California Department of Fish and Wildlife

North Central Region

Summary of Fish Rescues Conducted within the Yolo and Sutter Bypasses

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Prepared By:

Marc Beccio

Environmental Scientist

Anadromous Fisheries

SUMMARY OF FISH RESCUES CONDUCTED WITHIN THE YOLO AND SUTTER BYPASSES

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ATTACHMENTS

1. Purpose

The purpose of this document is to summarize historical fish rescue efforts within the Yolo and Sutter Bypasses with respect to the timing and location of fish rescues, species composition and numbers of fish rescued; and relative success of fish rescue efforts. The majority of fish rescue efforts within the Yolo and Sutter bypasses were conducted within their respective weir aprons delineating the upstream end of the bypasses (Fremont Weir in the Yolo Bypass and Tisdale Weir in the Sutter Bypass). To aid in identifying other potential stranding and isolation sites Geographic Information System (GIS) data analysis was utilized to create figures showing known and potential isolation and stranding areas. The information contained in this document will: 1) lead to more efficient mobilization and implementation of future rescue efforts; and 2) provide a framework for floodplain habitat modifications to increase hydrological connectivity of features inundated during overtopping events with perennial waters that are eventually tributary to the Sacramento River (e.g., the Tule Canal and the Toe Drain). Data are also included for two recently established fish salvage or relocation sites in the Yolo Bypass: Wallace Weir and the Colusa Basin Drainage Canal. Fish isolation and stranding within the Yolo and Sutter bypasses; and subsequent fish rescues have been conducted by California Department of Fish and Wildlife (CDFW) for many decades. Cataloging of these efforts would aid in prioritizing remediation of isolation or stranding sites in the Yolo Bypass and dedicating contingency funding for fish rescues of salmon and sturgeon.

The U.S. Bureau of Reclamation (USBR) operates the Federal Central Valley Project (CVP) in coordination with the State Water Project (SWP) which is operated by the California Department of Water Resources (DWR). Operation of the CVP and SWP can significantly impact water quantity and quality, fish distribution and survival, and available aquatic habitats in the Central Valley and San Francisco Bay-Delta. The National Marine Fisheries Service (NMFS) evaluated these stressors in their 2009 Biological Opinion on the Long-term Coordinated Operation of the CVP and SWP BIOP and concluded they are likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*; federal and state endangered), Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha*; federal and state threatened) Central Valley steelhead *Oncorhynchus mykiss*; federal threatened), and the southern Distinct Population Segment of North American green sturgeon (*Acipenser medirostris*; federal threatened).

Based on their conclusion, NMFS identified reasonable and prudent alternatives (RPAs) to the proposed action that is expected to avoid the likelihood of jeopardy to these species and adverse modification of their Critical Habitat. The RPAs include:

Action I.7." Reduce Migratory Delays and Loss of Salmon, Steelhead, and Sturgeon at Fremont Weir and Other Structures in the Yolo Bypass"

This action requires the USBR and/or DWR to provide high quality, reliable fish passage beyond barriers in the Yolo Bypass. In the interim to completion of large-scale improvements addressing Action I.7, USBR has contracted CDFW to conduct fish rescues within the Yolo Bypass.

2. Background

The approximately 59,000-acre Yolo Bypass and approximately 18,000-acre Sutter Bypass are essentially leveed floodplains or basins designed to convey floodwaters from the Sacramento River and west side streams and drains around the populated regions of the central Sacramento Valley **(Figures 1 and 2)**. During high outflow events, water is diverted via floodgates or by overtopping of weirs and inundates the bypasses, which are bounded by a system of levees that serve to contain floodwaters within the bypasses.

Inundation of the Yolo Bypass occurs when Sacramento River flows overtop the Fremont Weir, located at RKM 226 (RM 140.4). The Fremont Weir spills on average once every two to three years (USBR and DWR 2012). Inundation of the Yolo Bypass occurs either through the operation of flood gates at the Sacramento Weir when Sacramento River flows are below bank-full levels or by overtopping of the Fremont Weir when Sacramento River stage height exceeds 33.5 feet above mean sea level; which occurs at a flow of approximately 1,622 cubic meters per second (57,290 cubic feet per second) (DWR 2016). Inundation of the Yolo Bypass is augmented by flows from west side tributaries including Cache Creek, Willow Slough, Willow Slough Bypass, Putah Creek, and South Fork Putah Creek (**Figure 3)**. Up to 80 percent of the Sacramento River's floodwaters are conveyed for a distance of approximately 50 km (31 miles) through the Yolo Bypass and returned to the Sacramento River via the Cache Slough Complex approximately two miles upstream of the town of Rio Vista. The Yolo Bypass capacity is 9,713 cubic meters per second (343,000 cfs) (DWR 2010).

The Tisdale Bypass is inundated by overtopping of the Tisdale Weir, located at river kilometer (RKM) 286 as measured from the Golden Gate Bridge (river mile [RM] 177.7) when Sacramento River flows exceed a stage height of 45.5 feet above mean sea level which occurs at a flow of approximately 595 cubic meters per second (21,012 cfs). The Tisdale Bypass conveys flows east for approximately seven km (four miles) into the Sutter Bypass. The Sutter Bypass also receives flood waters from overtopping of the Colusa and Moulton weirs. Of all Sacramento River flood control structures, the Tisdale Weir spills with the greatest frequency and longest duration. Tisdale Weir overtopping often occurs as a result of flash flows from various Sacramento River tributaries (e.g., Cottonwood, Cow, Butte, Big Chico creeks). The Tisdale Weir capacity is 1,076 cubic meters per second (38,000 cfs) (DWR 2010).

The Yolo Bypass serves as a migration corridor for adult and juvenile anadromous fish, rearing habitat for juvenile salmonids and other freshwater fish species. The perennially inundated areas of the Yolo Bypass such as the Knights Landing Ridge Cut, Tule Canal, and Toe Drain are habitat for a number of resident native and non-native fish species. DWR has documented 42 fish species within the Yolo Bypass (DWR 2002). Among these are several federal and state anadromous listed species including Sacramento River winter-run Chinook salmon (federal and state endangered), Central Valley spring-run Chinook salmon (federal and state threatened) Central Valley steelhead; (federal threatened), and the southern distinct population segment (DPS) green sturgeon (federal threatened). Flows within the Yolo Bypass are typically much greater than flows within the Sacramento River during weir overtopping events, attracting anadromous fish migrating up the Sacramento River into the Yolo Bypass at the Cache Slough complex. Even in years when the Fremont Weir does not spill, west side tributary and drainage canal flows can

attract anadromous fish into the Yolo Bypass at the Cache Slough complex, particularly during periods of high tides and low Sacramento River flows. Fish attracted by west side stream and drainage canal flows migrate upstream through the Toe Drain, Tule Canal, Knights Landing Ridge Cut, and Colusa Basin Drain Canal. Similarly to fish isolated and stranded during weir spill events, fish attracted into the Yolo Bypass by west side tributary and drainage canal flows are unable to return to the Sacramento River. CDFW initiated fish trapping and rescue efforts in the CBDC in 2013 and at the Wallace Weir in the Knights Landing Ridge Cut in 2014 to return anadromous fish that migrated upstream after entering the Yolo Bypass at the Cache Slough Complex.

Juvenile or young-of-year (YOY) anadromous fish species emigrating from the Sacramento River and its tributaries typically enter the Yolo and Sutter bypasses when flows overtop their respective weirs. While YOY salmonids can make their way back to the Sacramento River when there is sufficient floodplain connectivity, YOY may also become isolated in weir aprons, shallow pools, drainages, and swales within the bypasses when floodwaters recede and connectivity to the Sacramento River is lost.

Adult Chinook salmon, steelhead, sturgeon and other fish may become isolated and subsequently stranded in the Tisdale Bypass when migrating either up the Sutter Bypass from the Sacramento River during or overtopping of the Tisdale Weir during high flow events. When flows recede below the top of the Tisdale Weir, these and other fish species can become stranded in the Tisdale Weir apron below the weir and in various ponds, scour pools, drainages, and swales within the Tisdale and Sutter bypasses. Butte Creek also drains through the Sutter Bypass prior to its confluence with the Sacramento River which can result in salmonids returning to Butte Creek or emigrating from Butte Creek to the Sacramento River becoming isolated in the Sutter or Tisdale bypasses.

Figure 1. Site and Vicinity – Yolo Bypass and Fremont Weir

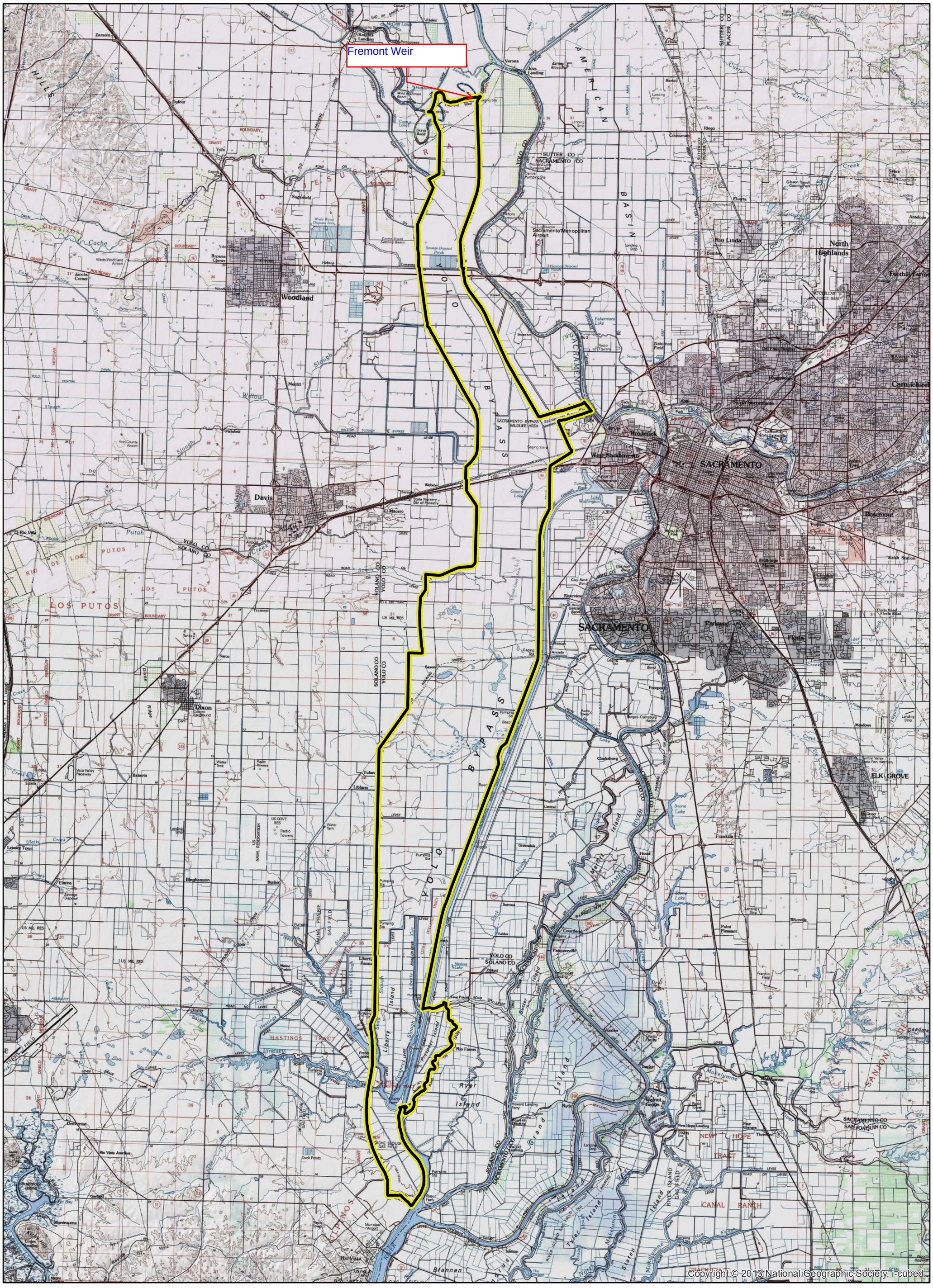
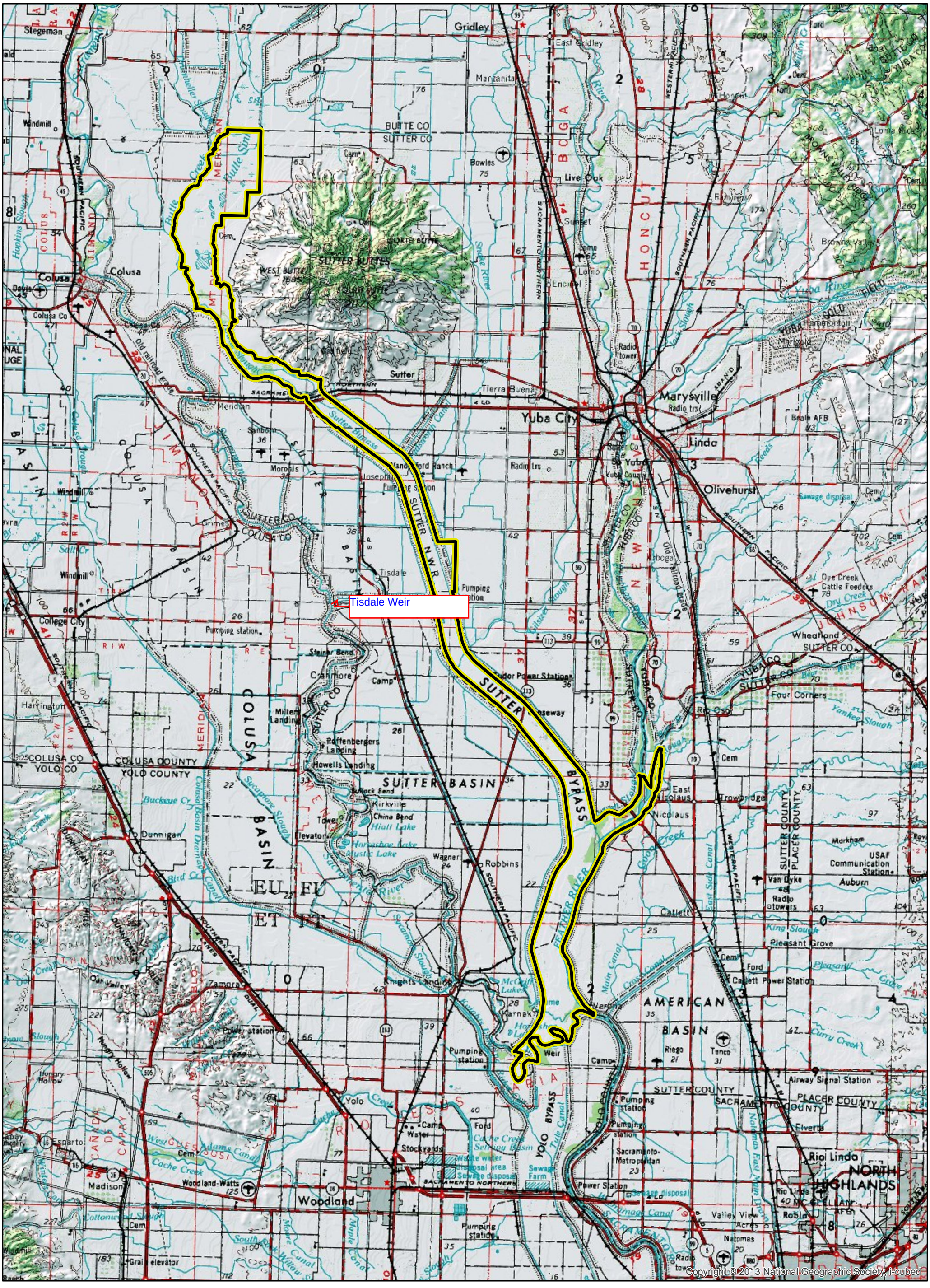


Figure 2. Site and Vicinity – Sutter Bypass and Tisdale Weir



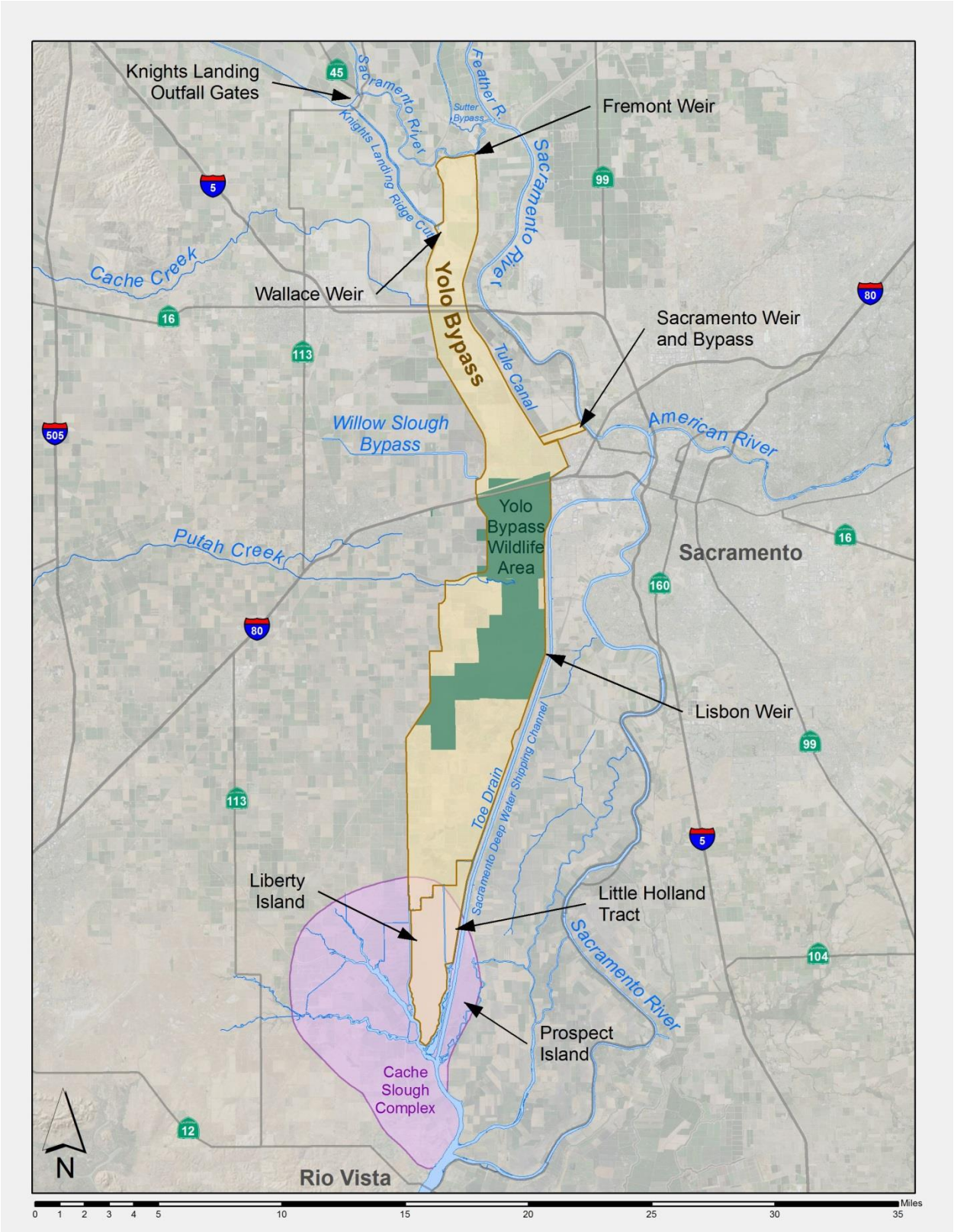


Figure 3. Yolo Bypass Westside Tributaries and Cache Slough Complex

Figure 4. View of Fremont Weir Denil fish ladder during overtopping event in January 2006. Flash boards are left in place until overtopping of the weir ceases.

A Denil fish ladder (a 1.2 meter-wide notch in the eastern portion of the Fremont Weir) was constructed in 1966 to facilitate adult fish passage back into the Sacramento River following several years of Chinook salmon stranding in the Yolo Bypass. CDFW operates the fish ladder which is opened by removal of the upstream flash boards when overtopping of the Fremont Weir ceases during the descending curve of the hydrograph. The timing of the flashboard removal is mandated by the Central Valley Flood Protection Board permit number 4899 issued to CDFW on 1 April 1965 (Central Valley Flood Protection Board 2016) **(Figures 4 and 5).**

The ladder was originally designed for salmonid passage, and has been somewhat effective in facilitating passage of adult salmonids to the Sacramento River as shown from a reduction in the number of adult Chinook salmon stranded behind the weir after its construction in 1966 (CDFW unpublished data). However; the size of the ladder in relation to the overall weir length in combination with the magnitude and duration of attractant flows may not enable all adult salmonids to locate and utilize the fish ladder. Further, passage to the Sacramento River can be impeded by obstructions or irregularities in the channel upstream from the fish ladder when flows within the channel begin to recede (USBR, DWR 2012). Importantly, the western portion of the weir does not have a fish ladder and is not hydrologically connected to the eastern portion of the weir once overtopping flows cease. Therefore fish stranded and isolated on the western portion of the weir do not have the opportunity to return to the Sacramento River on their own volition.

Figure 5. View of Fremont Weir Denil fish ladder after cessation of an overtopping event in March 2016. Note that flash boards have been removed to facilitate fish passage through the weir.

Based on the number of adult sturgeon stranded in the weir apron, the design, configuration, and operation of the fish ladder may have been ineffective to facilitate passage of adult sturgeon (CDFW unpublished data, USBR and DWR 2012). The Denil fish ladder infrastructure was removed to facilitate sturgeon passage in 2012. However; there has been only one overtopping event since the removal of the ladder infrastructure (late March 2016) so there is insufficient data to determine if the modification of the ladder has resulted in an increase in sturgeon passage. In addition to the weir apron, isolation and subsequent stranding also occurs in various ponds, scour pools, drainages, and swales downstream of the Fremont Weir.

3. Methods

Data from historical fish rescue efforts were obtained through the following sources: The CDFW Region 2 Anadromous Fisheries files, the CDFW Document Library, which contains scanned documents dating back to the 1930s; personal communications with current and retired CDFW staff and other agency personnel involved with fish rescue efforts, and internet searches for scientific literature and newspaper articles. Data were compiled in an Excel spreadsheet for subsequent analysis. Data parameters from fish rescue efforts included rescue location, rescue date, document date, document author(s), species and numbers of each rescued, origin (wild or hatchery), and life stage. Equipment used to conduct fish rescues typically consisted of beach seines, backpack electro-fishers, dip nets and a trammel net. Various fish crowder racks were used on occasion to crowd fish into areas that could be readily seined or dip netted. Beginning in 2011, fish rescue efforts included acoustic tagging of adult green and white sturgeon and

anchor tagging of adult Chinook salmon to provide data on the survival and continued migration of recued fish to their respective spawning grounds. Depending on the distance between capture and release points, staff carried fish to the Sacramento River or fish were placed and held in rescue trailers supplied with oxygen tanks and water circulators prior to transport and release into the Sacramento River.

In addition to the fish rescues documented in the above tables, CDFW staff conducted a number of "undocumented" fish rescues at the Fremont Weir during the 1980s and early 1990s prior to the listing of Sacramento River winter run Chinook salmon, Central Valley Chinook salmon, Central Valley steelhead, and green sturgeon. CDFW policy regarding fish rescues prior to the listing of these species was somewhat inconsistent. Dates, species composition, and numbers of fish rescued during these efforts were either not recorded or the data was no longer available.

GIS and other geomorphological data where compiled and analyzed for mapping of known and potential isolation and stranding sites (e.g., ponds, scour pools, swales, drainages, ponded areas formed by temporary and permanent road crossings and earthen berms); these were identified using a combination of aerial photographs, global positioning system (GPS) coordinates, light detection and ranging data (LiDAR), and site descriptions from reports of fish rescue efforts. LiDAR data was determined to provide the best overall method for identifying all possible fish isolation and stranding areas within the Yolo Bypass. The source data used to create figures identifying Yolo Bypass fish isolation and stranding locations was the Central Valley Floodplain Evaluation and Delineation (CVFED) digital elevation model (DEM) which was derived from a March/April 2008 LiDAR data collection. The CVFED LiDAR data has a vertical accuracy of 0.18 meter (0.6 feet) and a horizontal accuracy of 1.1 meter (3.5 feet). The average point spacing was one meter (3.28 feet). The DEM data was received from DWR as 375 tiles in ESRI GridFloat (.flt) format. The data was projected as UTM Zone 10 North, NAD 83, U.S. and a vertical datum of NAVD88. The tiles were mosaicked together to produce a raster DEM with a spatial resolution (i.e., pixel size) of 0.97 meter (3.125 feet).

The Fill tool in ESRI's ArcGIS 10.3 software was used to identify sinks in the DEM and fill them. Sinks are cells or a contiguous group of cells that represent a depression in the DEM that cannot drain via surface drainage because all surrounding cells are higher in elevation. Once identified, these sinks were "filled" by replacing the original elevation value of the cells with the elevation value of the lowest neighboring cell. Each sink was filled, in an iterative manner, from its lowest point up to its pour point – that is the elevation at which natural outflow to cells of lower elevation was achieved. The depth of each sink was then determined by subtracting the original DEM from the "filled" DEM. It should be noted that many of the sinks identified within the Yolo Bypass are due to the presence of levees and dikes which block the flow of water across the landscape. Potential stranding sites within the Yolo Bypass were overlaid on Digital Elevation Model (DEM) background imagery and are shown in **Attachment 1.** LIDAR data for the Sutter Bypass is not available, and minimal ground truthing efforts for potential stranding areas have been conducted. **Attachment 2** shows several known and potential isolation and stranding areas within the vicinity of the Tisdale Weir overlaid on an aerial photograph.

The Colusa Basin Drainage Canal (CBDC) fish trapping site is located at N 38°54'10.78" and W121°54'54.71". The CBDC fish trap consists of a resistance weir designed to funnel fish into a trap (Figure 5). The CBD fish trapping site was fished from 2 November 2013 through 5 June 2014 and

beginning 14 August 2015 through the date of this report. Salmonids captured at the CBD site were placed in fish transport trailers and transported and released into the Sacramento River at the Elkhorn boat launch facility. All other fish species captured were released in the channel upstream of the trap and therefore were not considered as "rescued" and are not included in **Table 3.**

The Wallace Weir trapping site is located approximately 250 meters downstream of the Wallace Weir at 38°43'09.24"N and 121°39'40.24"W. Initially a fyke trap was utilized to capture fish and was fished for 156 days beginning September 9, 2014 and ending June 8, 2015. The fyke trap was replaced by a fish barrier trap (**Figure 6**) on October 19, 2015 and fished almost continuously through January 19, 2016 until high flows within the channel damaged the trap. The trap was repaired and began fishing on 23 February 2016, however; it was removed after nine days of fishing effort prior to the flooding of the Yolo Bypass in early March. Salmonids captured at the Wallace Weir site were placed in fish transport trailers and released into the Sacramento River at the Elkhorn boat launch facility. All other fish species captured were released in the channel upstream of the trap and therefore were not considered as "rescued" and are not included in Table 3. Rescue efforts at this location included capture and relocation of federal and state threatened Sacramento River winter run Chinook salmon and Central Valley spring-run Chinook salmon (**Table 3**).

All Chinook salmon captured at the CBDC and Wallace Weir sites were tagged with two anchor tags affixed below the dorsal fin and tissue samples were collected from a small (2-3 mm^2) clip from the caudal fin. Recapture of tagged fish at spawning sites (carcass surveys and hatchery returns) may provide a relative indication of the success of fish rescue efforts conducted at the CBDC and Wallace Weir sites. Genetic analysis of tissues samples provided information as to run designation and origin of Chinook salmon rescued from the CBDC and Wallace Weir trapping sites.

4. Results

A total of 28 fish rescue efforts were documented by CDFW at the Fremont Weir and within the Yolo Bypass from 1955 through the summer of 2016 (**Table 1**). Rescue efforts at this location included the capture and relocation of over 10,000 fish consisting of 19 species from the Fremont Weir apron and ponds, swales, and other inundated features in the Yolo Bypass to the adjacent Sacramento River. Four of these species are currently listed as endangered or threatened (Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and southern DPS green sturgeon). The majority of fish rescue efforts in the Yolo Bypass area were conducted at or in the immediate vicinity of the Fremont Weir apron. In addition, evidence suggests that two sturgeon observed in the west apron of the Fremont Weir were taken by poachers prior to rescue efforts in at the end of March 2016.

A total of 13 fish rescue efforts were documented at the Tisdale Weir and Sutter/Tisdale Bypass from 1986 through the spring of 2016 (**Table 2**). Rescue efforts at this location included the relocation of over 900 fish consisting of 21 species, including the four aforementioned federal and state listed species. Rescue efforts at this location were limited to the weir apron and inundated areas immediately downstream of the weir.

Table 1. Summary of Fish Rescue Efforts Conducted at the Fremont Weir and Yolo Bypass, 1958 through July 2016 Boldface denotes federal and/or state listed species.

Date	Species/ESU/DPS	Life Stage	Number Rescued
8 July 2016 (Tule Pond)	White sturgeon	Adult	2
1 July 2016 (Tule Pond)	White sturgeon	Adult	4
	Sacramento sucker	adult; juvenile	16; 3
	Sacramento pikeminnow	juvenile	1
	Common carp	adult	2
	Red shiner	not determined	36
	Sacramento splittail	adult	1
	Chinook salmon/fall run	juvenile	3
	Smallmouth bass	juvenile	1
	Green sunfish	adult	4
	Bigscale logperch	not determined	3
30 March 2016	Fathead minnow	adult	1
	Red shiner	not determined	6
	Threadfin shad	not determined	2
	Chinook salmon/spring run	**juvenile**	**8**
	Chinook salmon/fall run	juvenile	63
	Inland silverside	juvenile	
29 March 2016	**Green sturgeon/sDPS**	**adult**	**1**
	Threadfin shad	not determined	2
	Sacramento sucker	juvenile	1
	Red shiner	juvenile	38
	Chinook salmon/spring run	**juvenile**	**10**
	Chinook salmon/fall run	juvenile	162
	Inland silverside	not determined	4
8 January 2013	Sacramento sucker	not determined	8
	Sacramento pikeminnow	not determined	1
	Sacramento splittail	not determined	1
	Chinook salmon	juvenile	1
	Chinook salmon	juvenile[1]	1
	prickly sculpin	not determined	9
	Sacramento pikeminnow	not determined	2
	Chinook salmon	adult[1]	3
	Chinook salmon	juvenile[1]	2
31 December 2012	Pacific lamprey	adult	not recorded
	White sturgeon	adult	1
	American shad	not determined	not recorded
	Sacramento sucker	not determined	not recorded

Date	Species/ESU/DPS	Life Stage	Number Rescued
	Sacramento splittail	not determined	not recorded
	Sacramento pikeminnow	not determined	not recorded
	Steelhead/Central Valley DPS	**not determined**	**not recorded**
	Striped bass	not determined	not recorded
	Largemouth bass	not determined	not recorded
	Smallmouth bass	not determined	not recorded
15 April 2011	White sturgeon	adult	1
	Chinook salmon	adult	54
	Chinook salmon	juvenile	84
14 April 2011	**Green sturgeon/sDPS**	**adult**	**12**
	White sturgeon	adult	4
11 April 2011	**Green sturgeon/sDPS**	**adult**	**13**
	White sturgeon	adult	17
	Chinook salmon	adult	1
	Chinook salmon	juvenile	75
10 May 2006	White sturgeon	adult	1
16 February 2006	White sturgeon	adult	12
14 February 2006	White sturgeon	adult	9
	Chinook salmon	adult	4
	Chinook salmon	juvenile	>100
	Steelhead/Central Valley DPS	**juvenile**	**6**
26 January 2006	White sturgeon	adult	1
	Chinook salmon	adult	4
11 March 2004	White sturgeon	adult	17
	Chinook salmon	adult	14
6 March 2003	White sturgeon	adult	10
2001	White sturgeon	adult	10 (estimate)
13 April 1998	Chinook salmon	adult	7
	Chinook salmon	juvenile	200
	Steelhead/Central Valley DPS	**juvenile**	**1**
	White sturgeon	adult	7
	Striped bass	not determined	350
1965	Chinook salmon	adult	641
1963	Chinook salmon	adult	283
	Steelhead/Central Valley DPS	juvenile	263
1962	Chinook salmon	adult	133
	Steelhead/Central Valley DPS	**juvenile**	**19**
	Striped bass	not determined	414
	White catfish	not determined	110
1960	Chinook salmon	adult	314

Date	Species/ESU/DPS	Life Stage	Number Rescued
	Steelhead/Central Valley DPS	**juvenile**	**62**
1959	Chinook salmon	adult	12
1958	Chinook salmon	adult	342
	Striped bass	not determined	231
	White catfish	not determined	7,305
1957	Chinook salmon	adult	25
	Chinook salmon	juvenile	3,150
	Black crappie	not determined	32
1956	Chinook salmon	adult	72
	Chinook salmon	juvenile	656

[1] Adipose fin clip

Table 2. Summary of Fish Rescue Efforts Conducted at the Tisdale Weir, 1986 through 2016.

Date	Species/ESU/DPS	Life Stage	Number Rescued
14 April 2016	Pacific lamprey	adult	2
	Lamprey-unidentified	adult, juvenile	12
	Threadfin shad	adult	2
	Sacramento sucker	adult, juvenile	185
	Sacramento pikeminnow	adult, juvenile	49
	Sacramento splittail	adult	1
	Golden shiner	not determined	74
	Carp	adult	2
	Chinook salmon/spring run[A,1]	**adult**	**21**
	Chinook salmon	juvenile	72; 9[3]
	Striped bass	adult	24
	Smallmouth bass	not determined	2
	Bluegill	adult	22
	Redear sunfish	adult	6
	Green sunfish	adult	2
	Tule perch	adult, juvenile	11
8 April 2016	Lamprey - unidentified.	adult	1
	American shad	adult	4
	Threadfin shad	adult	3
	Sacramento sucker	adult	1
	Sacramento pikeminnow	adult	16
	Sacramento splittail	adult	5
	Hitch	adult	1
	Chinook salmon/spring run[A,1]	**adult**	**19**
	Chinook salmon	juvenile	148; 20[3]
	Steelhead/Central Valley DPS	**juvenile[2]**	**2**

Date	Species/ESU/DPS	Life Stage	Number Rescued
	Striped bass	adult	1
31 March 2016	White sturgeon	adult	1
17 February 2016	Sacramento sucker	not determined	64
	Hardhead	not determined	19
	Sacramento pikeminnow	not determined	32
	Sacramento splittail	not determined	31
	Hitch	not determined	1
	Goldfish	not determined	1
	Fathead minnow	not determined	2
	Golden shiner	not determined	3
	Chinook salmon/winter run	**adult**	**1**
	Chinook salmon/winter run	**juvenile[1]**	**10**
	Chinook salmon/winter run	**juvenile[2]**	**3**
	Chinook salmon/late fall run	juvenile	1
	Chinook salmon/fall run	juvenile	3
	Steelhead/Central Valley DPS	**juvenile[2]**	**60**
	Bluegill	not determined	2
	Striped bass	not determined	2
	Bigscale logperch	not determined	3
	Tule perch	not determined	1
11 February 2016	**Chinook salmon/winter run**	**juvenile[1]**	**1**
	Chinook salmon/winter run	**juvenile[2]**	**2**
	Steelhead/Central Valley DPS	**juvenile[2]**	**1**
23 February 2015	Chinook salmon	adult	4
	Chinook salmon/spring run	**juvenile[1]**	**7**
	Chinook salmon/winter run	**juvenile[1]**	**7**
	Chinook salmon/fall-late fall	juvenile[1]	2
	Chinook salmon/winter run	juvenile[2]	18
	Chinook salmon/fall-late fall	juvenile[2]	1
	Steelhead/Central Valley DPS	**juvenile[1]**	**7**
	Steelhead/Central Valley DPS	**juvenile[2,3]**	**112**
	Sacramento pikeminnow	not determined	23
	Sacramento splittail	not determined	5
	Tule perch	not determined	2
	Threadfin shad	not determined	17
	Wakasagi	not determined	4
	Inland silverside	not determined	8
	Golden shiner	not determined	1
8 January 2015	Sacramento sucker	not determined	35
	Sacramento pikeminnow	not determined	53

Date	Species/ESU/DPS	Life Stage	Number Rescued
	Sacramento splittail	not determined	3
	Sacramento hitch	not determined	1
	Hardhead	not determined	1
	Steelhead/Central Valley DPS	**adult[1]**	**1**
	Red ear sunfish	not determined	1
17 April 2012	Sacramento pikeminnow	not determined	not determined
	Sacramento splittail	not determined	not determined
	Common carp	not determined	not determined
	Golden shiner	not determined	not determined
	Chinook salmon	adult	9
	Chinook salmon	Juvenile	>120
	Striped bass	not determined	4
	Tule perch	not determined	not determined
	Largemouth bass	not determined	not determined
	Black crappie	not determined	not determined
14 April 2011	**Green sturgeon/sDPS**	**adult**	**11**
	White sturgeon	adult	3
	Chinook salmon	adult[1]	40
	Chinook salmon	adult[2]	13
	Chinook salmon	juvenile	14
6 March 2003	Chinook salmon	adult	2
26 April 1995	American shad	not determined	1
	Chinook salmon	adult	3
	Chinook salmon	juvenile	2
	Striped bass	not determined	10
21 April 1986	Sacramento pikeminnow	not determined	not determined
	Sacramento hitch	not determined	not determined
	Chinook salmon	adult	7
	Bluegill	not determined	not determined
	Black crappie	not determined	not determined
	Tule perch	not determined	not determined

[1] Wild origin; [2] Hatchery origin; [3] Adipose fin clip; [A] Based on run timing

Figure 6. View of the Colusa Basin Drainage Canal Resistance Weir and Fish Trap.

The green sturgeon rescued from the Fremont Weir on 29 March 2016 was acoustically tagged and released in the Sacramento River and subsequently detected moving upstream (Knights Landing on 30 March 2016 and Colusa on 2 April 2016). Monitoring of acoustically tagged green sturgeon rescued during April 2011 provided evidence that 71 percent of the green sturgeon rescued from the Fremont and Tisdale weirs reached their spawning grounds in the Sacramento River the same spawning season (Thomas et al. 2013). Some rescued green sturgeon "dropped back" and were not detected moving upstream to their spawning grounds after being relocated into the Sacramento River but may have survived to spawn in subsequent years. The white sturgeon rescued from the Tisdale Weir on 31 March 2016, a post spawn female, was subsequently detected moving downstream at Knights Landing on 4 April 2016 and at the Tower Bridge on 5 April 2106. Nine anchor-tagged late-fall run Chinook salmon tagged at Wallace Weir in 2014 were subsequently "recaptured" (e.g., tag returns) at spawning grounds. One anchor tagged hatchery origin winter run Chinook salmon rescued from the Tisdale Weir on 14 April 2016 was "recaptured" at the Livingston Stone National Fish Hatchery in early June 2016.

Figure 7. View of the Wallace Weir Fish Trap. Photo Taken 5 October 2015.

Table 3. Summary of Salmonids Rescued at the Colusa Basin Drainage Canal, 18 March 2014 through 3 December 2015.

Date	Species/ESU/DPS	Life Stage	Number Rescued
3/18/2014	Chinook salmon/spring run	adult	1
11/20/2015	Chinook salmon/ fall-late fall run	adult	3
11/25/2015	Chinook salmon/ fall-late fall run	adult	1
11/26/2015	Chinook salmon/ fall-late fall run	adult	1
12/03/2015	Chinook salmon/ fall-late fall run	adult	1

Table 4. Summary of Salmonids Rescued at the Wallace Weir, 30 October 2014 through 17 January December 2016.

Date	Species/ESU/DPS	Life Stage	Number Rescued
10/28/2014 through 12/03/2014	Chinook salmon/ fall-late fall run	adult	752
2/28/2015	Steelhead/Central Valley DPS	adult	1
3/11/2015	Chinook salmon/spring run	adult	1
3/19/2015	Chinook salmon/spring run	adult	1
4/21/2015	Chinook salmon/winter run	adult	1
12/07/2015 through 01/17/2016	Chinook salmon/ fall-late fall run	adult	755

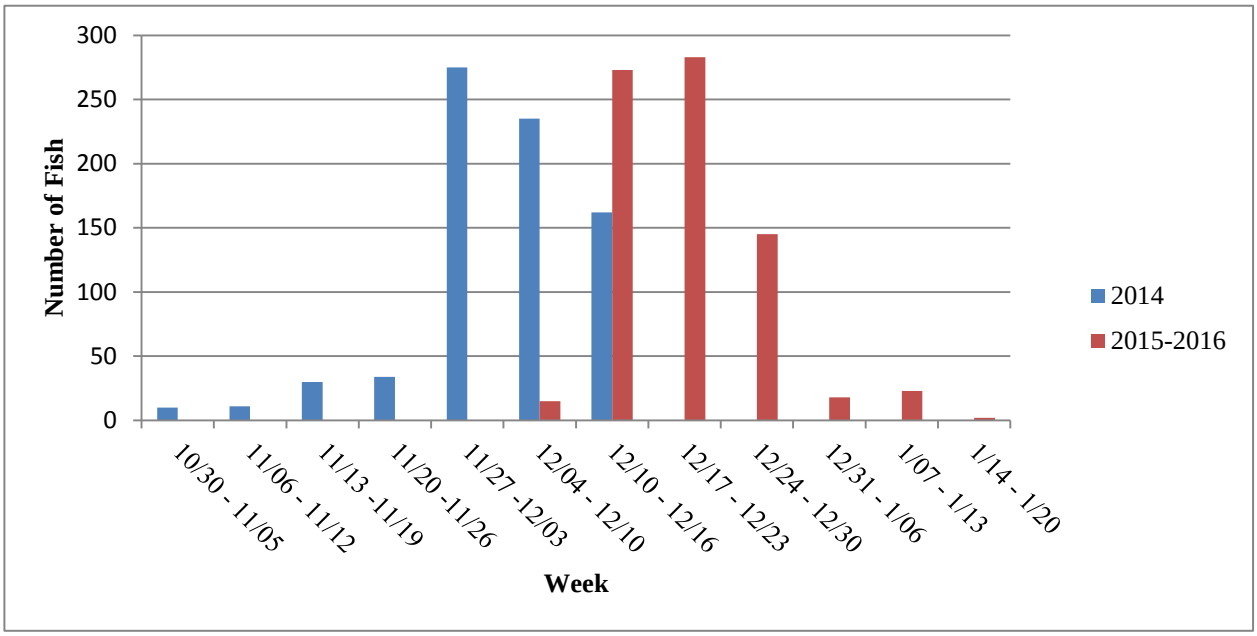


Figure 8. Timing of fall/late fall run Chinook salmon rescued from the Wallace Weir Fish Trapping Site.

Potential stranding sites within the Yolo Bypass are shown in **Attachment 1, Tiles 1 through 12.** GIS analysis shows that most of the potential stranding spots are located in the northern portion of the Yolo Bypass, based on factors such as feature size, maximum depth, and proximity to perennially inundated water bodies (**Tiles 1 through 3**). While ground truthing efforts to document stranding throughout the bypasses have been minimal, it is likely that actual stranding and isolation areas vary with each overtopping event and are influenced by factors such as distance from the weir or perennial channels, timing of overtopping events, flow duration, and flow magnitude. All of the fish rescues documented within the Yolo Bypass were conducted either in the Fremont Weir apron or within the immediate vicinity of the Fremont Weir (**Attachment 1, Tile 1**). Inundation depth of features where fish rescues were conducted typically ranged from two to four feet. Features with inundation depths of greater than four feet provide challenges for successful fish rescues as they are not readily wadeable; and often contain large quantities of woody debris which limit the effective use of beach seines, dip nets, and crowder racks. **Attachment 2** shows several known and potential isolation and stranding areas within the vicinity of the Tisdale Weir overlaid on an aerial photograph.

5. Discussion

Fish rescue efforts conducted at the Tisdale Weir/Bypass and Fremont Weir/Yolo Bypass prevented thousands of fish from perishing from factors such as stranding, poor water quality conditions, and poaching. In particular, fish rescue efforts targeting adult salmon and sturgeon in the Yolo and Sutter bypasses likely enabled some stranded fish to continue their migration to reach suitable spawning habitat. Green sturgeon are long-lived fish that reach sexual maturity at approximately 15 years of age and typically spawn every three to four years (Van Eenennaam *et al*. 2006), (Brown 2007; Poytress *et al*. 2012) and therefore the rescue of even low numbers of this species provides potential brood stock for a number of future spawning events. Apart from fish rescues conducted at the immediate vicinity of the

Fremont and Tisdale weirs, fish rescues conducted within the various ponds, scour pools, swales, and drainages within bypasses were poorly documented and apparently of limited success due to factors such as accessibility, depth, and presence of debris (**Figure 7)**. Salmonids and sturgeon that become isolated in these features would likely not be able to survive summer water temperatures and may also be targeted by poachers. In addition, many of these features do not remain inundated through the dry season. The variation in timing of fish rescue efforts at the Wallace Weir fish trap site in 2014 versus 2015-2016 may be attributable to factors such as water year type, water management operations, and occurrence of large magnitude early-season rainfall events. The current design of the Wallace Weir fish trap limits operation of the trap to relatively low-flow conditions (e.g., flows under 400 cfs, CDFW unpublished data). A modified weir similar to the Knights Landing Outfall Gate structure will be installed at the Wallace Weir and should be operational by late-fall of 2016. The new weir/fish trap will allow for capture and relocation of fish during much higher flows within the Knights Landing Ridge Cut.

Figure 9. View of an oxbow pond south of the west section of the Fremont Weir. Bank gradient and presence of woody debris reduce the likelihood of rescuing fish isolated within this feature. Photo taken 5 October 2015.

Figure 10. View of the "Tule Pond" in the Yolo Bypass southeast of the Fremont Weir. Sturgeon, Chinook salmon, steelhead, and other fish species may become isolated within the Tule Pond when hydrological connectivity to the Tule Canal is lost during receding flows.

Figure 11. View isolated pool southeast of the Fremont Weir. An adult green sturgeon is visible in the upper portion of the photo.

While fish rescues do provide benefits in terms of potentially saving fish, there are potential drawbacks associated with fish rescues. By the time fish rescue efforts can be implemented, adult salmonids and sturgeon that are isolated within the Yolo and Sutter/Tisdale bypasses have likely been subjected to stressors associated with receding flows (e.g., poor water quality, predation and poaching attempts) and delayed spawning migrations. In addition, the rescue effort itself is stressful to fish and has the potential to result in delayed mortality from capture and handling. The feasibility and likelihood of success of rescue efforts are influenced by such factors as site accessibility, water depth, debris load, submerged and emergent vegetation, and distance to release point. Capture and handling of adult sturgeon also has the potential to result in injury of rescue staff and damage to rescue equipment. Fish rescue efforts are costly in terms of staff compensation, equipment, and reallocated time designated to other projects.

Fish rescue efforts should be viewed as a last resort in terms of fisheries conservation measures within the Yolo and Sutter bypasses. The *Yolo Bypass Salmonid Habitat Restoration and Fish Passage Implementation Plan Long-Term Operation of the Central Valley Project and State Water Project Biological Opinion Reasonable and Prudent Alternative Action I.7* (Bureau of Reclamation and Department of Water Resources 2012) presents a number of options regarding modification of the Fremont Weir fish ladder to facilitate fish passage and allow return to the Sacramento River. The plan also provides suggestions for re-contouring portions of the Yolo Bypass to increase connectivity to the Tule Canal and Toe Drain; thereby reducing isolation and stranding in the numerous ponds, swales, and ditches; and behind road crossings and other barriers. The LIDAR data showing potential inundation depths (**Attachment 1**) provides baseline data for projects designed to increase connectivity of current isolation and stranding areas to perennial waters (e.g., Tule Canal and Toe Drain) which are hydrologically connected to the Sacramento River. There are likely numerous other isolation and stranding areas within the Sutter Bypass that have not yet been identified. Once LIDAR data for the Sutter Bypass become available, mapping of these areas should be relatively straightforward.

Design and construction of fish passage improvement measures at the Fremont Weir and within the Yolo Bypass are scheduled to begin in 2016 and continue through 2019. While some of the proposed fish passage designs will likely increase fish passage through the Yolo and Sutter bypasses and back to the Sacramento River, sturgeon in particular may still be susceptible to isolation and stranding due to increased duration of flows through the bypass, as these modifications are also intended to increase floodplain inundation for salmonid rearing. Monitoring for isolation and stranding of fish within the Yolo and Tisdale/Sutter bypasses should continue even after completion of fish passage improvement measures to determine if the measures are successful. Fish rescue efforts should be conducted as necessary to reduce lethal take of listed species.

6. References

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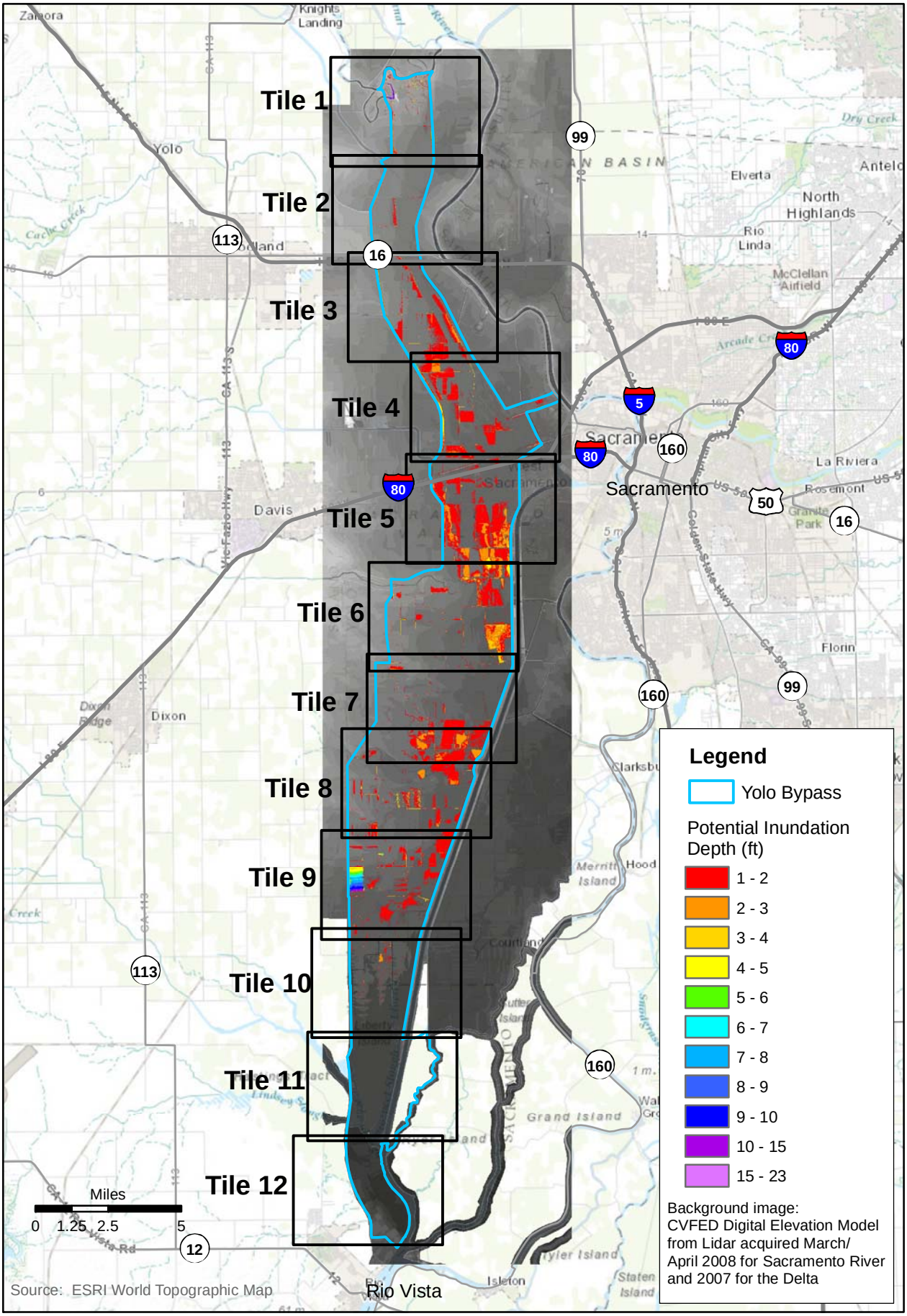
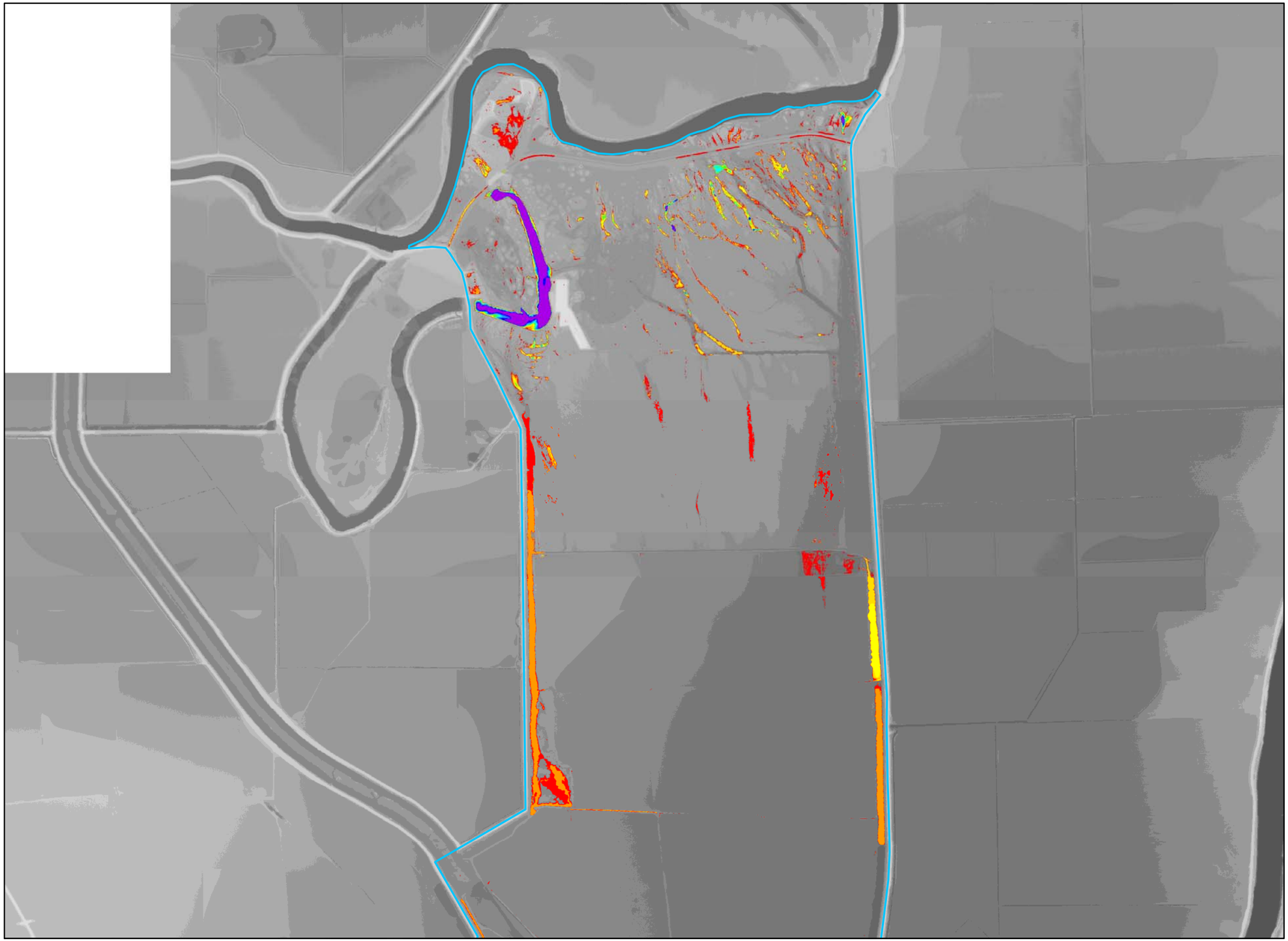
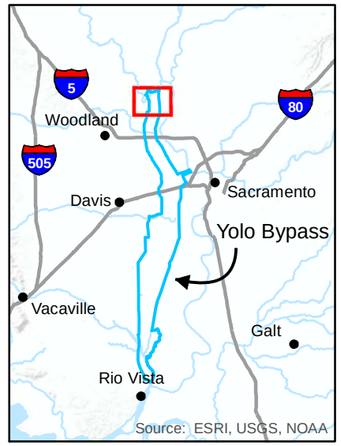
Attachment 1. Potential Isolation and Stranding Areas within the Yolo Bypass - Index Map



Attachment 1. Potential Isolation and Stranding Areas within the Yolo Bypass - Tile 1 of 12





Legend

- Yolo Bypass

Potential Inundation Depth (ft)

- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10
- 10 - 15
- 15 - 23

Background image:
CVFED Digital Elevation Model
(from Lidar acquired March/April 2008 for Sacramento River and 2007 for the Delta)

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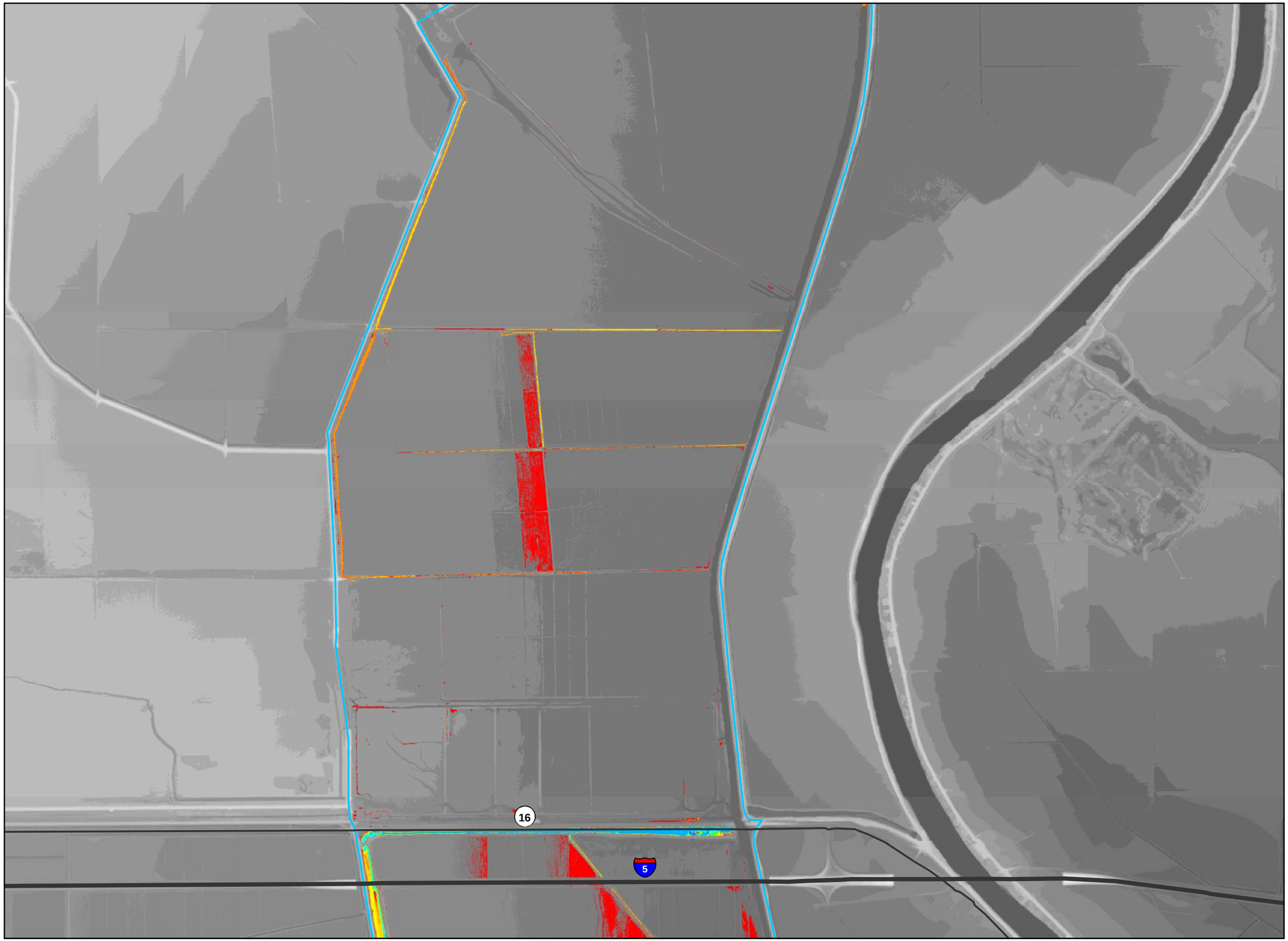
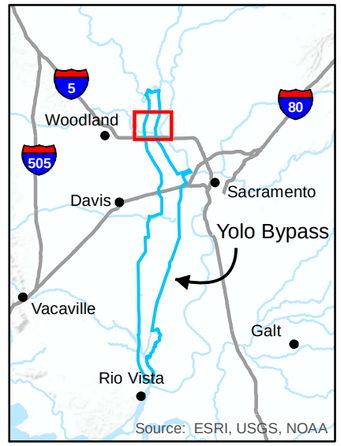
Attachment 1. Potential Isolation and Stranding Areas within the Yolo Bypass - Tile 2 of 12





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- Yolo Bypass

Potential Inundation Depth (ft)

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Background image:
CVFED Digital Elevation Model
(from Lidar acquired March/April 2008 for Sacramento River and 2007 for the Delta)

Miles
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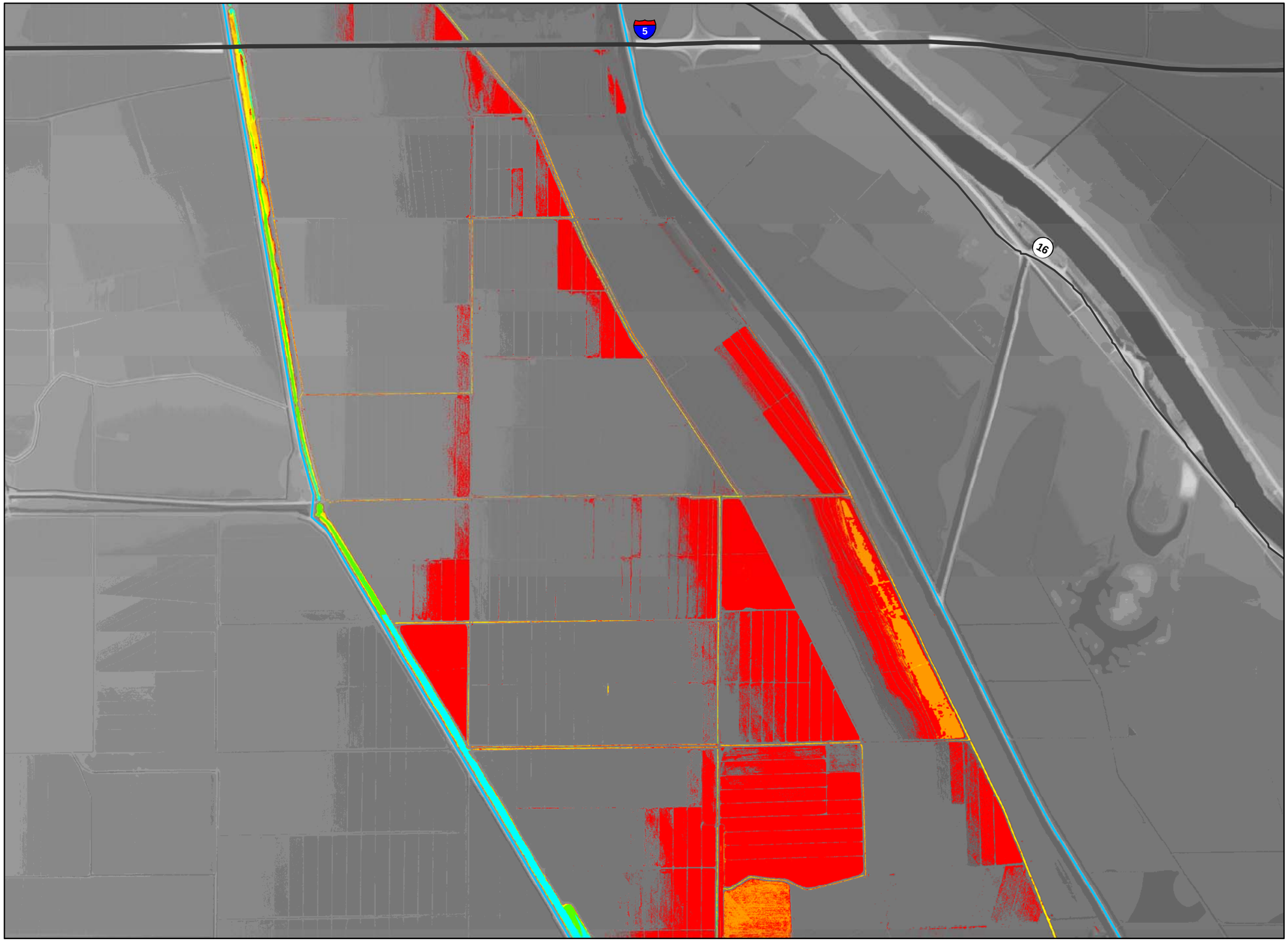
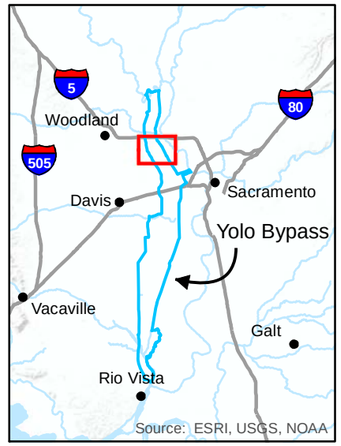
Attachment 1. Potential Isolation and Stranding Areas within the Yolo Bypass - Tile 3 of 12





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- Yolo Bypass

Potential Inundation Depth (ft)

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Background image:
CVFED Digital Elevation Model
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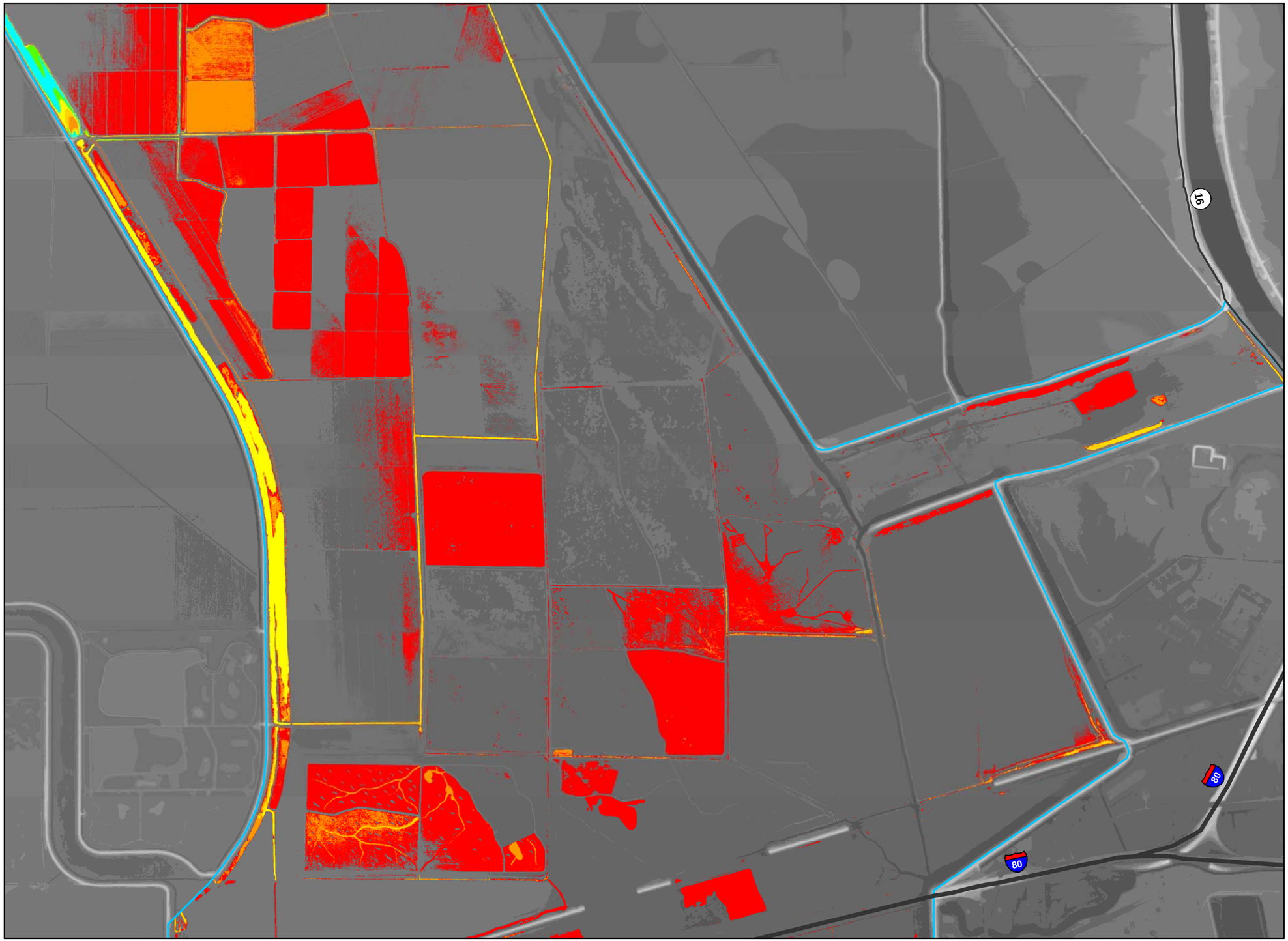
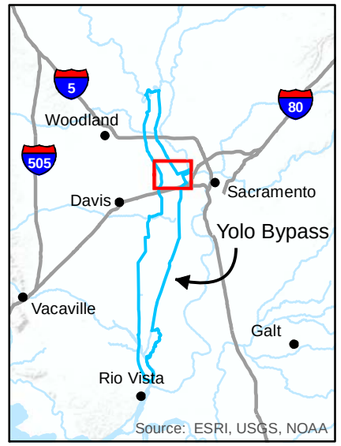
Attachment 1. Potential Isolation and Stranding Areas within the Yolo Bypass - Tile 4 of 12





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- Yolo Bypass

Potential Inundation Depth (ft)

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Background image:
CVFED Digital Elevation Model
(from Lidar acquired March/April 2008 for Sacramento River and 2007 for the Delta)

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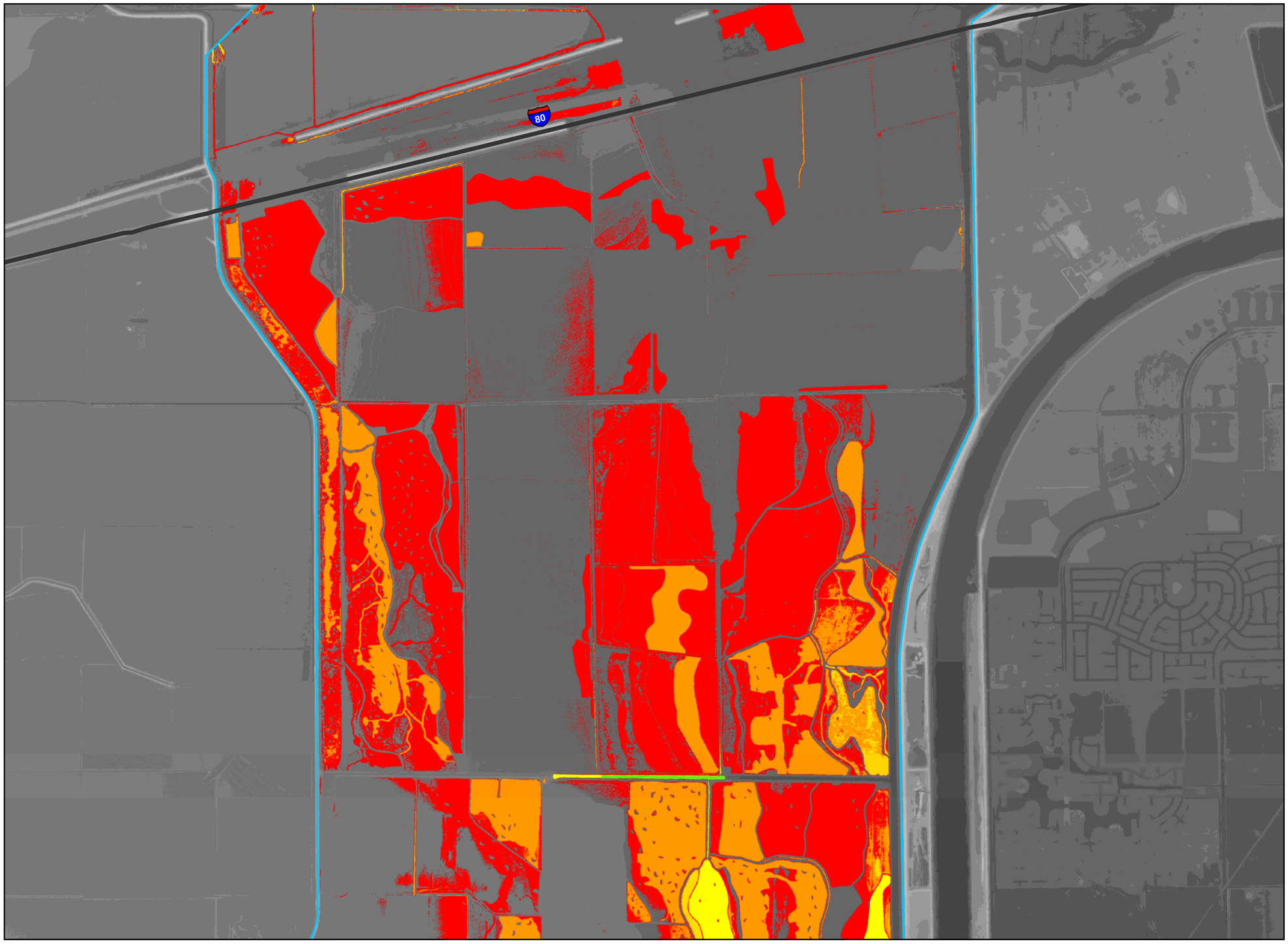
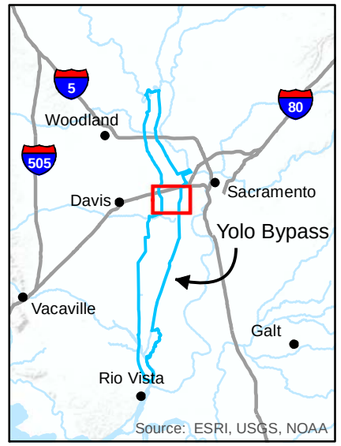
Attachment 1. Potential Isolation and Stranding Areas within the Yolo Bypass - Tile 5 of 12





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Yolo Bypass

Potential Inundation Depth (ft)

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Background image:
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(from Lidar acquired March/April 2008 for Sacramento River and 2007 for the Delta)

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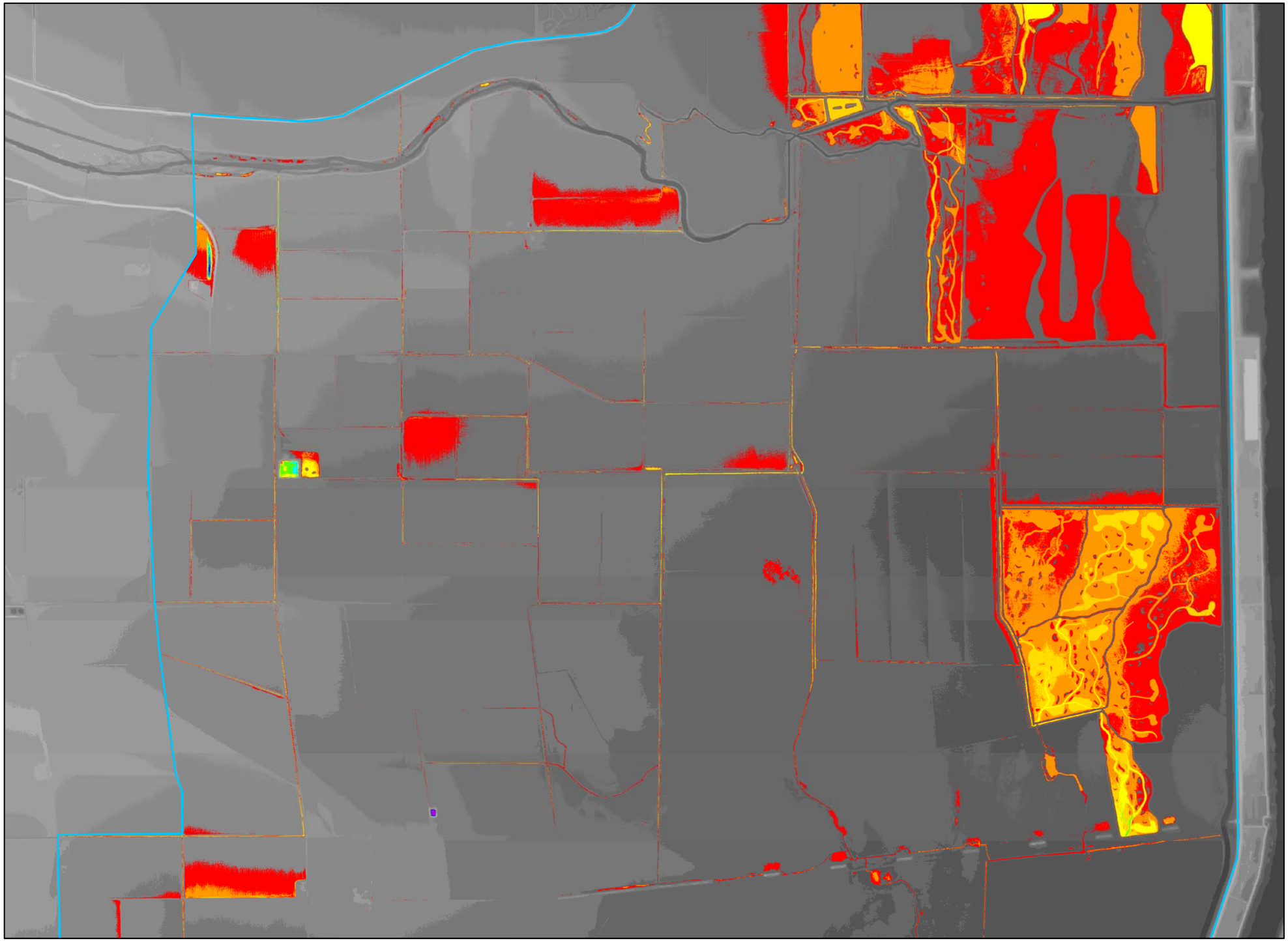
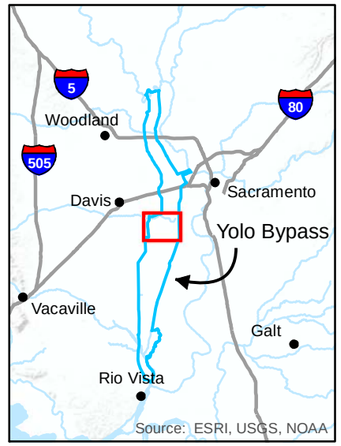
Attachment 1. Potential Isolation and Stranding Areas within the Yolo Bypass - Tile 6 of 12





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- Yolo Bypass

Potential Inundation Depth (ft)

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Background image:
CVFED Digital Elevation Model
(from Lidar acquired March/April 2008 for Sacramento River and 2007 for the Delta)

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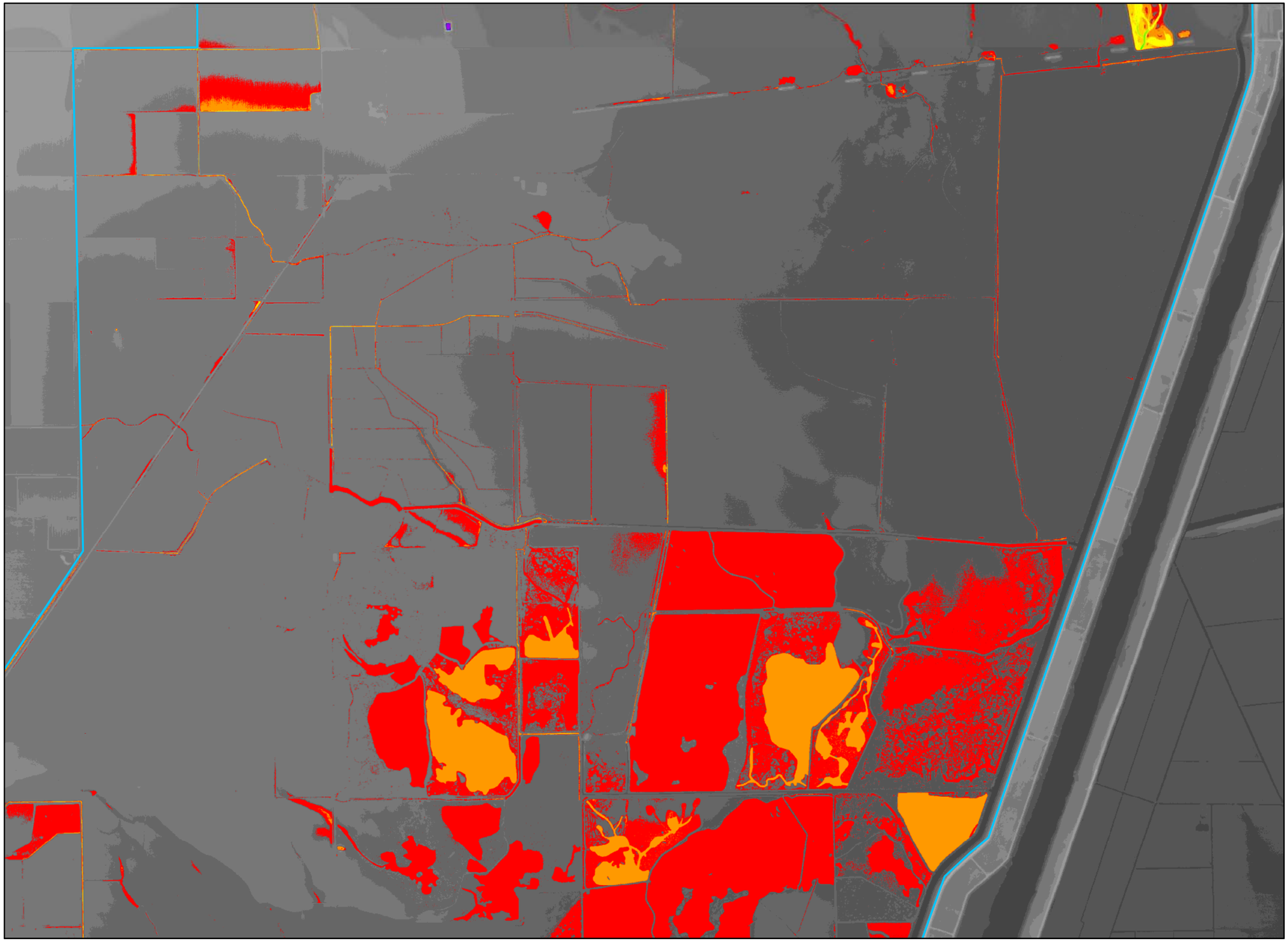
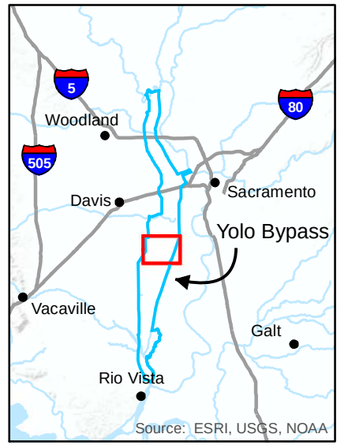
Attachment 1. Potential Isolation and Stranding Areas within the Yolo Bypass - Tile 7 of 12





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- Yolo Bypass

Potential Inundation Depth (ft)

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Background image:
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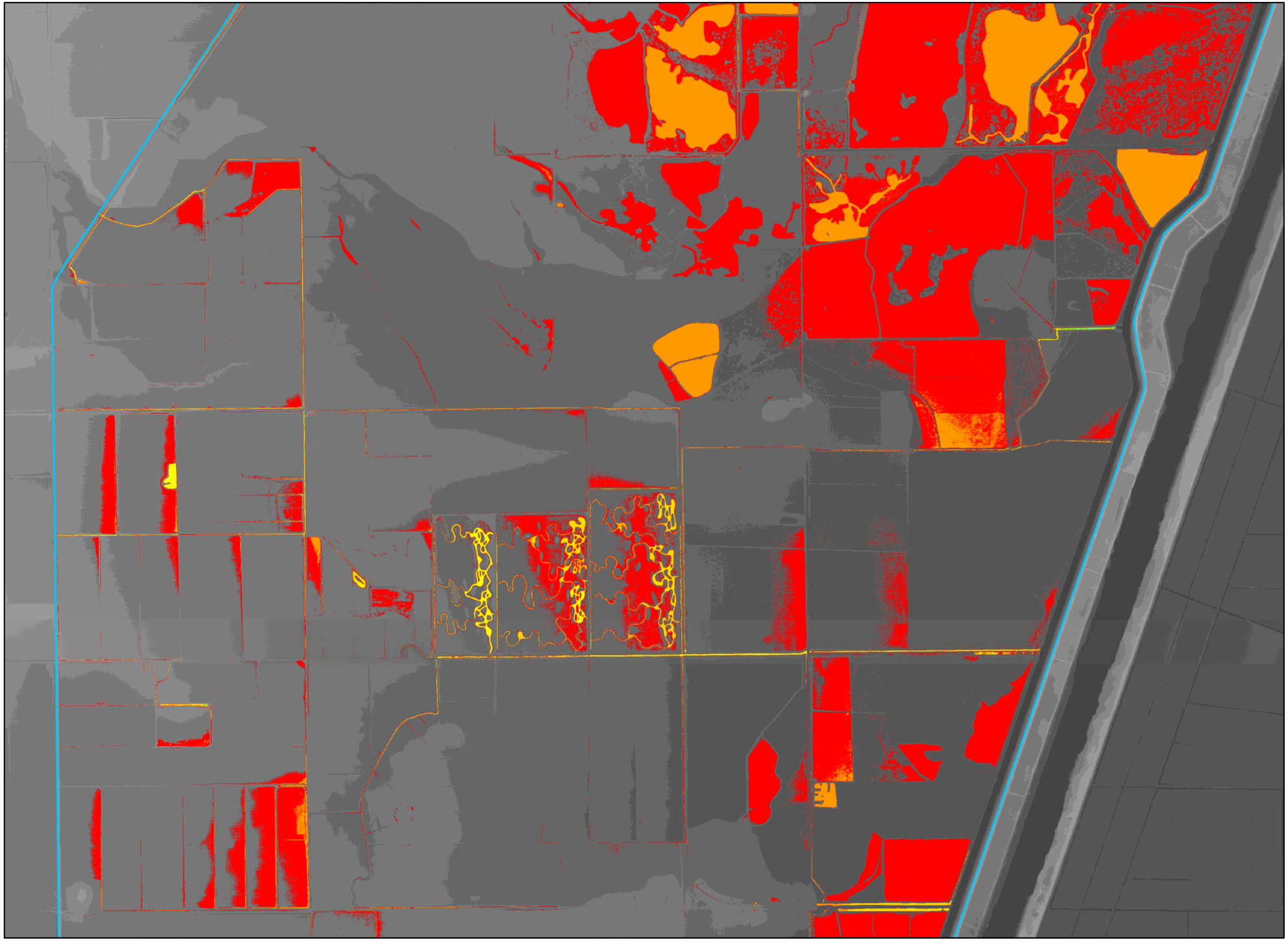
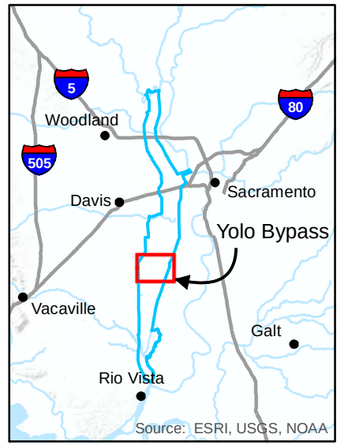
Attachment 1. Potential Isolation and Stranding Areas within the Yolo Bypass - Tile 8 of 12





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- Yolo Bypass

Potential Inundation Depth (ft)

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Background image:
CVFED Digital Elevation Model
(from Lidar acquired March/April 2008 for Sacramento River and 2007 for the Delta)

Miles
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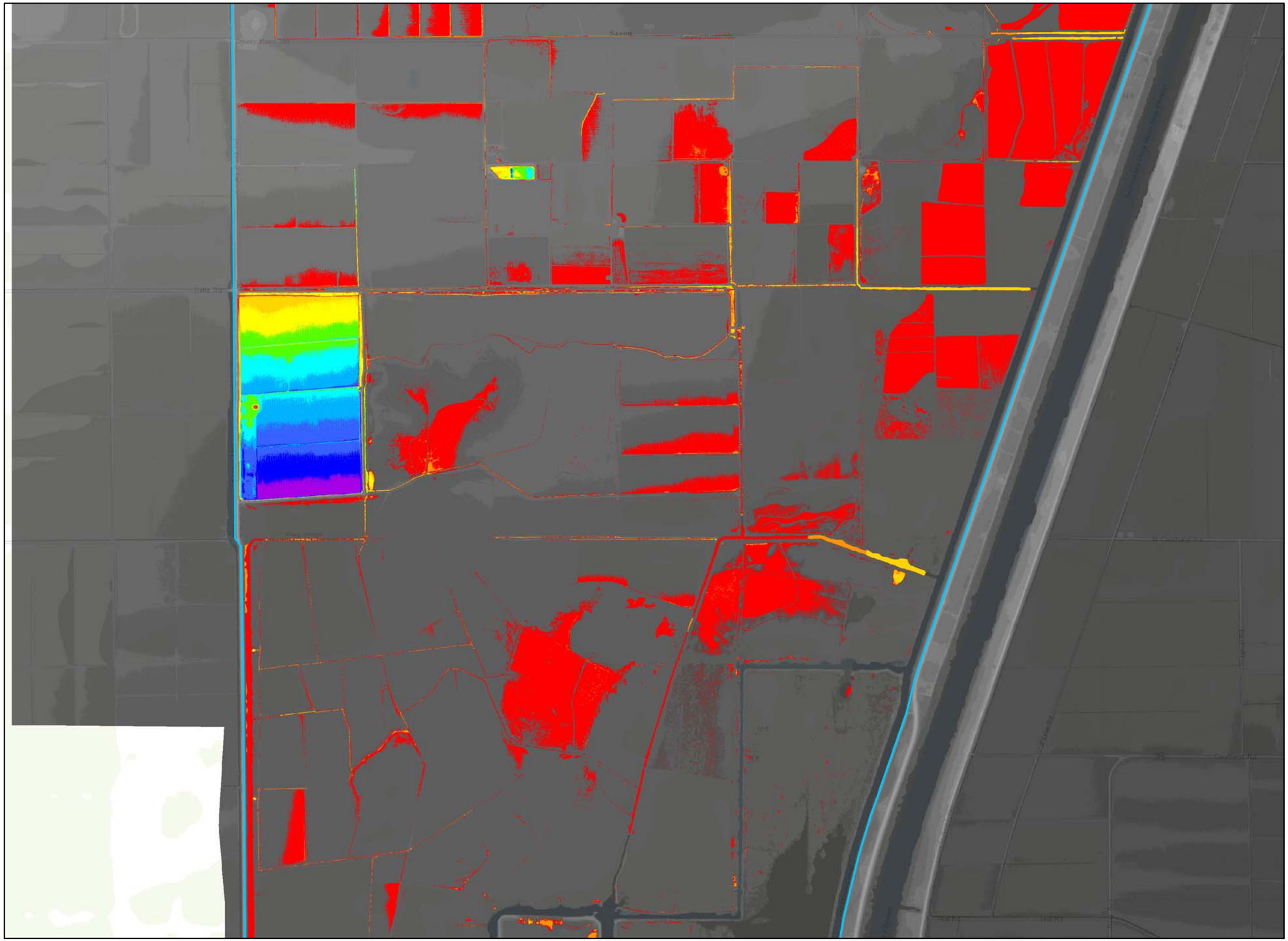
Attachment 1. Potential Isolation and Stranding Areas within the Yolo Bypass - Tile 9 of 12



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Potential Inundation Depth (ft)

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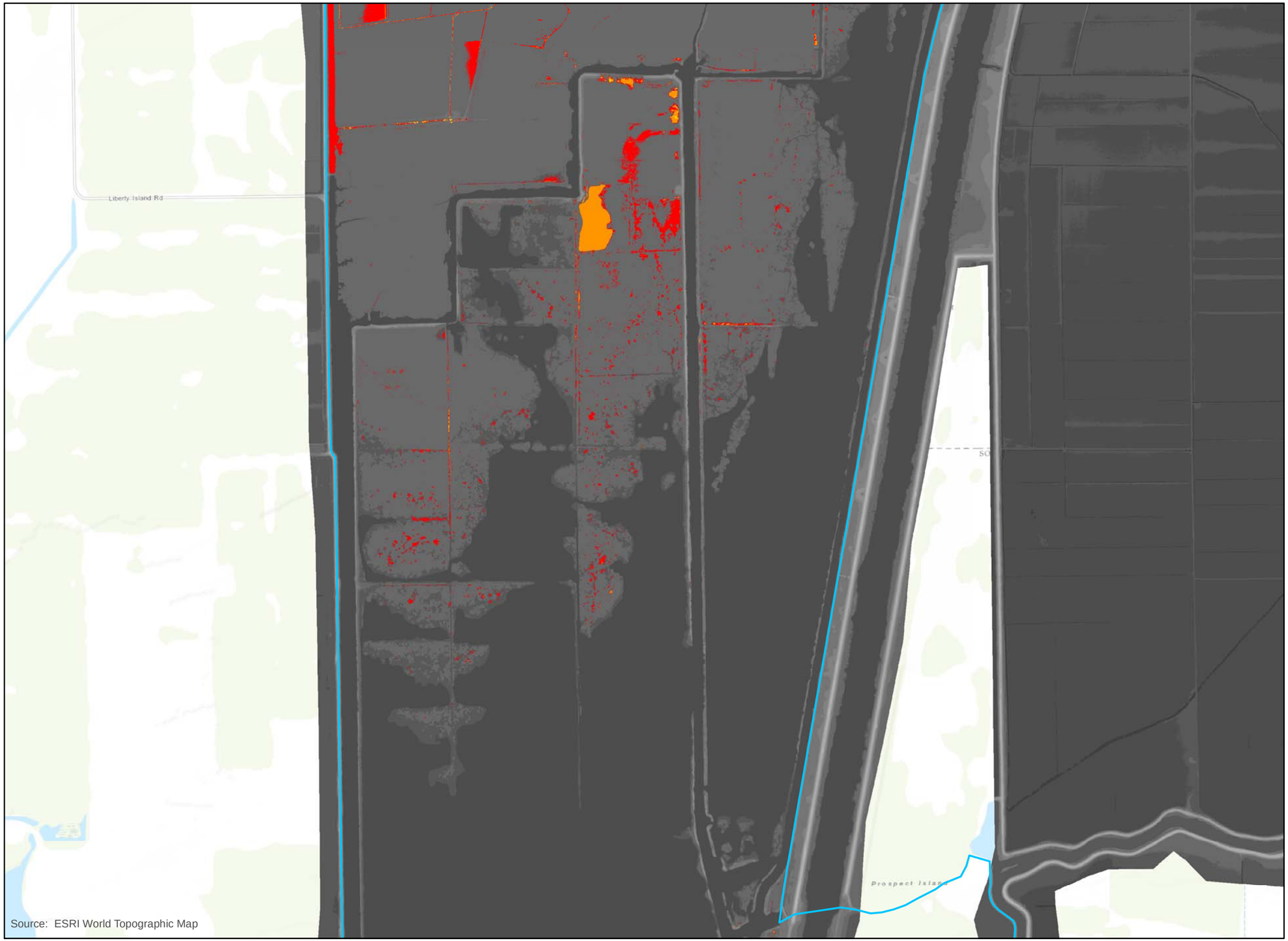

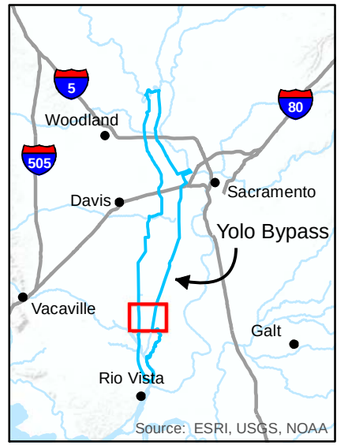

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- Yolo Bypass

Potential Inundation Depth (ft)

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Background image:
CVFED Digital Elevation Model
(from Lidar acquired March/April 2008 for Sacramento River and 2007 for the Delta)

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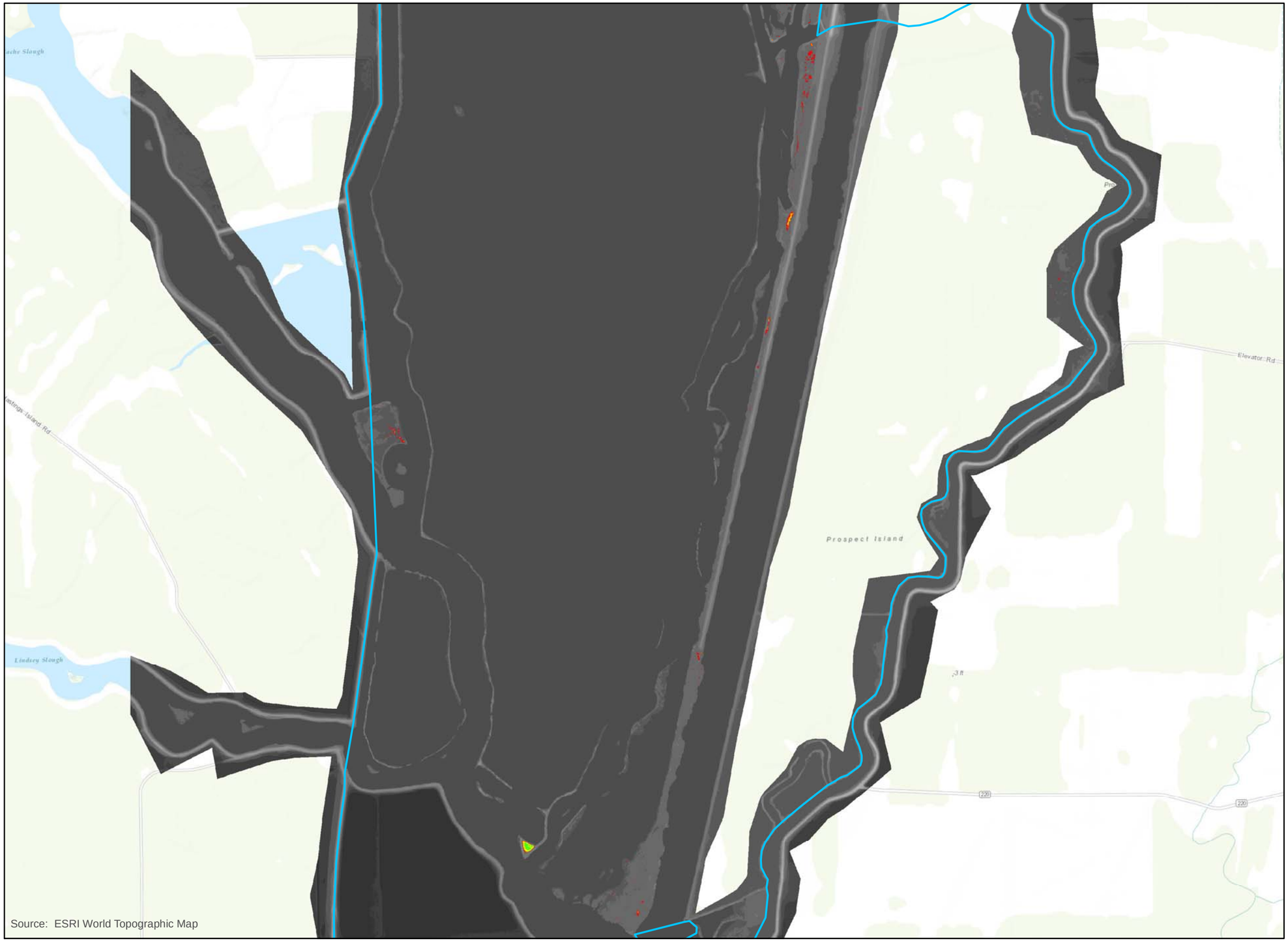
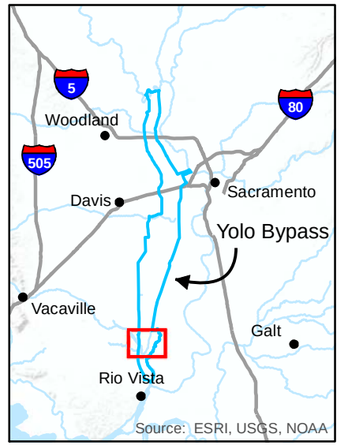
Attachment 1. Potential Isolation and Stranding Areas within the Yolo Bypass - Tile 11 of 12





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- Yolo Bypass

Potential Inundation Depth (ft)

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Background image:
CVFED Digital Elevation Model
(from Lidar acquired March/April 2008 for Sacramento River and 2007 for the Delta)

Miles
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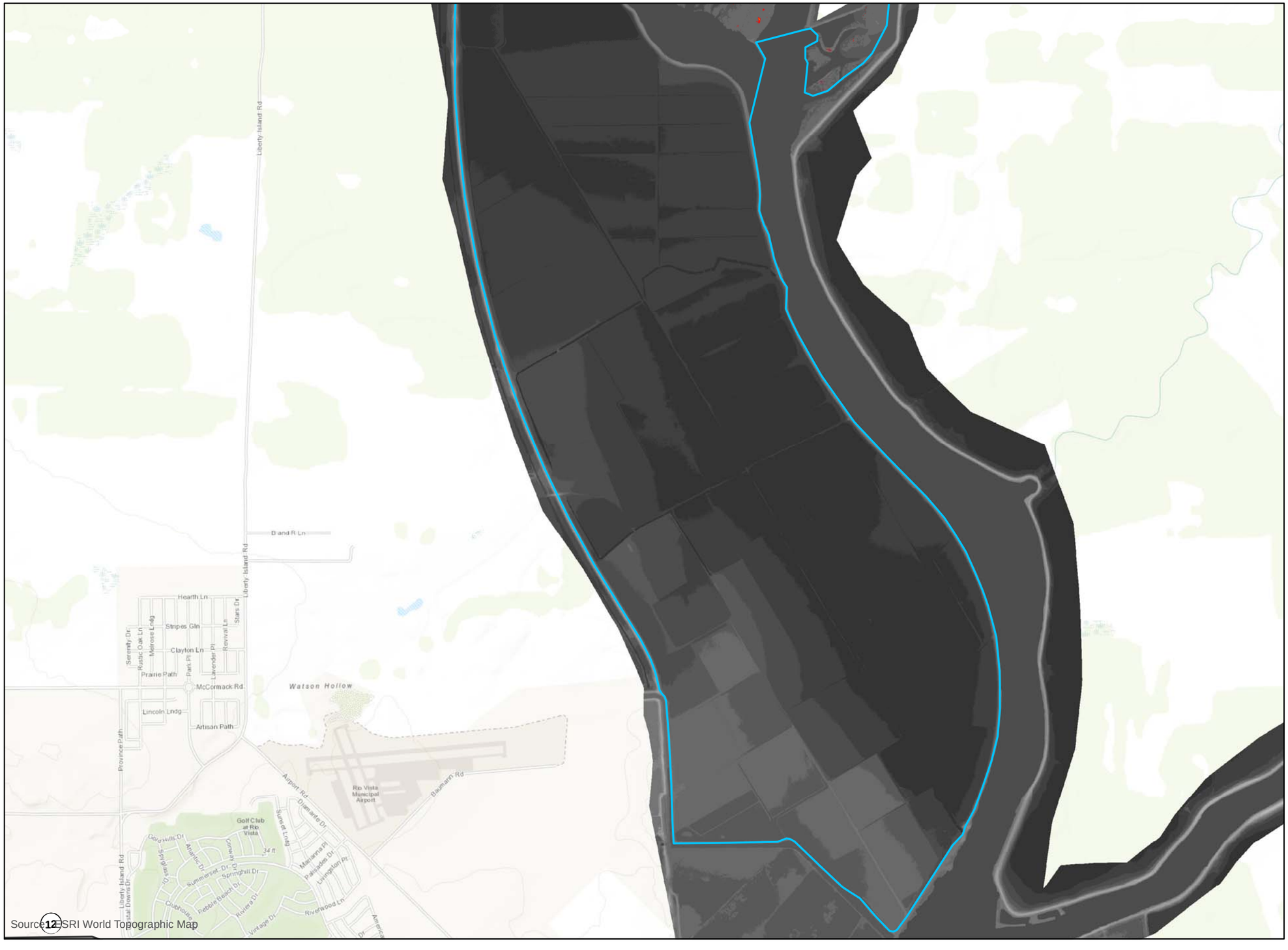
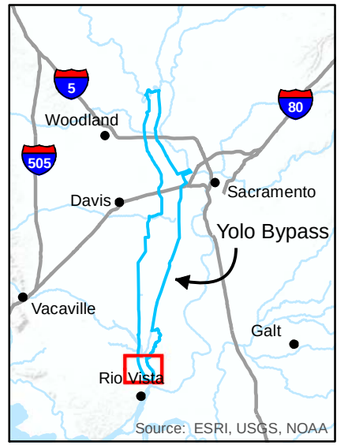
Attachment 1. Potential Isolation and Stranding Areas within the Yolo Bypass - Tile 12 of 12





Legend

- Yolo Bypass

Potential Inundation Depth (ft)

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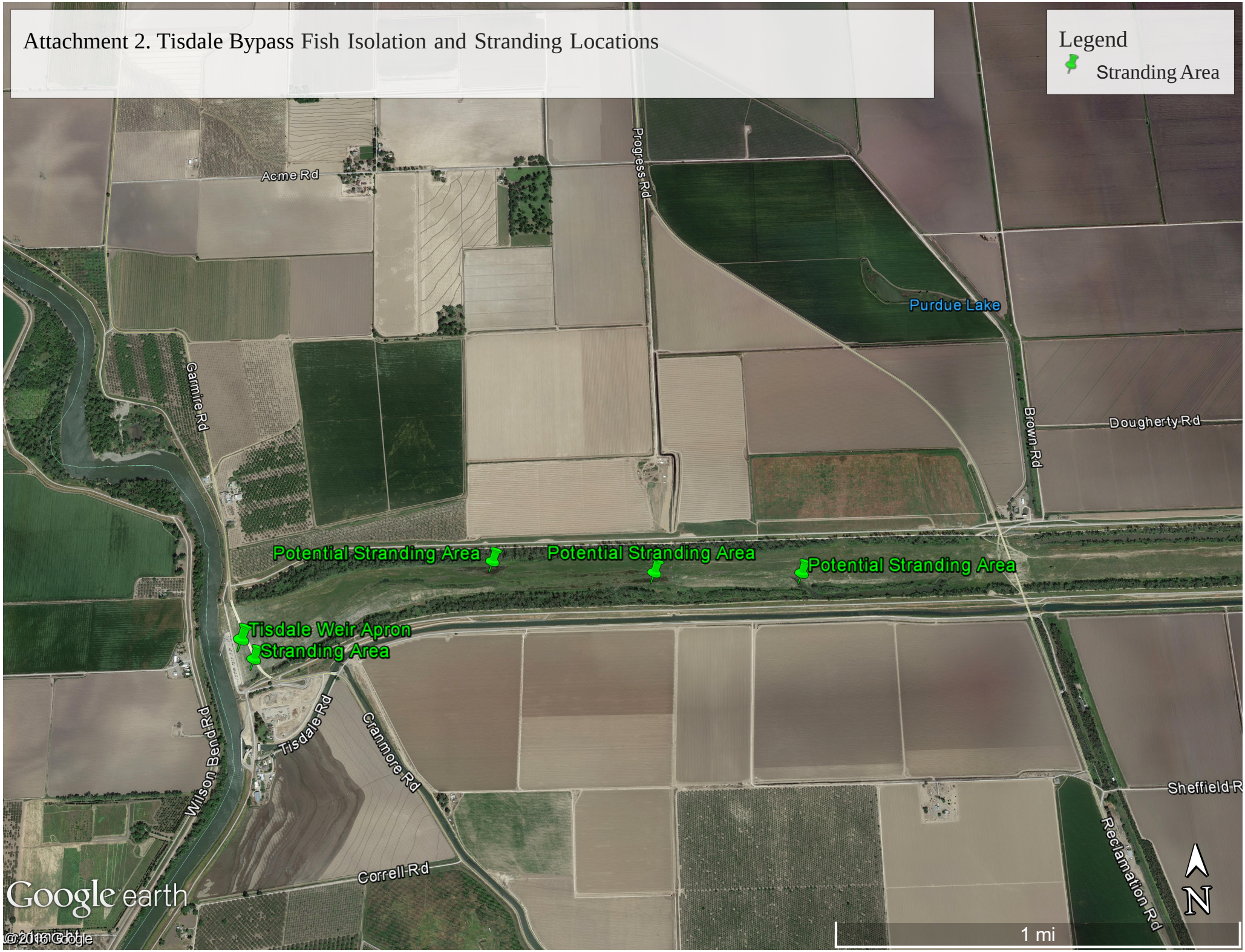
Background image:
CVFED Digital Elevation Model
(from Lidar acquired March/April 2008 for Sacramento River and 2007 for the Delta)

Miles
0 0.125 0.25 0.5


Attachment 2. Tisdale Bypass Fish Isolation and Stranding Locations
Legend
Stranding Area
Acme Rd
Progress Rd
Purdue Lake
Garnire Rd
Brown Rd
Dougherty Rd
Potential Stranding Area
Potential Stranding Area
Potential Stranding Area
Tisdale Weir Apron
Stranding Area
Wilson Bend Rd
Tisdale Rd
Cranmore Rd
Correll Rd
Sheffield R
Reclamation Rd
N
1 mi
Google earth
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