Grayson Riverbend Preserve Restoration Project

Grayson, Stanislaus County, California

Hydraulic Impact Analysis

Prepared for:

RIVER PARTNERS

Prepared by:

MBK ENGINEERS

January 31, 2020

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PE Certification

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.

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1. Purpose

River Partners proposes to enhance and restore habitat along the San Joaquin River in Stanislaus County. The Grayson Riverbend Preserve Restoration Project (Project) is located along the banks of the San Joaquin River and Laird Slough, and neighbors the town of Grayson and the West Unit of the San Joaquin National Wildlife Refuge (**Figure 1**). The Project area is owned in-fee title by River Partners. The goal of the Project is to enhance and restore both degraded remnant riparian habitat and agricultural lands. This is achieved through replanting of native riparian forests and associated habitats. MBK Engineers (MBK) has prepared a hydraulic analysis of the proposed Project in support of the California Central Valley Flood Protection Board's (CVFPB) Encroachment Permit Application and is documented in this report.

2. Project Description

The Project consists of enhancing and restoring approximately 285 acres of habitat. The Project area is owned in fee title by River Partners and is located mostly within the floodplains of the San Joaquin River and CVFPB Designated Floodway. While most of the property is currently leased for agriculture, the site assessment revealed that nearly 106 acres of remnant, riparian, habitat still exists on the property. The restoration plan (**Figure 2**) will be aimed at both restoring the current agricultural fields to riparian and floodplain habitat, as well as enhancing the existing degraded remnant riparian areas. Three restoration plant communities are planned to feature: Mixed Riparian Forest, Oak Woodlands, and Cottonwood-Willow Riparian Forests. In addition, an existing farmer berm is proposed to be degraded to natural ground levels.

2.1 Habitat Restoration

The proposed habitat restoration areas for the Project site are shown in **Figure 2**. The habitat restoration consists of active vegetation restoration using three plant communities. The following sections describe each plant community, including a list and composition of the native plants in each type of location.

2.1.1 Mixed Riparian Forest Community

The Mixed Riparian Forest community has a diverse and even mix of trees and shrubs. This community will be planted at a density of approximately 227 plants/acre on approximately 103 acres of the Project site. **Table 1** lists the plants and density for the Mixed Riparian Forest Community.

Table 1. Mixed Riparian Forest Community

Common Name	Scientific Name	Percent Composition (%)	Density (plants/acre)	Total Number
Tree Species				
Arroyo willow	*Salix lasiolepis*	8%	18	1,870
Black willow	*Salix gooddingii*	8%	18	1,870
Fremont's cottonwood	*Populus fremontii*	8%	18	1,870
Oregon ash	*Fraxinus latifolius*	6%	14	1,403
Box Elder	*Acer negundo*	8%	18	1,870
Sandbar Willowf	*Salix exigua*	8%	18	1,870
Valley oak	*Quercus lobata*	12%	27	2,806
Total Trees		**58%**	**132**	**13,559**

Common Name	Scientific Name	Percent Composition (%)	Density (plants/acre)	Total Number
Shrub Species				
Blackberryf	*Rubus ursinus*	10%	23	2338
California rosef	*Rosa californica*	10%	23	2338
Coyote brushf	*Baccharis pilularis*	2%	4	468
Buttonbush	*Cephalanthus occidentalis*	4%	9	935
Elderberry	*Sambucus mexicana*	4%	9	935
Golden currantf	*Rives aureum*	10%	23	2338
Quailbush	*Atriplex lentiformis*	2%	4	468
Total Shrubs		**42%**	**95**	**9820**
Totals		**100%**	**227**	

2.1.2 Oak Woodland Community

The Oak Woodland Riparian Forest community also has a diverse mix of tree and shrub species. The association will be planted at a density of 227 plants/acre on approximately 32 acres of the Project site. **Table 2** lists the plants and density for the Oak Woodland community.

Table 2. Oak Woodland Community

Common Name	Scientific Name	Percent Composition (%)	Density (plants/acre)	Total Number
Tree Species				
Arroyo willow	*Salix lasiolepis*	4%	9	291
Valley oak	*Quercus lobata*	18%	41	1,308
Sandbar willow	*Salix exigua*	2%	4	145
Black willow	*Salix gooddingii*	4%	9	291
Box elder	*Acer negundo*	8%	18	581
Fremont's cottonwood	*Populus fremontii*	2%	4	145
Oregon ash	*Fraxinus latifolius*	4%	9	291
Total Trees		**42%**	**95**	**3,052**
Shrub Species				
California rose	*Rosa californica*	12%	27	872
California blackberry	*Rubus ursinus*	12%	27	872
Buttonbush	*Cephalanthus occidentalis*	4%	9	291
Mulefat	*Baccharis salicifolius*	8%	18	581
Coyote brushf	*Baccharis pilularis*	2%	5	145
Elderberry	*Sambucus mexicana*	8%	18	581
Golden currantf	*Ribes aureum*	10%	23	726
Quailbush	*Atriplex lentiformis*	2%	5	145
Total Shrubs		**58%**	**132**	**4,213**
Totals		**100%**	**227**	**7,265**

2.1.3 Cottonwood Willow Forest Community

The Cottonwood Willow Forest community has a high percentage of willow trees and a mix of shrub species. This community will be planted at a density of 227 plants/acre on approximately 12 acres of the Project site. **Table 3** lists the plants and density for this community.

Table 3. Willow Scrub Community

Common Name	Scientific Name	Percent Composition (%)	Density (plants/acre)	Total Number
Tree Species				
Arroyo willow	*Salix lasiolepis*	12%	27	327
Black willow	*Salix gooddingii*	8%	18	218
Fremont Cottonwood	*Populus fremontii*	12%	27	327
Oregon ash	*Fraxinus latifolius*	6%	14	163
Box elder	*Acer negundo*	6%	14	163
Sandbar willow	*Salix exigua*	10%	23	272
Valley oak	*Quercus lobate*	6%	14	163
Total Trees		**60%**	**136**	**1,633**
Shrub Species				
Blackberryf	*Rubus ursinus*	12%	27	327
California rose	*Rosa californica*	10%	23	272
Buttonbush	*Cephalanthus occidentalis*	8%	18	218
Golden currantf	*Ribes aureum*	10%	23	272
Total Shrubs		**40%**	**91**	**1,089**
Totals		**100%**	**227**	**2,722**

2.2 Farmer Berm Degrade

A farmer berm will be degraded by 600 lineal feet measured starting from the southerly end of the project area as shown in **Figure 2**. The berm is proposed to be degraded to elevation 38.0 feet North American Vertical Datum (NAVD88).

3. Hydraulic Model

A hydraulic model of the lower San Joaquin River flood control system was developed for this study using HEC-RAS version 5.0.7. HEC-RAS is capable of simulating one-dimensional (1D) and two-dimensional (2D) unsteady flow calculations through a full network of open channels. The Grayson HEC-RAS model simulates the lower San Joaquin River, from Newman to Vernalis, and includes both the Tuolumne River and Stanislaus River (**Figure 3**). The Grayson HEC-RAS model was developed using portions of an existing HEC-RAS model of the lower San Joaquin flood control project, developed by the California Department of Water Resources (DWR).

DWR's HEC-RAS model simulates the entire upper and lower San Joaquin flood control project, from Friant Dam down to the Sacramento-San Joaquin Delta. The model was developed as part of the Central Valley Floodplain Evaluation and Delineation Program (CVFED) and is available as part of DWR's Library of Models, referenced as Model No. 16001. The CVFED HEC-RAS model was truncated to the study area of interest, refined, and calibrated, to form the Grayson HEC-RAS model. The geometry refinements and calibration of the Grayson HEC-RAS model are described in the following sections.

3.1 Topography and Sources of Data

The Grayson HEC-RAS model and all of the results are referenced in the Universal Transverse Mercator (UTM) Zone 10 coordinate horizontal system and the North American Vertical Datum of 1988 (NAVD88). All horizontal and vertical units are in U.S. survey feet.

The primary source of topographic data for the development of the Grayson HEC-RAS model was Light Detection and Ranging (LiDAR) data compiled by DWR under the CVFED Program. The LiDAR data is comprised of points that densely cover the entire region. The minimum expected horizontal accuracy was tested to meet or exceed a 3.5-foot horizontal accuracy at 95 percent confidence level using RMSE(r) x 1.7308 as defined by the National Standards for Spatial Data Accuracy (NSSDA). Final ground surface LiDAR point elevation data in areas other than open terrain meet or exceed NSSDA standards of 0.6-foot root-mean-square error (RMSE) vertical (Accuracy z = 1.2 feet at the 95 percent confidence level). Accuracy was tested to meet a 0.6-foot fundamental vertical accuracy at 95 percent confidence level using RMSE(z) x 1.9600, as defined by the NSSDA.

3.2 HEC-RAS Model Geometry Development

The Grayson HEC-RAS model simulates the lower San Joaquin River, from Newman to Vernalis, and includes its major tributaries (i.e., Tuolumne River and Stanislaus River) along the reach. The Grayson HEC-RAS model simulates the system using both 1D and 2D HEC-RAS components. The river channels outside of the Project area were simulated using 1D cross sections. Since spatially varied vegetation is proposed for the Project area, a HEC-RAS 2D flow area was used to simulate the vegetation and proposed Project features. The 2D flow area extends from the San Joaquin River at Patterson, down to the San Joaquin River at Maze Road and includes the lower portion of the Tuolumne River.

Areas behind levees were simulated using storage areas (i.e., ponding area defined by an elevation-volume relationship). These storage areas were extended out far enough to capture the expected areas of flooding during a 100-year flood event. The Grayson HEC-RAS model schematic is shown in **Figure 3**.

3.3 Model Calibration

The Grayson HEC-RAS model was calibrated to the April 2006 flood event using observed data throughout the model domain. The calibration was performed to verify that the selected model parameters are reasonable and that the model can reasonably reproduce an actual flood event. The April 2006 flood event was selected for calibration as: the flood event was contained within the State-Federal project levee and non-project levees of the San Joaquin River; there is ample observed flow and stage data; availability of high water marks (HWM) throughout the Project reach; and flows are similar to the 1955 Design Flow.

3.4 Boundary Conditions

Upstream and downstream ends of the model were provided boundary conditions using flow data from the April 2006 flood event that was available from various gaging stations from DWR and U.S. Geological Survey (USGS). **Table 4** shows the location and source of flow and stage data used in the development of the boundary conditions.

Table 4. Boundary Conditions – April 2006 Calibration

HEC-RAS Location	Boundary Condition Type	Source
San Joaquin River – SJR8 RS 79.24	Upstream Flow	San Joaquin River near Newman - USGS Station #1127400
San Joaquin River – SJR8 RS 69.64	Upstream Flow	Orestimba Cr at River Road – USGS Station #11274538
Tuolumne River TLR1 RS 16.81	Upstream Flow	Tuolumne River At Modesto – USGS Station #11290000
Stanislaus River SSR1 RS 15.25	Upstream Flow	Stanislaus River at Ripon – USGS Station #11303000
San Joaquin River SJR 6 RS 32.59	Downstream Stage	San Joaquin River near Vernalis – USGS Station #11303500

Plots of the upstream flow boundary conditions are provided in **Figure 4**. The downstream stage boundary condition used in the calibration is plotted in **Figure 5**.

3.5 Levee Breaches

Six levee breaches that would affect model calibration of water surface elevation and flow were identified from aerial photos from August 2006 (Google, 2006). These levee breaches were to the north-west of Grayson on the non-State-Federal project levees of the San Joaquin River National Wildlife Refuge (SJNWR). The levee breach dimensions were estimated from aerial photos and coded into the calibration simulation. **Figure 6** shows the location of the levee breaches.

3.6 Observed Data

Observed stage and flow data for the April 2006 flood event was available from DWR and USGS gaging stations. The observed peak stage and flow at the gages were used to compare with the computed peak stage and flow from the April 2006 flood simulation. **Table 5** lists the available gages within the model domain.

Table 5. Stage and Flow Gages

Gage	HEC-RAS Location	Type
San Joaquin River at Crows Landing; USGS Gage Sta. #11274550	SJR R8 RS 67.91	Flow and Stage
San Joaquin River at Patterson; DWR Gage Sta. #B07200	SJR R8 RS 59.32	Flow and Stage
San Joaquin River at Maze Road; DWR Gage Sta. #B07040	SJR R7 RS 37.74	Flow and Stage

Surveyed high water marks from DWR (DWR and CVFED, 2015) were available along the San Joaquin River and Stanislaus River for the April 2006 flood event. The high water marks were used to calibrate Grayson HEC-RAS model by comparing the high water mark elevation with the computed maximum water surface elevation (WSE). The locations of the high water marks (HWMs) are shown in **Figure 7.**

3.7 Manning's Roughness Coefficient

For 1D cross sections, the Manning's roughness coefficients were assigned to the left bank, main channel, and right bank of the cross section. The Manning's roughness coefficients were based on the CVFED hydraulic model and adjusted using engineering judgement to calibrate the model. The final calibrated Manning's roughness coefficient for the 1D cross sections are listed in **Table 6**.

Table 6. April 2006 Calibration Manning's Roughness Coefficient – 1D Cross Sections

River	Channel Roughness Coefficient Range	Overbank Roughness Coefficient Range
Stanislaus River	0.045	0.04-0.1
Tuolumne River	0.045	0.055-0.09
San Joaquin River	0.045	0.05-0.085

Manning's roughness coefficients for the 2D flow area were assigned spatially, using a land use survey of Stanislaus County conducted by DWR (DWR, 2010). The Manning's roughness coefficient values were based on Table 3-1 from the *HEC-RAS River Analysis Stem Hydraulic Reference Manual Version 5.0 (February 2016)*, and adjusted using engineering judgement to calibrate the model. **Table 7** lists the calibrated Manning's roughness coefficients for the 2D flow area. Spatial variation of the Manning's roughness coefficient for the Grayson area is shown in **Figure 8**.

Table 7. April 2006 Calibration Manning's Roughness Coefficient – 2D Flow Area

Land Use/Veg/Habitat	Manning's Roughness Coefficient
Idle, Rice, Urban	0.03
Grass, Pasture, Fallow, Wetland, Truck Crop	0.035
Wetland	0.04
Field, Grain, River Channel, Open Water	0.04-0.045
Vineyard	0.05
Citrus, Deciduous, Native Vegetation	0.07
Young Riparian Forest	0.08

3.6 Results

The Grayson HEC-RAS model was simulated with the April 2006 boundary conditions from Section 3.4. For each of the gage locations in **Table 5**, plots of computed values versus observed values are plotted in **Figure 9** through **Figure 14**. **Table 8** tabulates the high water mark elevation, computed maximum water surface elevation, and the difference for each of the high water mark locations shown on **Figure 7**.

Figure 9, **Figure 11**, and **Figure 13** show that the model is reasonably quantifying flows in the Grayson Project reach. Computed maximum water surface elevations versus observed high water marks in the Project reach are shown in **Table 8**. The results show the Grayson model reasonably quantifies the maximum water surface elevation in the Project area and is adequate for evaluating impacts to water surface elevation.

Table 8. High Water Mark and Computed Maximum Water Surface Elevation Comparison

HWM ID	Surveyed HWM (ft.-NAVD88)	Computed WSE (ft.-NAVD88)	Difference (ft.)	Notes
1	41.10	41.58	0.48	
2	46.59	44.45	-2.14	
3	42.29	40.32	-1.97	
4	37.88	34.82	-3.06	
5	38.71	36.62	-2.09	
6	35.56	34.14	-1.42	
7	34.90	34.45	-0.45	
8	34.14	34.06	-0.08	
9	34.35	33.94	-0.41	
10	34.22	33.93	-0.29	
11	32.11	32.22	0.11	
12	33.43	33.04	-0.39	
13	35.54	33.89	-1.65	
14	32.59	33.43	0.84	
15	32.53	32.51	-0.02	
16	36.57	33.79	-2.78	
17	33.39	33.71	0.32	
18	32.73	33.77	1.04	
19	35.39	33.76	-1.63	
20	32.37	32.66	0.29	
21	33.14	33.92	0.78	
22	33.13	34.04	0.91	
23	34.21	34.22	0.01	
24	34.62	34.75	0.13	
25	34.26	34.35	0.09	
26	34.47	34.78	0.31	
27	36.40	35.13	-1.27	
28	35.03	35.51	0.48	
29	35.17	35.57	0.40	Maze Road
30	34.84	35.68	0.84	
31	40.16	40.10	-0.06	
32	39.85	40.19	0.34	
33	40.63	40.70	0.07	
34	41.53	41.03	-0.50	
35	43.47	42.39	-1.08	

HWM ID	Surveyed HWM (ft.-NAVD88)	Computed WSE (ft.-NAVD88)	Difference (ft.)	Notes
36	44.27	42.96	-1.31	
37	48.78	48.51	-0.27	
38	48.83	48.82	-0.01	
39	49.72	49.37	-0.35	
40	50.07	49.90	-0.17	
41	51.18	50.18	-1.00	
42	51.27	51.30	0.03	
43	51.87	51.75	-0.12	
44	52.26	52.52	0.26	
45	54.67	53.20	-1.47	E Las Palmas Ave
46	52.83	53.35	0.52	
47	52.39	53.53	1.14	
48	53.15	54.16	1.01	
49	54.96	54.73	-0.23	
50	54.77	54.83	0.06	
51	54.87	55.07	0.20	
52	52.81	54.57	1.76	Disturbed HWM per Surveyor
53	53.10	54.64	1.54	Disturbed HWM per Surveyor
54	54.35	54.89	0.54	
55	55.14	55.21	0.07	
56	54.19	55.35	1.16	
57	55.72	55.83	0.11	
58	56.95	56.71	-0.24	
59	56.68	57.05	0.37	
60	58.25	57.75	-0.50	
61	58.37	57.92	-0.45	
62	58.81	58.08	-0.73	
63	58.29	58.30	0.01	

4. Hydraulic Analysis

4.1 Methodology

The methodology to determine hydraulic impacts was to configure and evaluate hydraulic model simulations of *with-* and *without-project* conditions. The simulation results of the proposed project will be compared to the without-project condition to determine changes in water surface elevation.

4.2 Without-Project Condition

The without project condition hydraulic model geometry was developed from the April 2006 flood event calibration geometry. The without project condition geometry reflects full maturity of habitat on the SJNWR. Those areas on the SJNWR consist of wetlands and riparian forest planted between 2001 and 2015. A

Manning's roughness coefficient of 0.085 was assigned to those areas. All other Manning's roughness coefficients for the 1D cross sections, and other areas of the 2D flow area, remain the same from the calibration geometry. **Figure 15** shows the Manning's roughness coefficient for the without project condition in the Grayson vicinity, and tabulated by land use, in **Table 9**.

Table 9. Without Project Condition – Manning's Roughness Coefficients in 2D Flow Area

Land Use/Veg/Habitat	Manning's Roughness Coefficient
Idle, Rice, Urban	0.03
Grass, Pasture, Fallow, Young Wetland, Truck Crop	0.035
Wetland	0.04
Field, Grain, River Channel, Open Water	0.04 - 0.045
Vineyard	0.05
Heavy Vegetated Pond	0.06
Citrus, Deciduous, Native Vegetation	0.07
Cottonwood Willow and Oak Woodland association	0.07
Young Riparian Forest	0.08
Mixed Riparian and Riparian Forest	0.085

4.3 Project Condition

The project condition hydraulic model geometry was developed from the without project condition geometry. The project condition geometry reflects the proposed vegetation along with the farmer berm degrade, shown in **Figure 2** and described in Section 2.

The proposed vegetation communities were simulated by modifying the Manning's roughness coefficients in the respective areas of the model domain. **Table 10** lists the Manning's roughness coefficients of the project condition vegetation for the 2D flow area, as shown in **Figure 16**.

Table 10. Project Condition – Manning's Roughness Coefficient 2D Flow Area

Land Use/Veg/Habitat	Manning's Roughness Coefficient
Idle, Rice, Urban	0.03
Grass, Pasture, Fallow, Young wetland, Truck Crop	0.035
Wetland, west field	0.04
Field, Grain, River Channel, Open Water	0.045
Vineyard	0.05
Heavy Vegetated Pond	0.06
Citrus, Deciduous, Native Vegetation	0.07
Cottonwood Willow association	0.08
Oak Woodland association	0.08
Young Riparian forest	0.08
Riparian Forest	0.085
Mixed Riparian association	0.085

4.1 Hydrology

The with- and without- project condition hydraulic model geometries were simulated for two flow scenarios, to evaluate impacts to water surface elevation. The Grayson HEC-RAS was simulated in unsteady flow conditions for the USACE 1955 Design Flow for the San Joaquin River at Tuolumne River, and USACE Sacramento and San Joaquin River Basins Comprehensive Study 100-year flows.

The USACE 1955 Design Flow for the San Joaquin River at the Tuolumne River is 45,000 cfs (USACE Sacramento District, 1955). This flow was simulated in the hydraulic model by scaling the April 2006 flood event so that the peak flow in the San Joaquin River near Newman was 45,000 cfs. As per the preceding projects in the area, the USACE and CVFPB recommended that a concurrent flow of 15,000 cfs was simulated on the Tuolumne River at Modesto and 6,000 cfs on the Stanislaus River at Ripon, in order to represent the USACE 1955 Design Flow. **Figure 17** plots the upstream flow hydrographs for the USACE 1955 Design Flow simulation.

Flow boundary conditions for the USACE Comprehensive Study 100-year flood are from the USACE Comprehensive Study San Joaquin River UNET model simulation of the San Joaquin River at Vernalis storm centering flood event. **Figure 18** shows plots of the Grayson HEC-RAS model flow boundary hydrographs used in the USACE Comprehensive Study 100-year flood simulations. The peak flows for the USACE 1955 Design Flow and USACE Comp Study 100-year are tabulated in **Table 11**.

The downstream boundary condition for both of the flow scenarios is the rating curve for the USGS San Joaquin River near Vernalis gaging station (11303500). A plot of the rating curve is provided in **Figure 19**.

Table 11. Boundary Condition - Peak Flow

Flood Event	Peak Flow (cfs)		
	San Joaquin River near Newman	Tuolumne River at Modesto	Stanislaus River at Ripon
USACE 1955 Design Flow	45,000	15,000	6,000
USACE Comprehensive Study 100-Year	37,100	63,700	9,200

4.2 Results

For each of the hydrologic conditions, the with- and without project condition maximum water surface elevations were compared to determine the changes in the maximum water surface elevation due to the project. **Figure 20** and **Figure 22** show the changes due to the Project on the maximum water surface elevations for the USACE 1955 Design Flow and USACE Comprehensive Study 100-year flood, respectively. Increases in water surface elevation as a result of the proposed Project are shown as positive values, while decreases are shown as negative values.

5. Conclusion

River Partners proposes to enhance and restore 285 acres of habitat along the San Joaquin River in Stanislaus County. This hydraulic analysis assesses the Project's potential effects on the State and Federal Flood control system. The results of the hydraulic analysis indicate that both increases and decreases in WSE occur under the with-project condition. Increase in WSE of at most +0.18 feet occur within the Project area and Designated Floodway during a 1955 Design Flow condition (**Figure 20**). Similarly, an increase in WSE of at most +0.12 feet occur within the Project area and Designated Floodway during a 1-in-100 year Flow Condition (**Figure 22**). A majority of increases in WSEs also occur within the Designated Floodway and are incremental increases over a flooding depth of over 6 feet in most locations as shown in **Figure 24** and **Figure 25**.

Moreover, **Figure 20** and **Figure 22** shows flooding outside of the Designated Floodway to the west of Project area during the 1955 Design Flow and 1-in-100 year flow, respectively. The existing condition simulations of both the 1955 Design Flow and 1-in-100 year flow shows this area as flooded during the without-project conditions as shown in **Figure 26** and **Figure 27**. In these figures, the with-project flood extent, shown in red, closely follows the existing flood extent and a majority of these lands are zone within Federal Emergency Management Agencies (FEMA) flood hazard zone A, which is designated as areas with a 1% annual change of flooding. Therefore, the project is not expected to drastically increase flood risk to neighboring properties or the flood control infrastructures.

Aggradation and erosion potential are measured using change in flow velocity. Significant reductions in flow velocity may cause sedimentation, and significant increases in flow velocity could potentially erode bare soils. The Project conditions show localized changes in flow velocities, mostly on the order of -1.0 feet per second, in the Project area and this magnitude would not significantly increase potential for aggradation or erosion during both the 1955 Design Flow (**Figure 21**) and 1-in-100 year flow (**Figure 23**).

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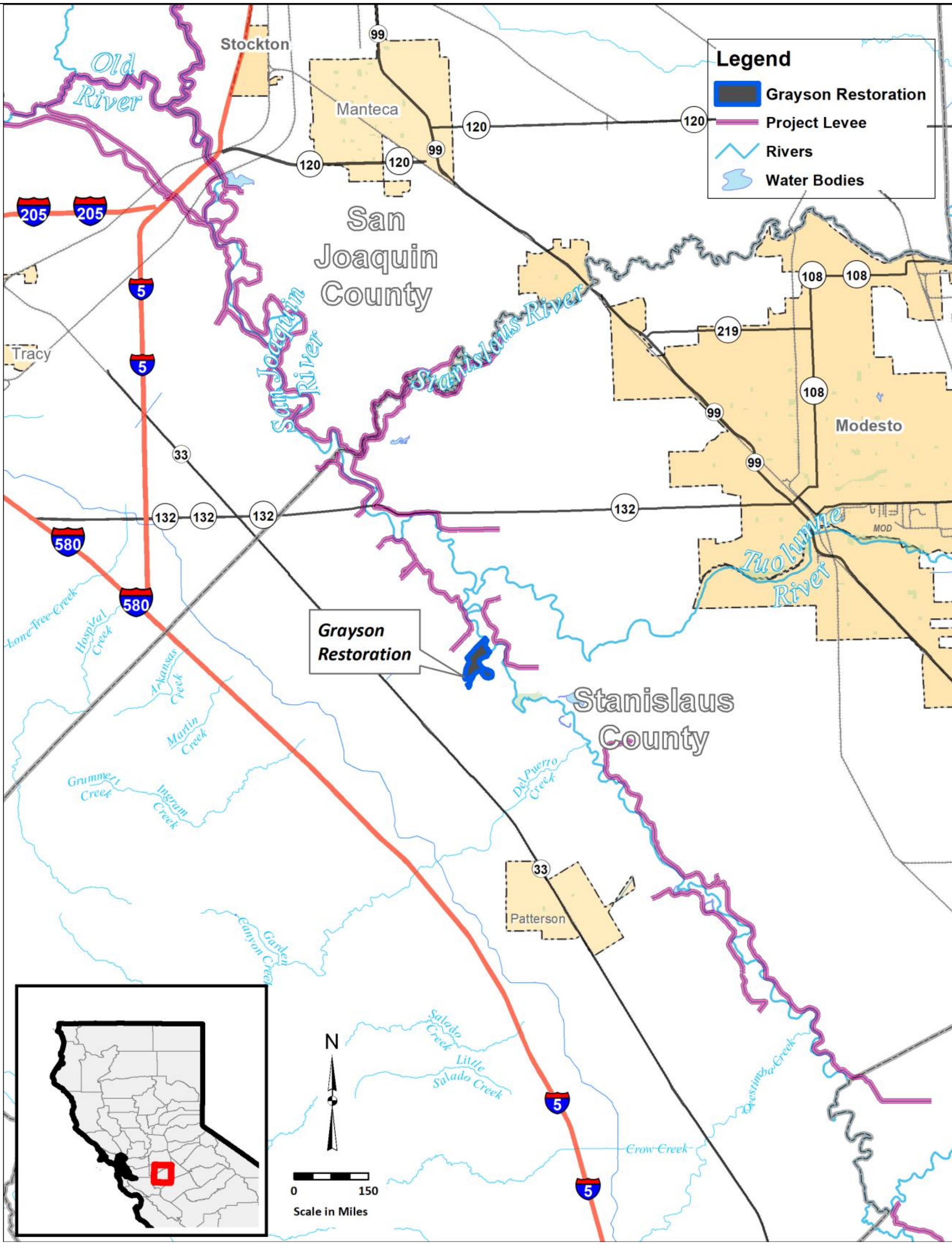
5. (USACE Sacramento District, 1955). *Design Memorandum No. 1, Lower San Joaquin River and Tributaries Project, California, San Joaquin River Levees General Design*. Sacramento California. December 23, 1955.

6. (Kukas, 2014). *Hydraulic Screening and Analysis Needed for USACE Review, U.S. Army Corps of Engineers (USACE), Sacramento District*. Sacramento, California. July 25, 2014.

Figures



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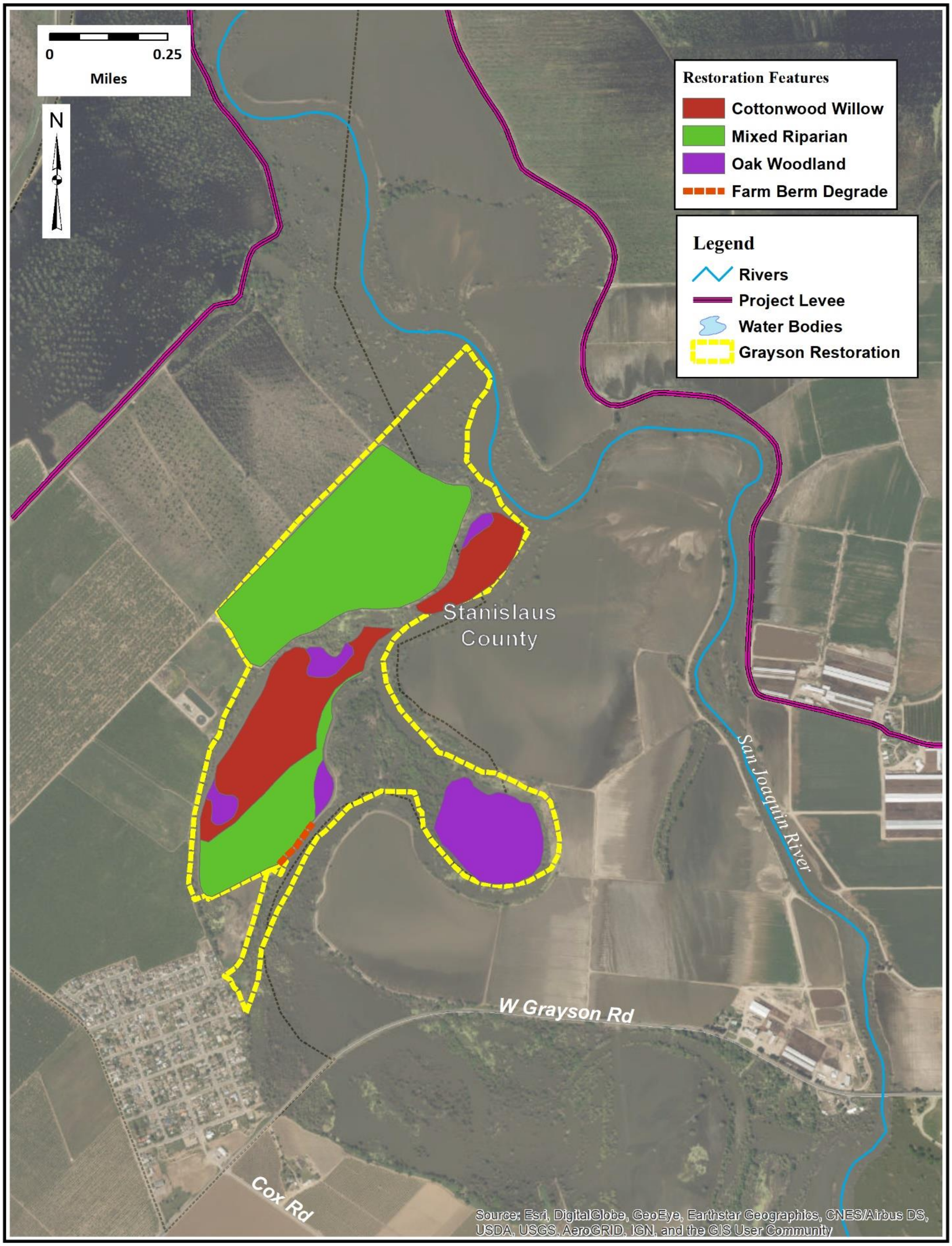
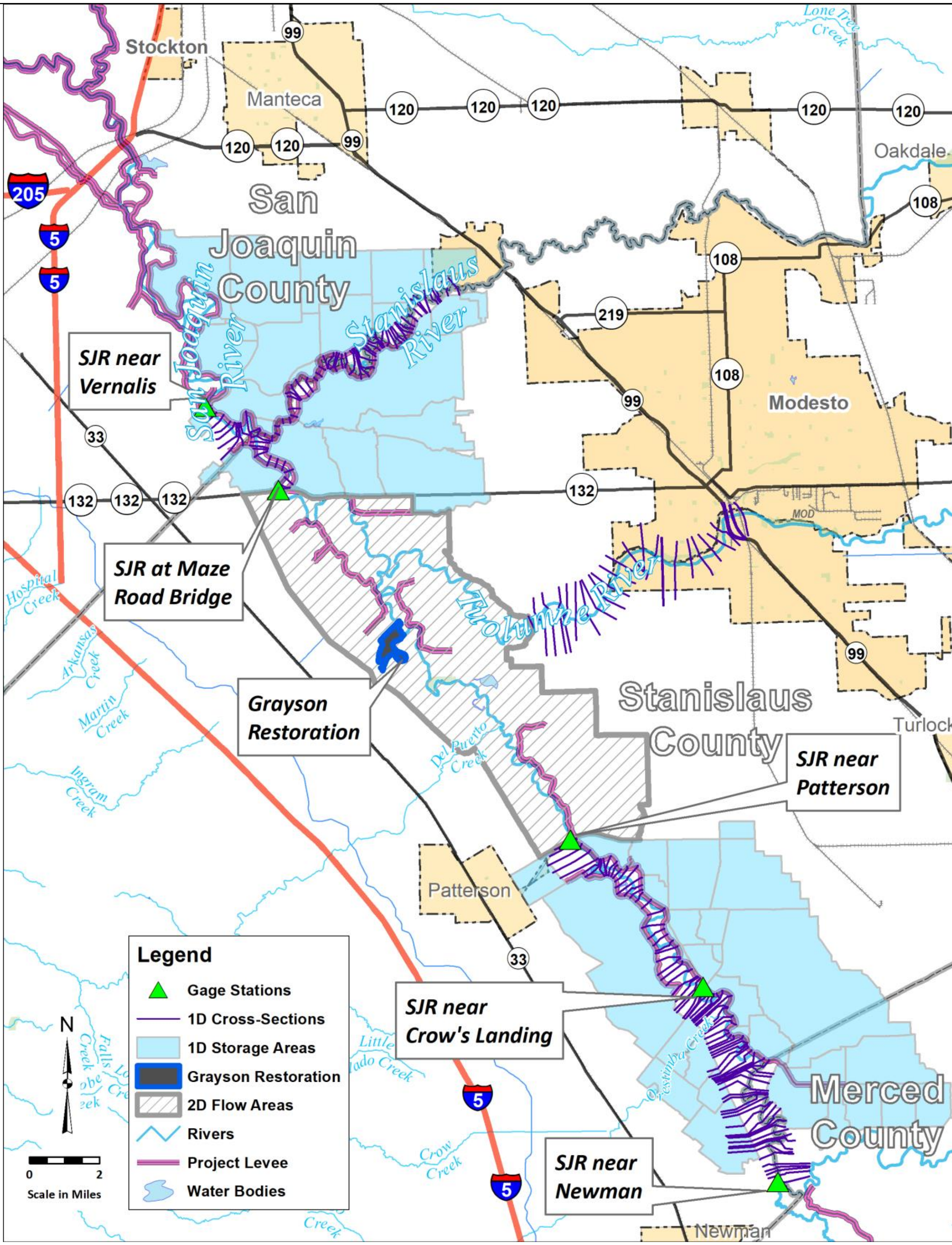
Grayson Riverbend Preserve Restoration Project

Vicinity Map

Figure 1



MBK ENGINEERS	Grayson Riverbend Preserve Restoration Project	**Restoration Features** **Figure 2**



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Grayson Riverbend Preserve Restoration Project

Model Extents & Gages

Figure 3

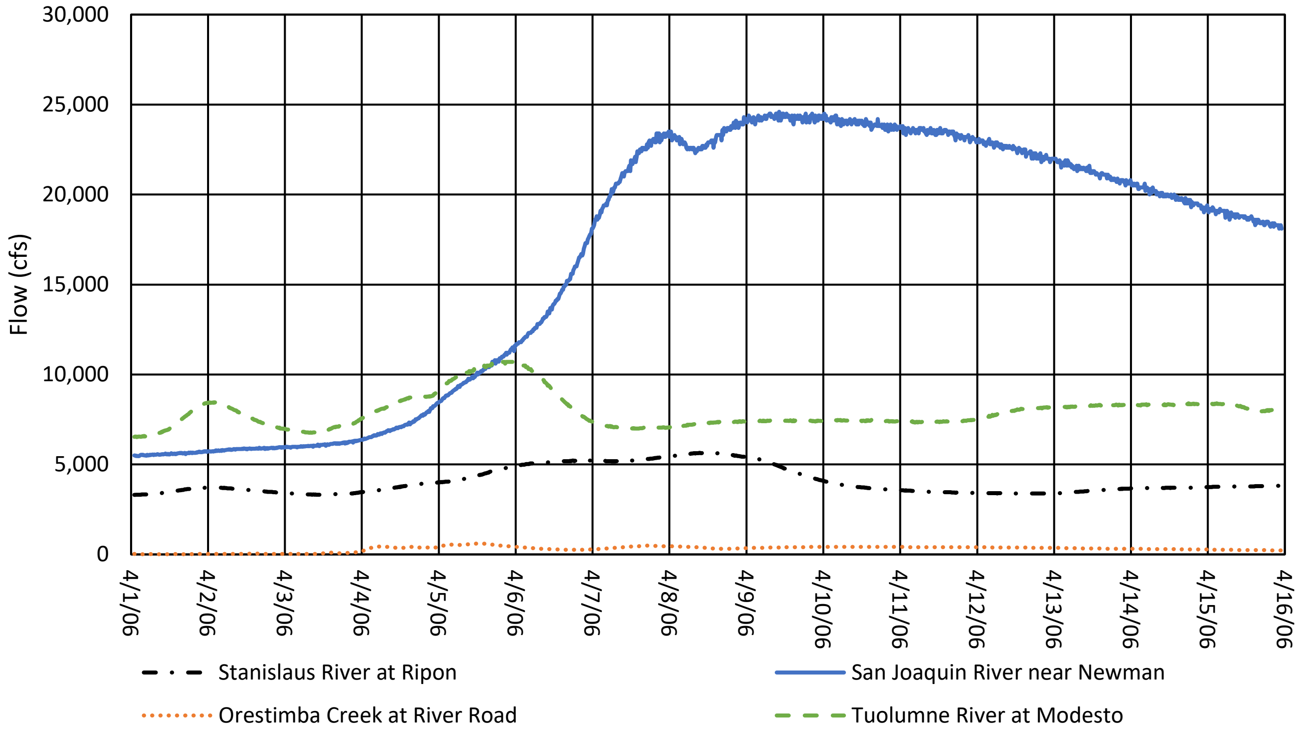


Figure 4. April 2006 Flood Event - Flow Boundary Conditions

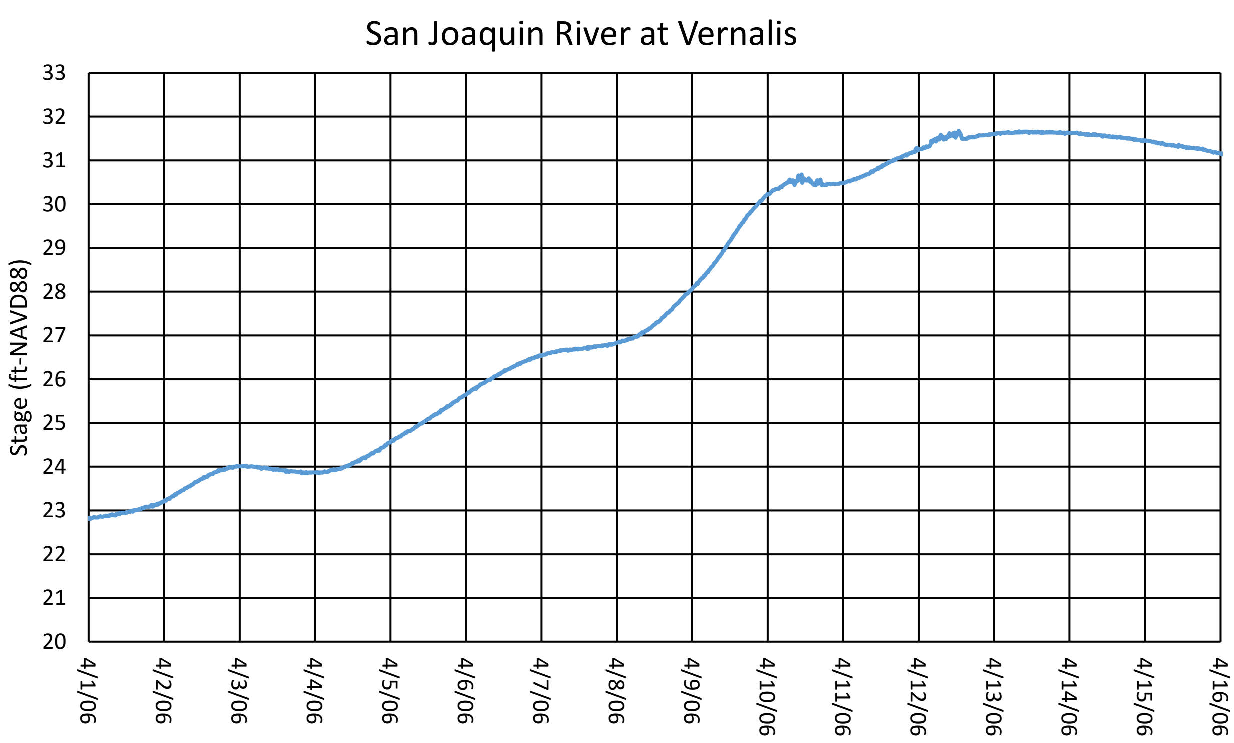
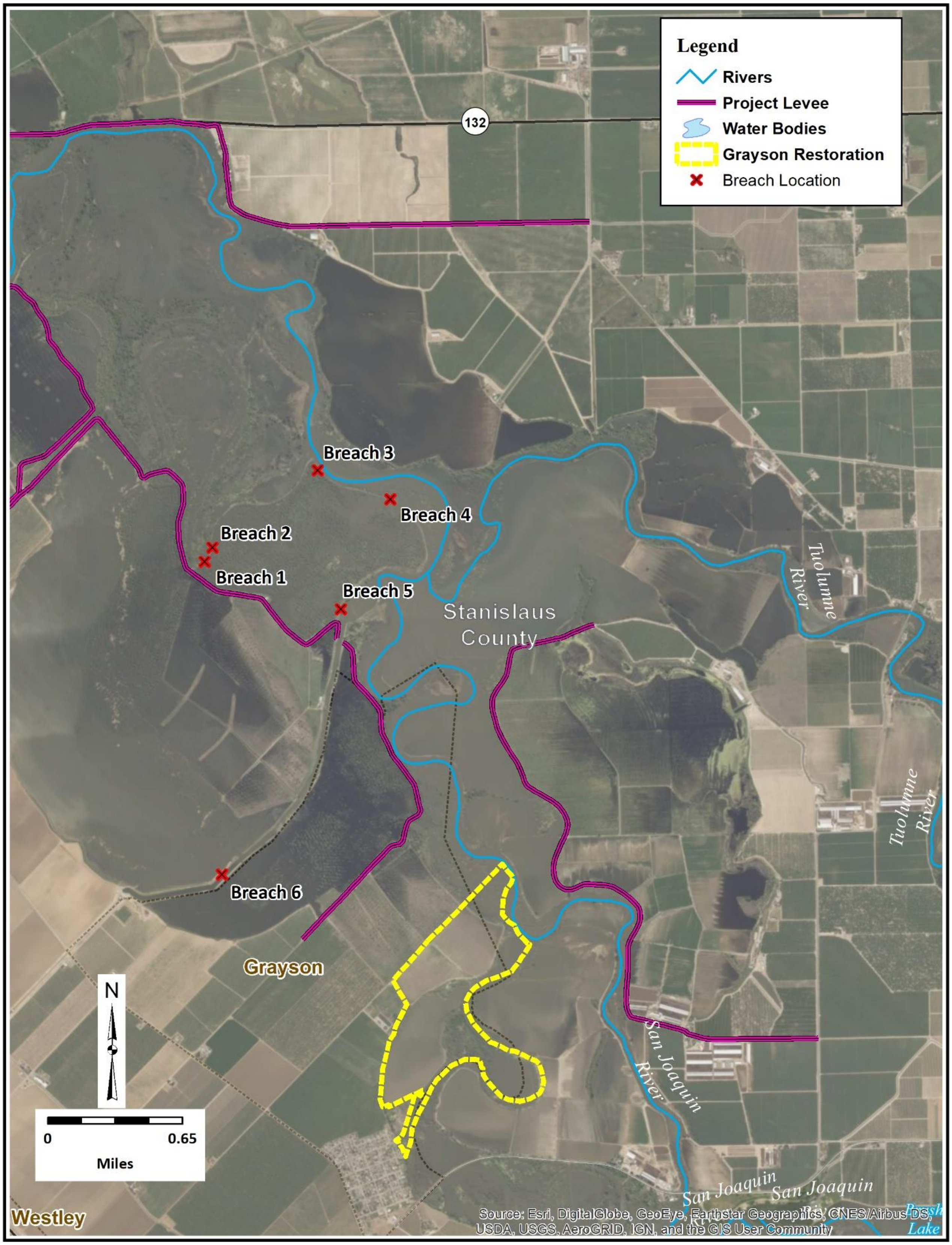
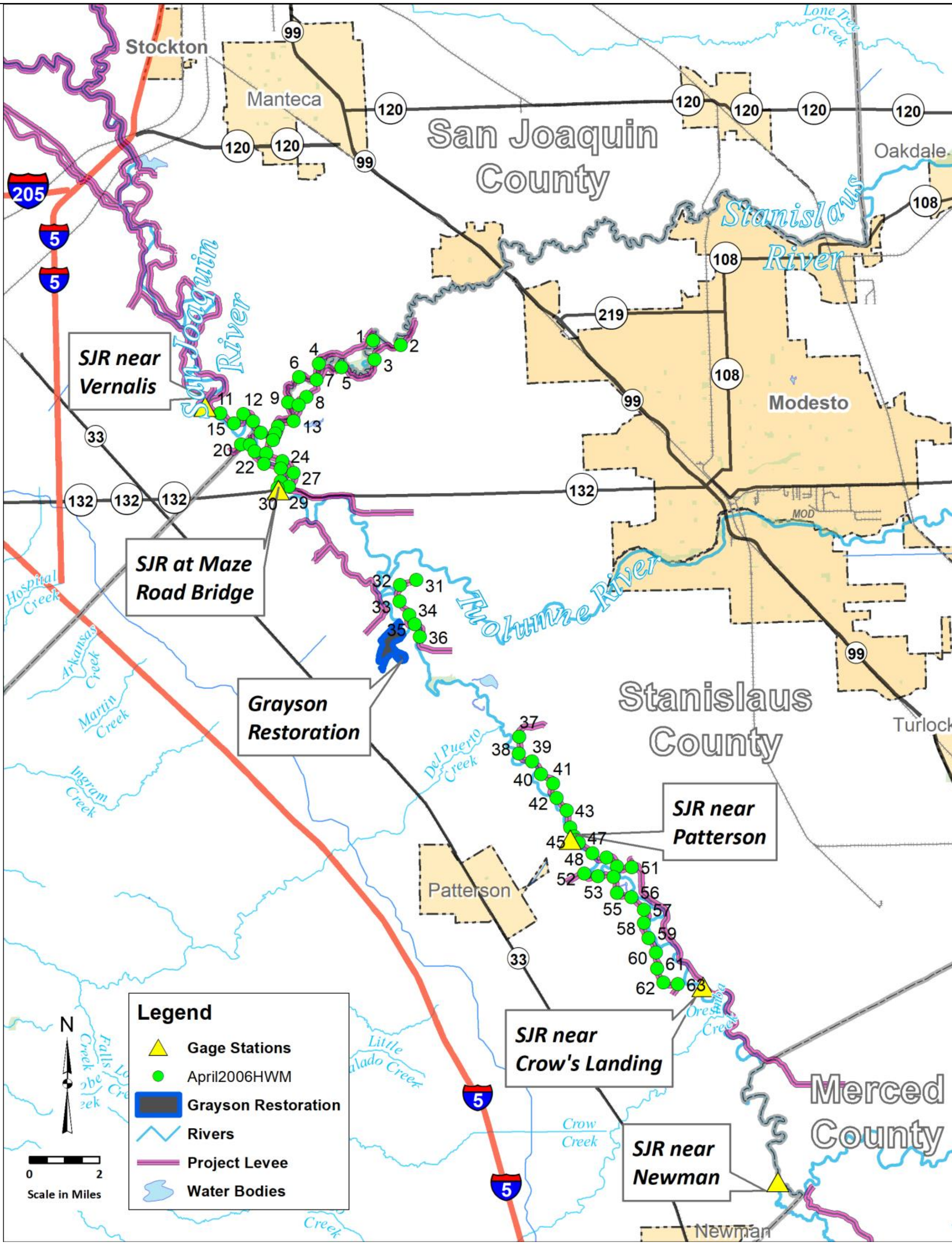


Figure 5. 2006 Flood Event - Stage Boundary Conditions



MBK ENGINEERS	Grayson Riverbend Preserve Restoration Project	2006 Breach Locations
		Figure 6



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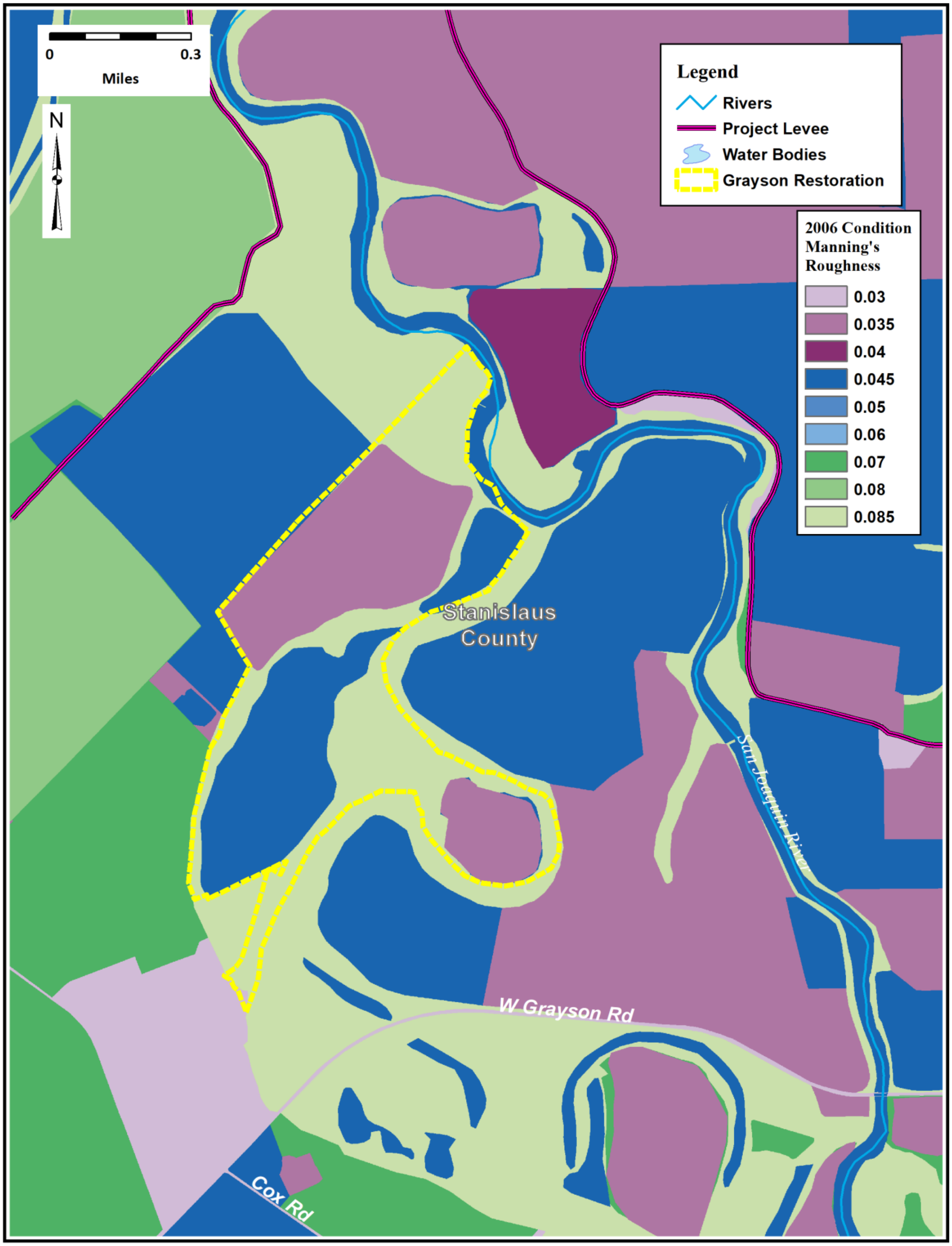
Grayson Riverbend Preserve Restoration Project

High Water Mark Locations

Figure 7



MBK ENGINEERS	Grayson Riverbend Preserve Restoration Project	Manning's Roughness Values - 2006 Event
		Figure 8

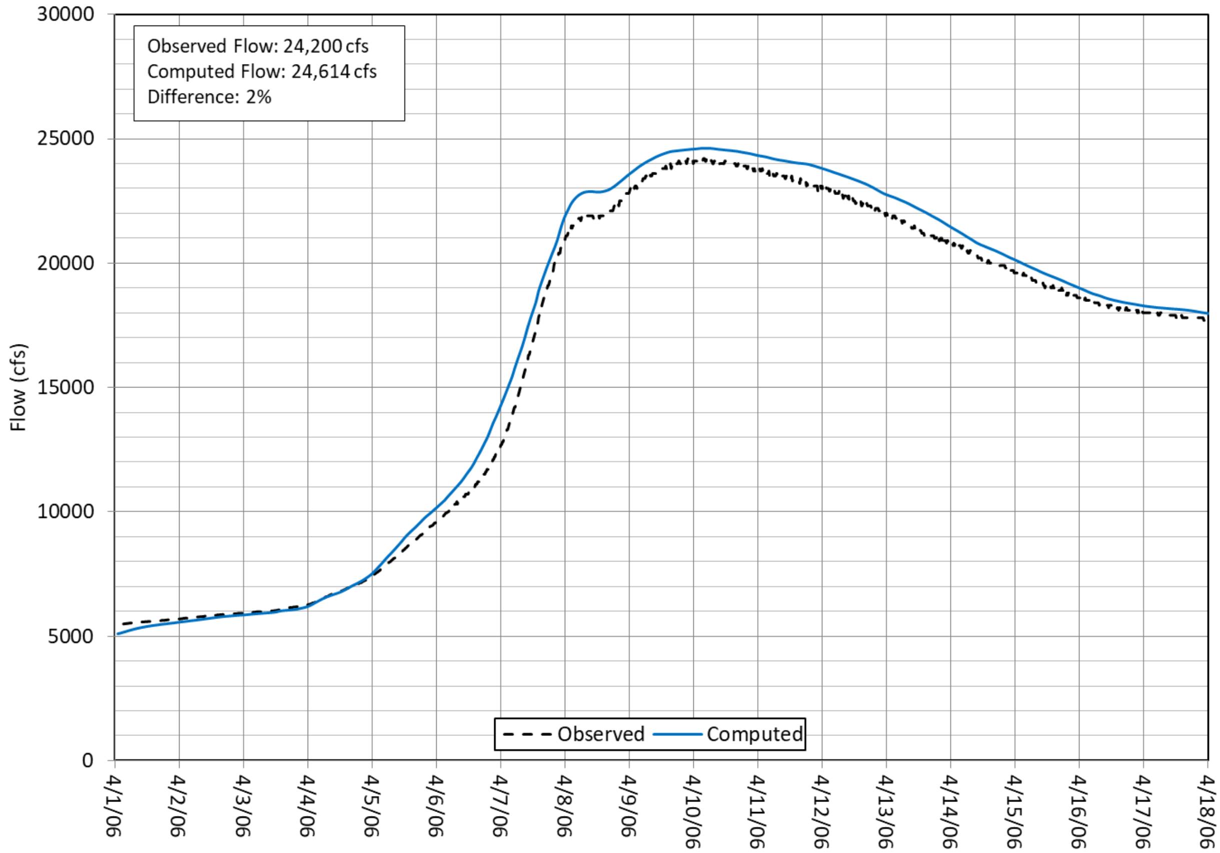


Figure 9. San Joaquin River at Crow's Landing – Flow

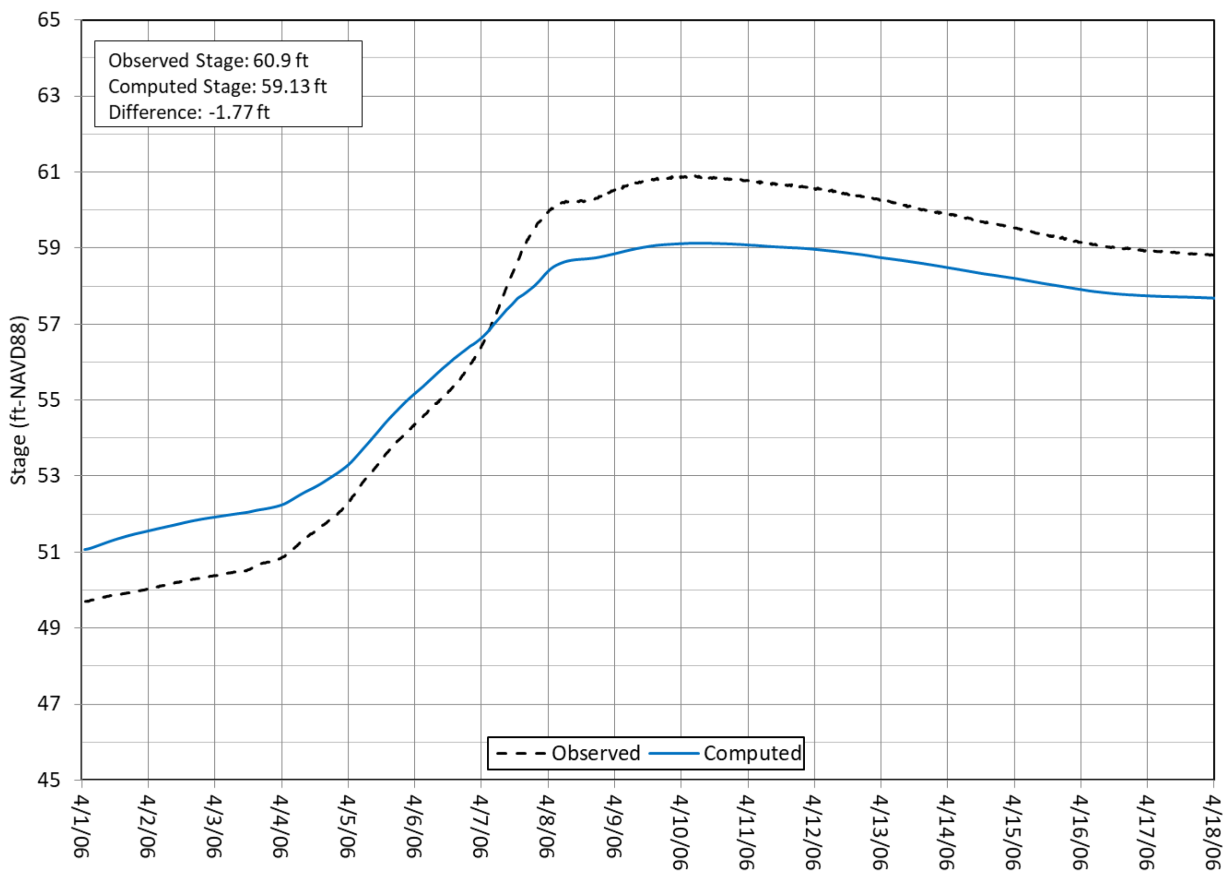


Figure 10. San Joaquin River at Crow's Landing – Stage

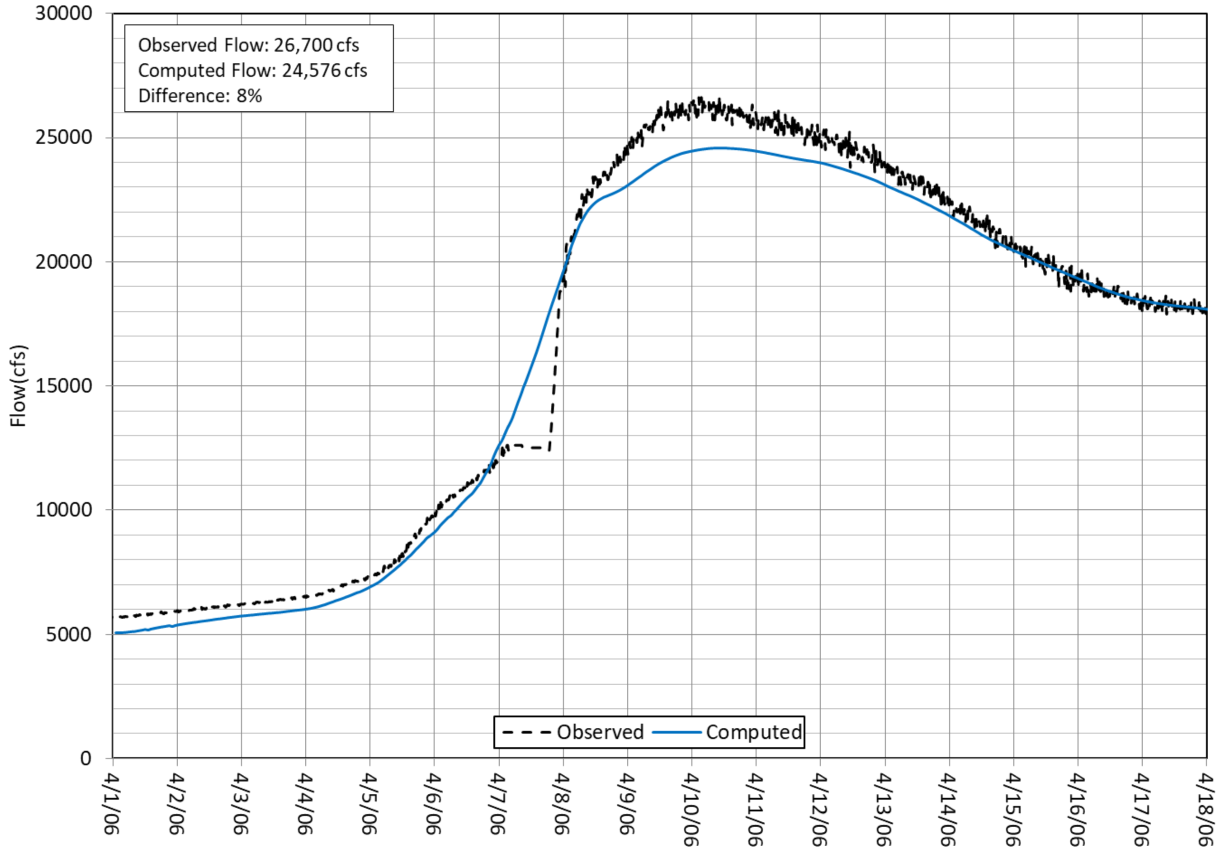


Figure 11. San Joaquin River at Patterson – Flow

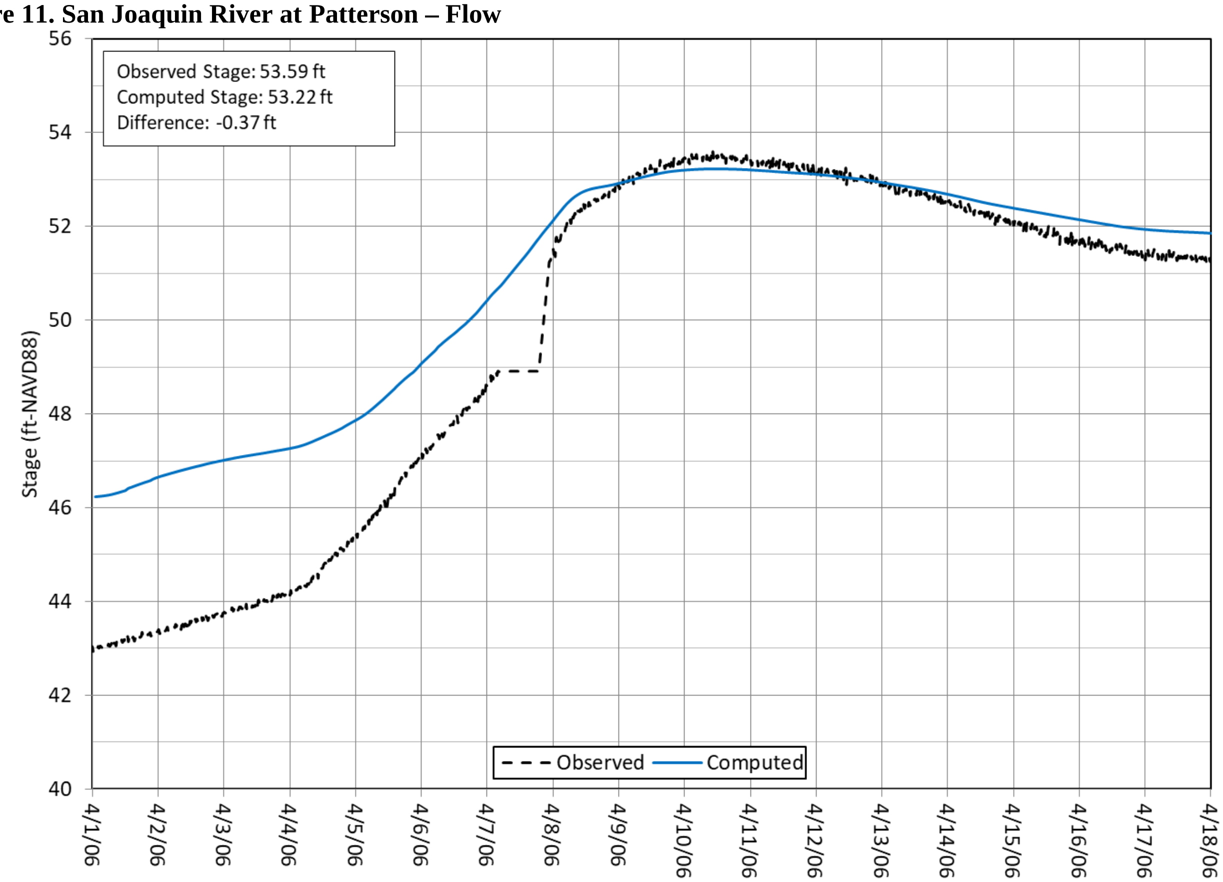


Figure 12. San Joaquin River at Patterson – Stage

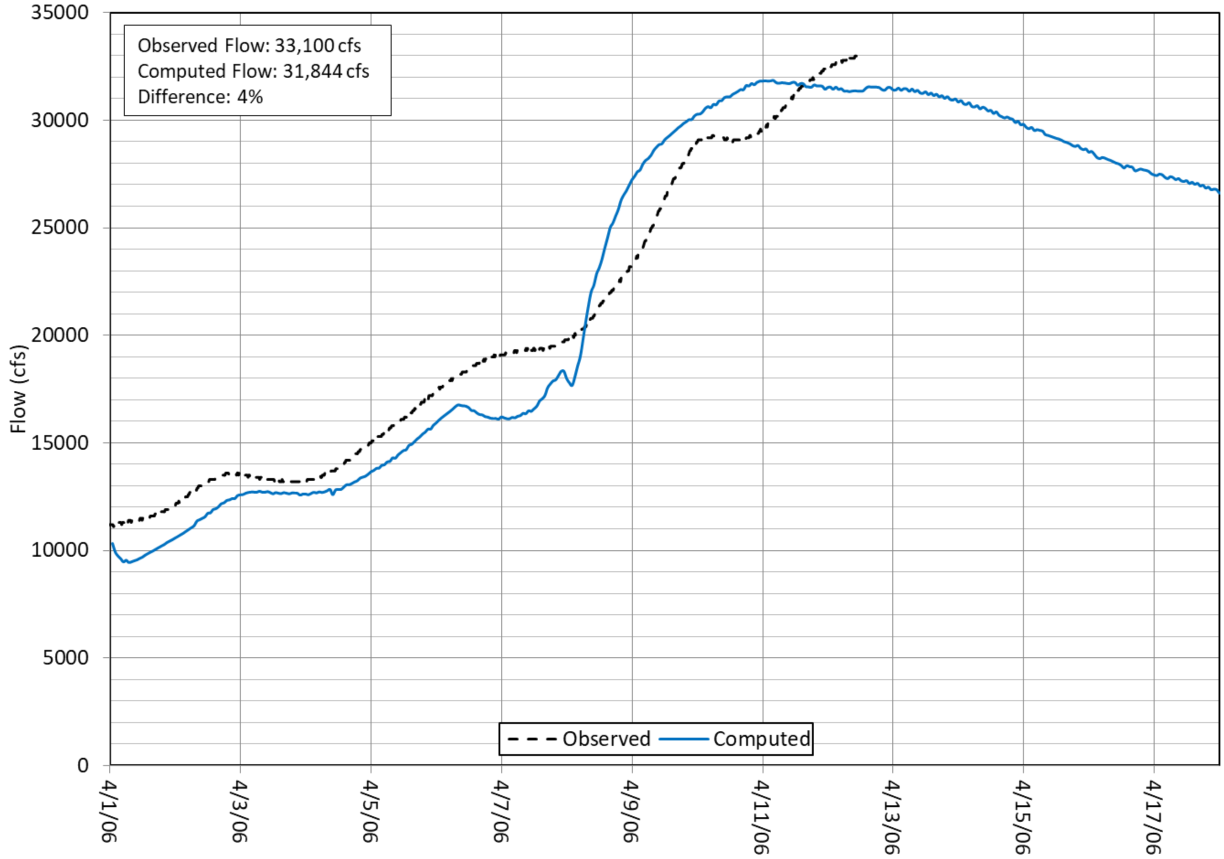


Figure 13. San Joaquin River at Maze Road – Flow

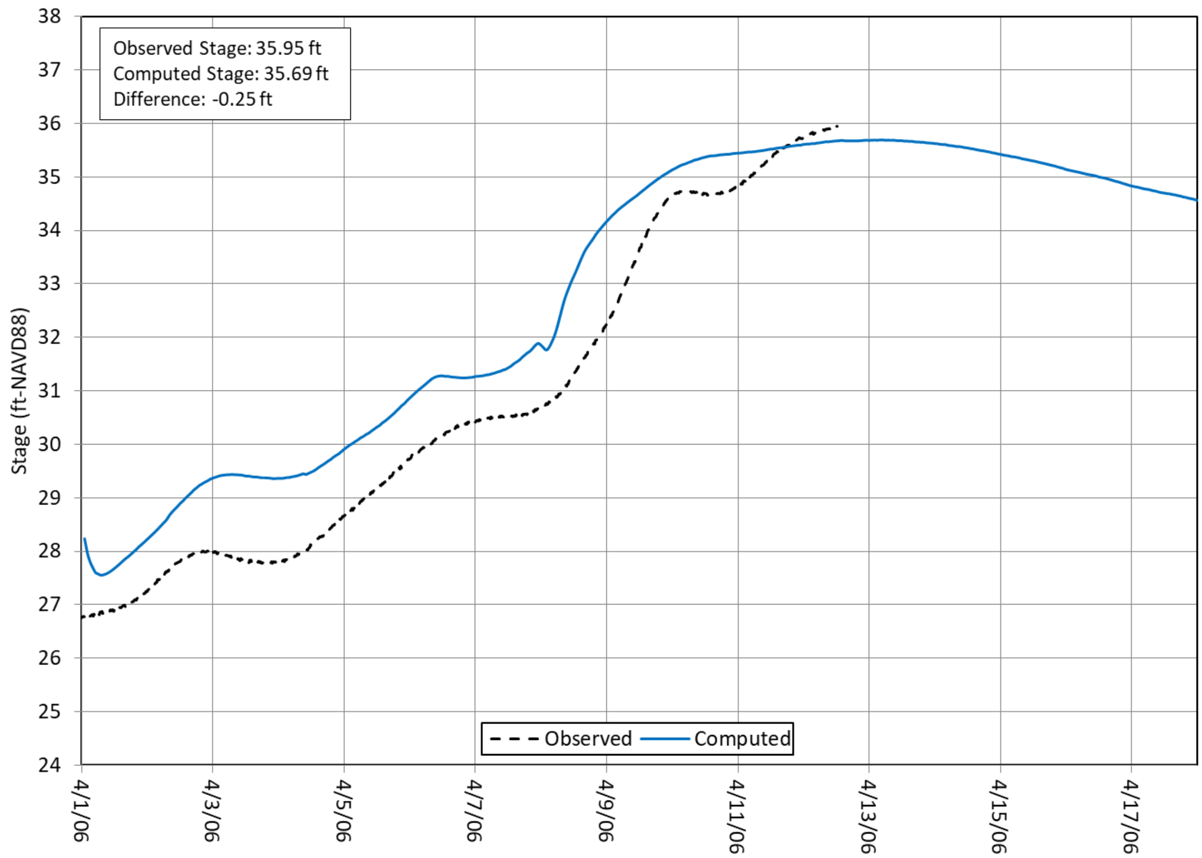
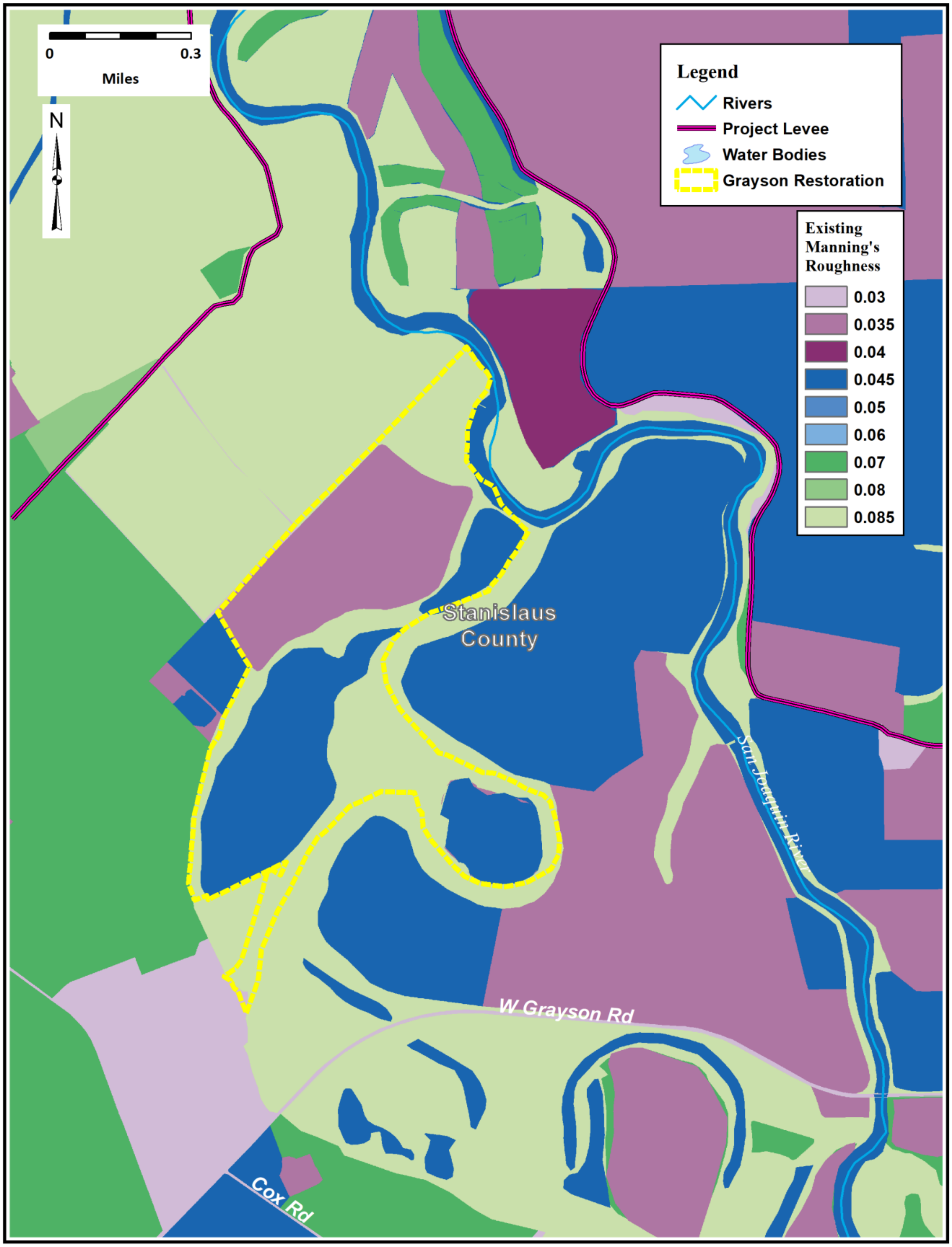


Figure 14. San Joaquin River at Maze Road – Stage



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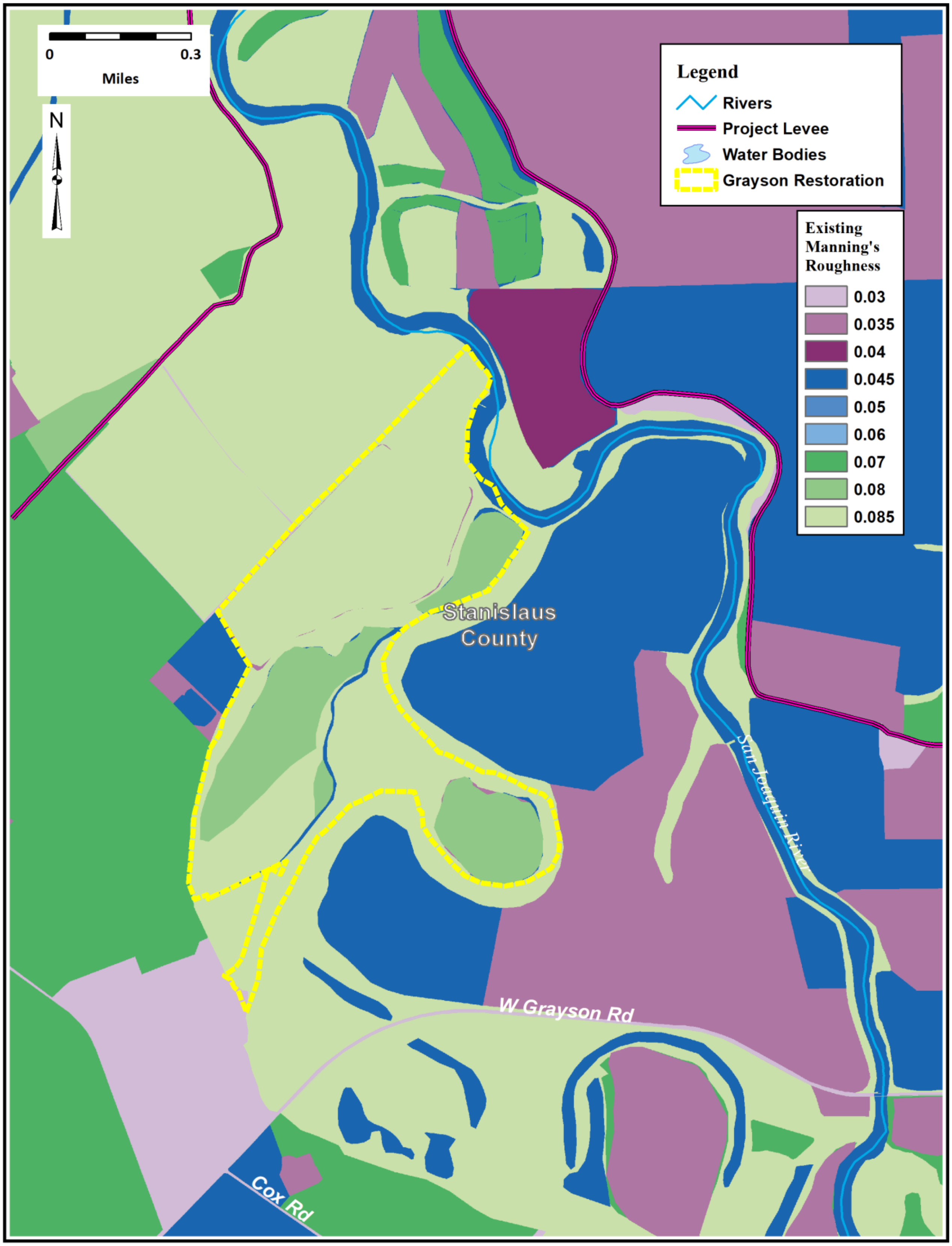
Grayson Riverbend Preserve Restoration Project

Manning's Roughness Coefficients Existing Condition

Figure 15



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Grayson Riverbend Preserve Restoration Project

Manning's Roughness Coefficients Project Condition

Figure 16

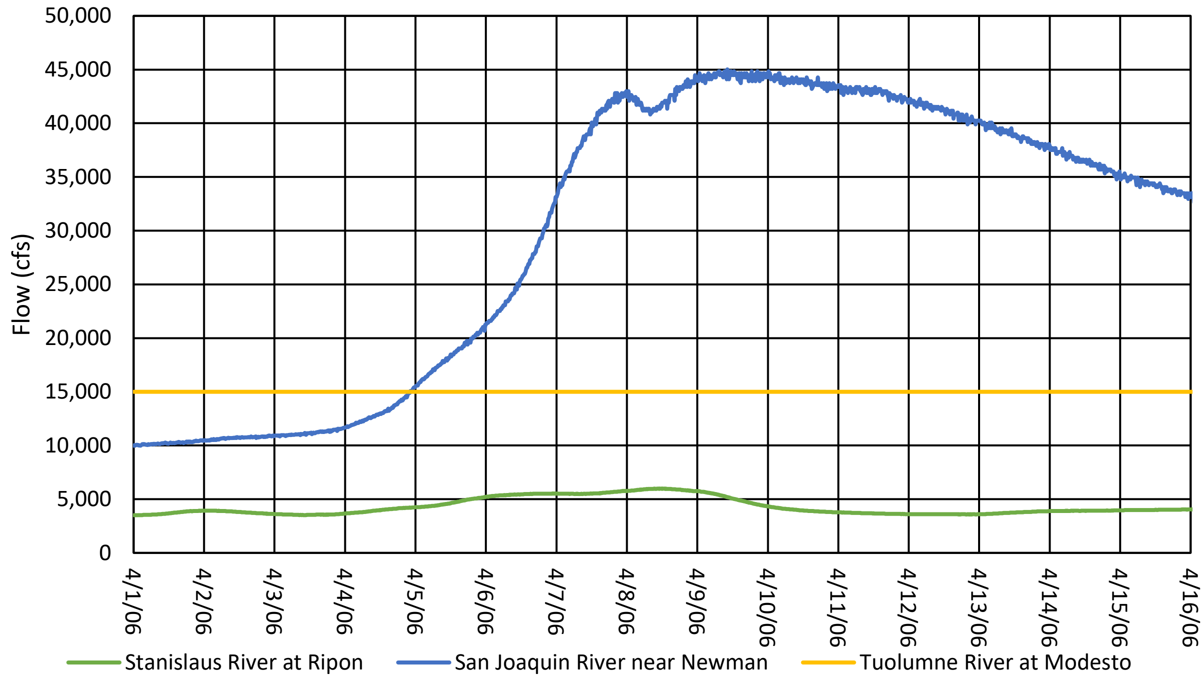


Figure 17. 1955 Design Flow Boundary Conditions

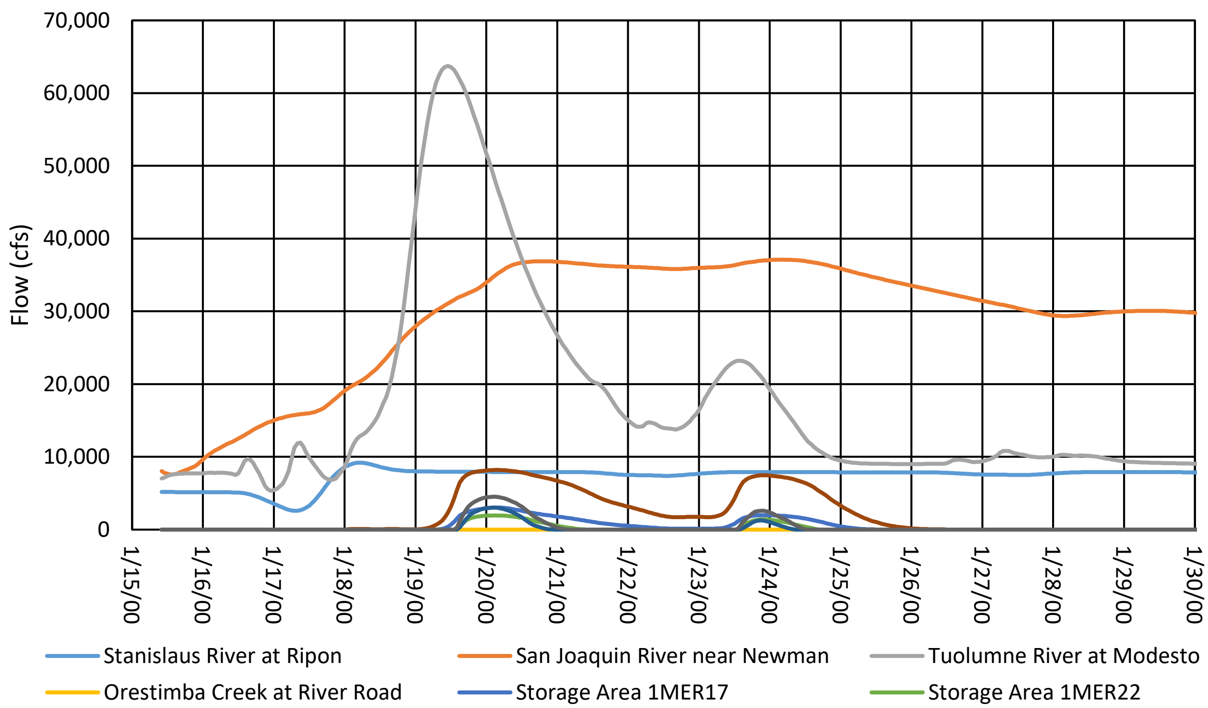


Figure 18. Comp Study 100-Year Flood Boundary Conditions

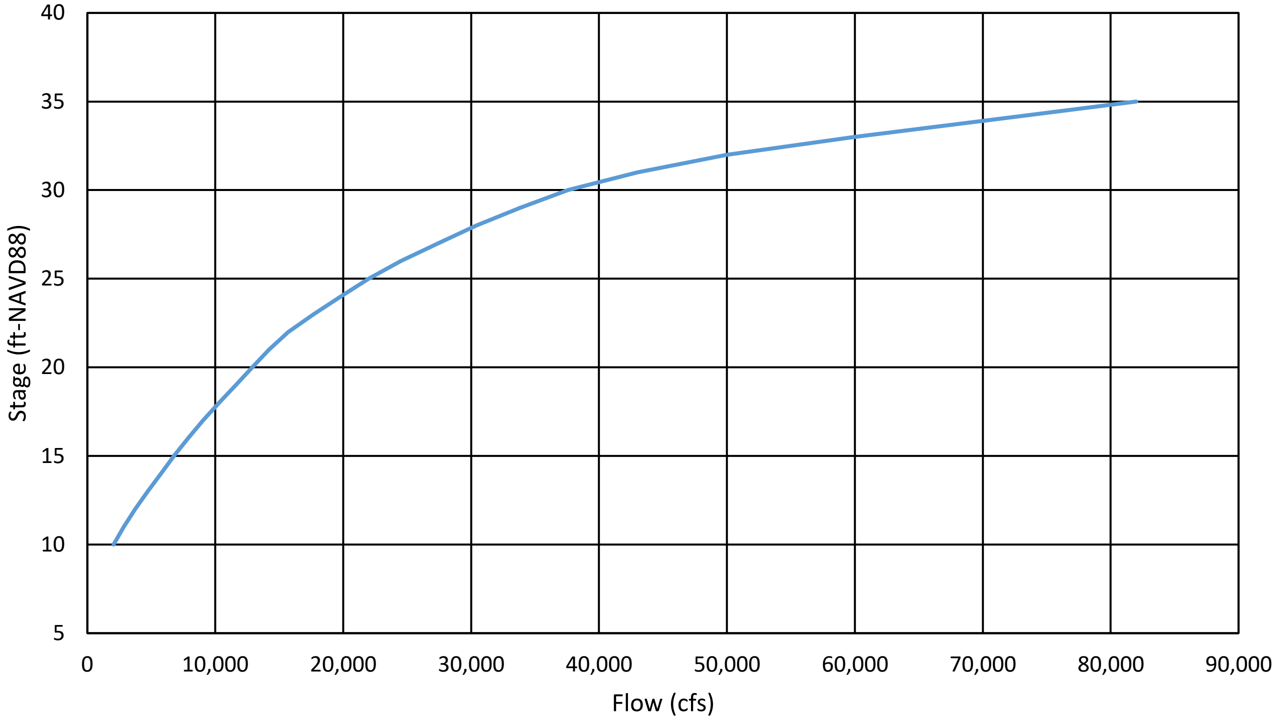
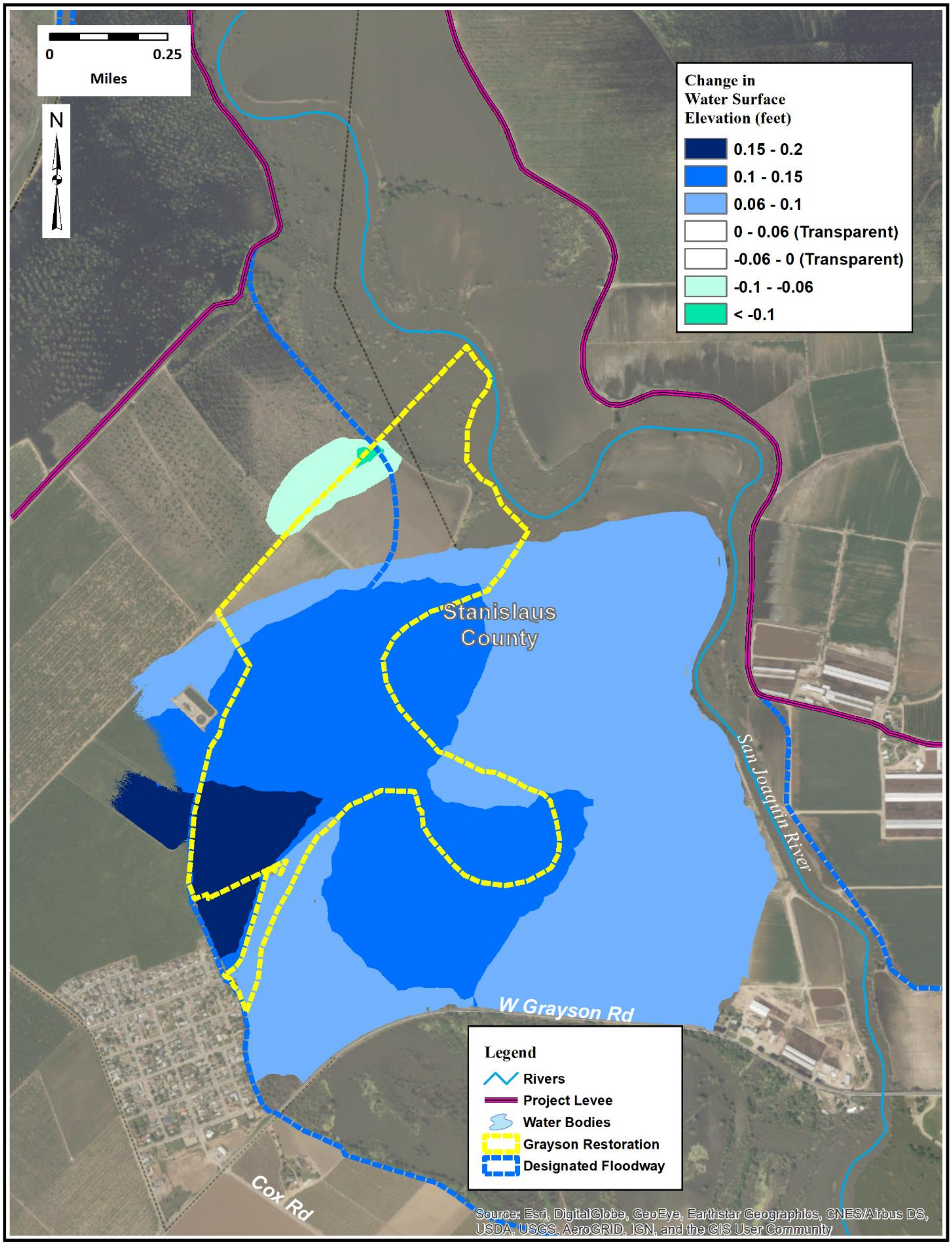
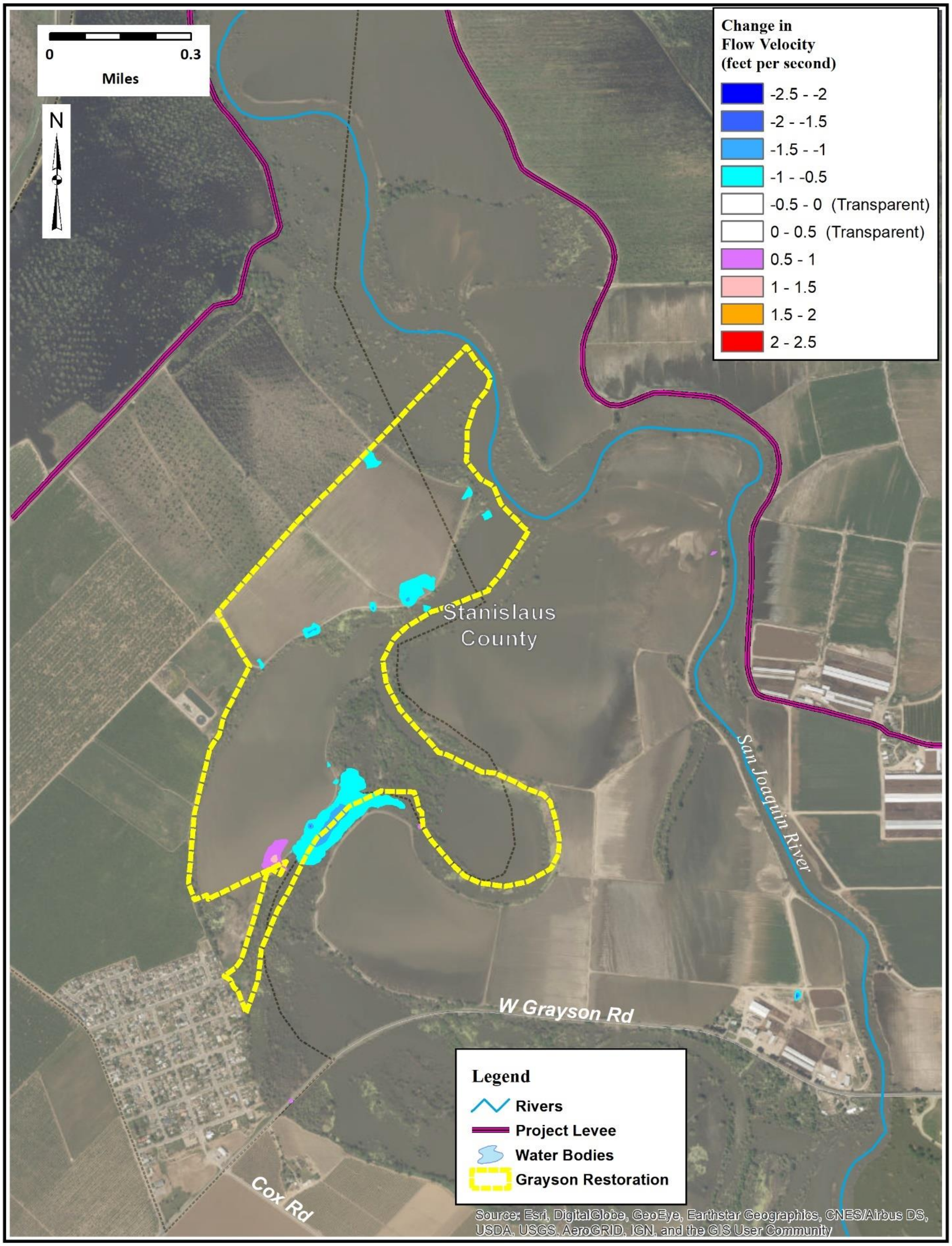


Figure 19. San Joaquin River near Vernalis Rating Curve



MBK ENGINEERS	Grayson Riverbend Preserve Restoration Project	Change in Water Surface Elevation 1955 Design Flow
		Figure 20



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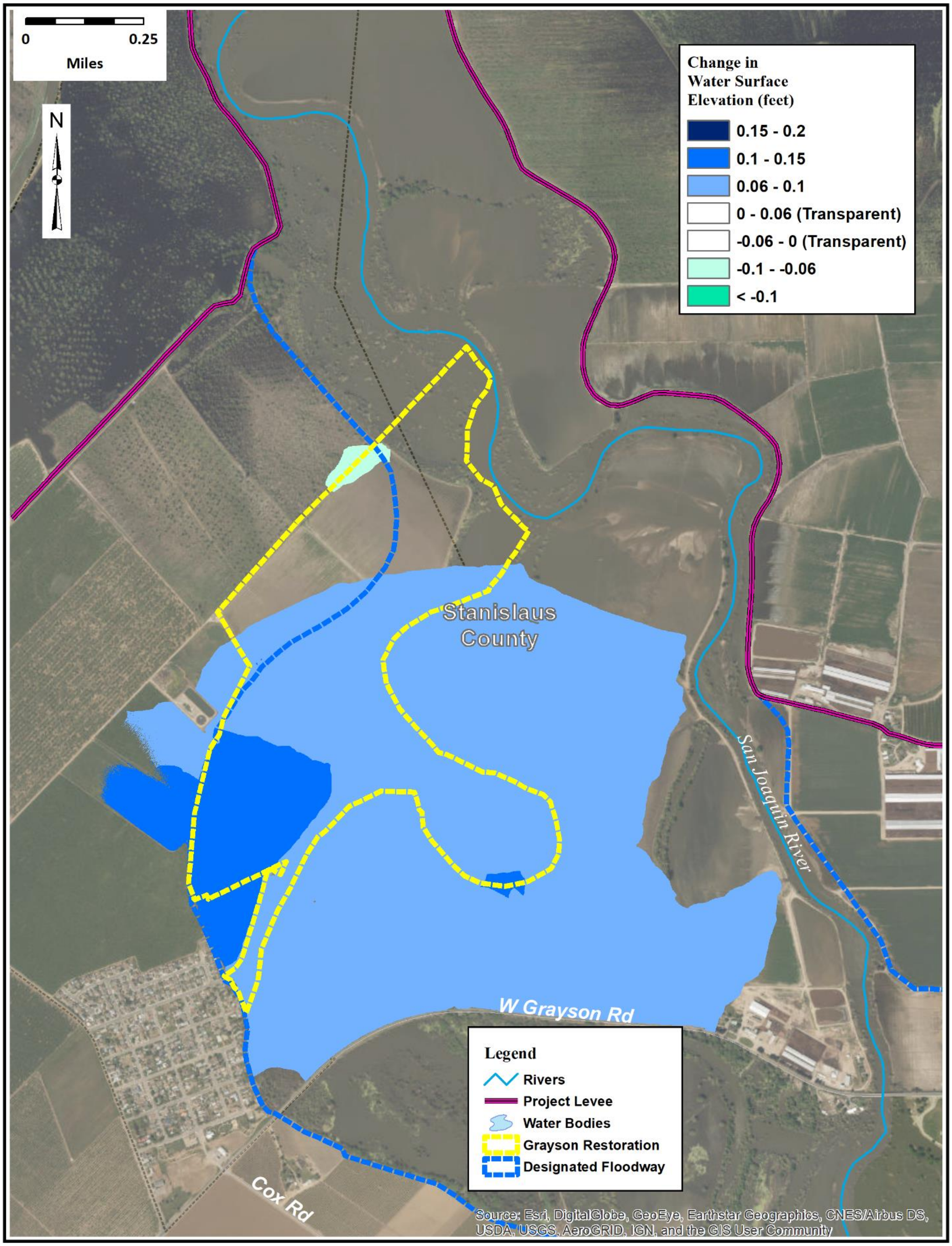
Grayson Riverbend Preserve
Restoration Project

Change in Flow Velocity
1955 Design Flow

Figure 21



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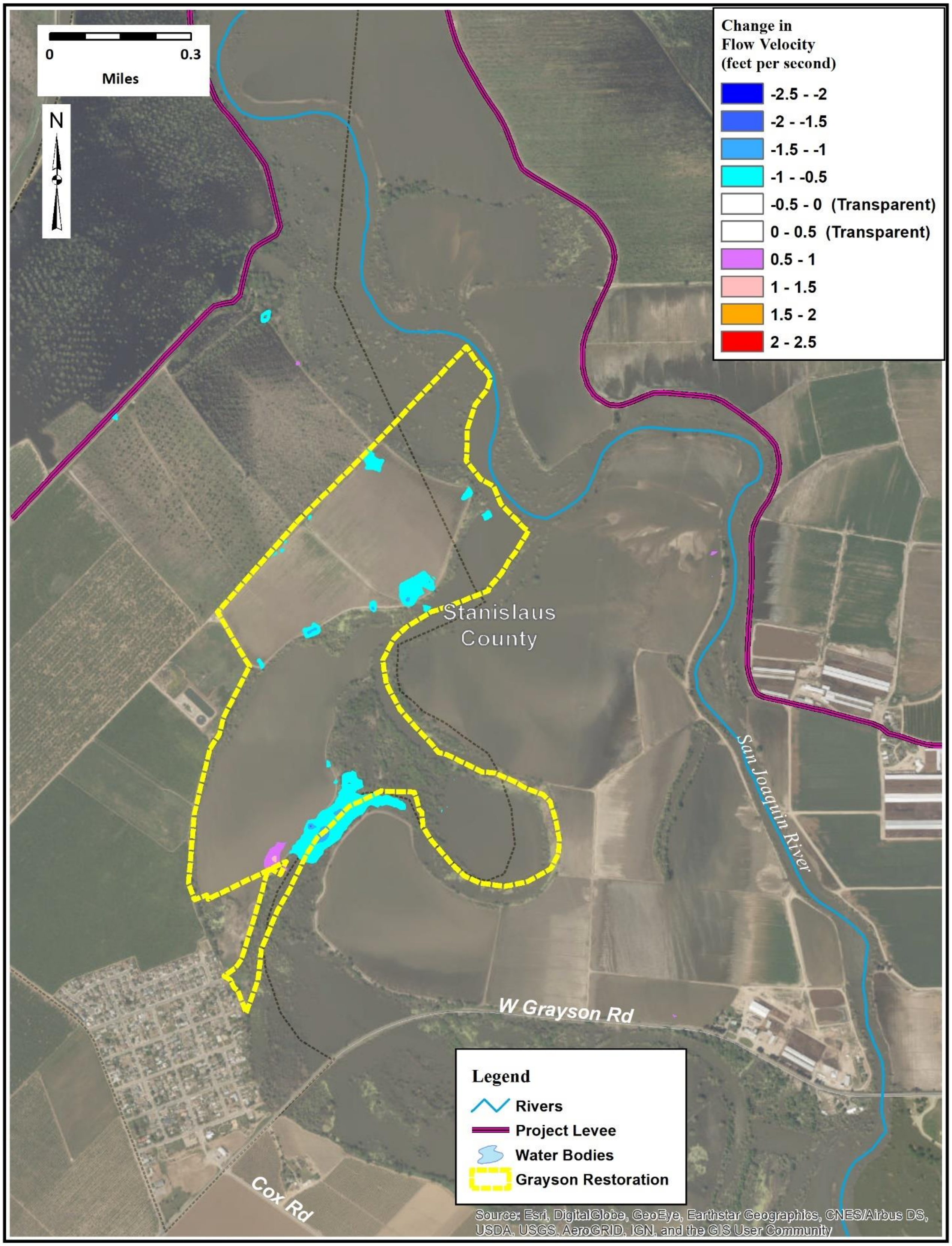
Grayson Riverbend Preserve Restoration Project

Change in Water Surface Elevation 1-in-100 Year Flow

Figure 22



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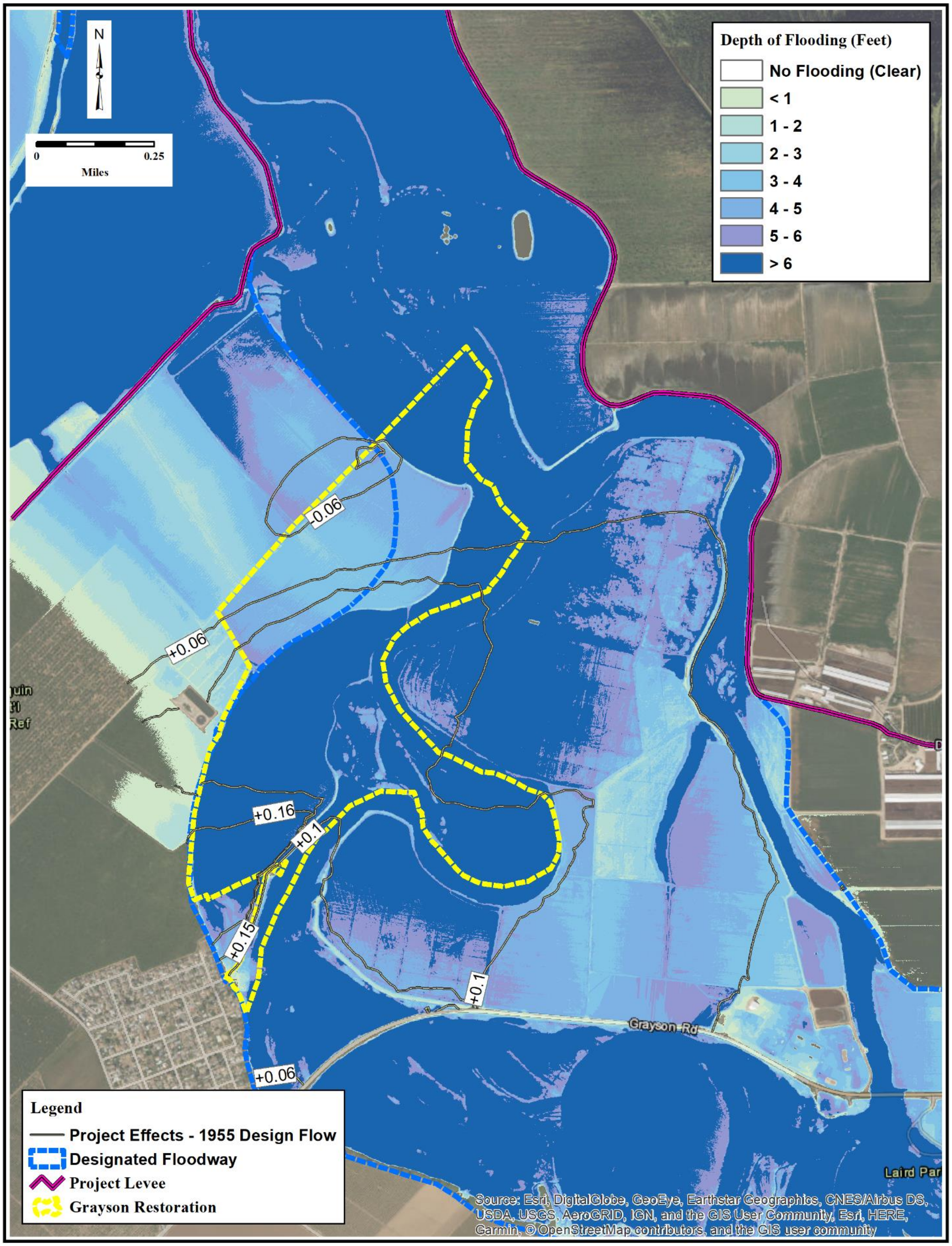
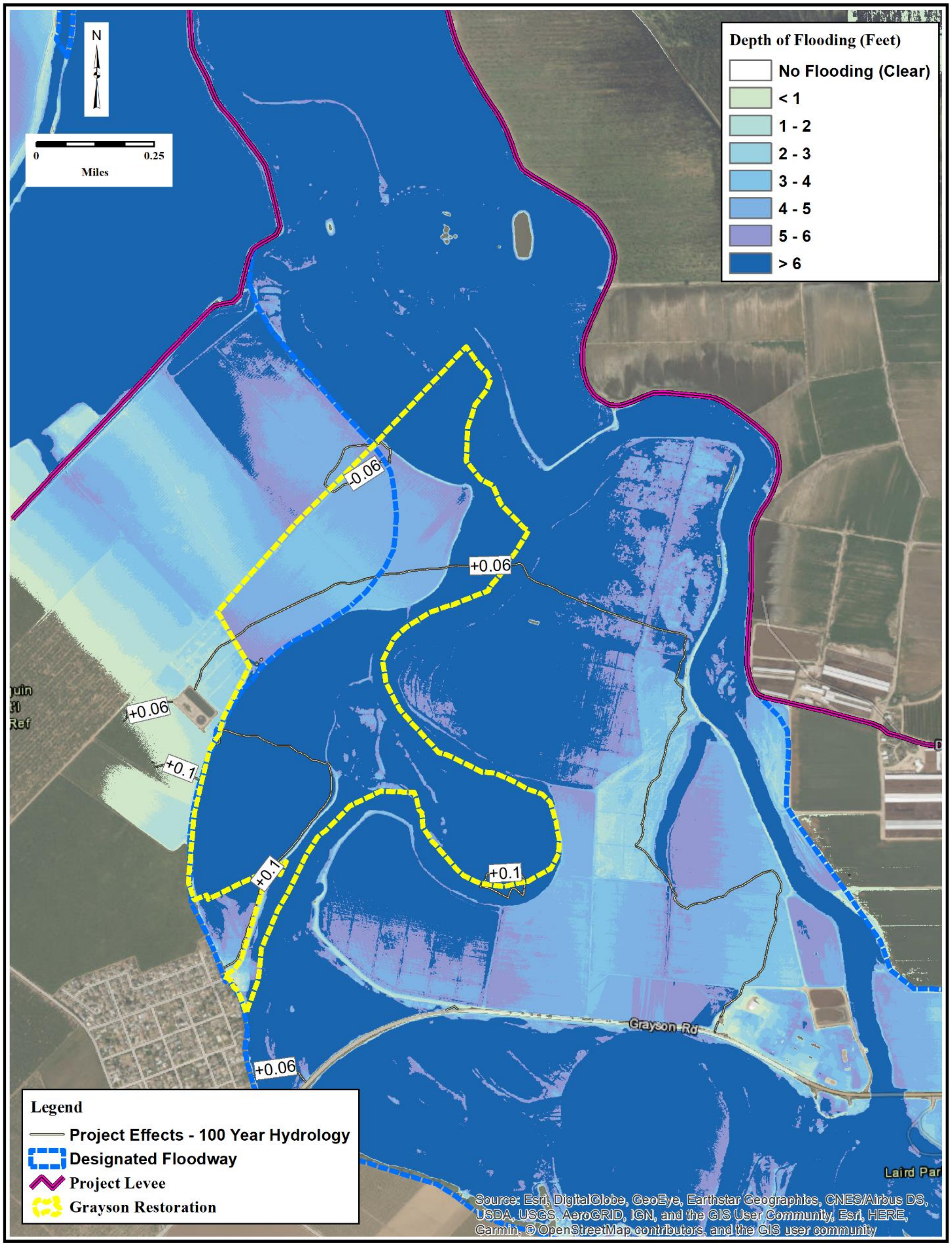
Grayson Riverbend Preserve Restoration Project

Change in Flow Velocity 1-in-100 Year Flow

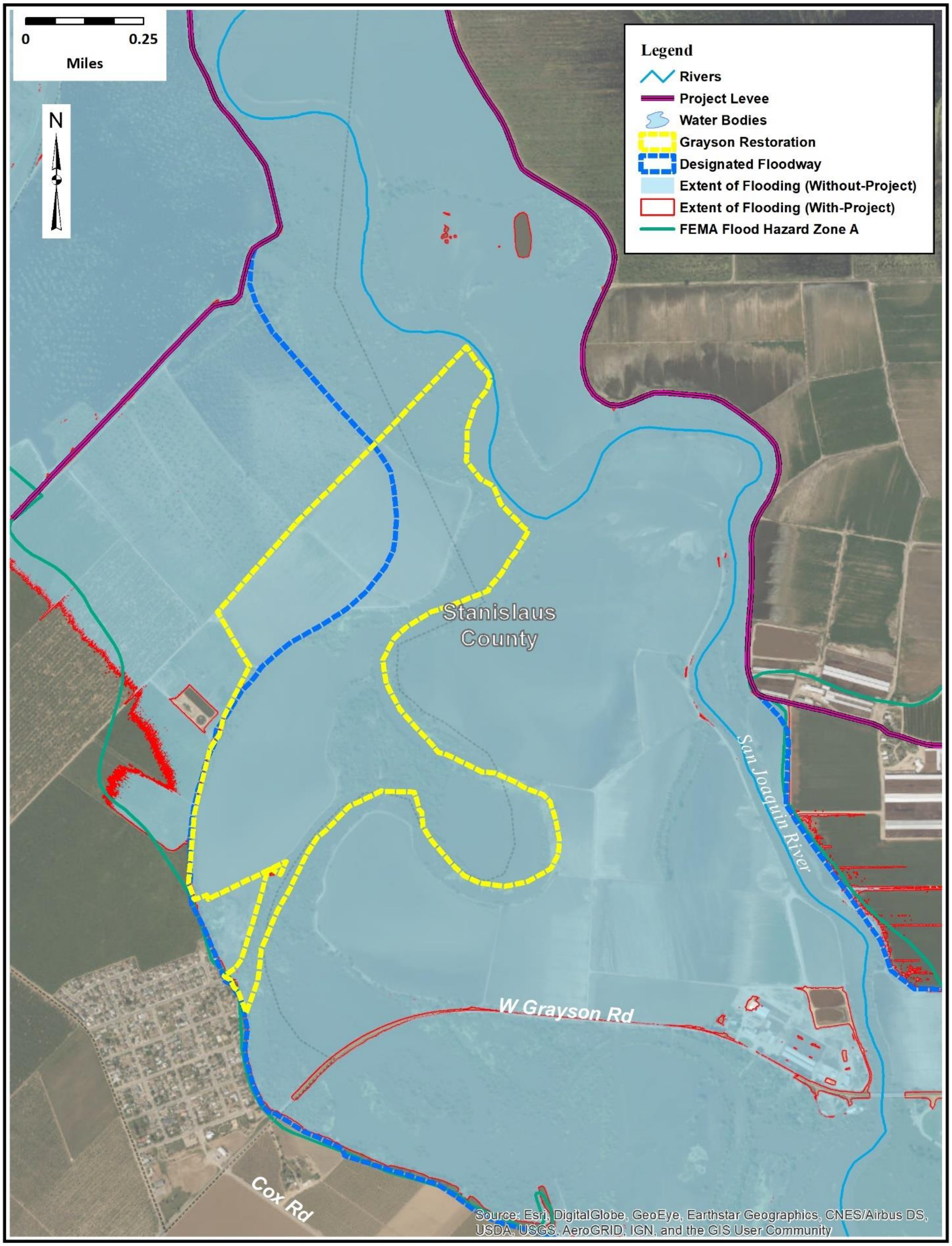
Figure 23



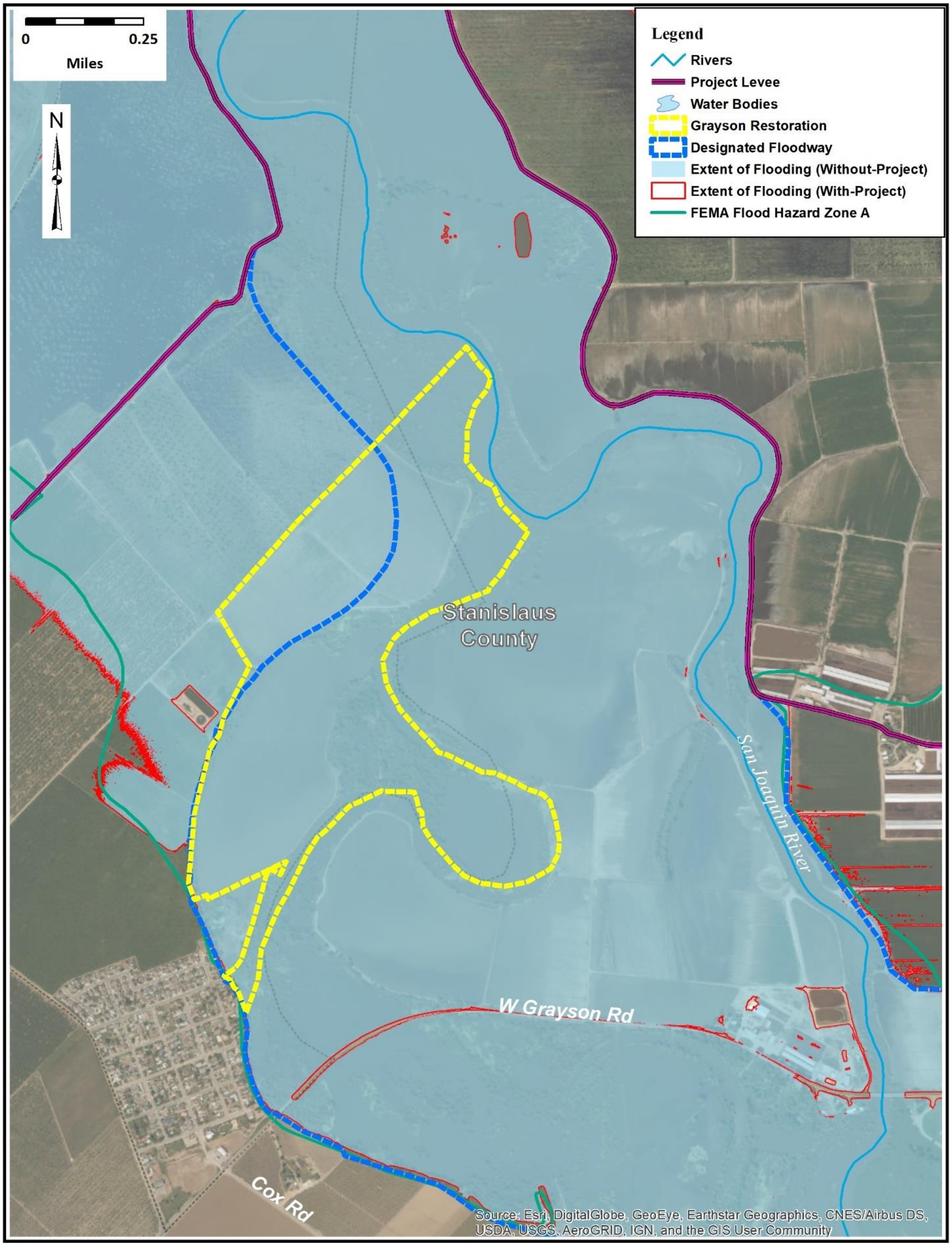
MBK ENGINEERS	Grayson Riverbend Preserve Restoration Project	Maximum Flood Depth 1955 Design Flow
		Figure 24



MBK ENGINEERS	Grayson Riverbend Preserve Restoration Project	Maximum Flood Depth 1-in-100 Year Flow
		Figure 25



MBK ENGINEERS	Grayson Riverbend Preserve Restoration Project	Maximum Flood Extent 1955 Design Flow
		Figure 26



MBK ENGINEERS	Grayson Riverbend Preserve Restoration Project	Maximum Flood Extent 1-in-100 Year Flow
		Figure 27