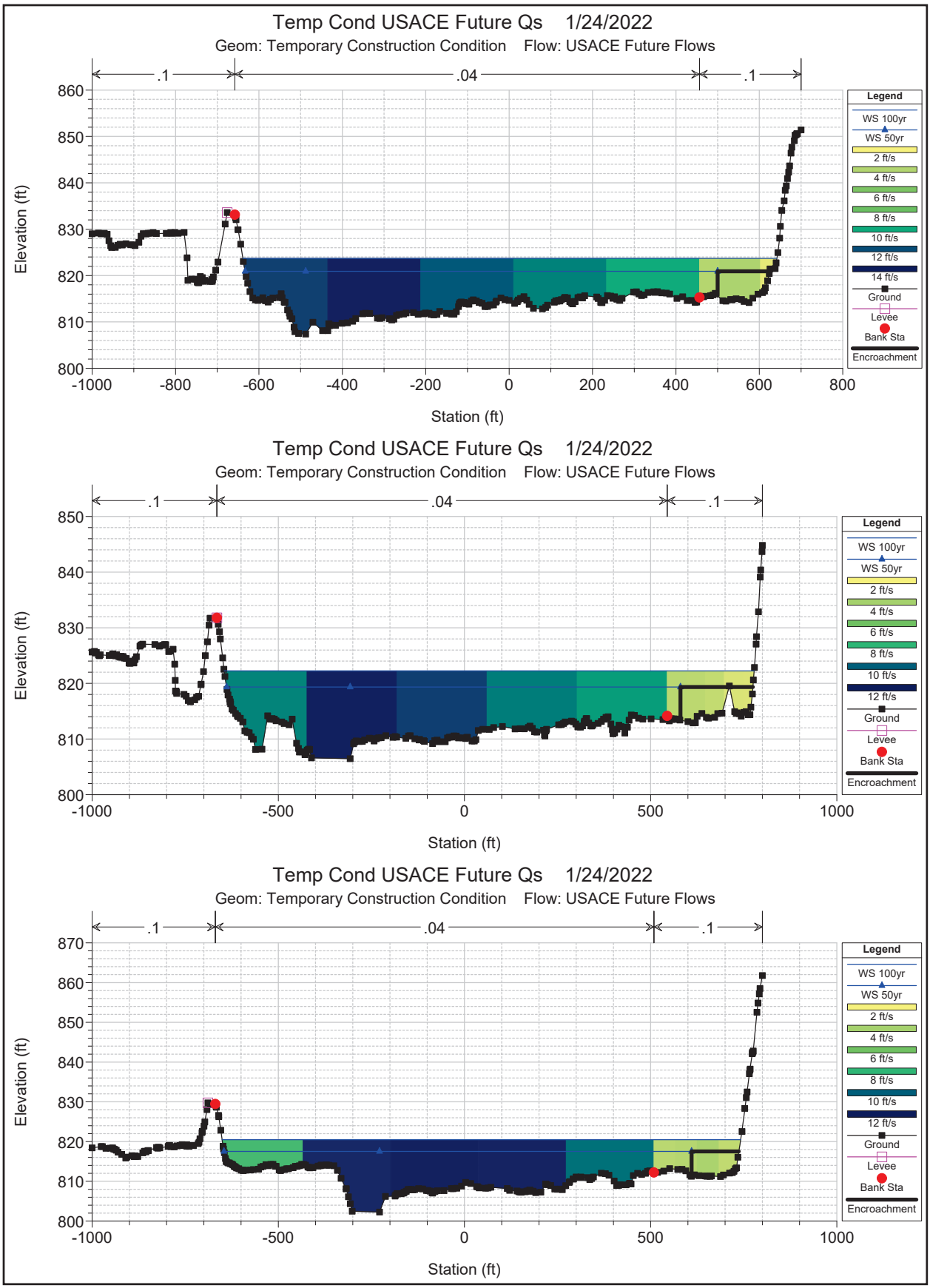
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Levees	103250	100yr	140000	814.21	830.04	827.31	832.32	0.004369	12.32	12387	1176	0.65
Levees	103250	50yr	82000	814.21	827.29	824.76	828.73	0.003900	9.71	8849	1077	0.58
Levees	103000	100yr	140000	812.88	829.03	826.19	831.23	0.004162	12.15	12898	1247	0.63
Levees	103000	50yr	82000	812.88	826.34	823.59	827.78	0.003716	9.65	8660	991	0.57
Levees	102500	100yr	140000	810.49	825.94	824.28	828.64	0.006307	13.66	11823	1252	0.76
Levees	102500	50yr	82000	810.49	823.31	821.92	825.30	0.006580	11.45	7500	1017	0.74
Levees	102000	100yr	140000	807.38	823.68	821.11	825.80	0.004569	11.88	12740	1281	0.65
Levees	102000	50yr	82000	807.38	820.93	818.89	822.40	0.004645	9.78	8543	1133	0.62
Levees	101500	100yr	140000	806.47	822.21	818.56	823.77	0.003085	10.21	14946	1423	0.54
Levees	101500	50yr	82000	806.47	819.34	816.37	820.42	0.003053	8.35	9966	1219	0.51
Levees	101000	100yr	140000	802.27	820.36	817.19	822.09	0.003605	10.78	14242	1392	0.58
Levees	101000	50yr	82000	802.27	817.53	815.04	818.74	0.003665	8.88	9588	1256	0.56
Levees	100500	100yr	140000	800.72	817.95	815.48	820.00	0.004777	11.71	12823	1315	0.66
Levees	100500	50yr	82000	800.72	815.12	813.32	816.55	0.005181	9.76	8859	1266	0.65
Levees	100000	100yr	140000	797.33	816.22	812.89	817.86	0.003430	10.28	13623	1316	0.56
Levees	100000	50yr	82000	797.33	813.04	810.76	814.22	0.003971	8.73	9395	1289	0.57
Levees	99500	100yr	140000	796.61	814.84	810.63	816.30	0.002681	9.71	14418	1262	0.51
Levees	99500	50yr	82000	796.61	811.49	808.42	812.49	0.002854	8.02	10222	1250	0.49
Levees	99000	100yr	140000	794.56	812.83	809.45	814.71	0.003605	11.00	12727	1153	0.58
Levees	99000	50yr	82000	794.56	809.38	807.12	810.74	0.004212	9.35	8769	1141	0.59
Levees	98750	100yr	140000	793.86	812.04	808.39	813.82	0.003303	10.69	13097	1161	0.56
Levees	98750	50yr	82000	793.86	808.36	806.03	809.69	0.004112	9.27	8845	1146	0.59
Levees	98355.0*	100yr	140000	790.54	811.12	805.94	812.65	0.002367	9.91	14133	1088	0.48
Levees	98355.0*	50yr	82000	790.54	807.33	803.40	808.36	0.002468	8.16	10045	1067	0.47
Levees	98288 BR U	100yr	140000	790.54	809.94	806.65	812.28	0.006025	12.27	11409	963	0.63
Levees	98288 BR U	50yr	82000	790.54	806.48	803.90	808.06	0.005507	10.10	8117	925	0.60
Levees	98288 BR D	100yr	140000	790.74	809.13	805.90	811.46	0.005580	12.25	11425	958	0.63
Levees	98288 BR D	50yr	82000	790.74	805.81	803.24	807.34	0.005128	9.93	8259	950	0.59
Levees	98250	100yr	140000	790.74	809.55	805.41	811.36	0.003047	10.79	12972	1058	0.54
Levees	98250	50yr	82000	790.74	806.03	802.92	807.25	0.003151	8.85	9270	1049	0.52
Levees	97500	100yr	140000	789.88	806.84	803.12	808.89	0.003489	11.49	12179	1009	0.58
Levees	97500	50yr	82000	789.88	803.20	800.45	804.63	0.003815	9.61	8536	991	0.58
Levees	97060	100yr	140000	788.01	805.76	800.79	807.49	0.002548	10.54	13280	987	0.51
Levees	97060	50yr	82000	788.01	802.08	798.17	803.20	0.002475	8.48	9667	977	0.48
Levees	96968 BR U	100yr	140000	788.01	805.16	801.13	807.29	0.005012	11.71	11955	927	0.57
Levees	96968 BR U	50yr	82000	788.01	801.69	798.40	803.06	0.004181	9.37	8755	917	0.53
Levees	96968 BR D	100yr	140000	787.45	803.80	800.58	806.16	0.005381	12.32	11366	952	0.63
Levees	96968 BR D	50yr	82000	787.45	800.51	797.89	802.04	0.004944	9.95	8244	940	0.59
Levees	96875	100yr	140000	787.45	803.57	800.42	805.91	0.004144	12.27	11414	974	0.63
Levees	96875	50yr	82000	787.45	800.24	797.77	801.80	0.004216	10.01	8191	962	0.60
Levees	96500	100yr	140000	785.73	802.02	798.84	804.36	0.004089	12.27	11407	965	0.63
Levees	96500	50yr	82000	785.73	798.68	796.15	800.23	0.004118	9.99	8204	951	0.60
Levees	96000	100yr	140000	784.59	800.08	796.69	802.35	0.003890	12.09	11576	965	0.62
Levees	96000	50yr	82000	784.59	796.74	794.02	798.23	0.003846	9.79	8373	951	0.58
Levees	95500	100yr	140000	783.09	798.04	794.80	800.36	0.004030	12.22	11458	965	0.63
Levees	95500	50yr	82000	783.09	794.75	792.14	796.27	0.003967	9.88	8304	953	0.59
Levees	95000	100yr	140000	780.79	795.64	792.92	798.18	0.004664	12.77	10963	963	0.67
Levees	95000	50yr	82000	780.79	792.33	790.24	794.05	0.004904	10.52	7791	951	0.65
Levees	94500	100yr	140000	778.09	793.71	790.33	795.98	0.003881	12.08	11587	964	0.61
Levees	94500	50yr	82000	778.09	790.26	787.66	791.78	0.003986	9.89	8290	951	0.59
Levees	94000	100yr	140000	774.30	792.04	788.11	794.11	0.003368	11.56	12111	966	0.58
Levees	94000	50yr	82000	774.30	788.58	785.44	789.93	0.003292	9.33	8792	953	0.54
Levees	93500	100yr	140000	773.64	789.99	786.64	792.27	0.003938	12.12	11549	965	0.62
Levees	93500	50yr	82000	773.64	786.56	783.98	788.09	0.004043	9.93	8260	951	0.59

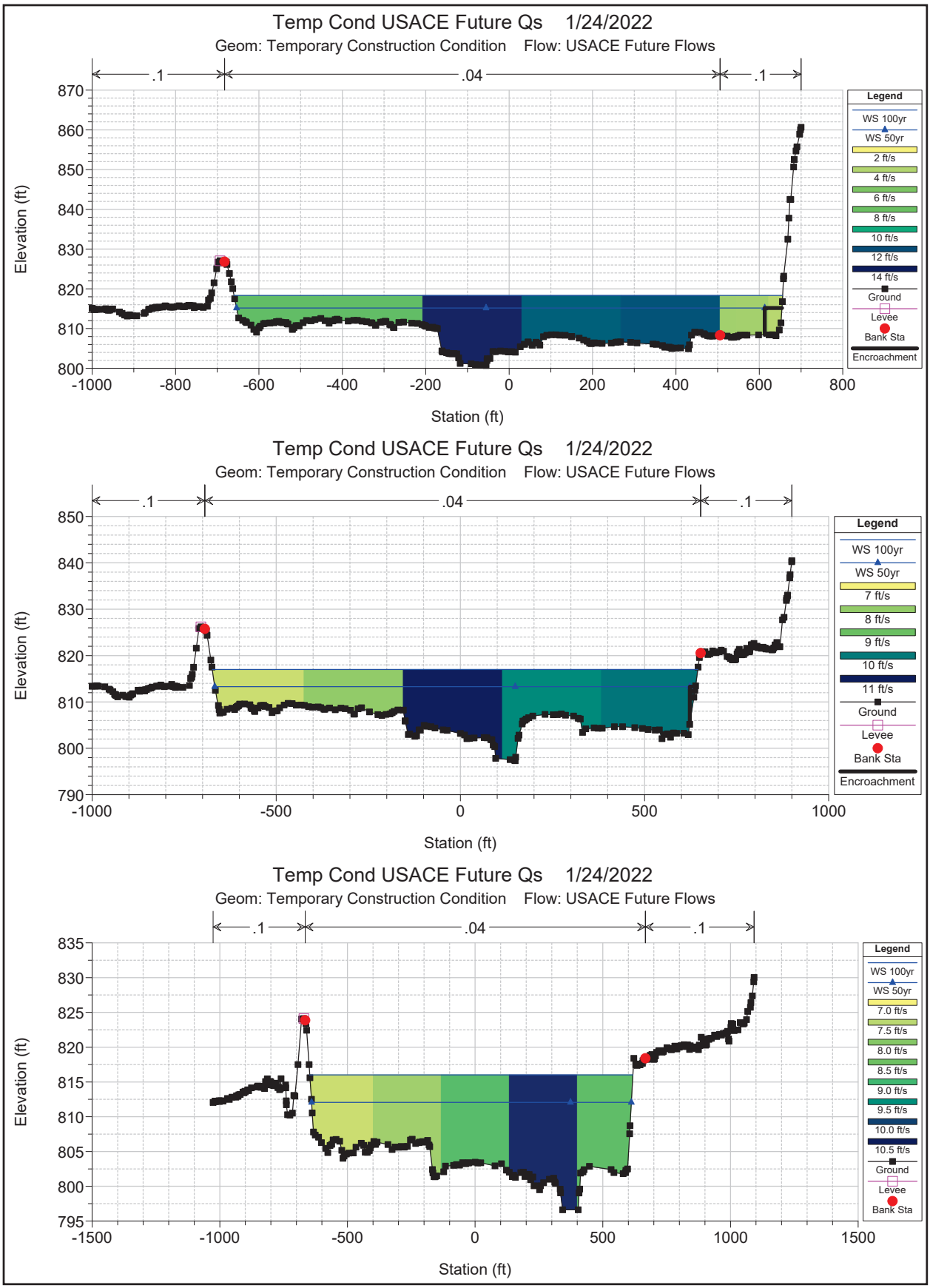
HEC-RAS Plan: ExCondJul2021FutureQs River: Santa Ana River Reach: Levees (Continued)

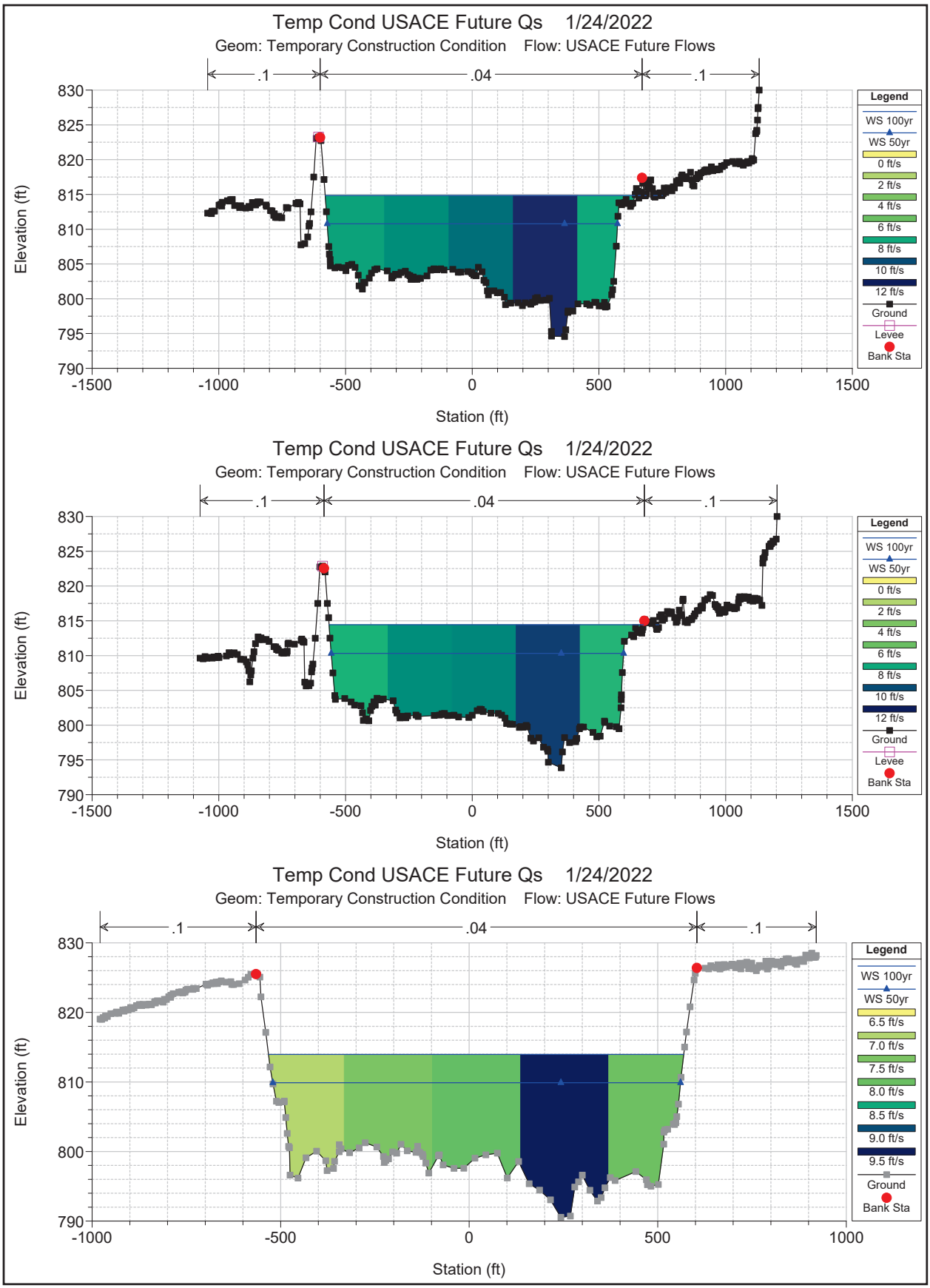
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Levees	93100	100yr	140000	769.93	788.67	784.75	790.75	0.003394	11.56	12111	967	0.58
Levees	93100	50yr	82000	769.93	785.23	782.05	786.58	0.003291	9.31	8808	952	0.54
Levees	93000	100yr	140000	770.34	788.13	784.69	790.37	0.003853	12.01	11652	966	0.61
Levees	93000	50yr	82000	770.34	784.72	782.02	786.21	0.003884	9.78	8381	953	0.58
Levees	92900	100yr	140000	769.97	787.67	784.39	789.97	0.004025	12.18	11491	967	0.62
Levees	92900	50yr	82000	769.97	784.25	781.73	785.80	0.004140	9.98	8214	953	0.60
Levees	92800	100yr	140000	770.12	787.19	784.08	789.56	0.004193	12.35	11338	967	0.64
Levees	92800	50yr	82000	770.12	783.75	781.41	785.37	0.004430	10.20	8039	953	0.62
Levees	92500	100yr	140000	769.46	785.96	782.75	788.30	0.004100	12.26	11415	966	0.63
Levees	92500	50yr	82000	769.46	782.38	780.08	784.02	0.004543	10.28	7975	951	0.63
Levees	92000	100yr	140000	769.06	784.44	780.22	786.42	0.003110	11.28	12411	969	0.56
Levees	92000	50yr	82000	769.06	780.64	777.53	782.00	0.003332	9.37	8756	953	0.54
Levees	91900	100yr	140000	767.60	784.17	779.77	786.10	0.002994	11.14	12566	972	0.55
Levees	91900	50yr	82000	767.60	780.34	777.09	781.66	0.003172	9.23	8886	954	0.53
Levees	91800	100yr	140000	764.88	784.00	779.03	785.77	0.002587	10.66	13128	971	0.51
Levees	91800	50yr	82000	764.88	780.16	776.36	781.33	0.002618	8.70	9421	955	0.49
Levees	91700	100yr	140000	763.15	783.73	778.79	785.51	0.002619	10.70	13082	971	0.51
Levees	91700	50yr	82000	763.15	779.88	776.12	781.07	0.002662	8.75	9374	955	0.49
Levees	91600	100yr	140000	762.33	783.46	778.50	785.25	0.002620	10.71	13073	970	0.51
Levees	91600	50yr	82000	762.33	779.61	775.83	780.80	0.002676	8.76	9360	955	0.49
Levees	91230	100yr	140000	763.35	782.97	776.22	784.35	0.001729	9.42	14869	981	0.43
Levees	91230	50yr	82000	763.35	779.12	773.55	779.96	0.001522	7.37	11128	965	0.38
Levees	91185 BR U	100yr	140000	763.35	782.69	776.55	784.29	0.003191	10.15	13797	926	0.46
Levees	91185 BR U	50yr	82000	763.35	778.95	773.78	779.92	0.002505	7.89	10388	913	0.41
Levees	91185 BR D	100yr	140000	763.52	782.14	777.57	784.04	0.003866	11.08	12638	957	0.54
Levees	91185 BR D	50yr	82000	763.52	778.46	774.91	779.71	0.003562	8.97	9141	945	0.51
Levees	91140	100yr	140000	763.52	782.14	777.47	783.98	0.002783	10.87	12878	975	0.53
Levees	91140	50yr	82000	763.52	778.45	774.82	779.66	0.002774	8.82	9296	963	0.50
Levees	90500	100yr	140000	760.94	779.35	776.07	781.73	0.004320	12.39	11303	979	0.64
Levees	90500	50yr	82000	760.94	775.80	773.24	777.44	0.004259	10.25	7998	910	0.61
Levees	90000	100yr	140000	759.03	777.15	773.96	779.50	0.004549	12.30	11382	1036	0.65
Levees	90000	50yr	82000	759.03	773.60	771.24	775.26	0.004466	10.33	7940	927	0.62
Levees	89500	100yr	140000	758.06	774.80	771.70	777.23	0.004521	12.50	11197	993	0.66
Levees	89500	50yr	82000	758.06	771.34	768.94	773.03	0.004428	10.41	7874	905	0.62
Levees	89000	100yr	140000	756.10	772.60	769.42	775.01	0.004334	12.45	11248	974	0.65
Levees	89000	50yr	82000	756.10	769.32	766.63	770.90	0.003975	10.08	8137	908	0.59
Levees	88500	100yr	140000	754.12	770.67	767.24	772.93	0.003825	12.08	11693	1015	0.61
Levees	88500	50yr	82000	754.12	767.62	764.55	769.01	0.003396	9.44	8683	950	0.55
Levees	88000	100yr	140000	752.19	768.16	765.86	770.70	0.005189	12.93	11575	1168	0.70
Levees	88000	50yr	82000	752.19	765.50	763.37	767.04	0.004557	10.07	8606	1106	0.62
Levees	87500	100yr	140000	750.31	765.79	763.46	768.01	0.005147	12.34	13162	1456	0.69
Levees	87500	50yr	82000	750.31	763.18	761.31	764.64	0.004957	9.94	9119	1276	0.64
Levees	87000	100yr	140000	748.30	763.34	761.13	765.33	0.004910	11.94	15108	1867	0.67
Levees	87000	50yr	82000	748.30	760.67	758.99	762.04	0.005010	9.81	10104	1569	0.64
Levees	86500	100yr	140000	746.45	762.11	758.39	763.34	0.002577	9.24	18960	2312	0.49
Levees	86500	50yr	82000	746.45	759.39	756.36	760.18	0.002378	7.35	13160	1945	0.45

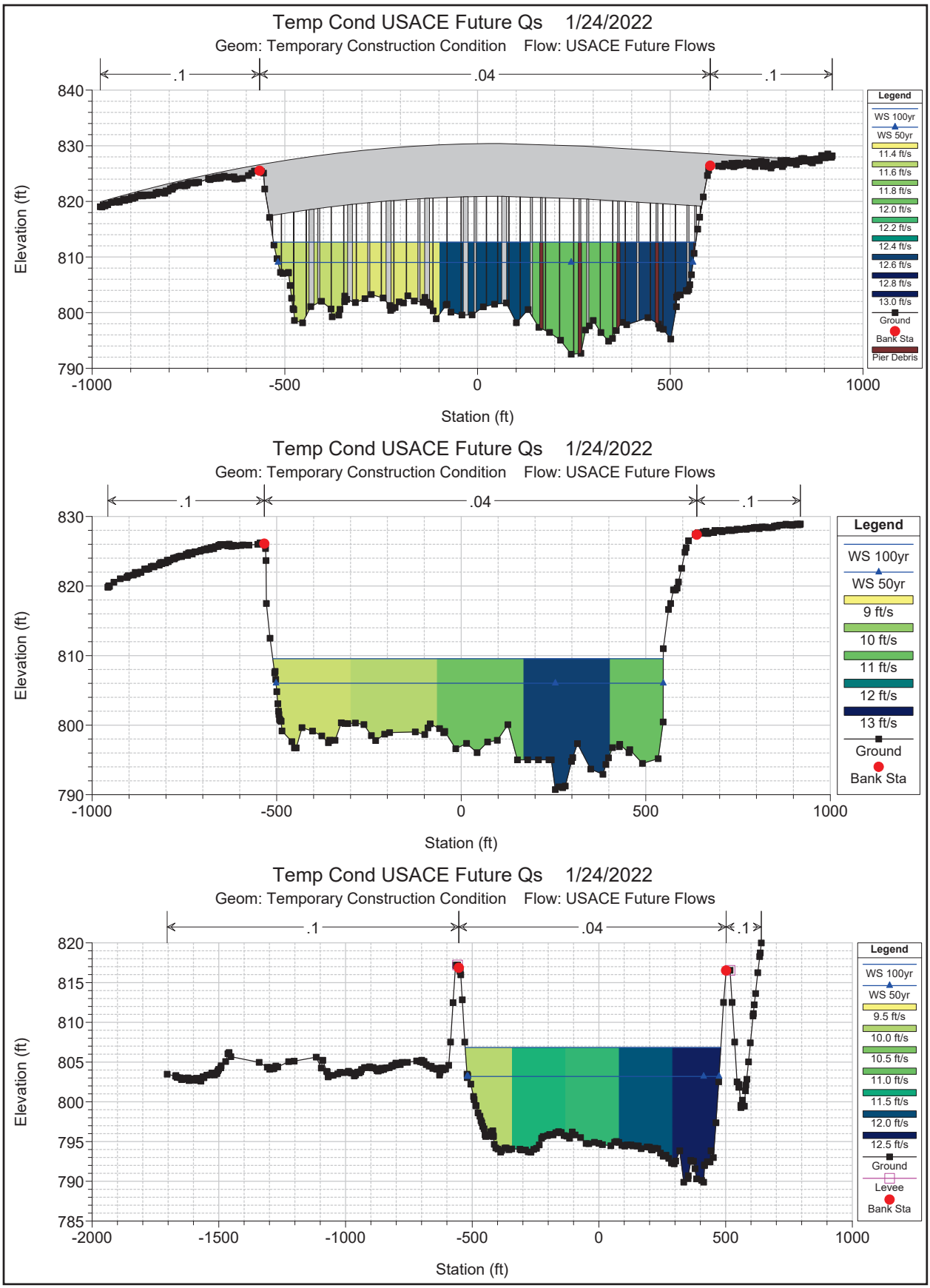
Temporary Conditions Hydraulic Analysis

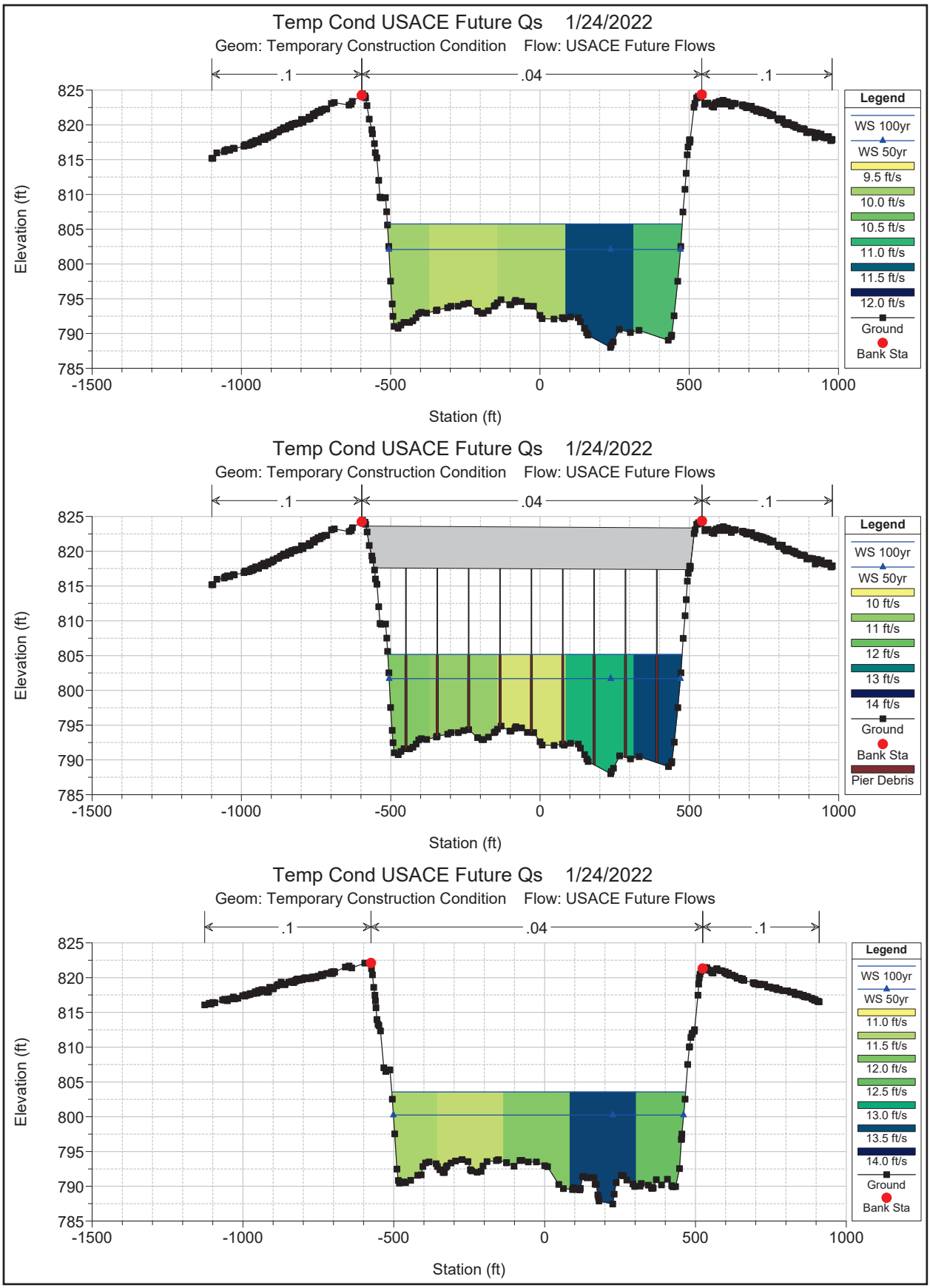


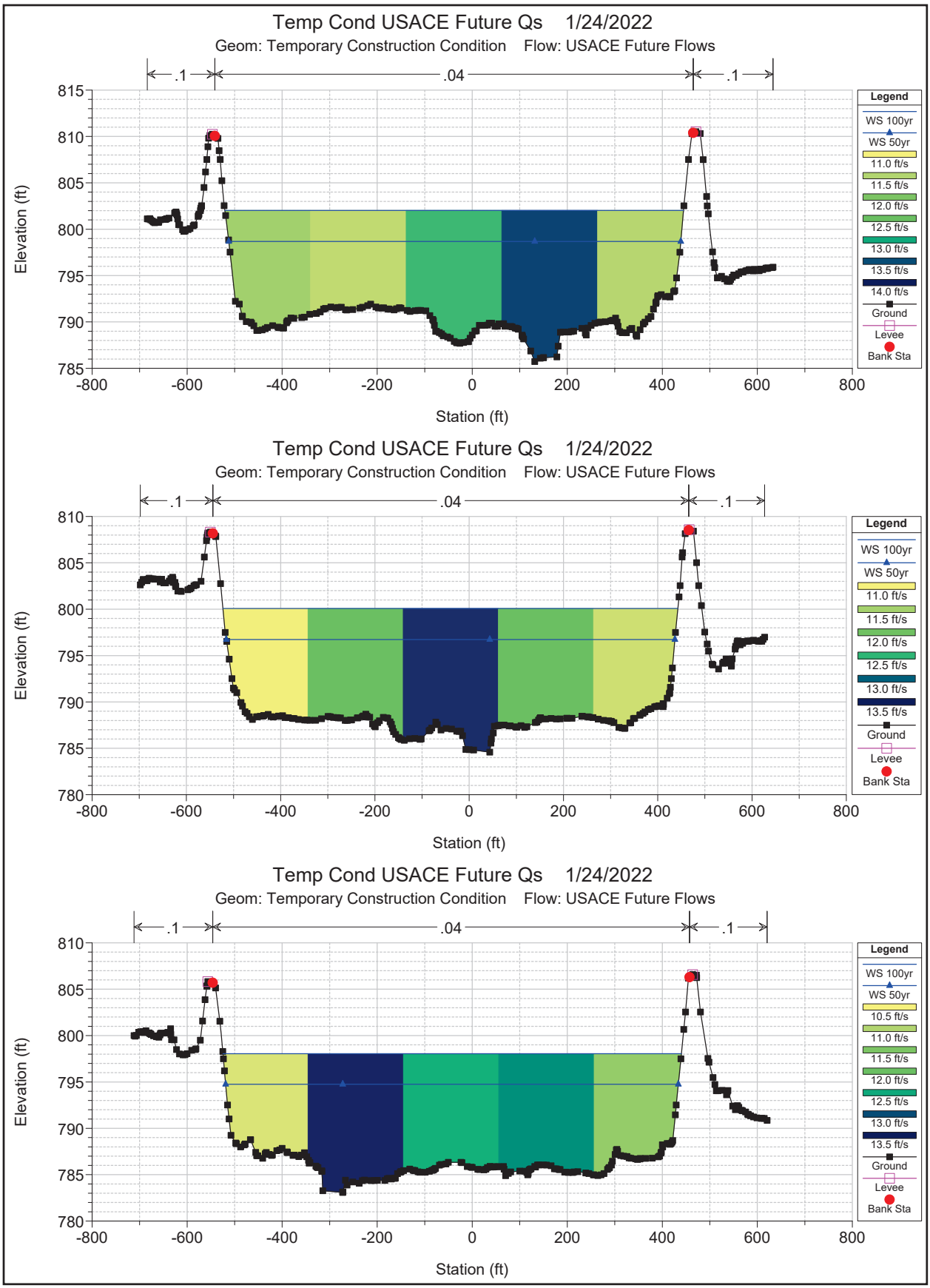


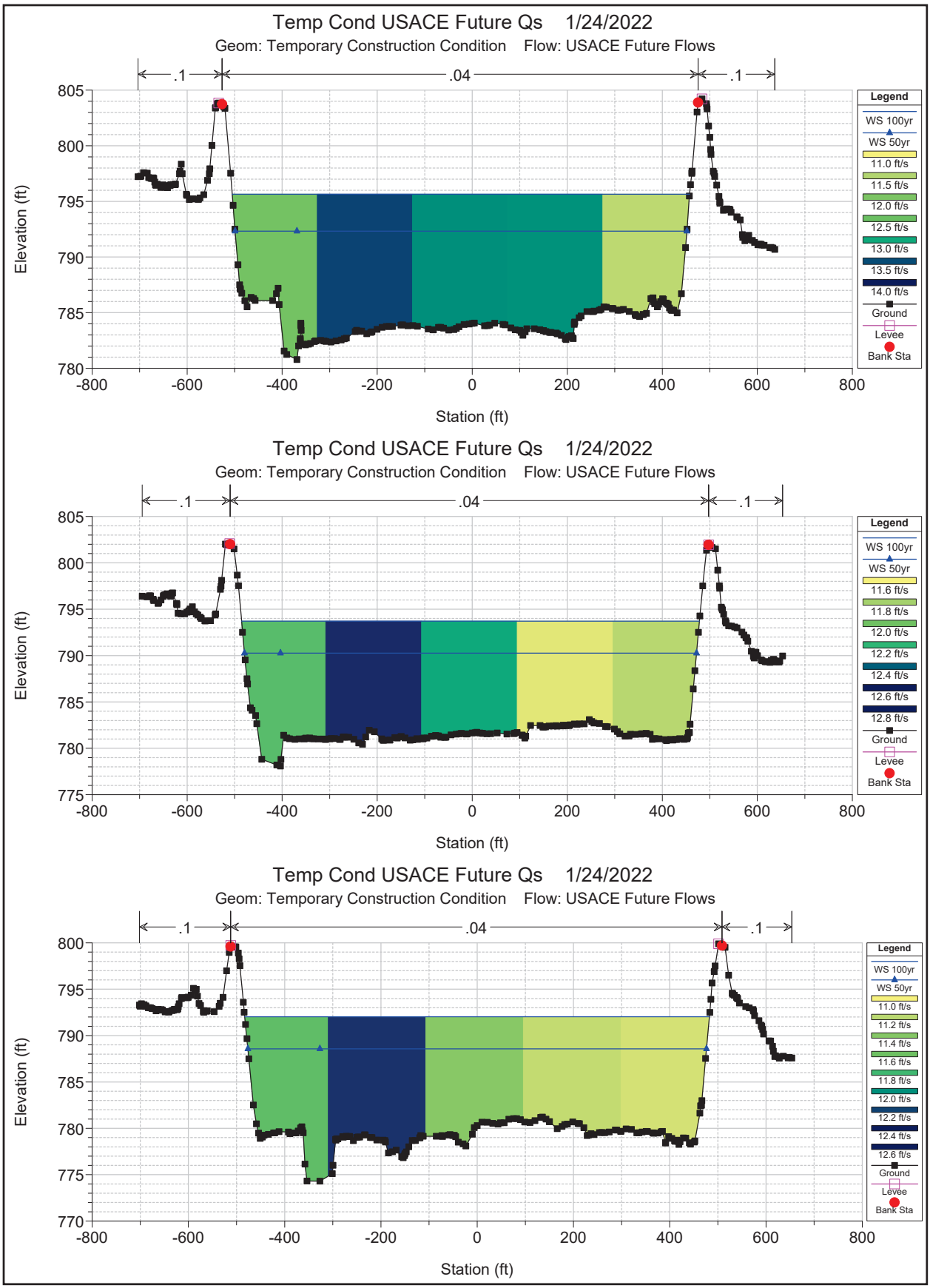


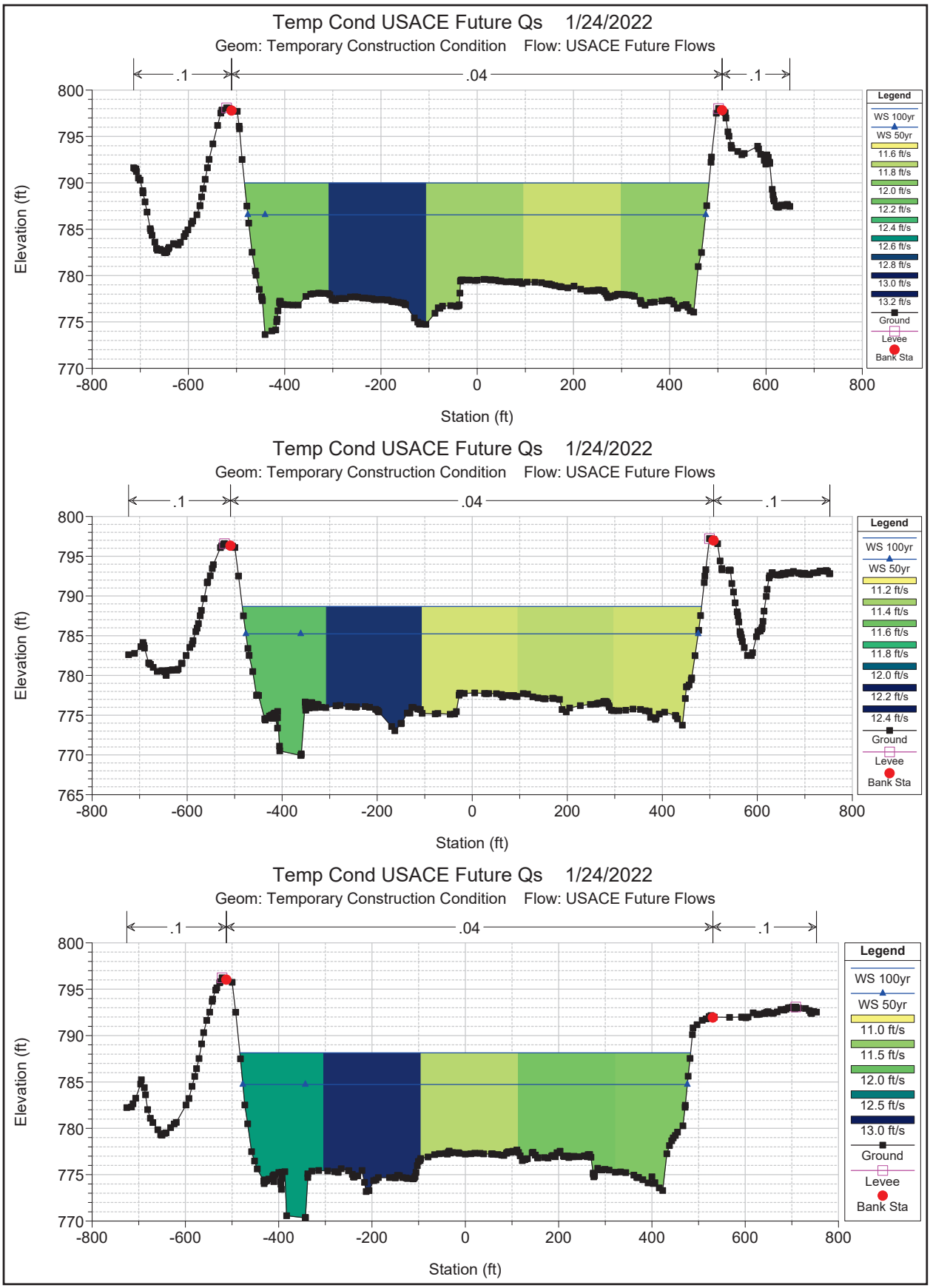


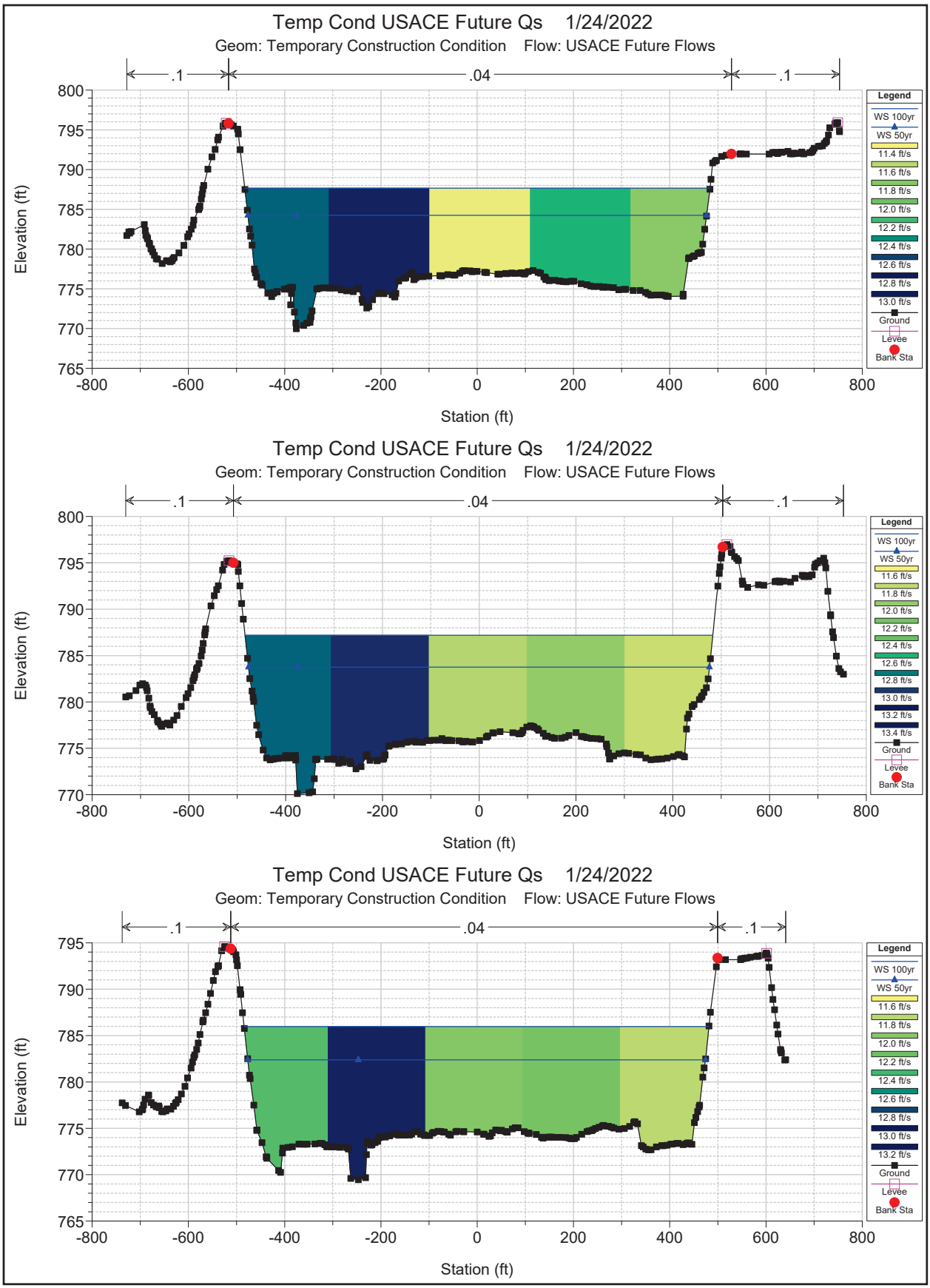


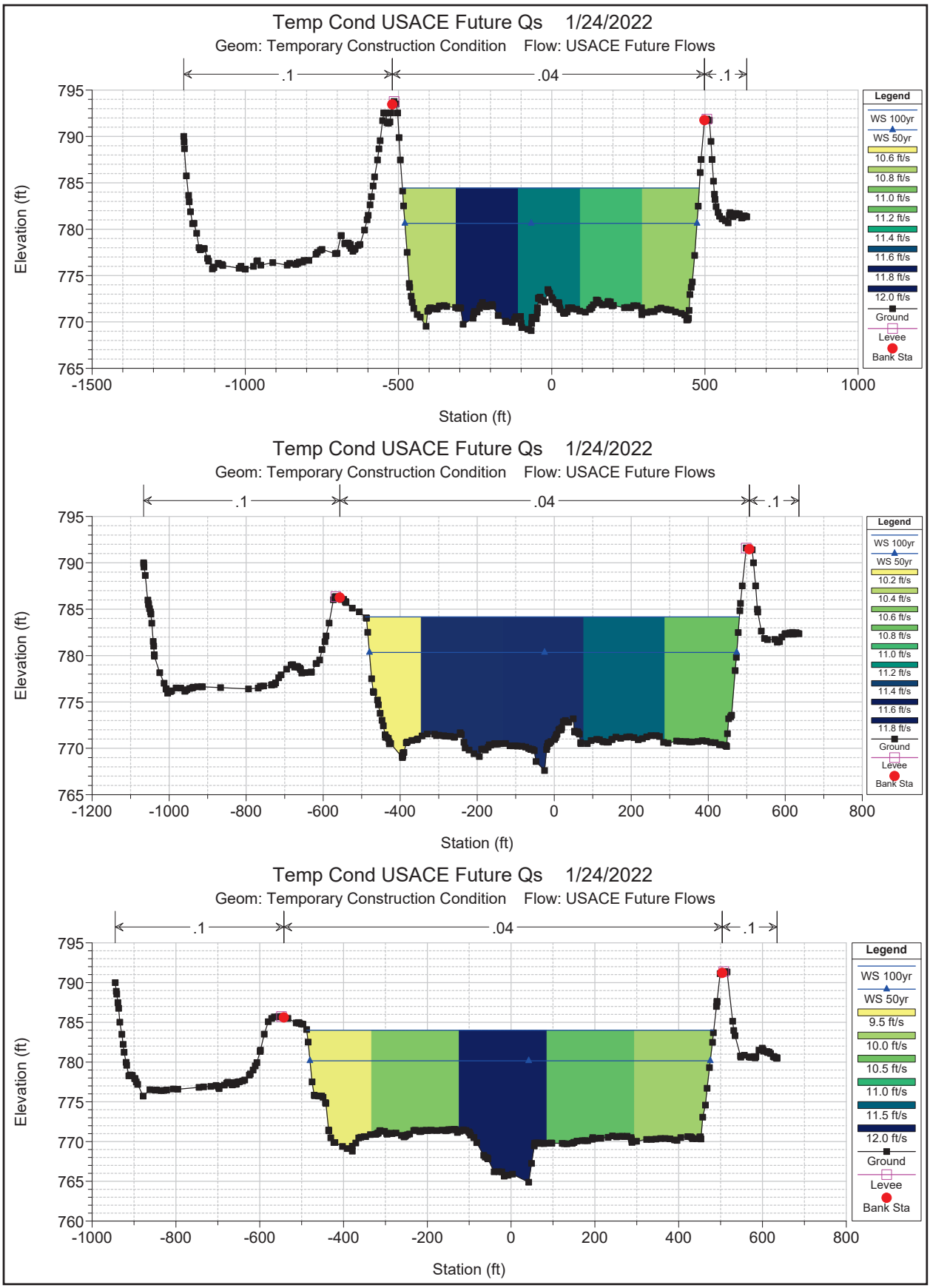


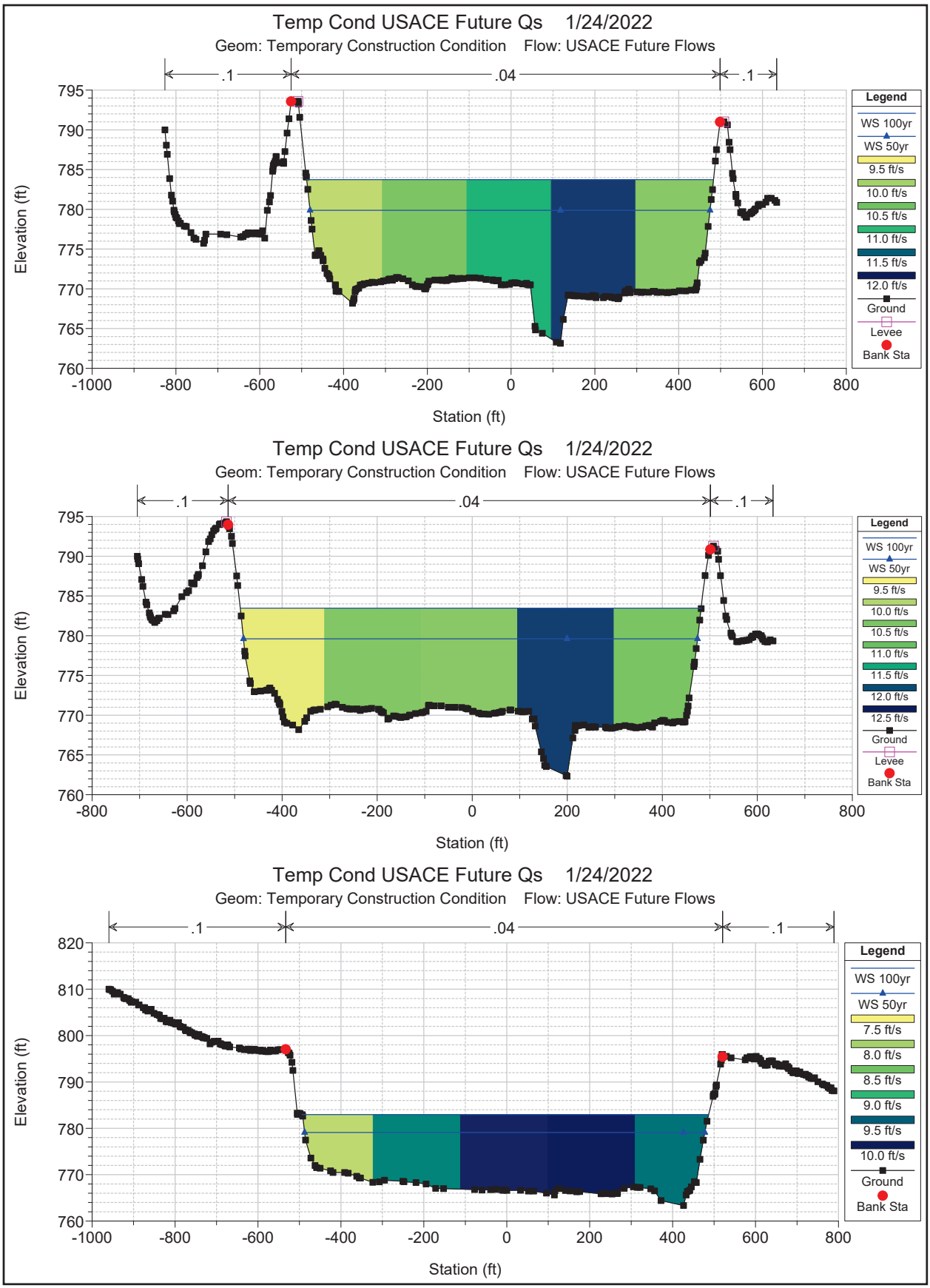


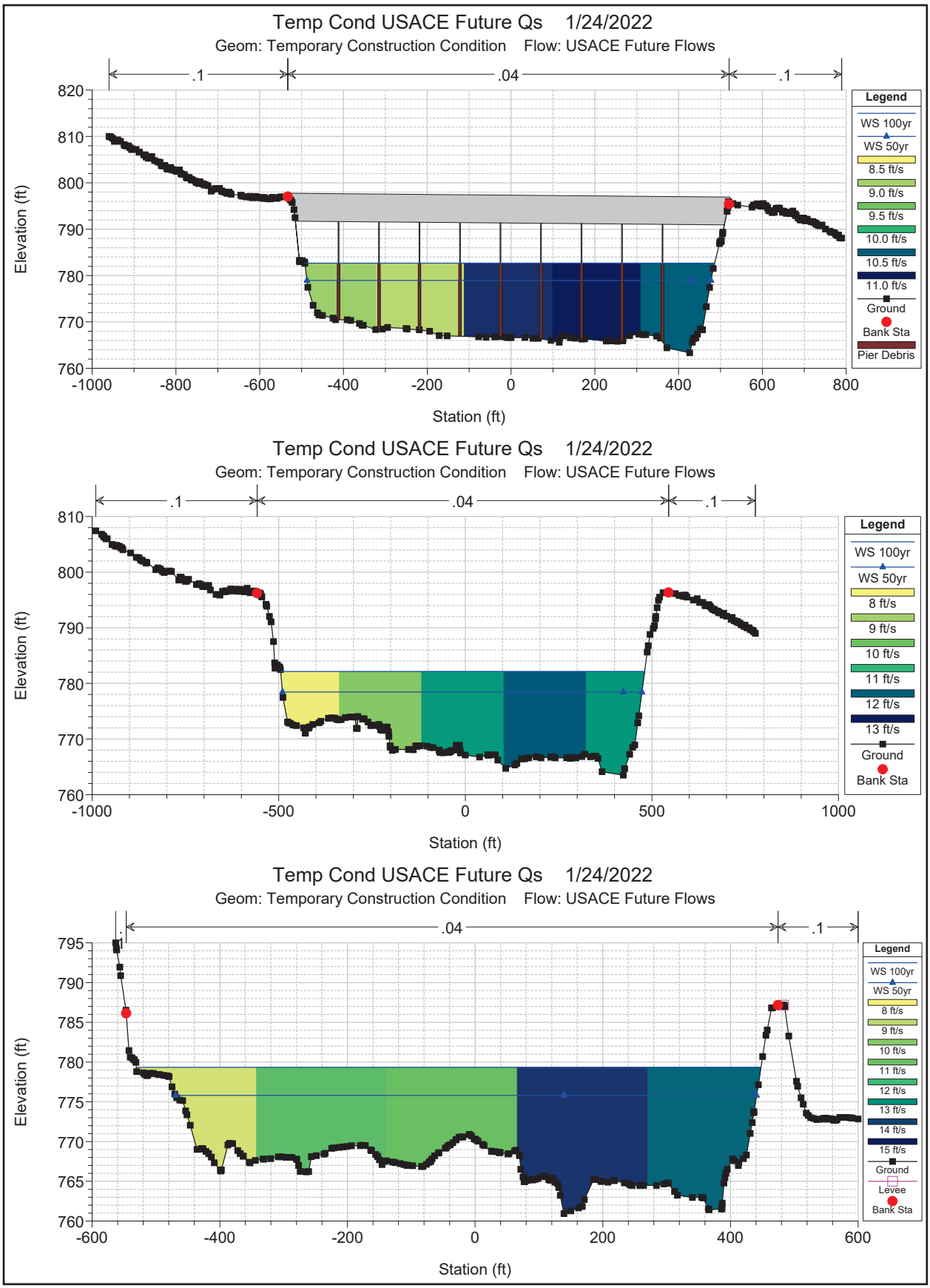


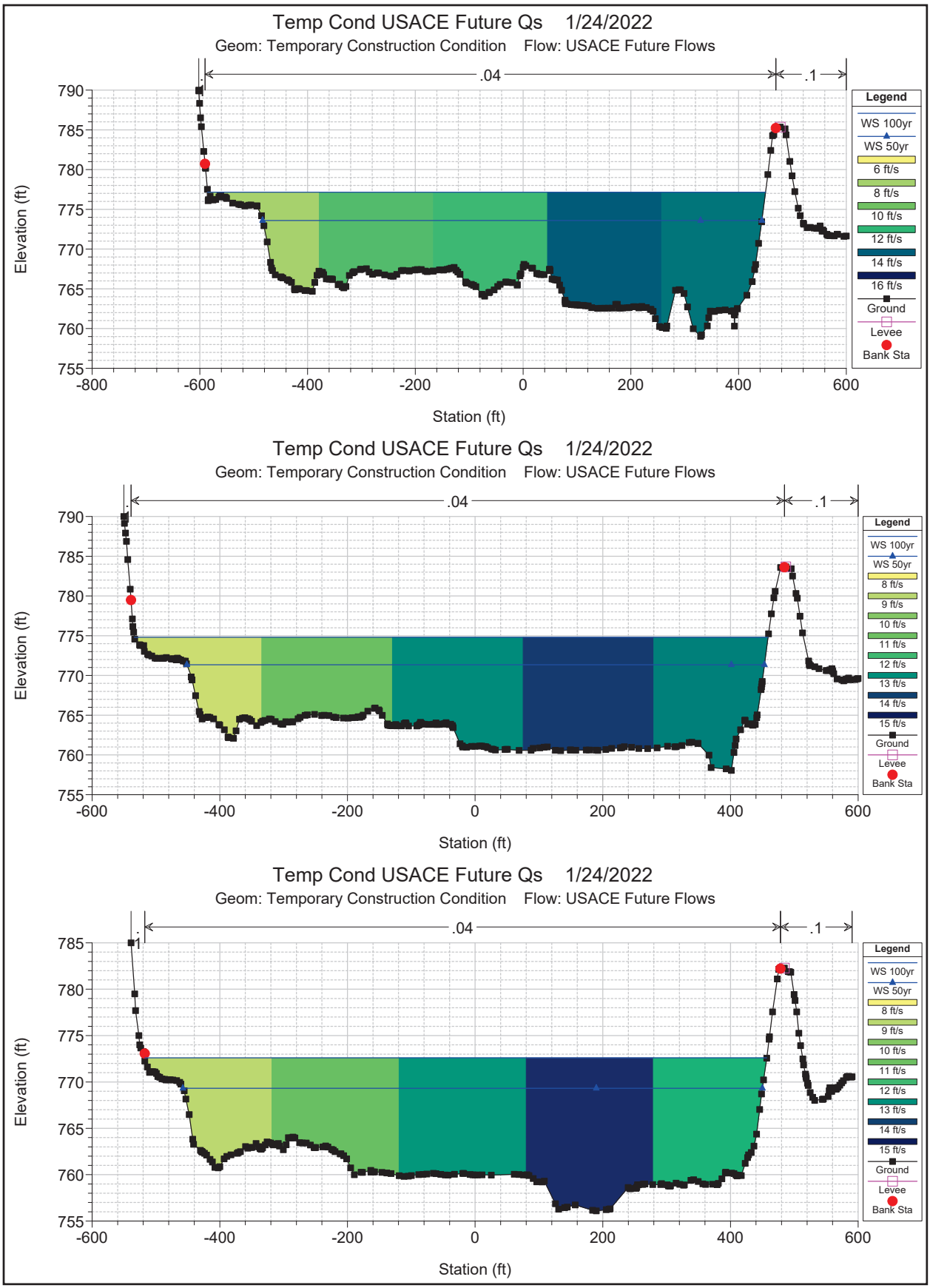


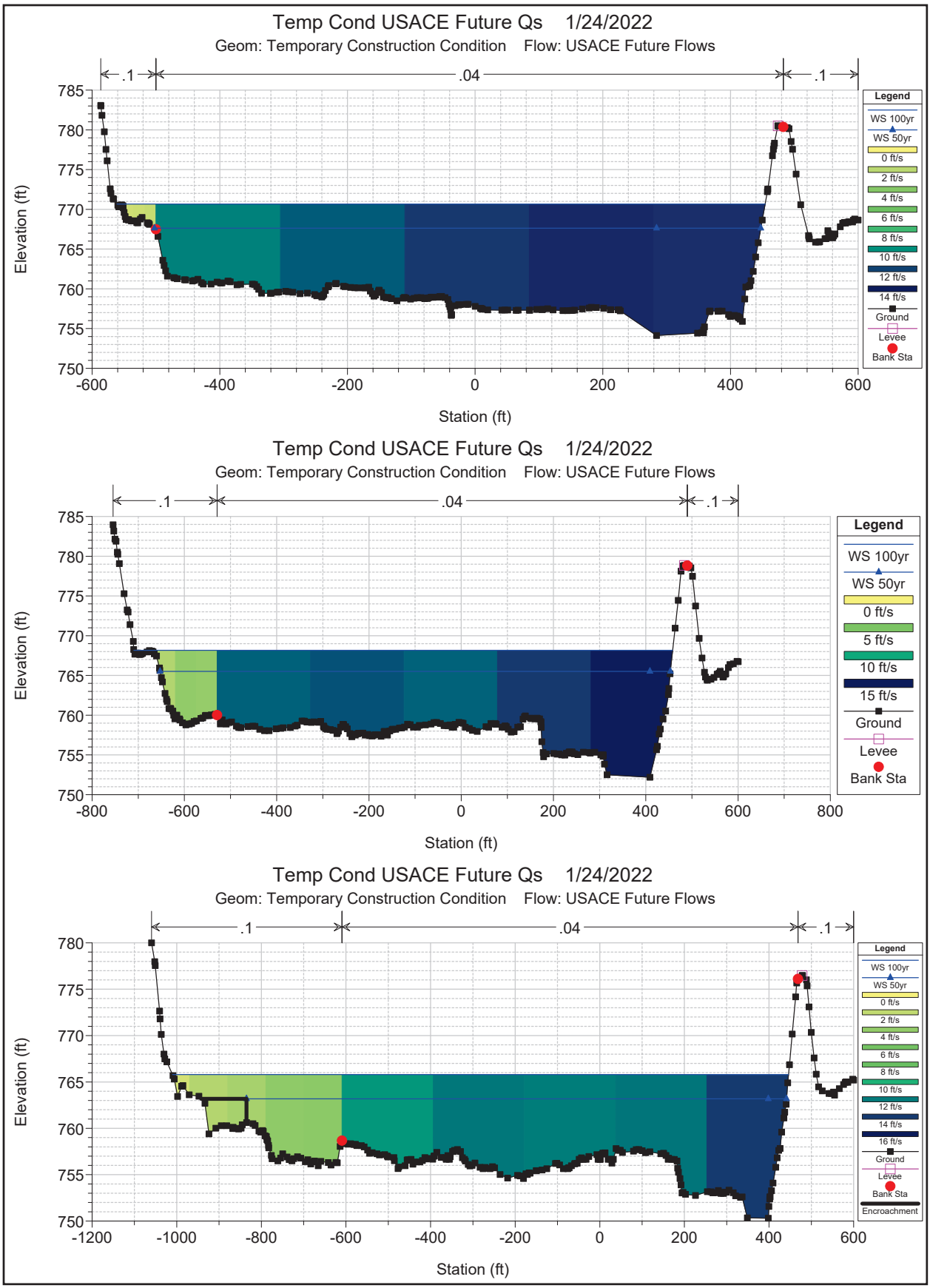


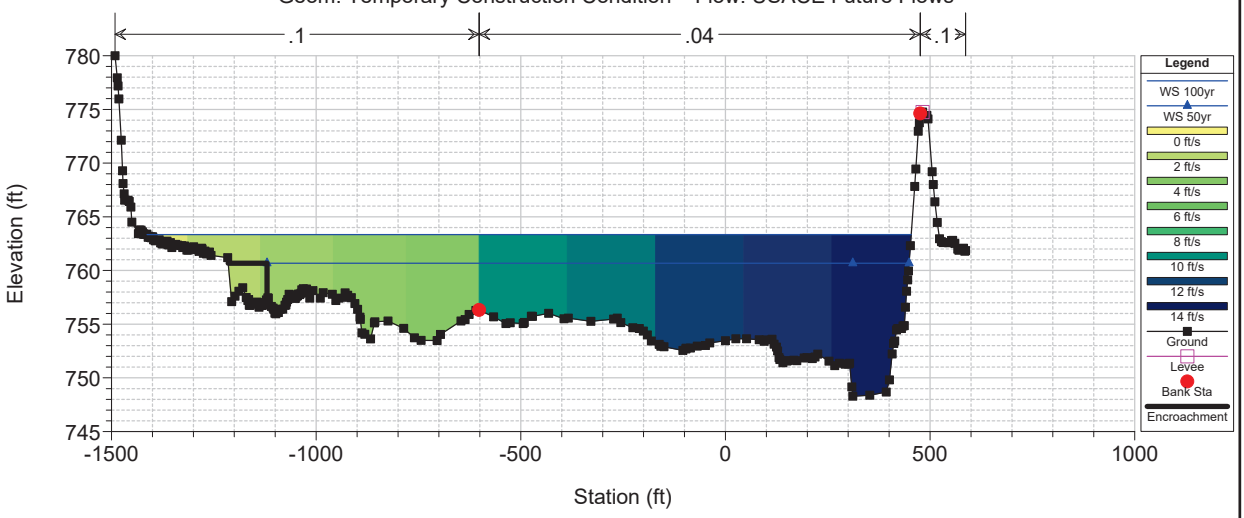


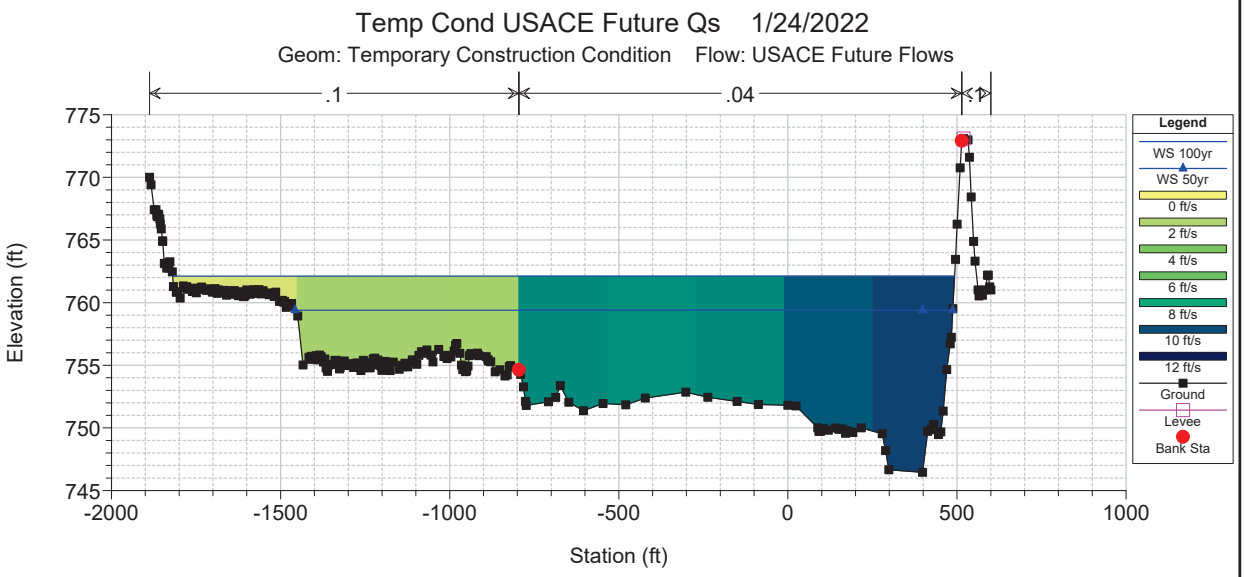


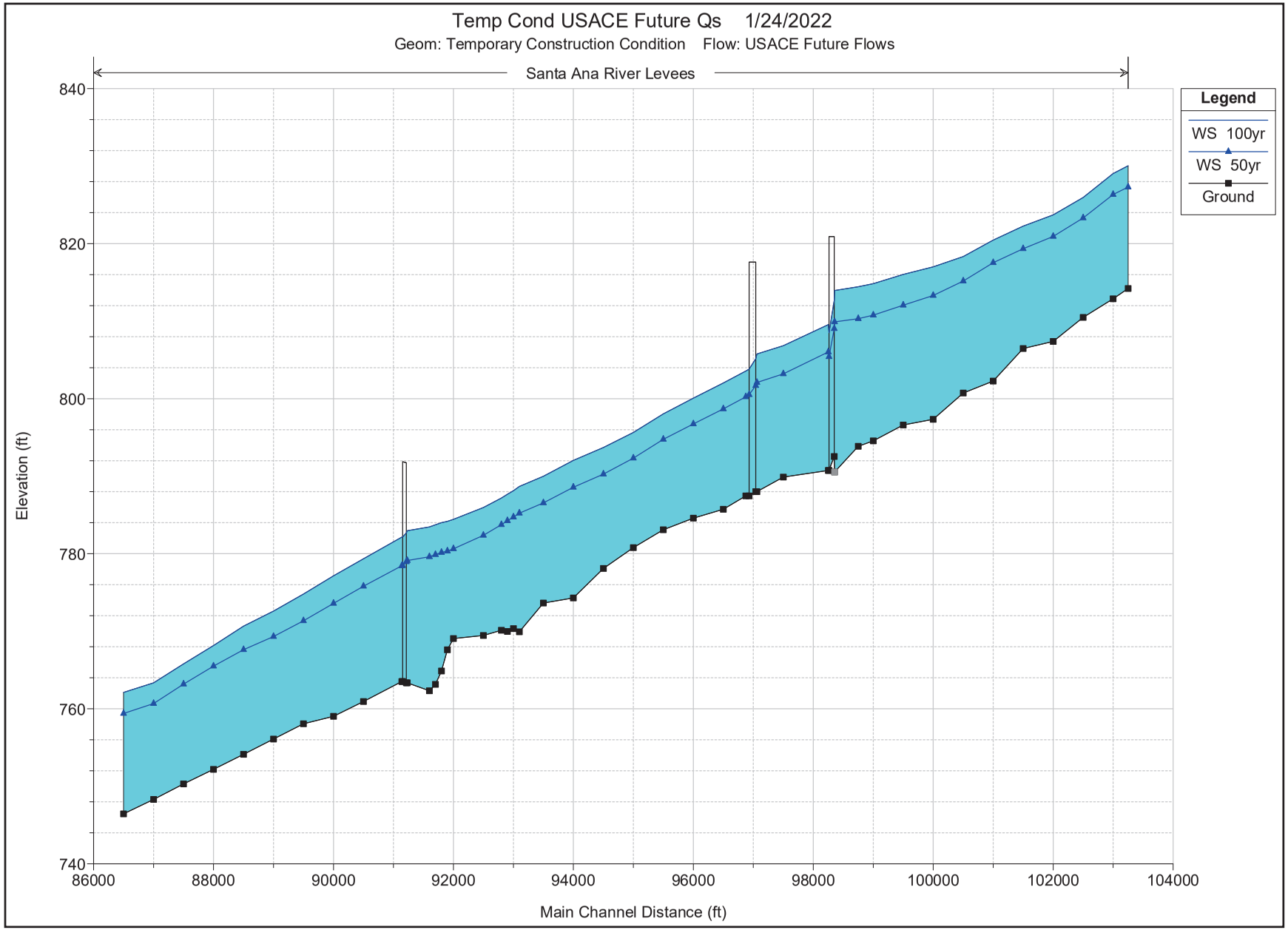











Temp Cond USACE Future Qs 1/24/2022
Geom: Temporary Construction Condition Flow: USACE Future Flows
Santa Ana River Levees
Legend
WS 100yr
WS 50yr
Ground
Elevation (ft)
840
820
800
780
760
740
86000
88000
90000
92000
94000
96000
98000
100000
102000
104000
Main Channel Distance (ft)

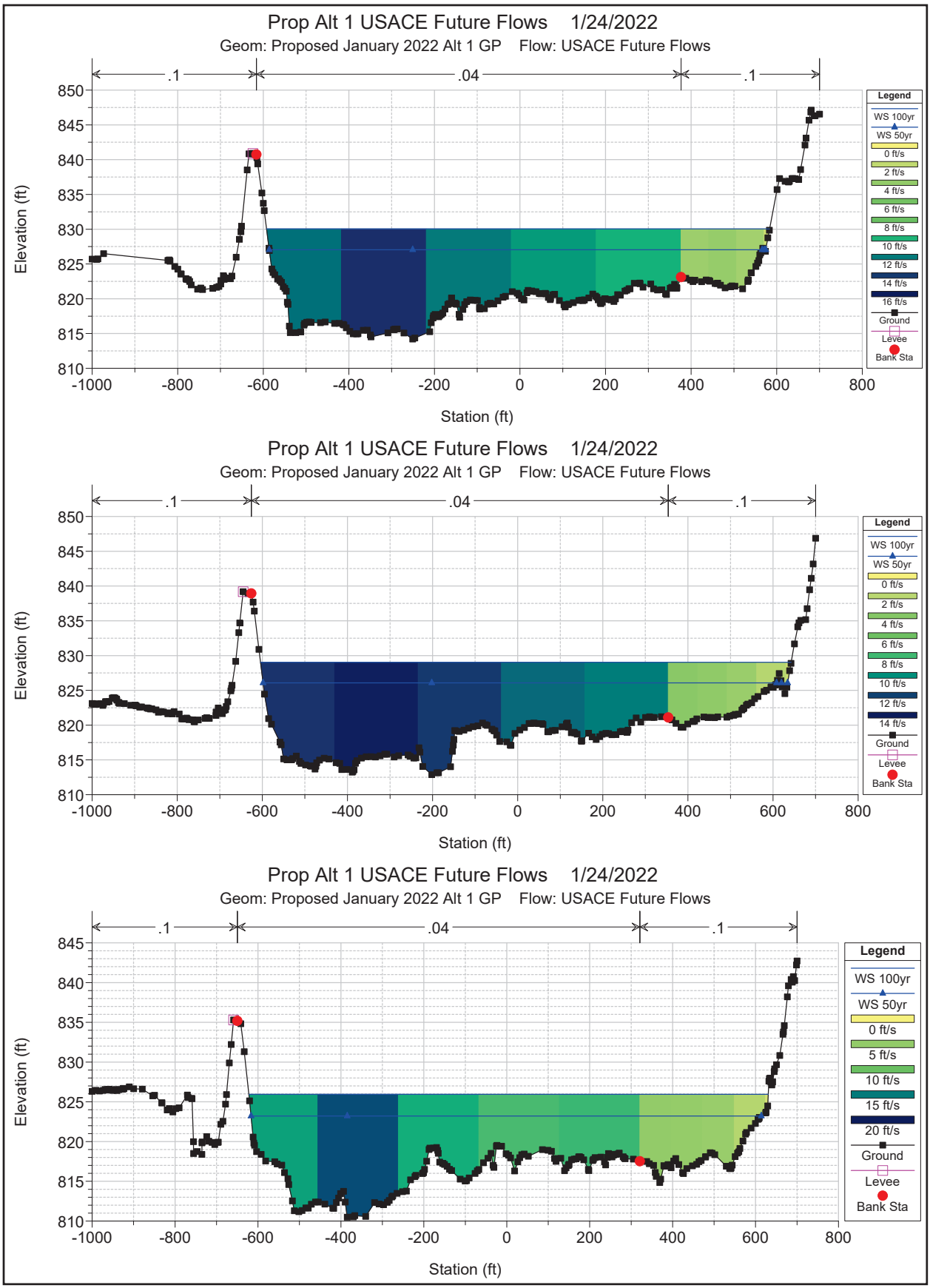
HEC-RAS Plan: TempJul2021BDHS River: Santa Ana River Reach: Levees

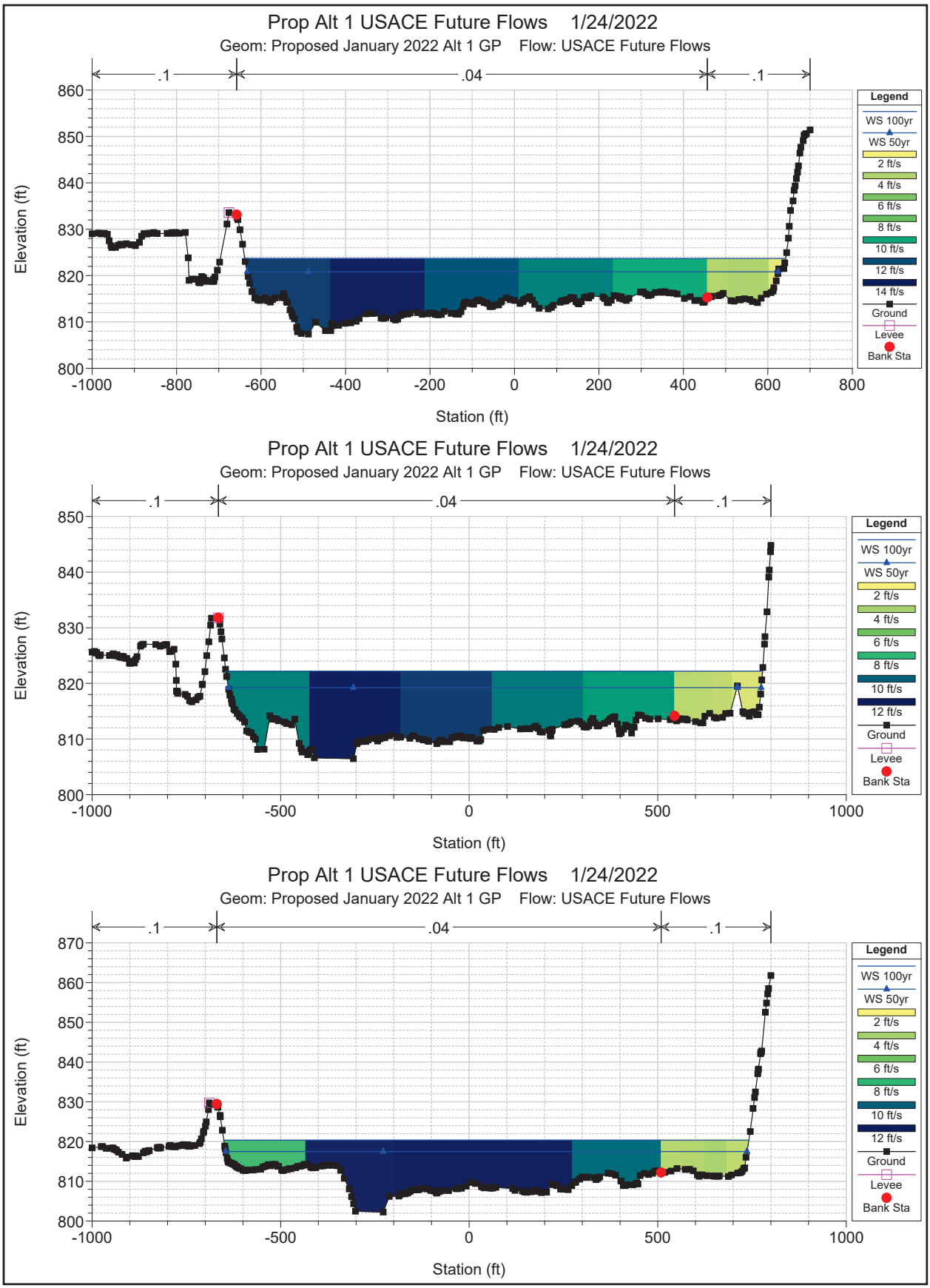
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Levees	103250	100yr	140000	814.21	830.04	827.31	832.32	0.004369	12.32	12387	1176	0.65
Levees	103250	50yr	82000	814.21	827.29	824.76	828.73	0.003900	9.71	8849	1077	0.58
Levees	103000	100yr	140000	812.88	829.03	826.19	831.23	0.004162	12.15	12898	1247	0.63
Levees	103000	50yr	82000	812.88	826.34	823.59	827.78	0.003716	9.65	8660	991	0.57
Levees	102500	100yr	140000	810.49	825.95	824.28	828.65	0.006297	13.66	11829	1252	0.76
Levees	102500	50yr	82000	810.49	823.31	821.92	825.30	0.006580	11.45	7500	1017	0.74
Levees	102000	100yr	140000	807.38	823.70	821.11	825.81	0.004538	11.85	12767	1281	0.65
Levees	102000	50yr	82000	807.38	820.93	818.89	822.40	0.004644	9.78	8543	1133	0.62
Levees	101500	100yr	140000	806.47	822.25	818.56	823.80	0.003046	10.17	15007	1423	0.54
Levees	101500	50yr	82000	806.47	819.34	816.37	820.42	0.003051	8.35	9968	1219	0.51
Levees	101000	100yr	140000	802.27	820.46	817.19	822.16	0.003492	10.67	14384	1393	0.57
Levees	101000	50yr	82000	802.27	817.53	815.04	818.74	0.003658	8.88	9594	1256	0.56
Levees	100500	100yr	140000	800.72	818.33	815.48	820.23	0.004202	11.27	13332	1316	0.62
Levees	100500	50yr	82000	800.72	815.18	813.32	816.59	0.005038	9.68	8935	1267	0.64
Levees	100000	100yr	140000	797.33	817.00	812.89	818.42	0.002699	9.55	14653	1319	0.51
Levees	100000	50yr	82000	797.33	813.31	810.76	814.41	0.003523	8.42	9741	1290	0.54
Levees	99500	100yr	140000	796.61	816.02	810.63	817.22	0.001938	8.80	15915	1266	0.44
Levees	99500	50yr	82000	796.61	812.06	808.42	812.94	0.002286	7.50	10934	1252	0.45
Levees	99000	100yr	140000	794.56	814.84	809.45	816.17	0.002216	9.26	15120	1246	0.47
Levees	99000	50yr	82000	794.56	810.78	807.12	811.75	0.002428	7.91	10364	1146	0.46
Levees	98750	100yr	140000	793.86	814.43	808.39	815.63	0.001861	8.76	15983	1253	0.43
Levees	98750	50yr	82000	793.86	810.32	806.03	811.17	0.001946	7.38	11105	1154	0.42
Levees	98355.0*	100yr	140000	790.54	813.95	805.92	814.98	0.001244	8.12	17233	1101	0.36
Levees	98355.0*	50yr	82000	790.54	809.90	803.33	810.53	0.001119	6.40	12804	1081	0.33
Levees	98288 BR U	100yr	140000	792.54	812.67	808.91	814.95	0.011020	12.11	11564	907	0.60
Levees	98288 BR U	50yr	82000	792.54	809.03	806.03	810.56	0.009042	9.90	8283	893	0.57
Levees	98288 BR D	100yr	140000	790.88	808.51	806.38	811.52	0.013275	13.92	10059	894	0.73
Levees	98288 BR D	50yr	82000	790.88	805.41	803.59	807.37	0.010970	11.24	7297	886	0.69
Levees	98250	100yr	140000	790.74	809.55		811.36	0.003047	10.79	12972	1058	0.54
Levees	98250	50yr	82000	790.74	806.03		807.25	0.003151	8.85	9270	1049	0.52
Levees	97500	100yr	140000	789.88	806.84	803.12	808.89	0.003489	11.49	12179	1009	0.58
Levees	97500	50yr	82000	789.88	803.20	800.45	804.63	0.003815	9.61	8536	991	0.58
Levees	97060	100yr	140000	788.01	805.76	800.76	807.49	0.002548	10.54	13280	987	0.51
Levees	97060	50yr	82000	788.01	802.08	798.15	803.20	0.002475	8.48	9667	977	0.48
Levees	96968 BR U	100yr	140000	788.01	805.16	801.13	807.29	0.005012	11.71	11955	927	0.57
Levees	96968 BR U	50yr	82000	788.01	801.69	798.40	803.06	0.004181	9.37	8755	917	0.53
Levees	96968 BR D	100yr	140000	787.45	803.80	800.58	806.16	0.005381	12.32	11366	952	0.63
Levees	96968 BR D	50yr	82000	787.45	800.51	797.89	802.04	0.004944	9.95	8244	940	0.59
Levees	96875	100yr	140000	787.45	803.57		805.91	0.004144	12.27	11414	974	0.63
Levees	96875	50yr	82000	787.45	800.24		801.80	0.004216	10.01	8191	962	0.60
Levees	96500	100yr	140000	785.73	802.02	798.84	804.36	0.004089	12.27	11407	965	0.63
Levees	96500	50yr	82000	785.73	798.68	796.15	800.23	0.004118	9.99	8204	951	0.60
Levees	96000	100yr	140000	784.59	800.08	796.69	802.35	0.003890	12.09	11576	965	0.62
Levees	96000	50yr	82000	784.59	796.74	794.02	798.23	0.003846	9.79	8373	951	0.58
Levees	95500	100yr	140000	783.09	798.04	794.80	800.36	0.004030	12.22	11458	965	0.63
Levees	95500	50yr	82000	783.09	794.75	792.14	796.27	0.003967	9.88	8304	953	0.59
Levees	95000	100yr	140000	780.79	795.64	792.92	798.18	0.004664	12.77	10963	963	0.67
Levees	95000	50yr	82000	780.79	792.33	790.24	794.05	0.004904	10.52	7791	951	0.65
Levees	94500	100yr	140000	778.09	793.71	790.33	795.98	0.003881	12.08	11587	964	0.61
Levees	94500	50yr	82000	778.09	790.26	787.66	791.78	0.003986	9.89	8290	951	0.59
Levees	94000	100yr	140000	774.30	792.04	788.11	794.11	0.003368	11.56	12111	966	0.58
Levees	94000	50yr	82000	774.30	788.58	785.44	789.93	0.003292	9.33	8792	953	0.54
Levees	93500	100yr	140000	773.64	789.99	786.64	792.27	0.003938	12.12	11549	965	0.62
Levees	93500	50yr	82000	773.64	786.56	783.98	788.09	0.004043	9.93	8260	951	0.59

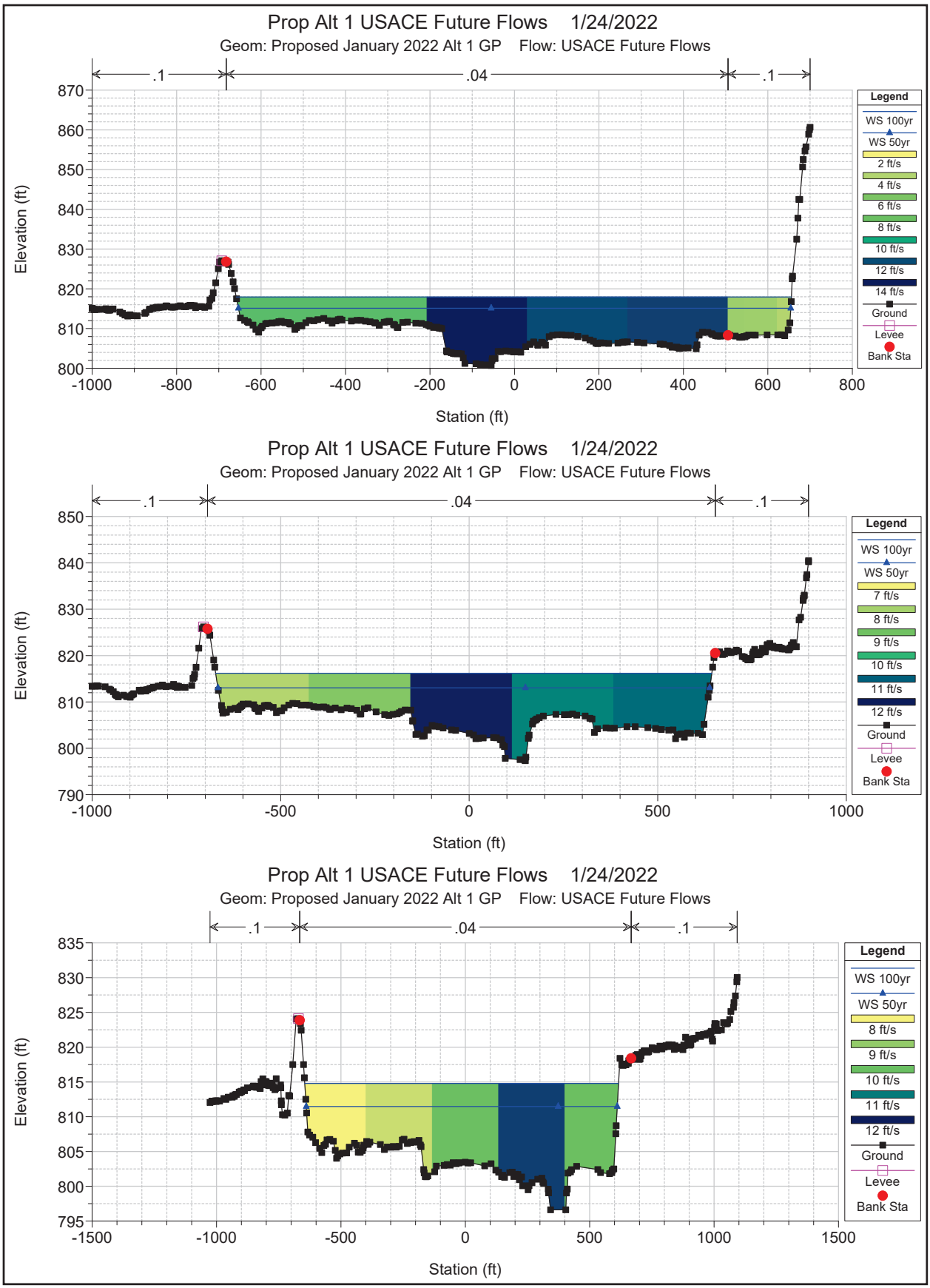
HEC-RAS Plan: TempJul2021BDHS River: Santa Ana River Reach: Levees (Continued)

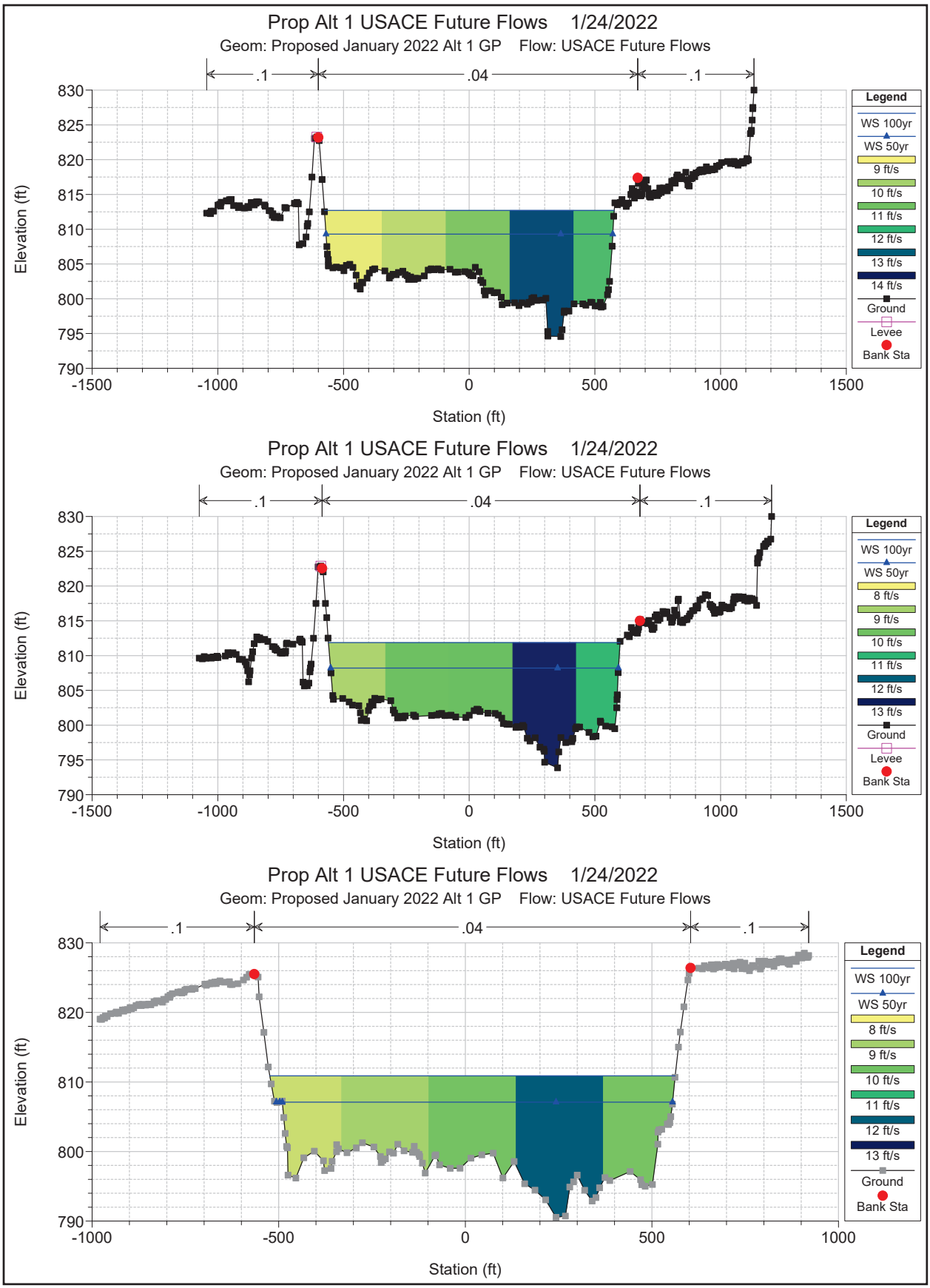
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Levees	93100	100yr	140000	769.93	788.67	784.75	790.75	0.003394	11.56	12111	967	0.58
Levees	93100	50yr	82000	769.93	785.23	782.05	786.58	0.003291	9.31	8808	952	0.54
Levees	93000	100yr	140000	770.34	788.13	784.69	790.37	0.003853	12.01	11652	966	0.61
Levees	93000	50yr	82000	770.34	784.72	782.02	786.21	0.003884	9.78	8381	953	0.58
Levees	92900	100yr	140000	769.97	787.67	784.39	789.97	0.004025	12.18	11491	967	0.62
Levees	92900	50yr	82000	769.97	784.25	781.73	785.80	0.004140	9.98	8214	953	0.60
Levees	92800	100yr	140000	770.12	787.19	784.08	789.56	0.004193	12.35	11338	967	0.64
Levees	92800	50yr	82000	770.12	783.75	781.41	785.37	0.004430	10.20	8039	953	0.62
Levees	92500	100yr	140000	769.46	785.96	782.75	788.30	0.004100	12.26	11415	966	0.63
Levees	92500	50yr	82000	769.46	782.38	780.08	784.02	0.004543	10.28	7975	951	0.63
Levees	92000	100yr	140000	769.06	784.44	780.22	786.42	0.003110	11.28	12411	969	0.56
Levees	92000	50yr	82000	769.06	780.64	777.53	782.00	0.003332	9.37	8756	953	0.54
Levees	91900	100yr	140000	767.60	784.17	779.77	786.10	0.002994	11.14	12566	972	0.55
Levees	91900	50yr	82000	767.60	780.34	777.09	781.66	0.003172	9.23	8886	954	0.53
Levees	91800	100yr	140000	764.88	784.00	779.03	785.77	0.002587	10.66	13128	971	0.51
Levees	91800	50yr	82000	764.88	780.16	776.36	781.33	0.002618	8.70	9421	955	0.49
Levees	91700	100yr	140000	763.15	783.73	778.79	785.51	0.002619	10.70	13082	971	0.51
Levees	91700	50yr	82000	763.15	779.88	776.12	781.07	0.002662	8.75	9374	955	0.49
Levees	91600	100yr	140000	762.33	783.46	778.50	785.25	0.002620	10.71	13073	970	0.51
Levees	91600	50yr	82000	762.33	779.61	775.83	780.80	0.002676	8.76	9360	955	0.49
Levees	91230	100yr	140000	763.35	782.97	776.19	784.35	0.001729	9.42	14869	981	0.43
Levees	91230	50yr	82000	763.35	779.12	773.49	779.96	0.001522	7.37	11128	965	0.38
Levees	91185 BR U	100yr	140000	763.35	782.69	776.55	784.29	0.003191	10.15	13797	926	0.46
Levees	91185 BR U	50yr	82000	763.35	778.95	773.78	779.92	0.002505	7.89	10388	913	0.41
Levees	91185 BR D	100yr	140000	763.52	782.14	777.57	784.04	0.003866	11.08	12638	957	0.54
Levees	91185 BR D	50yr	82000	763.52	778.46	774.91	779.71	0.003562	8.97	9141	945	0.51
Levees	91140	100yr	140000	763.52	782.14		783.98	0.002783	10.87	12878	975	0.53
Levees	91140	50yr	82000	763.52	778.45		779.66	0.002774	8.82	9296	963	0.50
Levees	90500	100yr	140000	760.94	779.35	776.07	781.73	0.004320	12.39	11303	979	0.64
Levees	90500	50yr	82000	760.94	775.80	773.24	777.44	0.004259	10.25	7998	910	0.61
Levees	90000	100yr	140000	759.03	777.15	773.96	779.50	0.004549	12.30	11382	1036	0.65
Levees	90000	50yr	82000	759.03	773.60	771.24	775.26	0.004466	10.33	7940	927	0.62
Levees	89500	100yr	140000	758.06	774.80	771.70	777.23	0.004521	12.50	11197	993	0.66
Levees	89500	50yr	82000	758.06	771.34	768.94	773.03	0.004428	10.41	7874	905	0.62
Levees	89000	100yr	140000	756.10	772.60	769.42	775.01	0.004334	12.45	11248	974	0.65
Levees	89000	50yr	82000	756.10	769.32	766.63	770.90	0.003975	10.08	8137	908	0.59
Levees	88500	100yr	140000	754.12	770.67	767.24	772.93	0.003825	12.08	11693	1015	0.61
Levees	88500	50yr	82000	754.12	767.62	764.55	769.01	0.003396	9.44	8683	950	0.55
Levees	88000	100yr	140000	752.19	768.16	765.86	770.70	0.005189	12.93	11575	1168	0.70
Levees	88000	50yr	82000	752.19	765.50	763.37	767.04	0.004557	10.07	8606	1106	0.62
Levees	87500	100yr	140000	750.31	765.79	763.46	768.01	0.005147	12.34	13162	1456	0.69
Levees	87500	50yr	82000	750.31	763.18	761.31	764.64	0.004957	9.94	9119	1276	0.64
Levees	87000	100yr	140000	748.30	763.34	761.13	765.33	0.004910	11.94	15108	1867	0.67
Levees	87000	50yr	82000	748.30	760.67	758.99	762.04	0.005010	9.81	10104	1569	0.64
Levees	86500	100yr	140000	746.45	762.11	758.39	763.34	0.002577	9.24	18960	2312	0.49
Levees	86500	50yr	82000	746.45	759.39	756.36	760.18	0.002378	7.35	13160	1945	0.45

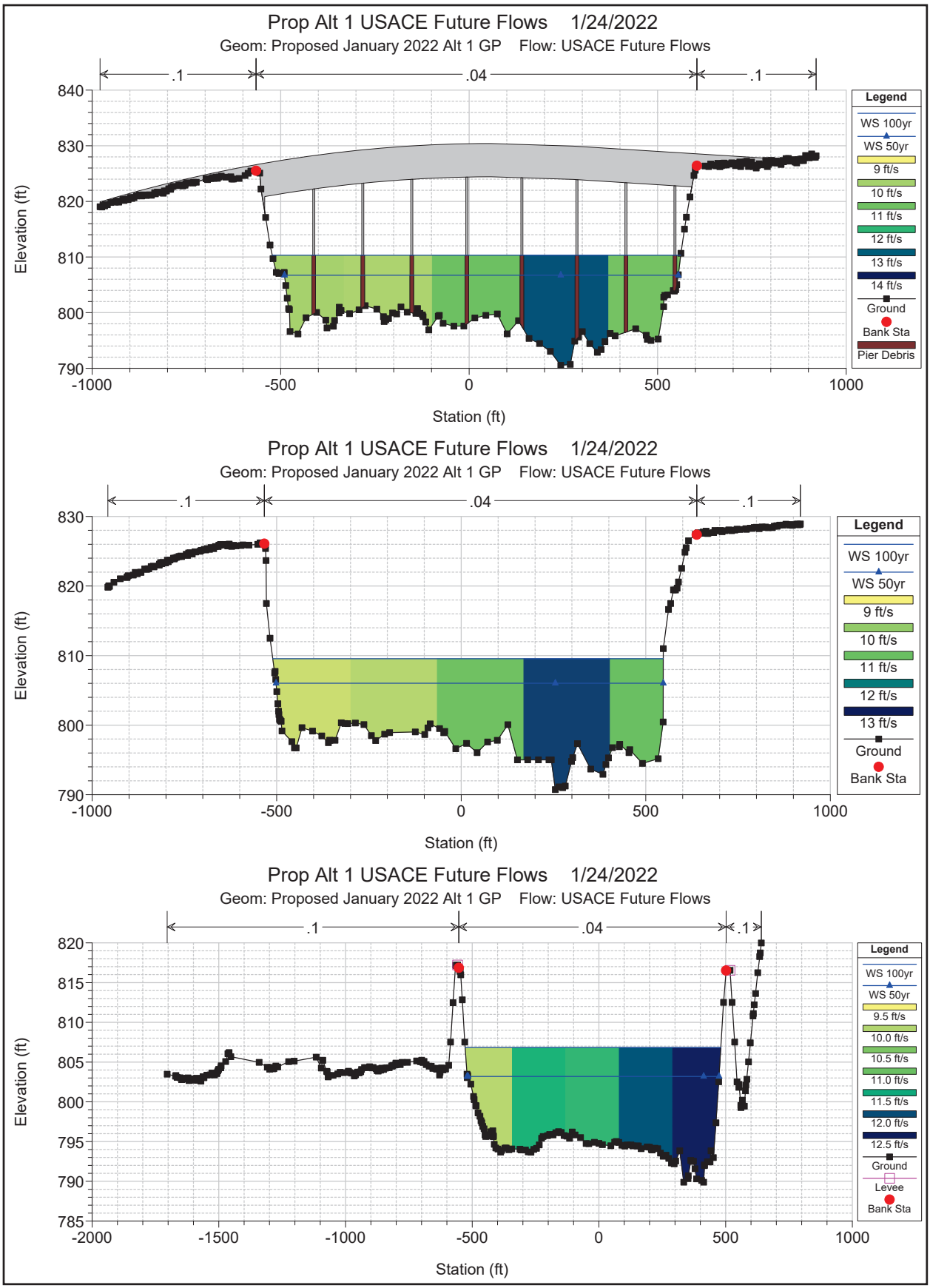
Proposed Conditions Hydraulic Analysis

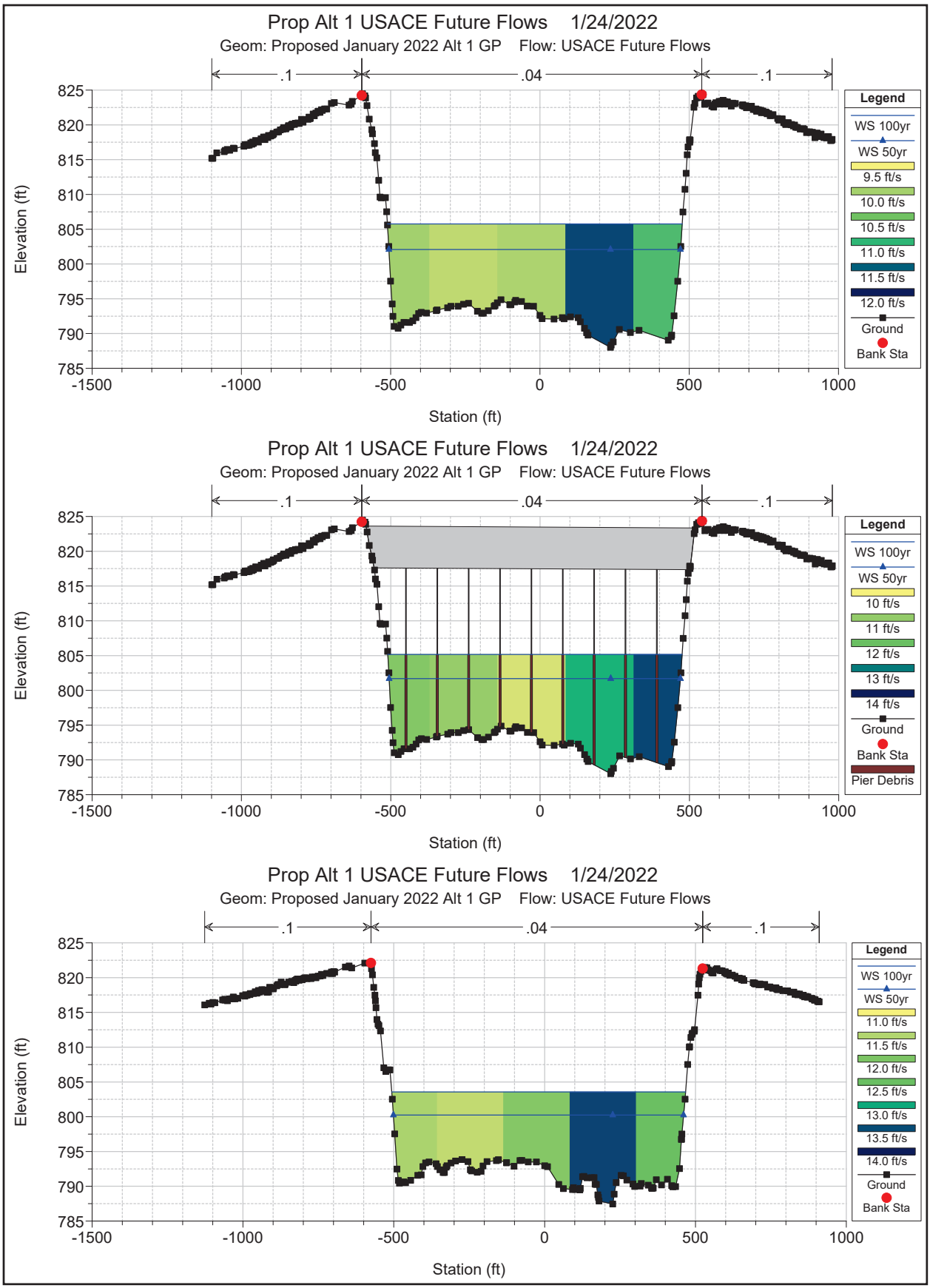

Prop Alt 1 USACE Future Flows 1/24/2022
Geom: Proposed January 2022 Alt 1 GP Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
16 ft/s
Ground
Levee
Bank Sta
Prop Alt 1 USACE Future Flows 1/24/2022
Geom: Proposed January 2022 Alt 1 GP Flow: USACE Future Flows
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Levee
Bank Sta
Prop Alt 1 USACE Future Flows 1/24/2022
Geom: Proposed January 2022 Alt 1 GP Flow: USACE Future Flows
Elevation (ft)
Station (ft)
Legend
WS 100yr
WS 50yr
0 ft/s
5 ft/s
10 ft/s
15 ft/s
20 ft/s
Ground
Levee
Bank Sta

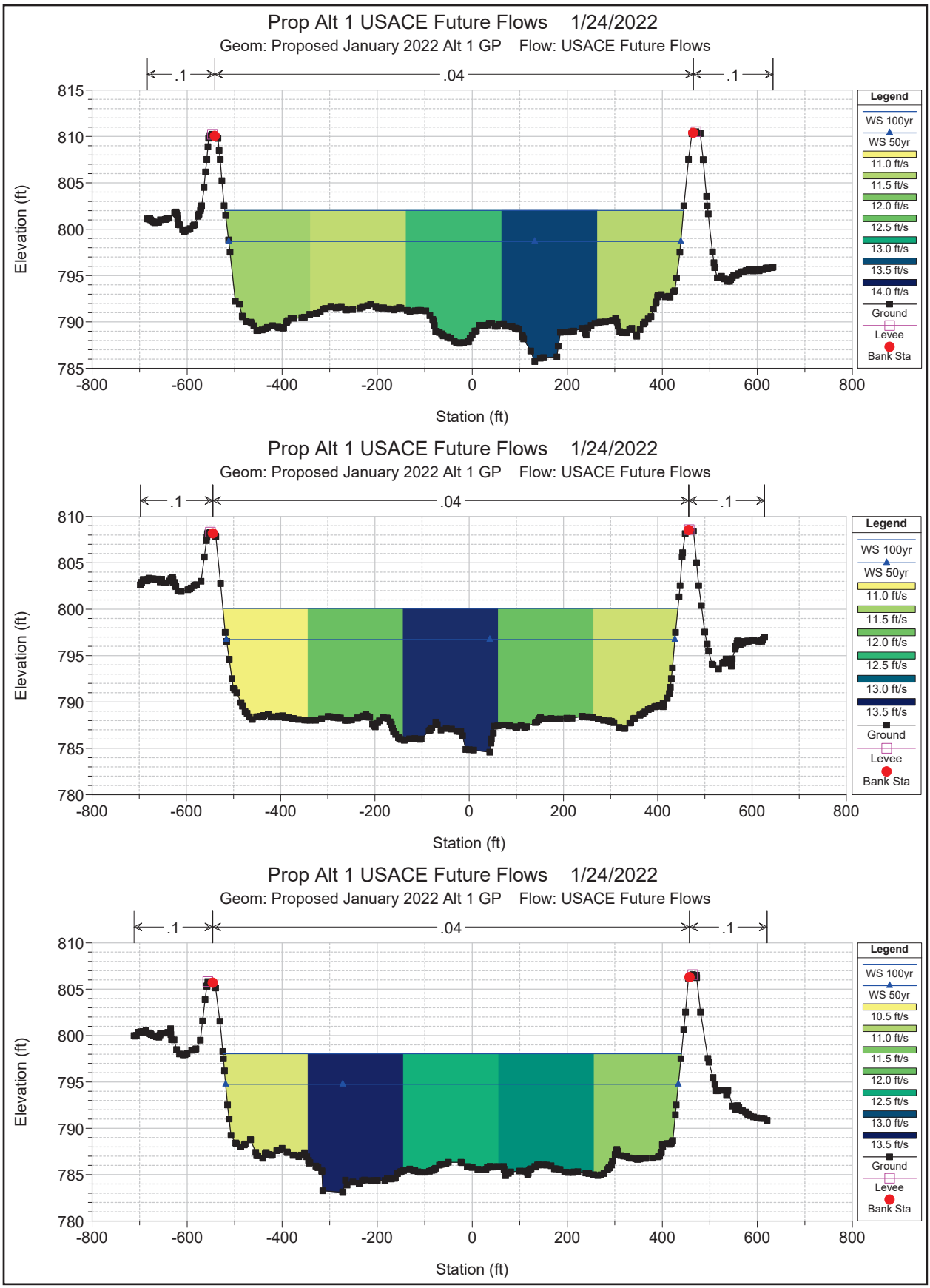


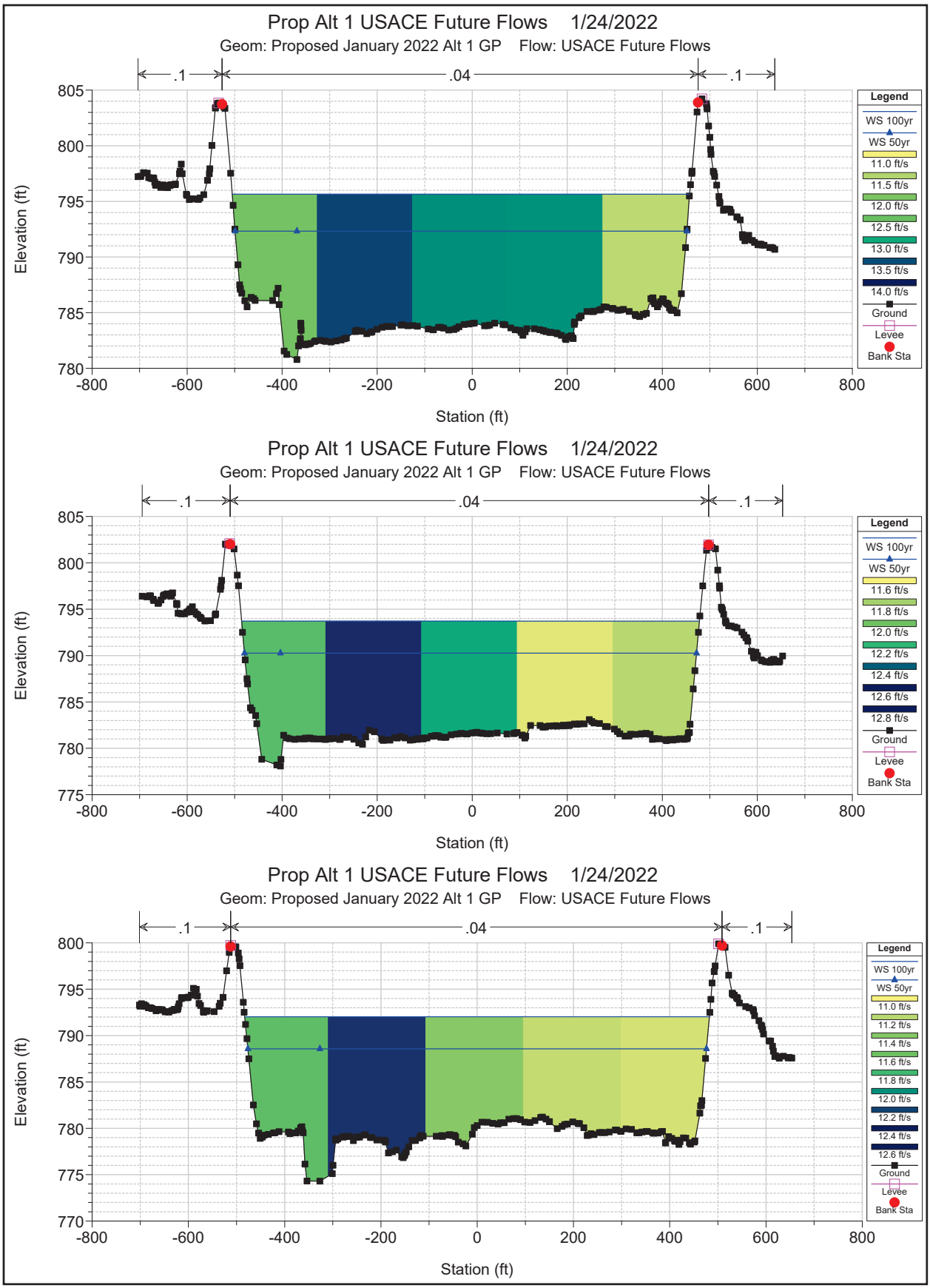


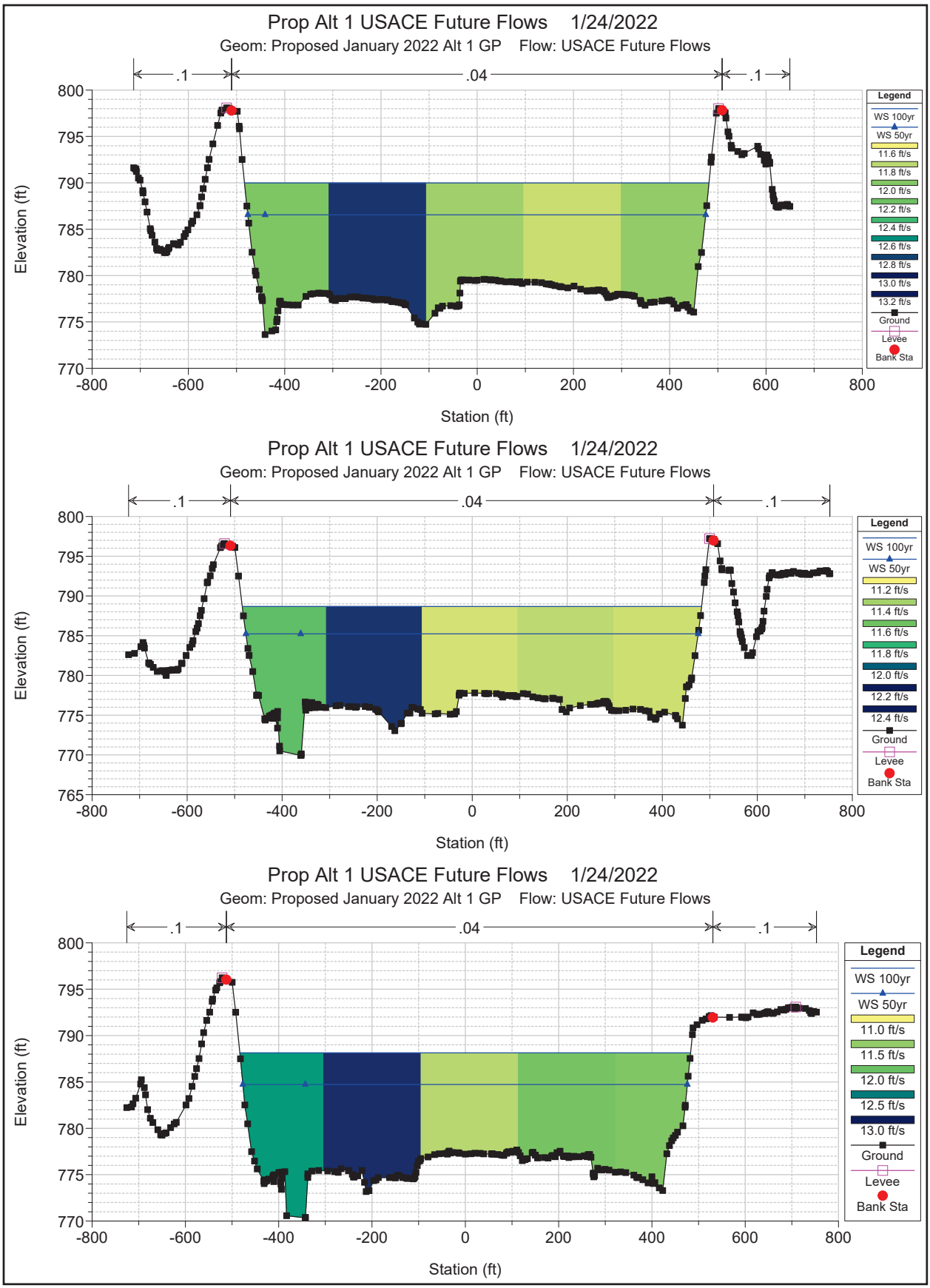


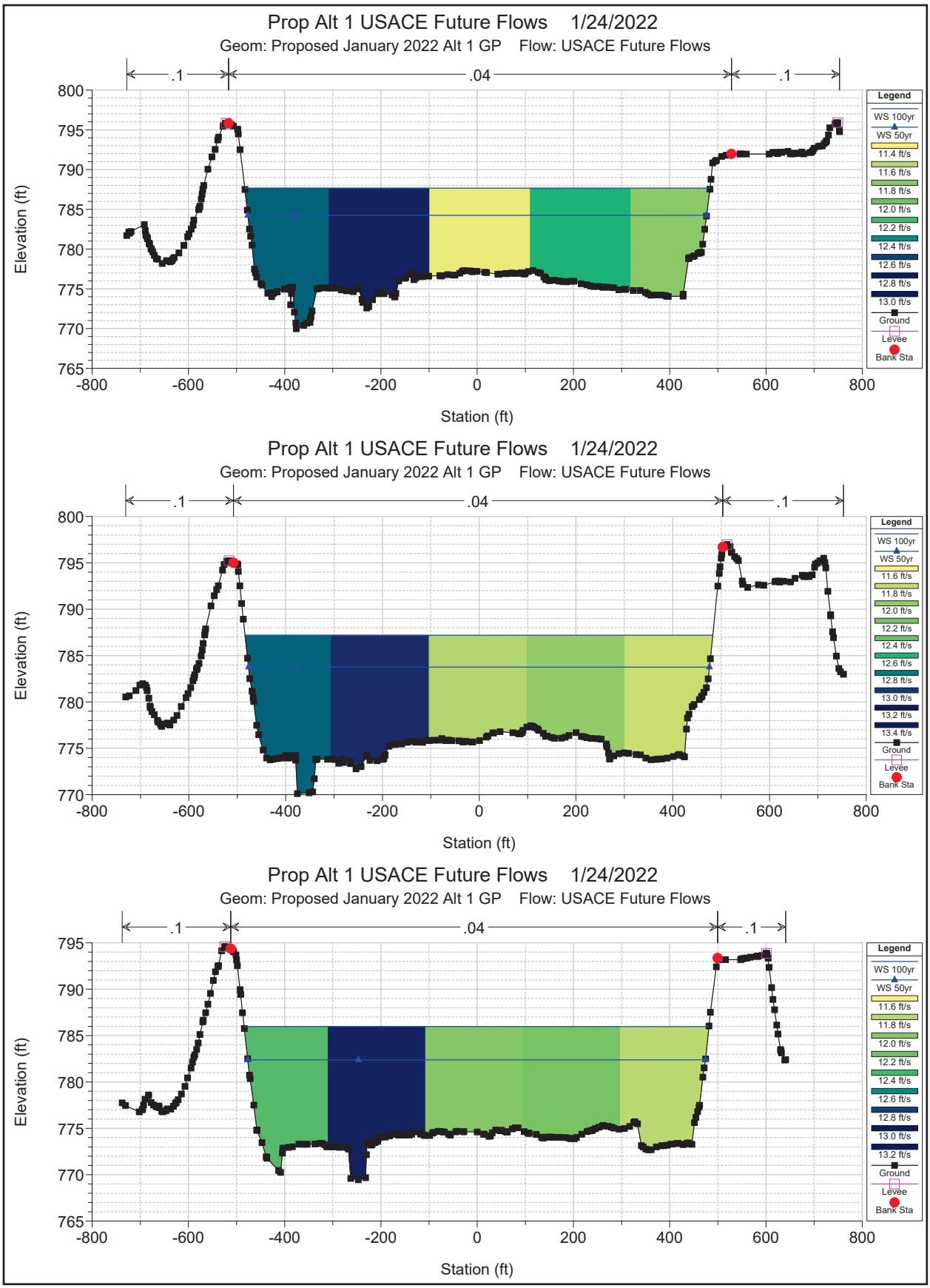


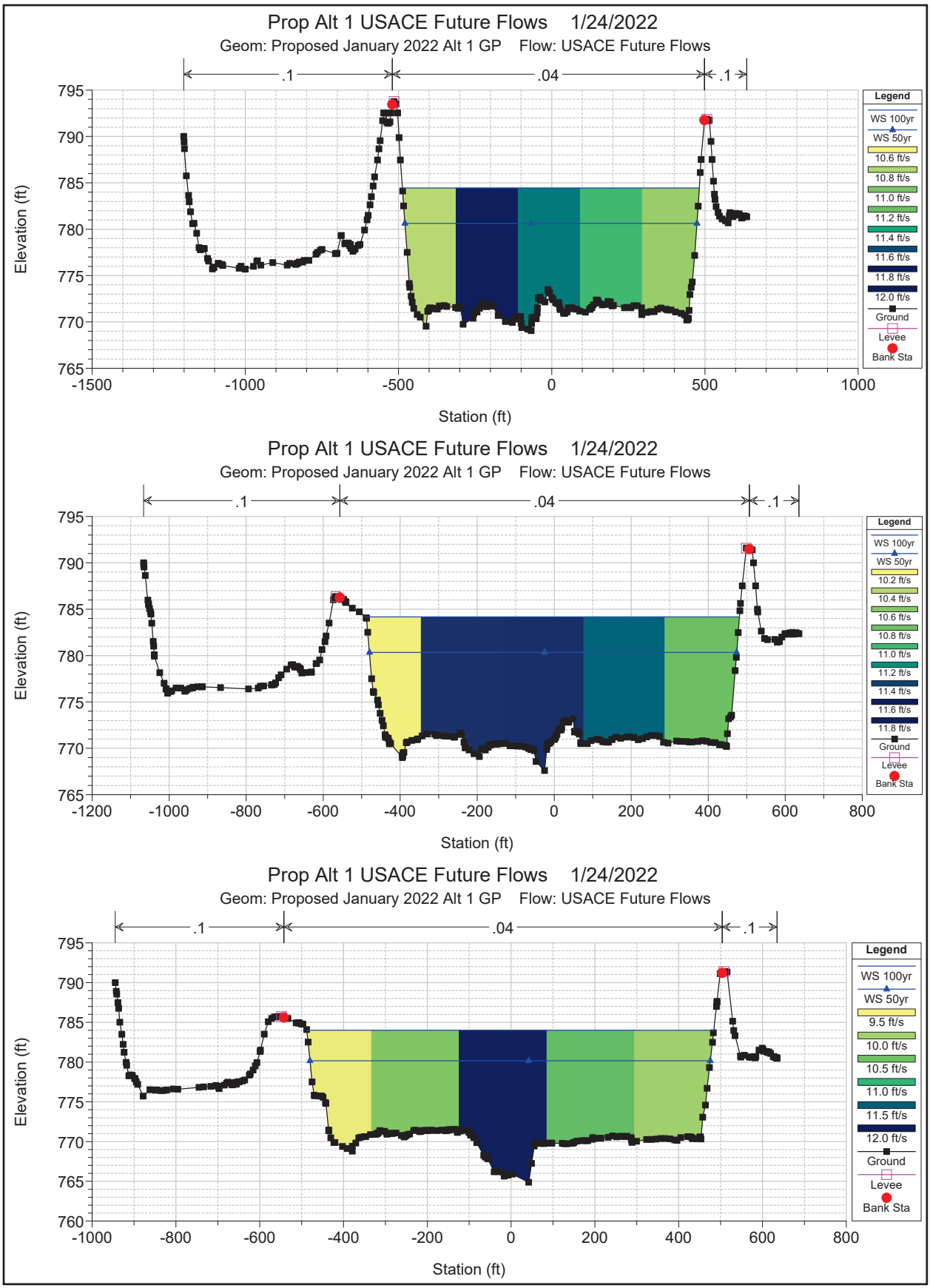


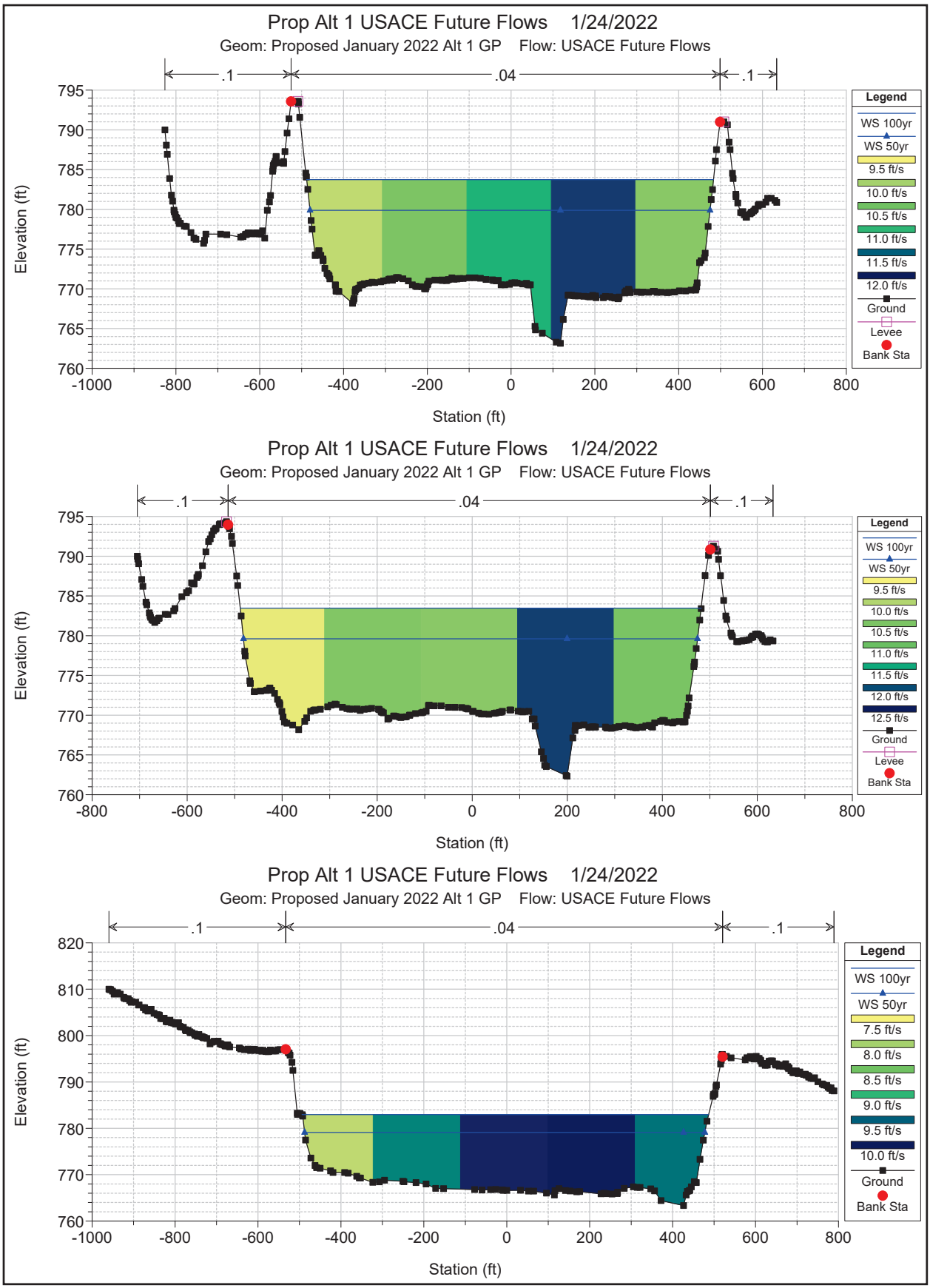


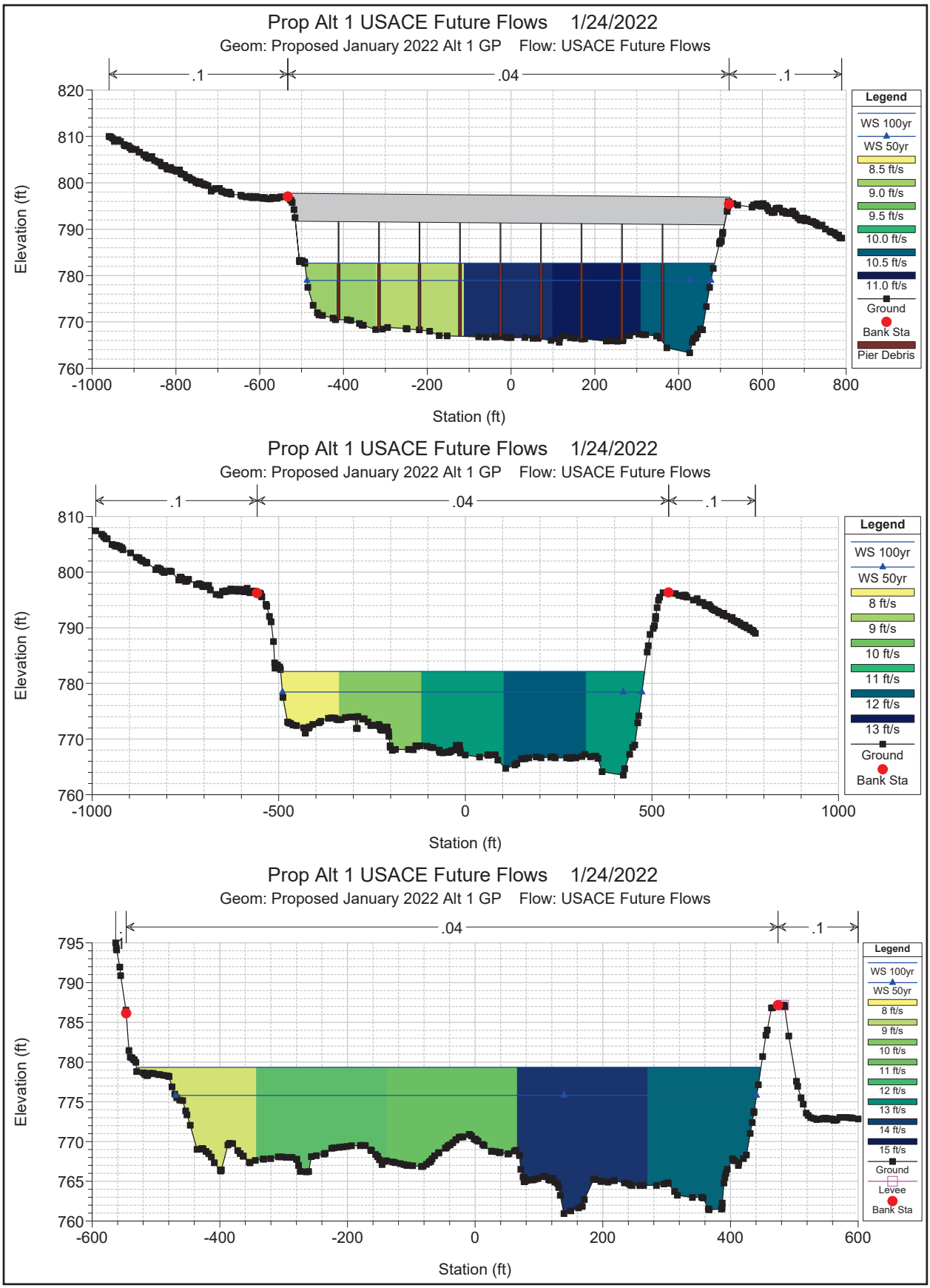


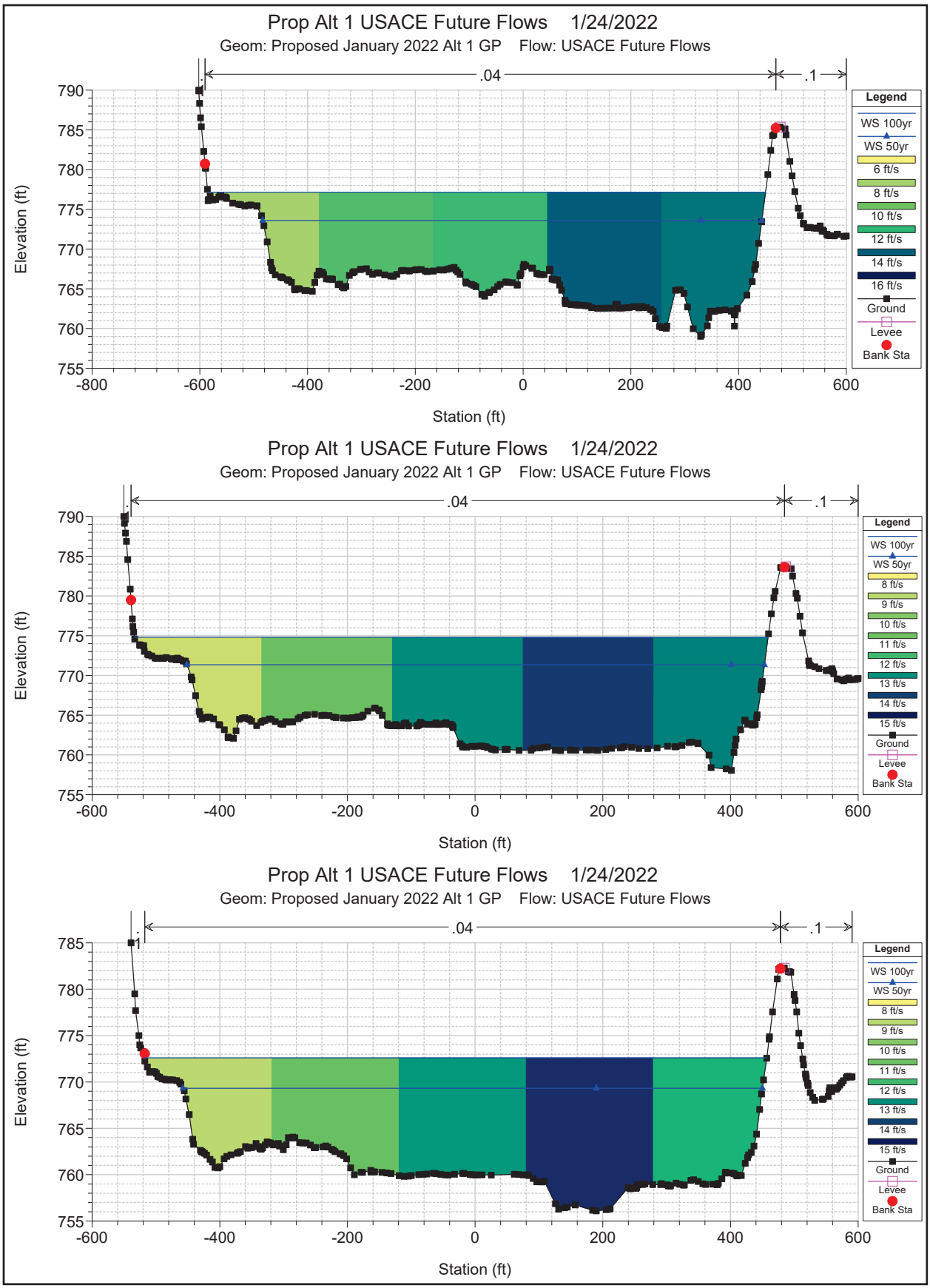


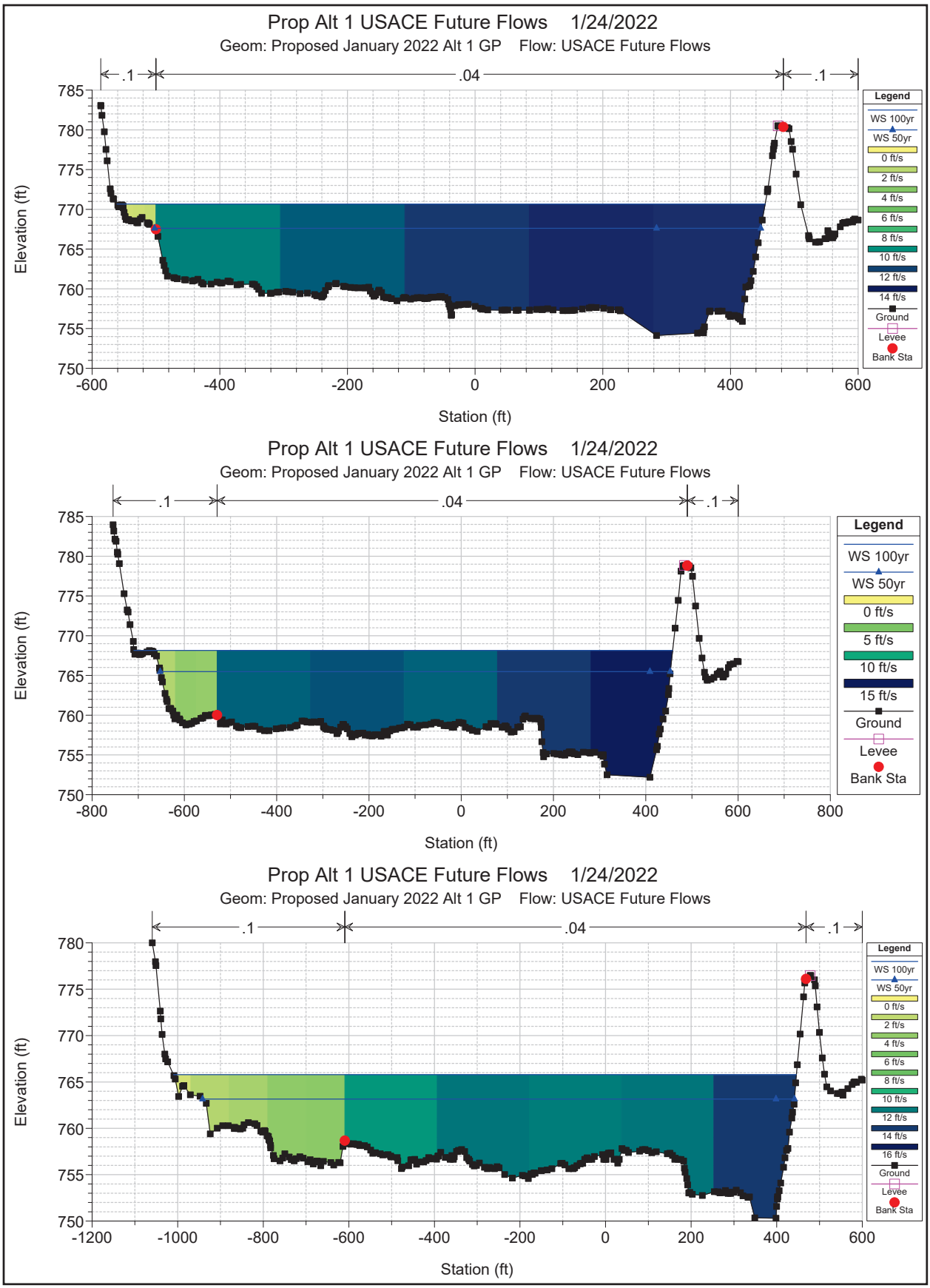


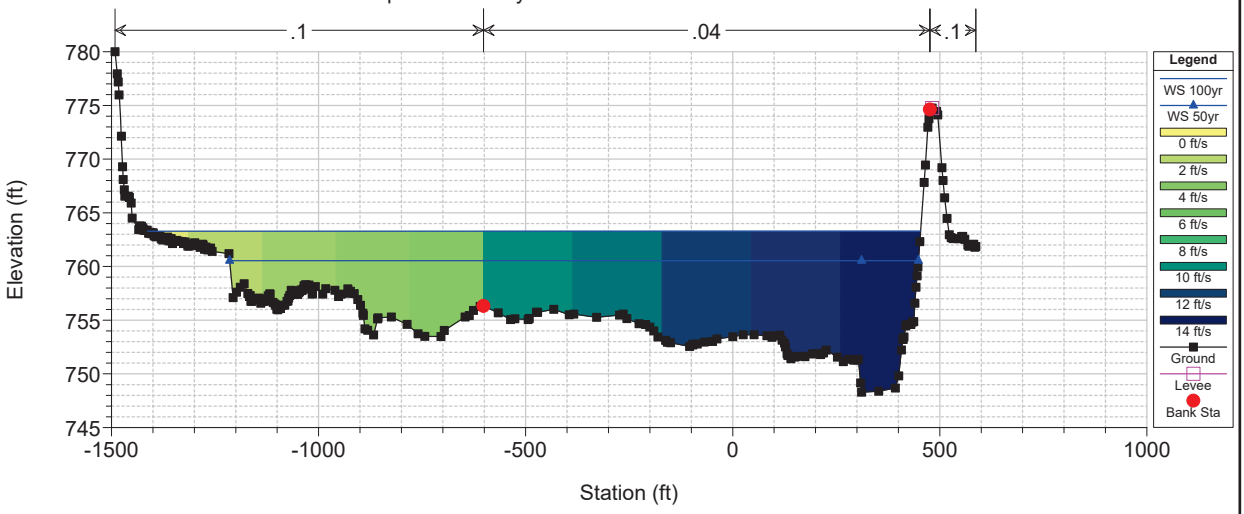


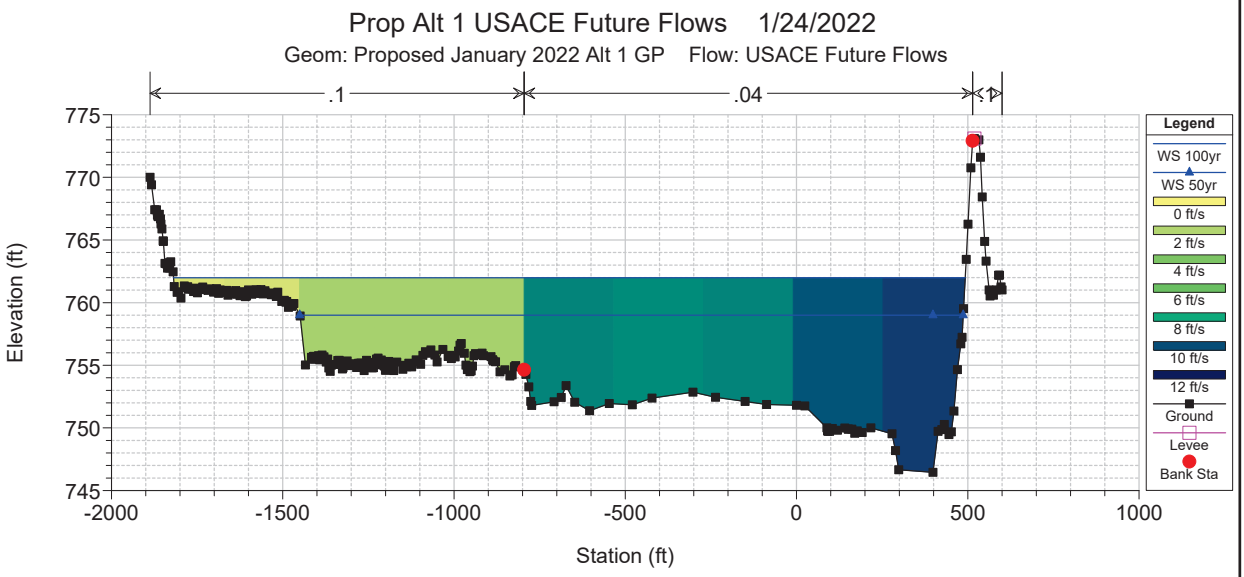


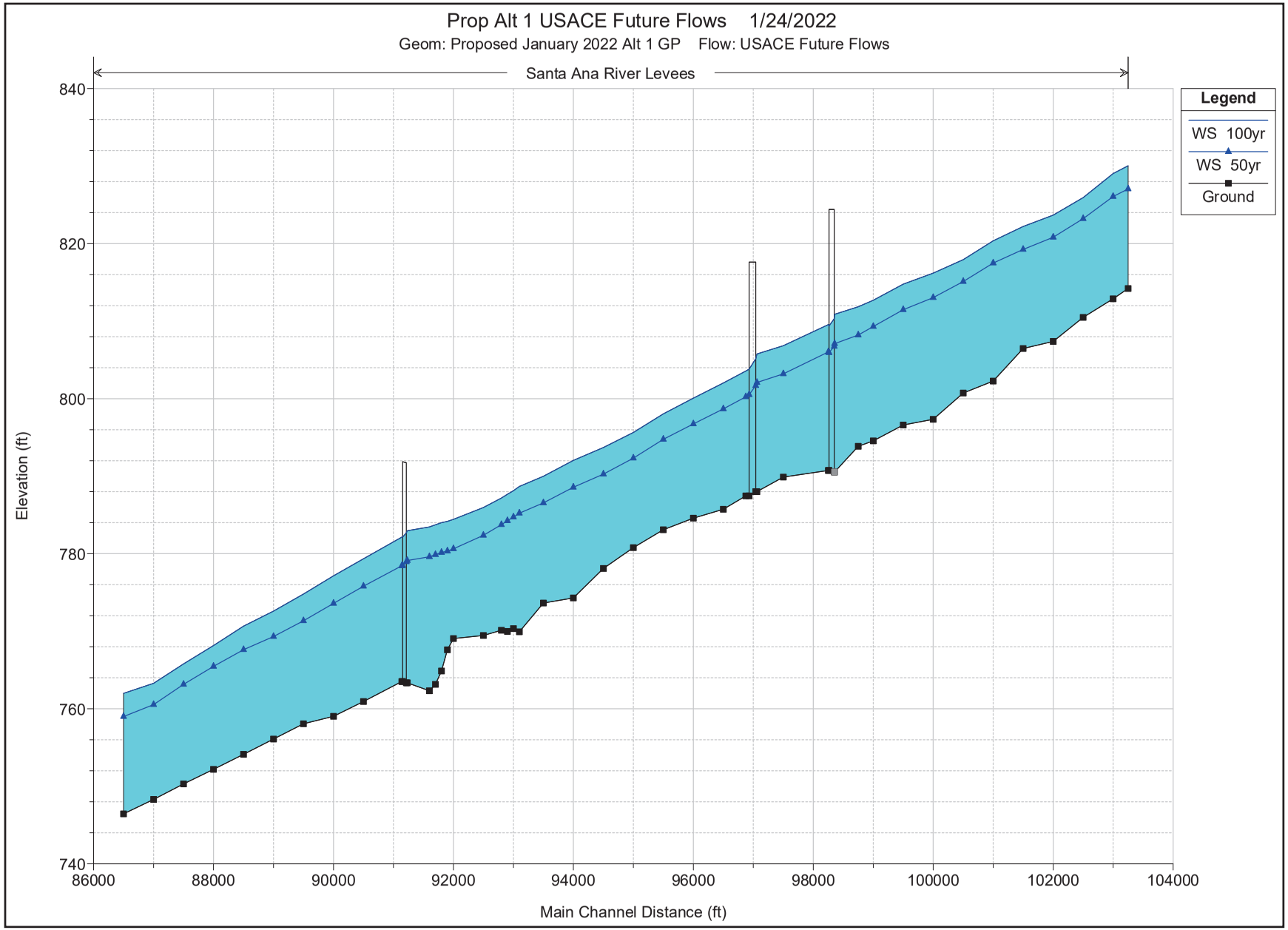

Prop Alt 1 USACE Future Flows 1/24/2022
Geom: Proposed January 2022 Alt 1 GP Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
820
810
800
790
780
770
760
-1000
-800
-600
-400
-200
0
200
400
600
800
Station (ft)
Legend
WS 100yr
WS 50yr
8.5 ft/s
9.0 ft/s
9.5 ft/s
10.0 ft/s
10.5 ft/s
11.0 ft/s
Ground
Bank Sta
Pier Debris
Prop Alt 1 USACE Future Flows 1/24/2022
Geom: Proposed January 2022 Alt 1 GP Flow: USACE Future Flows
.1
.04
.1
Elevation (ft)
810
800
790
780
770
760
-1000
-500
0
500
1000
Station (ft)
Legend
WS 100yr
WS 50yr
8 ft/s
9 ft/s
10 ft/s
11 ft/s
12 ft/s
13 ft/s
Ground
Bank Sta
Prop Alt 1 USACE Future Flows 1/24/2022
Geom: Proposed January 2022 Alt 1 GP Flow: USACE Future Flows
.04
.1
Elevation (ft)
795
790
785
780
775
770
765
760
-600
-400
-200
0
200
400
600
Station (ft)
Legend
WS 100yr
WS 50yr
8 ft/s
9 ft/s
10 ft/s
11 ft/s
12 ft/s
13 ft/s
14 ft/s
15 ft/s
Ground
Levee
Bank Sta










Prop Alt 1 USACE Future Flows 1/24/2022
Geom: Proposed January 2022 Alt 1 GP Flow: USACE Future Flows
Santa Ana River Levees
Legend
WS 100yr
WS 50yr
Ground
Elevation (ft)
840
820
800
780
760
740
86000
88000
90000
92000
94000
96000
98000
100000
102000
104000
Main Channel Distance (ft)

HEC-RAS Plan: PropAlt1FutureQs River: Santa Ana River Reach: Levees

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)	
Levees	103250	100yr	140000	814.21	830.04	827.31	832.32	0.004369	12.32	12387	1176	0.65
Levees	103250	50yr	82000	814.21	827.05	824.77	828.54	0.004208	9.90	8895	1156	0.60
Levees	103000	100yr	140000	812.88	829.03	826.19	831.23	0.004162	12.15	12898	1247	0.63
Levees	103000	50yr	82000	812.88	826.08	823.62	827.50	0.003912	9.71	9248	1221	0.58
Levees	102500	100yr	140000	810.49	825.94	824.28	828.64	0.006308	13.66	11823	1252	0.76
Levees	102500	50yr	82000	810.49	823.22	821.77	825.02	0.006278	11.10	8435	1231	0.72
Levees	102000	100yr	140000	807.38	823.68	821.11	825.80	0.004570	11.88	12739	1281	0.65
Levees	102000	50yr	82000	807.38	820.82	818.82	822.23	0.004611	9.66	9102	1257	0.62
Levees	101500	100yr	140000	806.47	822.21	818.56	823.77	0.003087	10.21	14945	1423	0.54
Levees	101500	50yr	82000	806.47	819.24	816.35	820.27	0.003018	8.24	10739	1411	0.51
Levees	101000	100yr	140000	802.27	820.36	817.19	822.09	0.003609	10.78	14238	1392	0.58
Levees	101000	50yr	82000	802.27	817.49	814.98	818.63	0.003538	8.70	10264	1382	0.55
Levees	100500	100yr	140000	800.72	817.93	815.48	819.99	0.004799	11.73	12805	1315	0.66
Levees	100500	50yr	82000	800.72	815.10	813.28	816.50	0.005090	9.66	9096	1308	0.64
Levees	100000	100yr	140000	797.33	816.19	812.89	817.84	0.003466	10.31	13580	1316	0.57
Levees	100000	50yr	82000	797.33	813.03	810.75	814.20	0.003942	8.69	9442	1304	0.57
Levees	99500	100yr	140000	796.61	814.78	810.63	816.26	0.002724	9.76	14348	1261	0.51
Levees	99500	50yr	82000	796.61	811.47	808.42	812.48	0.002878	8.04	10197	1250	0.50
Levees	99000	100yr	140000	794.56	812.70	809.45	814.63	0.003750	11.13	12575	1153	0.59
Levees	99000	50yr	82000	794.56	809.30	807.12	810.69	0.004360	9.45	8678	1141	0.60
Levees	98750	100yr	140000	793.86	811.86	808.39	813.70	0.003484	10.87	12885	1160	0.57
Levees	98750	50yr	82000	793.86	808.21	806.03	809.59	0.004389	9.46	8672	1145	0.61
Levees	98355.0*	100yr	140000	790.54	810.87	805.92	812.46	0.002520	10.10	13862	1086	0.50
Levees	98355.0*	50yr	82000	790.54	807.09	803.33	808.18	0.002644	8.37	9792	1054	0.48
Levees	98288 BR U	100yr	140000	790.54	810.33	806.27	812.31	0.004666	11.27	12418	1007	0.57
Levees	98288 BR U	50yr	82000	790.54	806.74	803.62	808.08	0.004332	9.28	8841	968	0.54
Levees	98288 BR D	100yr	140000	790.88	809.36	805.68	811.40	0.004467	11.46	12218	1014	0.58
Levees	98288 BR D	50yr	82000	790.88	805.93	803.13	807.29	0.004317	9.37	8754	1005	0.56
Levees	98250	100yr	140000	790.74	809.55		811.36	0.003047	10.79	12972	1058	0.54
Levees	98250	50yr	82000	790.74	806.03		807.25	0.003151	8.85	9270	1049	0.52
Levees	97500	100yr	140000	789.88	806.84	803.12	808.89	0.003489	11.49	12179	1009	0.58
Levees	97500	50yr	82000	789.88	803.20	800.45	804.63	0.003815	9.61	8536	991	0.58
Levees	97060	100yr	140000	788.01	805.76	800.76	807.49	0.002548	10.54	13280	987	0.51
Levees	97060	50yr	82000	788.01	802.08	798.15	803.20	0.002475	8.48	9667	977	0.48
Levees	96968 BR U	100yr	140000	788.01	805.16	801.13	807.29	0.005012	11.71	11955	927	0.57
Levees	96968 BR U	50yr	82000	788.01	801.69	798.40	803.06	0.004181	9.37	8755	917	0.53
Levees	96968 BR D	100yr	140000	787.45	803.80	800.58	806.16	0.005381	12.32	11366	952	0.63
Levees	96968 BR D	50yr	82000	787.45	800.51	797.89	802.04	0.004944	9.95	8244	940	0.59
Levees	96875	100yr	140000	787.45	803.57		805.91	0.004144	12.27	11414	974	0.63
Levees	96875	50yr	82000	787.45	800.24		801.80	0.004216	10.01	8191	962	0.60
Levees	96500	100yr	140000	785.73	802.02	798.84	804.36	0.004089	12.27	11407	965	0.63
Levees	96500	50yr	82000	785.73	798.68	796.15	800.23	0.004118	9.99	8204	951	0.60
Levees	96000	100yr	140000	784.59	800.08	796.69	802.35	0.003890	12.09	11576	965	0.62
Levees	96000	50yr	82000	784.59	796.74	794.02	798.23	0.003846	9.79	8373	951	0.58
Levees	95500	100yr	140000	783.09	798.04	794.80	800.36	0.004030	12.22	11458	965	0.63
Levees	95500	50yr	82000	783.09	794.75	792.14	796.27	0.003967	9.88	8304	953	0.59
Levees	95000	100yr	140000	780.79	795.64	792.92	798.18	0.004664	12.77	10963	963	0.67
Levees	95000	50yr	82000	780.79	792.33	790.24	794.05	0.004904	10.52	7791	951	0.65
Levees	94500	100yr	140000	778.09	793.71	790.33	795.98	0.003881	12.08	11587	964	0.61
Levees	94500	50yr	82000	778.09	790.26	787.66	791.78	0.003986	9.89	8290	951	0.59
Levees	94000	100yr	140000	774.30	792.04	788.11	794.11	0.003368	11.56	12111	966	0.58
Levees	94000	50yr	82000	774.30	788.58	785.44	789.93	0.003292	9.33	8792	953	0.54
Levees	93500	100yr	140000	773.64	789.99	786.64	792.27	0.003938	12.12	11549	965	0.62
Levees	93500	50yr	82000	773.64	786.56	783.98	788.09	0.004043	9.93	8260	951	0.59

HEC-RAS Plan: PropAlt1FutureQs River: Santa Ana River Reach: Levees (Continued)

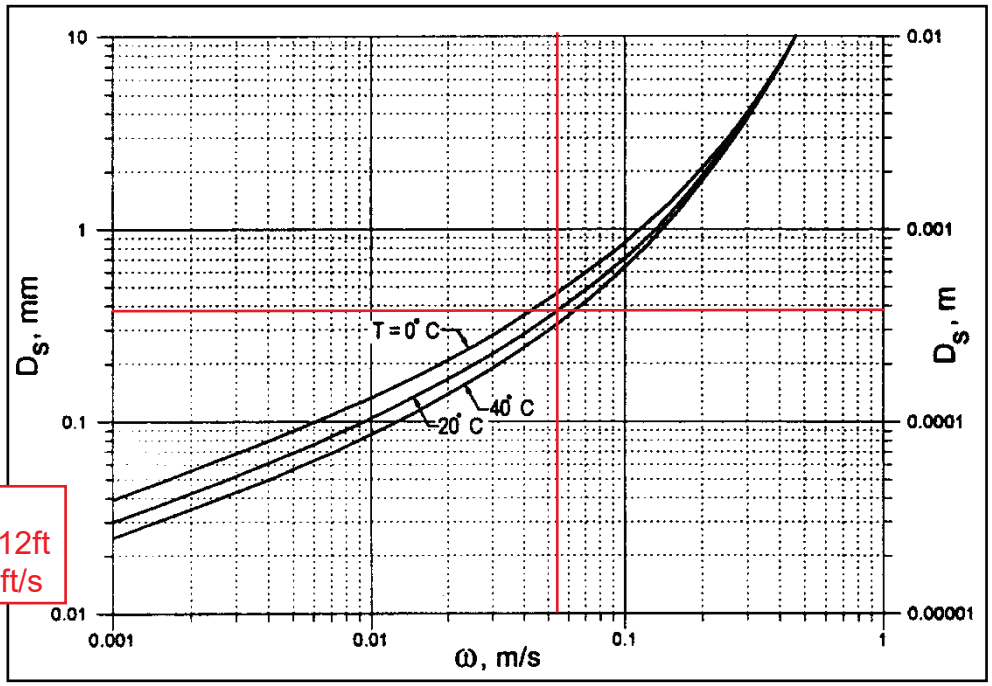
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Levees	93100	100yr	140000	769.93	788.67	784.75	790.75	0.003394	11.56	12111	967	0.58
Levees	93100	50yr	82000	769.93	785.23	782.05	786.58	0.003291	9.31	8808	952	0.54
Levees	93000	100yr	140000	770.34	788.13	784.69	790.37	0.003853	12.01	11652	966	0.61
Levees	93000	50yr	82000	770.34	784.72	782.02	786.21	0.003884	9.78	8381	953	0.58
Levees	92900	100yr	140000	769.97	787.67	784.39	789.97	0.004025	12.18	11491	967	0.62
Levees	92900	50yr	82000	769.97	784.25	781.73	785.80	0.004140	9.98	8214	953	0.60
Levees	92800	100yr	140000	770.12	787.19	784.08	789.56	0.004193	12.35	11338	967	0.64
Levees	92800	50yr	82000	770.12	783.75	781.41	785.37	0.004430	10.20	8039	953	0.62
Levees	92500	100yr	140000	769.46	785.96	782.75	788.30	0.004100	12.26	11415	966	0.63
Levees	92500	50yr	82000	769.46	782.38	780.08	784.02	0.004543	10.28	7975	951	0.63
Levees	92000	100yr	140000	769.06	784.44	780.22	786.42	0.003110	11.28	12411	969	0.56
Levees	92000	50yr	82000	769.06	780.64	777.53	782.00	0.003332	9.37	8756	953	0.54
Levees	91900	100yr	140000	767.60	784.17	779.77	786.10	0.002994	11.14	12566	972	0.55
Levees	91900	50yr	82000	767.60	780.34	777.09	781.66	0.003172	9.23	8886	954	0.53
Levees	91800	100yr	140000	764.88	784.00	779.03	785.77	0.002587	10.66	13128	971	0.51
Levees	91800	50yr	82000	764.88	780.16	776.36	781.33	0.002618	8.70	9421	955	0.49
Levees	91700	100yr	140000	763.15	783.73	778.79	785.51	0.002619	10.70	13082	971	0.51
Levees	91700	50yr	82000	763.15	779.88	776.12	781.07	0.002662	8.75	9374	955	0.49
Levees	91600	100yr	140000	762.33	783.46	778.50	785.25	0.002620	10.71	13073	970	0.51
Levees	91600	50yr	82000	762.33	779.61	775.83	780.80	0.002676	8.76	9360	955	0.49
Levees	91230	100yr	140000	763.35	782.97	776.18	784.35	0.001729	9.42	14869	981	0.43
Levees	91230	50yr	82000	763.35	779.12	773.49	779.96	0.001522	7.37	11128	965	0.38
Levees	91185 BR U	100yr	140000	763.35	782.69	776.55	784.29	0.003191	10.15	13797	926	0.46
Levees	91185 BR U	50yr	82000	763.35	778.95	773.78	779.92	0.002505	7.89	10388	913	0.41
Levees	91185 BR D	100yr	140000	763.52	782.14	777.57	784.04	0.003866	11.08	12638	957	0.54
Levees	91185 BR D	50yr	82000	763.52	778.46	774.91	779.71	0.003562	8.97	9141	945	0.51
Levees	91140	100yr	140000	763.52	782.14		783.98	0.002783	10.87	12878	975	0.53
Levees	91140	50yr	82000	763.52	778.45		779.66	0.002774	8.82	9296	963	0.50
Levees	90500	100yr	140000	760.94	779.35	776.07	781.73	0.004320	12.39	11303	979	0.64
Levees	90500	50yr	82000	760.94	775.80	773.24	777.44	0.004259	10.25	7998	910	0.61
Levees	90000	100yr	140000	759.03	777.15	773.96	779.50	0.004549	12.30	11382	1036	0.65
Levees	90000	50yr	82000	759.03	773.60	771.24	775.26	0.004466	10.33	7940	927	0.62
Levees	89500	100yr	140000	758.06	774.80	771.70	777.23	0.004521	12.50	11197	993	0.66
Levees	89500	50yr	82000	758.06	771.34	768.94	773.03	0.004429	10.41	7873	905	0.62
Levees	89000	100yr	140000	756.10	772.60	769.42	775.01	0.004335	12.45	11247	974	0.65
Levees	89000	50yr	82000	756.10	769.32	766.63	770.90	0.003978	10.08	8135	908	0.59
Levees	88500	100yr	140000	754.12	770.67	767.24	772.93	0.003825	12.08	11692	1015	0.61
Levees	88500	50yr	82000	754.12	767.62	764.55	769.01	0.003403	9.45	8679	950	0.55
Levees	88000	100yr	140000	752.19	768.15	765.86	770.70	0.005192	12.94	11573	1168	0.70
Levees	88000	50yr	82000	752.19	765.48	763.37	767.03	0.004608	10.10	8576	1106	0.63
Levees	87500	100yr	140000	750.31	765.78	763.46	768.01	0.005165	12.36	13147	1456	0.69
Levees	87500	50yr	82000	750.31	763.15	761.37	764.60	0.004980	9.93	9371	1383	0.64
Levees	87000	100yr	140000	748.30	763.28	761.13	765.30	0.005019	12.02	14996	1866	0.68
Levees	87000	50yr	82000	748.30	760.54	759.03	761.94	0.005248	9.92	10198	1663	0.66
Levees	86500	100yr	140000	746.45	761.99	758.39	763.25	0.002686	9.36	18673	2311	0.50
Levees	86500	50yr	82000	746.45	759.00	756.36	759.88	0.002822	7.75	12403	1937	0.49

APPENDIX H

Contraction Scour Fall Velocity

correctly account for the increase in transport that will occur as the result of the bed planing out (which decreases resistance to flow, increases the velocity and the transport of bed material at the bridge). That is, Laursen's equation indicates a decrease in scour for this case, whereas in reality, there would be an increase in scour depth. In addition, at flood flows, a plane bedform will usually exist upstream and through the bridge waterway, and the values of Manning n will be equal. Consequently, the n value ratio is not recommended or presented in Equation 6.2.

4. W_1 and W_2 are not always easily defined. In some cases, it is acceptable to use the topwidth of the main channel to define these widths. Whether topwidth or bottom width is used, it is important to be consistent so that W_1 and W_2 refer to either bottom widths or top widths.



Avg
D50=0.38mm=0.0012ft
T=0.054 m/s=0.177ft/s

Figure 6.8. Fall velocity of sand-sized particles with specific gravity of 2.65 in metric units.

5. The average width of the bridge opening (W_2) is normally taken as the bottom width, with the width of the piers subtracted.

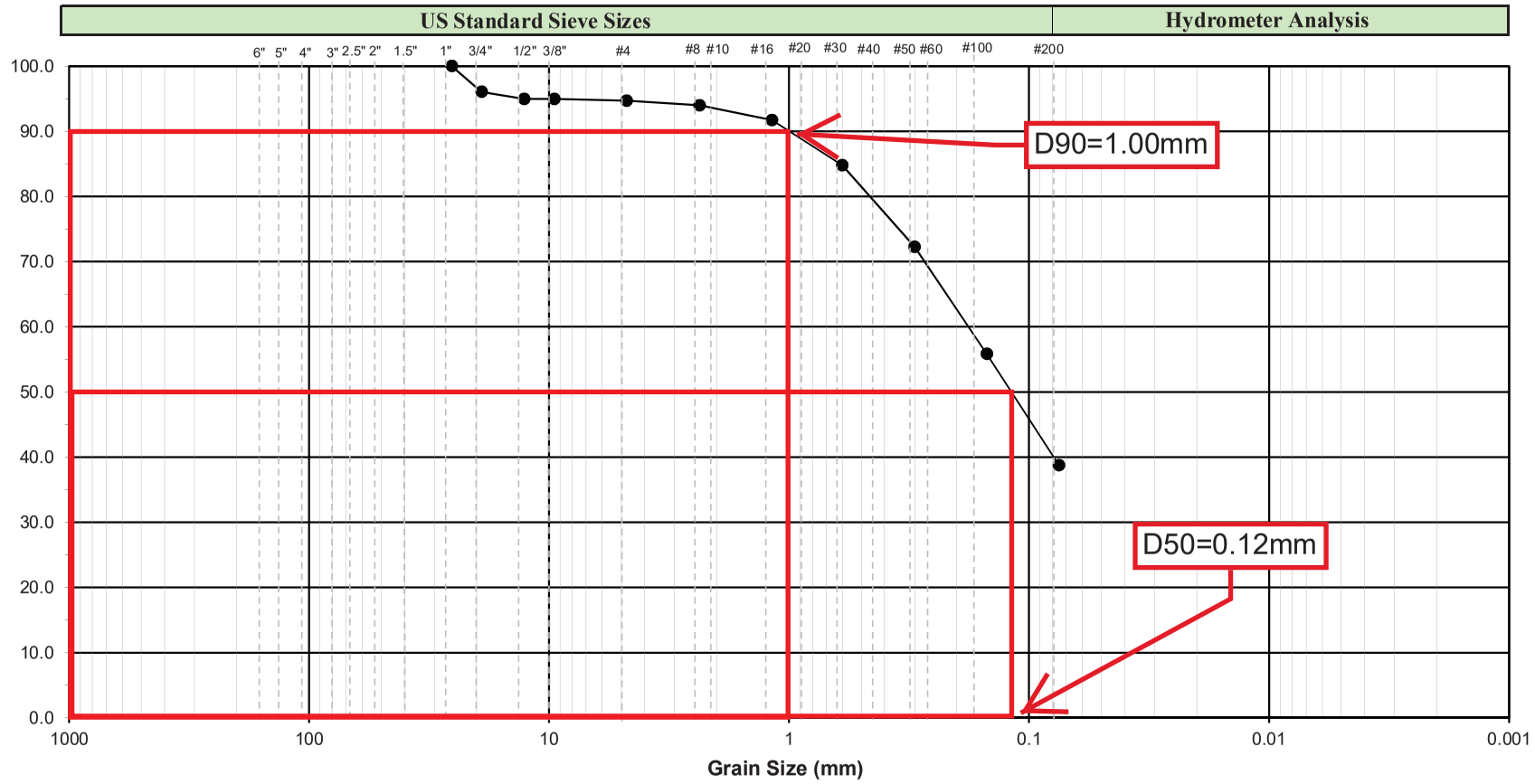
6. Laursen's equation will overestimate the depth of scour at the bridge if the bridge is located at the upstream end of a natural contraction or if the contraction is the result of the bridge abutments and piers. At this time, however, it is the best equation available.

7. In sand channel streams where the contraction scour hole is filled in on the falling stage, the y_0 depth may be approximated by y_1. Sketches or surveys through the bridge can help in determining the existing bed elevation.

8. **Scour depths with live-bed contraction scour may be limited by coarse sediments in the bed material armoring the bed. Where coarse sediments are present, it is recommended that scour depths be calculated for live-bed scour conditions using the clear-water scour equation (given in the next section) in addition to the live-bed equation, and that the smaller calculated scour depth be used.**

APPENDIX I

Grain Size Distribution Graphs



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)		Depth (m)		Soil Color	Soil Description	U.S.C.S.
●	Pier 2	S-1	0 to 1				Very dark brown	Silty sand	SM
Remark									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

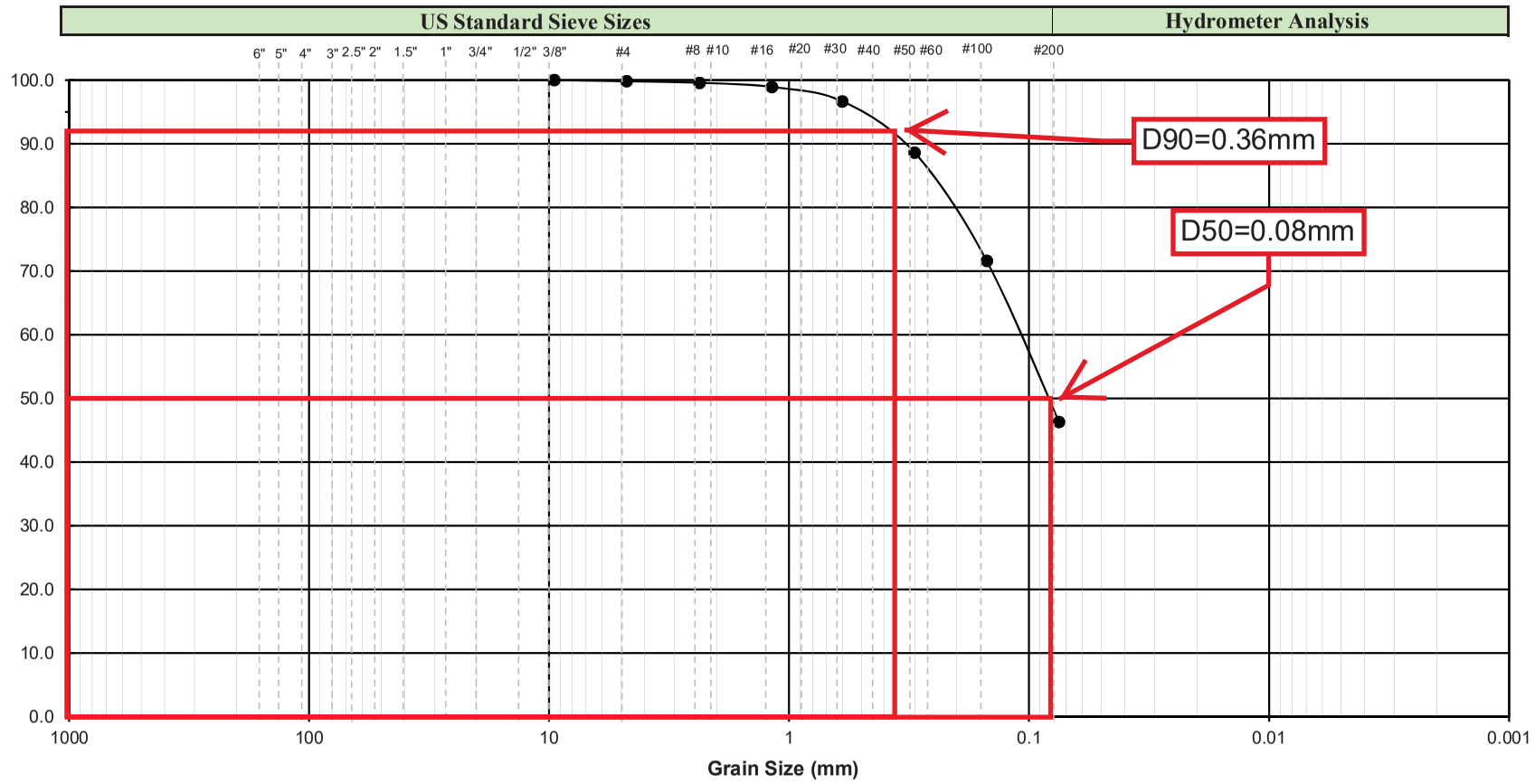
Dokken, Replacement of Market St Bridge at SAR, Riverside County

Project No. : 20-154

Date : 03/08/21

GRAIN SIZE ANALYSIS
(ASTM D-422)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)		Depth (m)		Soil Color	Soil Description	U.S.C.S.
●	Pier 3	S-1	0 to 1				Dark olive gray	Silty sand	SM
Remark									

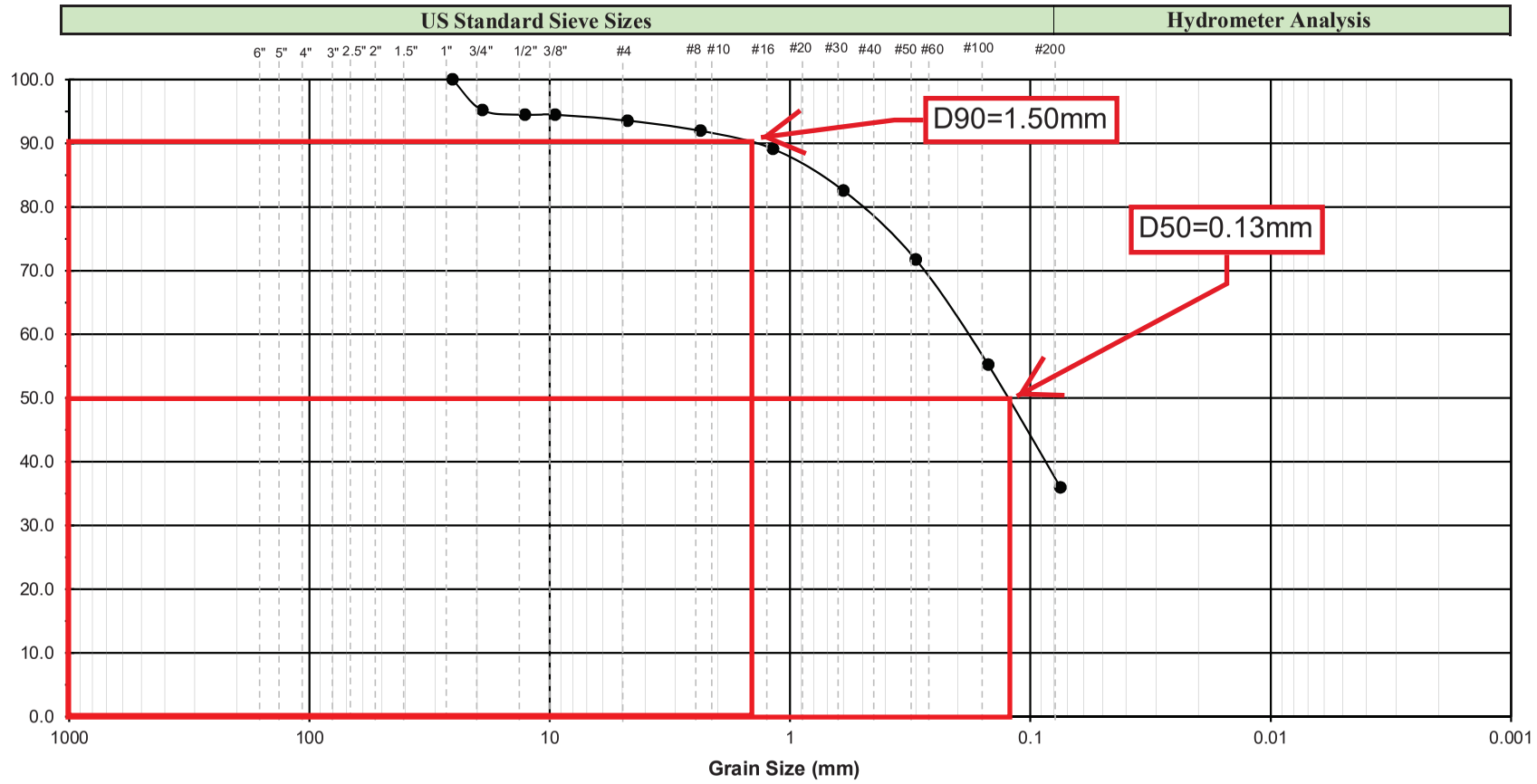
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Dokken, Replacement of Market St Bridge at SAR, Riverside County

Project No. : 20-154 Date : 03/08/21

GRAIN SIZE ANALYSIS
(ASTM D-422)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)		Depth (m)		Soil Color	Soil Description	U.S.C.S.
●	Pier 4	S-1	0 to 1				Light gray	Silty sand	SM
Remark									

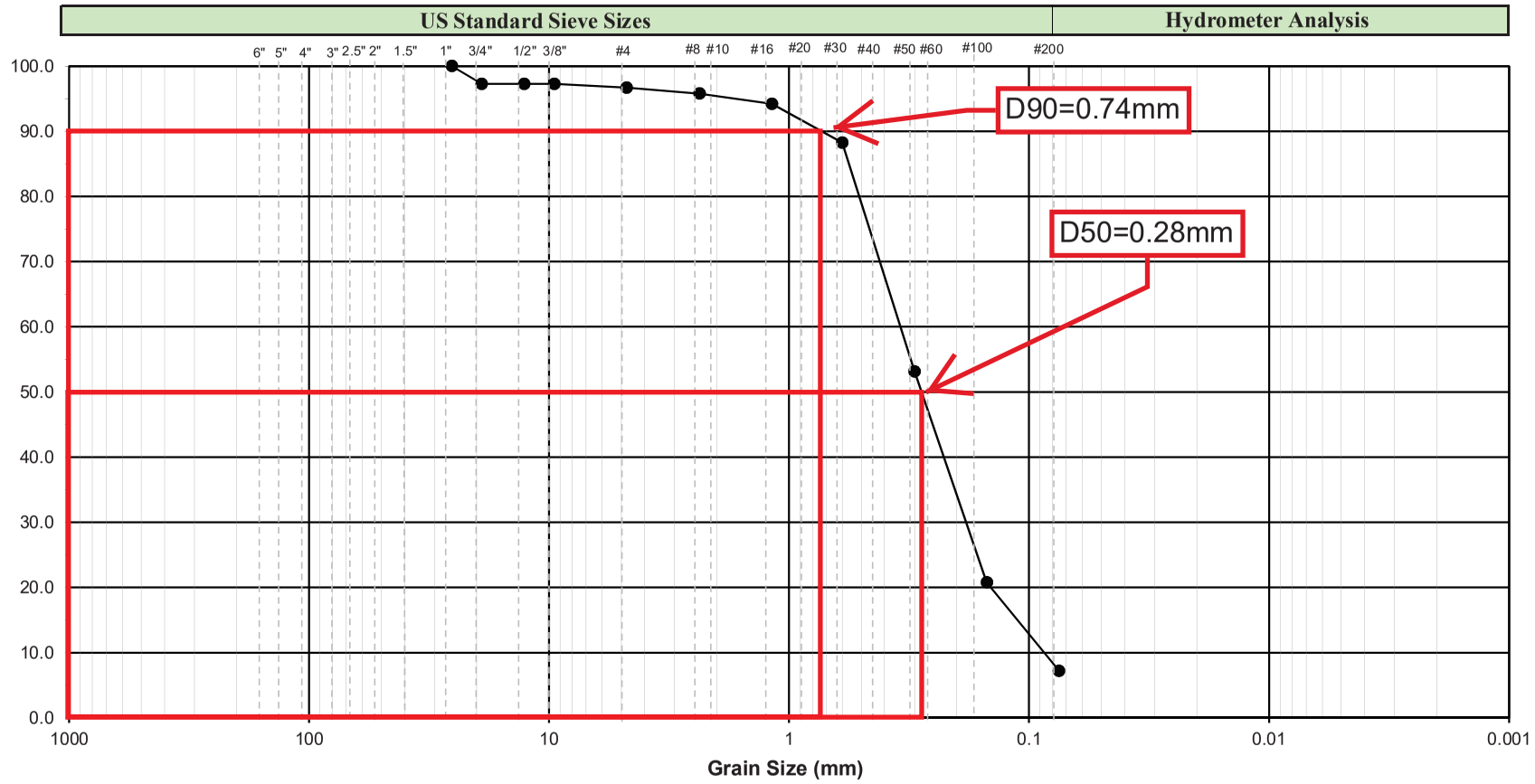
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Dokken, Replacement of Market St Bridge at SAR, Riverside County

Project No. : 20-154 Date : 03/08/21

GRAIN SIZE ANALYSIS
(ASTM D-422)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)		Depth (m)		Soil Color	Soil Description	U.S.C.S.
●	Pier 5	S-1	0 to 1				Gray	Poorly graded sand with silt	SP-SM
Remark									

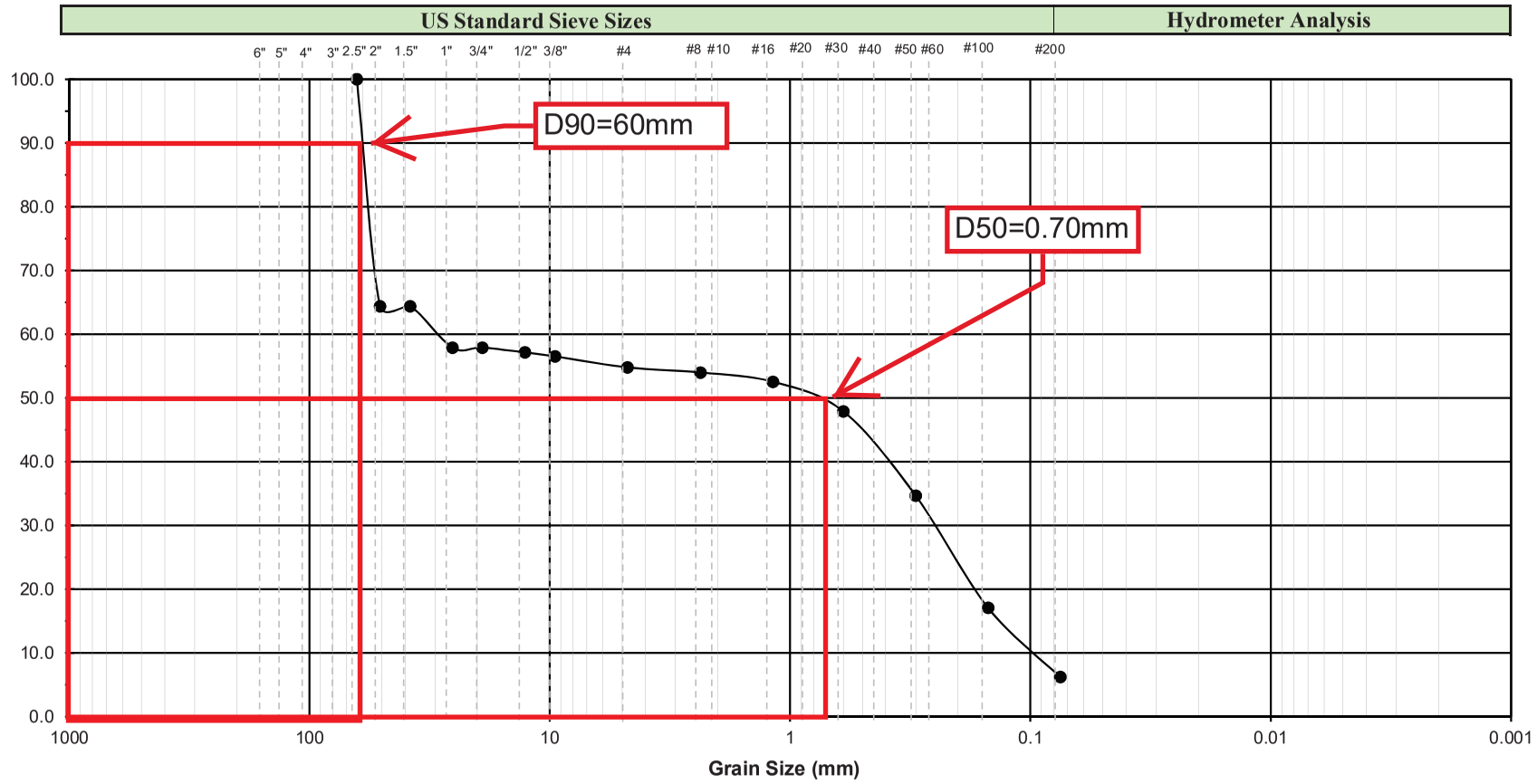
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Dokken, Replacement of Market St Bridge at SAR, Riverside County

Project No. : 20-154 Date : 03/08/21

GRAIN SIZE ANALYSIS
(ASTM D-422)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)		Depth (m)		Soil Color	Soil Description	U.S.C.S.
●	Pier 6	S-1	0 to 1				Gray	Poorly graded sand with silt with gravel	SP-SM
Remark									

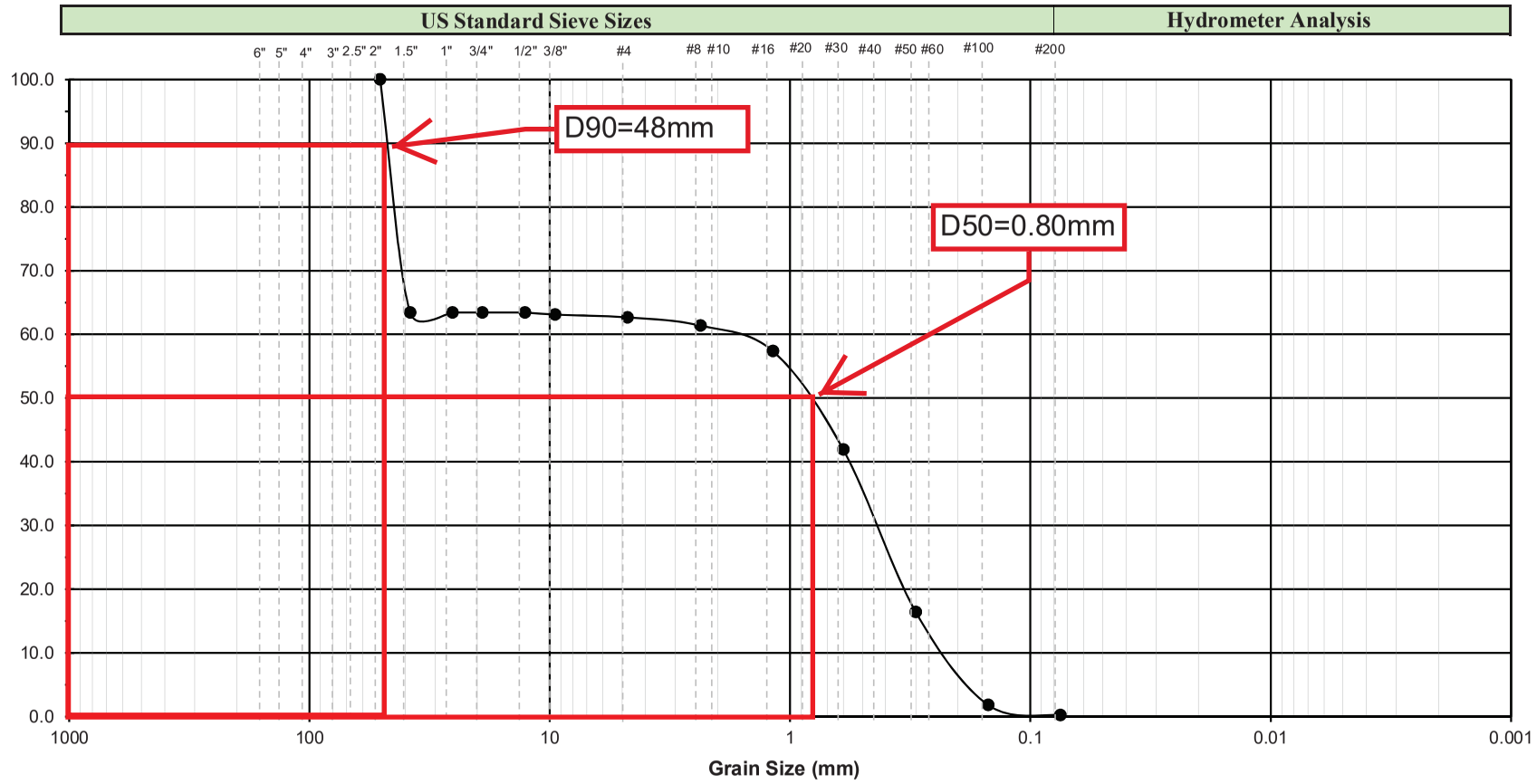
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Dokken, Replacement of Market St Bridge at SAR, Riverside County

Project No. : 20-154 Date : 03/08/21

GRAIN SIZE ANALYSIS
(ASTM D-422)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)		Depth (m)		Soil Color	Soil Description	U.S.C.S.
●	Pier 7	S-1	0 to 1				Light brown	Poorly graded sand with gravel	SP
Remark									

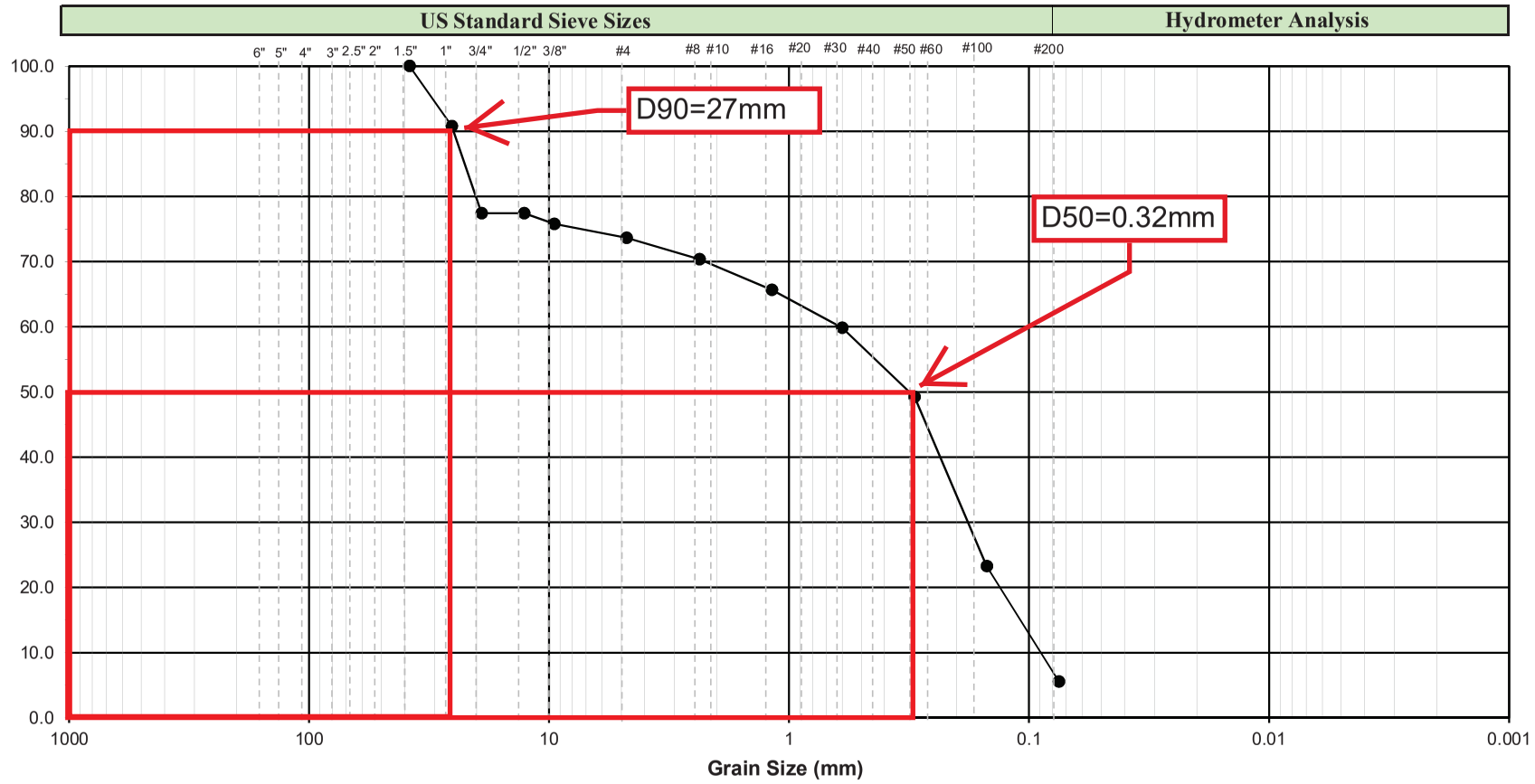
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Dokken, Replacement of Market St Bridge at SAR, Riverside County

Project No. : 20-154 **Date :** 03/08/21

GRAIN SIZE ANALYSIS
(ASTM D-422)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)		Depth (m)		Soil Color	Soil Description	U.S.C.S.
●	Pier 8	S-1	0 to 1				Olive-gray	Poorly graded sand with silt with gravel	SP-SM
Remark									

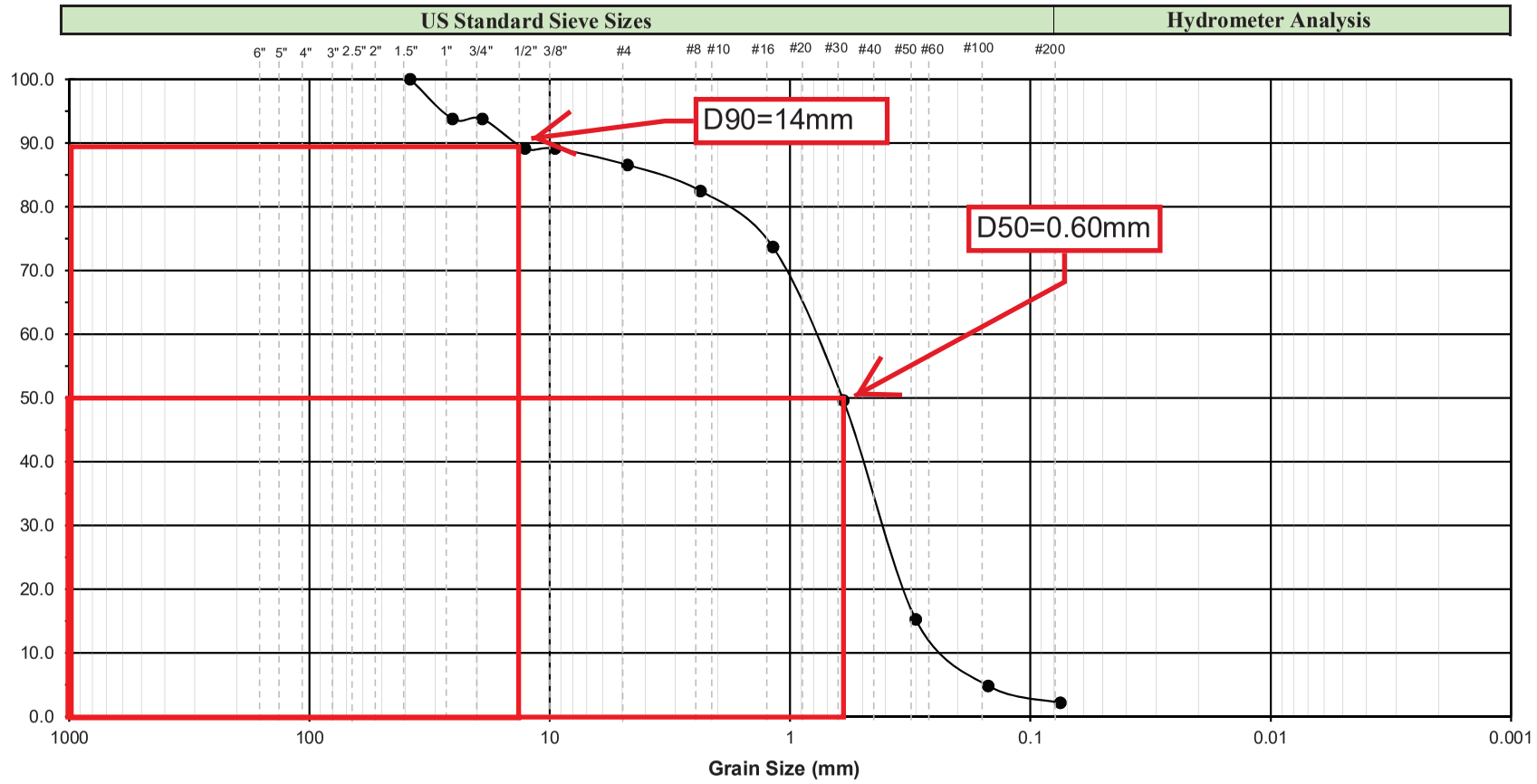
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Dokken, Replacement of Market St Bridge at SAR, Riverside County

Project No. : 20-154 **Date :** 03/08/21

GRAIN SIZE ANALYSIS
(ASTM D-422)

Figure No. :



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Boring Number	Sample Number	Depth (ft)		Depth (m)		Soil Color	Soil Description	U.S.C.S.
●	Pier 9	S-1	0 to 1				Olive-brown	Poorly graded sand	SP
Remark									

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Dokken, Replacement of Market St Bridge at SAR, Riverside County

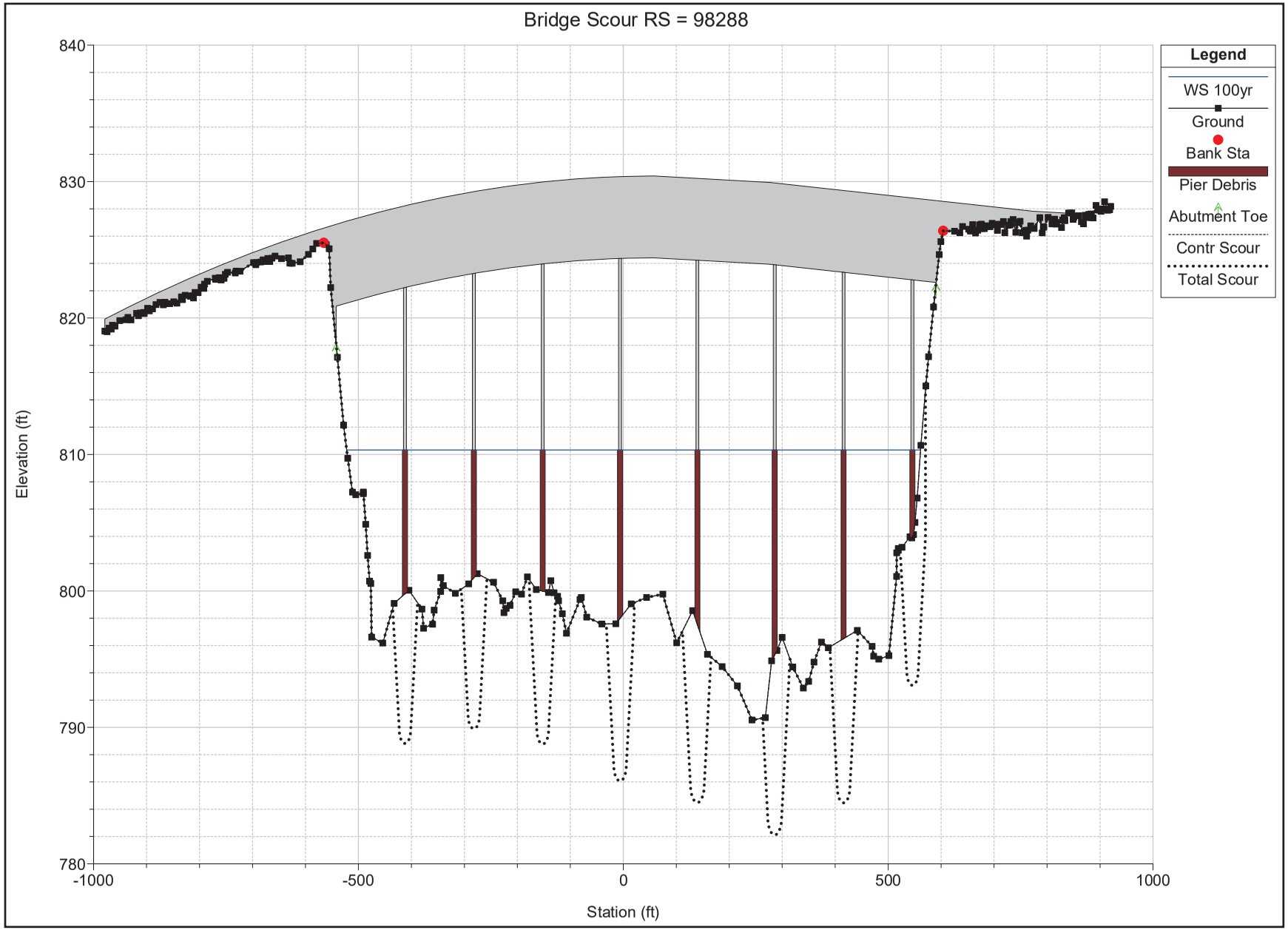
Project No. : 20-154 Date : 03/08/21

GRAIN SIZE ANALYSIS
(ASTM D-422)

Figure No. :

APPENDIX J

Scour Analysis


Bridge Scour RS = 98288
Legend
WS 100yr
Ground
Bank Sta
Pier Debris
Abutment Toe
Contr Scour
Total Scour
Elevation (ft)
840
830
820
810
800
790
780
-1000
-500
0
500
1000
Station (ft)

Contraction Scour

		Left	Channel	Right
Input Data				
	Average Depth (ft):		11.11	
	Approach Velocity (ft/s):		10.87	
	Br Average Depth (ft):		12.33	
	BR Opening Flow (cfs):		140000.00	
	BR Top WD (ft):		1007.41	
	Grain Size D50 (mm):		0.38	
	Approach Flow (cfs):		140000.00	
	Approach Top WD (ft):		1159.79	
	K1 Coefficient:		0.690	
Results				
	Scour Depth Ys (ft):		0.00	
	Critical Velocity (ft/s):		1.80	
	Equation:		Live	

Pier Scour

Pier: #1 (CL = -412.14)

Input Data		
	Pier Shape:	Round nose
	Pier Width (ft):	5.50
	Grain Size D50 (mm):	0.60000
	Depth Upstream (ft):	11.08
	Velocity Upstream (ft/s):	8.52
	K1 Nose Shape:	1.00
	Pier Angle:	0.00
	Pier Length (ft):	88.00
	K2 Angle Coef:	1.00
	K3 Bed Cond Coef:	1.10
	Grain Size D90 (mm):	
	K4 Armouring Coef:	1.00
Results		
	Scour Depth Ys (ft):	10.98
	Froude #:	0.45
	Equation:	CSU equation

Pier: #2 (CL = -282.14)

Input Data		
	Pier Shape:	Round nose
	Pier Width (ft):	5.50
	Grain Size D50 (mm):	0.32000
	Depth Upstream (ft):	9.91
	Velocity Upstream (ft/s):	8.99
	K1 Nose Shape:	1.00
	Pier Angle:	0.00
	Pier Length (ft):	88.00
	K2 Angle Coef:	1.00
	K3 Bed Cond Coef:	1.10
	Grain Size D90 (mm):	
	K4 Armouring Coef:	1.00
Results		
	Scour Depth Ys (ft):	11.07
	Froude #:	0.50
	Equation:	CSU equation

Pier: #3 (CL = -152.14)

Input Data

Pier Shape:	Round nose
Pier Width (ft):	5.50
Grain Size D50 (mm):	0.80000
Depth Upstream (ft):	10.89
Velocity Upstream (ft/s):	8.99
K1 Nose Shape:	1.00
Pier Angle:	0.00
Pier Length (ft):	88.00
K2 Angle Coef:	1.00
K3 Bed Cond Coef:	1.10
Grain Size D90 (mm):	
K4 Armouring Coef:	1.00

Results

Scour Depth Ys (ft):	11.21
Froude #:	0.48
Equation:	CSU equation

Pier: #4 (CL = -6.14)

Input Data

Pier Shape:	Round nose
Pier Width (ft):	5.50
Grain Size D50 (mm):	0.70000
Depth Upstream (ft):	12.88
Velocity Upstream (ft/s):	9.84
K1 Nose Shape:	1.00
Pier Angle:	0.00
Pier Length (ft):	88.00
K2 Angle Coef:	1.00
K3 Bed Cond Coef:	1.10
Grain Size D90 (mm):	
K4 Armouring Coef:	1.00

Results

Scour Depth Ys (ft):	11.92
Froude #:	0.48
Equation:	CSU equation

Pier: #5 (CL = 139.86)

Input Data

Pier Shape:	Round nose
Pier Width (ft):	5.50
Grain Size D50 (mm):	0.28000
Depth Upstream (ft):	13.33
Velocity Upstream (ft/s):	12.02
K1 Nose Shape:	1.00
Pier Angle:	0.00
Pier Length (ft):	88.00
K2 Angle Coef:	1.00
K3 Bed Cond Coef:	1.10
Grain Size D90 (mm):	
K4 Armouring Coef:	1.00

Results

Scour Depth Ys (ft):	13.05
Froude #:	0.58
Equation:	CSU equation

Pier: #6 (CL = 285.86)

Input Data

Pier Shape:	Round nose
Pier Width (ft):	5.50
Grain Size D50 (mm):	0.13000
Depth Upstream (ft):	15.55
Velocity Upstream (ft/s):	12.02
K1 Nose Shape:	1.00
Pier Angle:	0.00
Pier Length (ft):	88.00
K2 Angle Coef:	1.00
K3 Bed Cond Coef:	1.10
Grain Size D90 (mm):	
K4 Armouring Coef:	1.00

Results

Scour Depth Ys (ft):	13.20
Froude #:	0.54
Equation:	CSU equation

Pier Scour Limited to Maximum of Ys = 2.4 * a

Pier: #7 (CL = 415.86)

Input Data

Pier Shape:	Round nose
Pier Width (ft):	5.50
Grain Size D50 (mm):	0.08000
Depth Upstream (ft):	14.37
Velocity Upstream (ft/s):	9.73
K1 Nose Shape:	1.00
Pier Angle:	0.00
Pier Length (ft):	88.00
K2 Angle Coef:	1.00
K3 Bed Cond Coef:	1.10
Grain Size D90 (mm):	
K4 Armouring Coef:	1.00

Results

Scour Depth Ys (ft):	12.04
Froude #:	0.45
Equation:	CSU equation

Pier: #8 (CL = 545.86)

Input Data

Pier Shape:	Round nose
Pier Width (ft):	5.50
Grain Size D50 (mm):	0.12000
Depth Upstream (ft):	6.89
Velocity Upstream (ft/s):	9.73
K1 Nose Shape:	1.00
Pier Angle:	0.00
Pier Length (ft):	88.00
K2 Angle Coef:	1.00
K3 Bed Cond Coef:	1.10
Grain Size D90 (mm):	
K4 Armouring Coef:	1.00

Results

Scour Depth Ys (ft):	10.90
Froude #:	0.65

Equation:	CSU equation