Crows Landing Industrial Business Park
Drainage Study

November 23, 2020

Prepared for

Stanislaus County Public Works

Prepared by

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INTRODUCTION

The Crows Landing Industrial Business Park (CLIBP) is a proposed development area owned by Stanislaus County just north of Fink Road between Davis Road and Bell Road, east of Interstate 5 as shown on **Figure 1**. The site was previously operated as an airfield by the federal government and transferred to the County for potential redevelopment. In 2018, the Stanislaus County Board of Supervisors adopted a Specific Plan to develop the site and certified an Environmental Impact Report (EIR) in accordance with the California Environmental Quality Act (CEQA). In order to proceed with the next stages of development, Stanislaus County has hired Wood Rodgers to develop studies and prepare improvement plans for various aspects of the project, including storm drainage.

BACKGROUND

While the federal government operated the area as a testing site under the National Aeronautics and Space Administration (NASA), there is very little available documentation regarding existing on-site drainage facilities and their design. The natural terrain is generally sloping from southwest to northeast, with all drainage eventually reaching the San Joaquin River and flowing into the Pacific Ocean through the San Francisco Bay. The local watershed that flows directly through the project area is known as Little Salado Creek.

In the 1950s and 1960s, major transportation and water supply facilities were constructed across the watershed, including Interstate 5 (I-5), the California Aqueduct, and the Delta Mendota Canal (DMC) that flows directly through the proposed development area. These facilities are operated by the California Department of Transportation (Caltrans), the California Department of Water Resources (DWR), and the San Luis & Delta Mendota Water Authority (SL&DMWA), in cooperation with the Federal Bureau of Reclamation, respectively.

The Little Salado Creek watershed was evaluated by AECOM as part of an initial drainage study that was performed in support of the EIR and Specific Plan. AECOM determined that flooding occurred along the Little Salado Creek channel corridor, as well as laterally upstream of the DMC. Copies of the initial study document and supporting calculations have been provided to Wood Rodgers, and are available upon request.

While larger scale watershed analyses have been performed for the San Joaquin River watershed, which includes the Little Salado Creek watershed, no other detailed drainage studies are known to be available focusing on this specific watershed area.

AGENCY COORDINATION

As discussed above, multiple agencies operate facilities that can affect drainage reaching the CLIBP. The following is a summary of these upstream facilities and how they affect project area drainage analyses.

Fink Road Sanitary Landfill

The Stanislaus County Department of Environmental Services operates a landfill site located within the watershed just west of Interstate 5 and south of Fink Road. The landfill collects and stores runoff entering the landfill within on-site detention areas that have been outfitted with overflow/outlet structures to release runoff during large storm events. While the detention basins do trap some volume and allow for infiltration and evaporation, it was outside of the purview of this study to determine the infiltration rate at the detention site during a storm event. To simplify the analysis, the detention basin storage below the overflow invert elevation was considered full before the storm event (from previous storms). This provides the highest estimate of outflow while still accounting for the storage attenuation present above the outlet, and the physical outlet size restrictions. Wood Rodgers contacted Mr. Craig Cissell (Manager III, Stanislaus County Landfill Division) to request information defining the storage, outflow and internal runoff conditions. A previous study performed by SCS Engineers was provided, as well as a site layout drawing that defines the different landfill activities and uses. Two isolated basins within the landfill site were excluded from the watershed runoff because they had been designed to collect seepage from the landfill refuse using containment berms. The digital information provided is included in **Appendix A**.

Interstate 5

Caltrans owns and maintains Interstate 5 and related facilities crossing the watershed. The roadway profile is elevated above existing ground and, therefore, acts as a barrier to overland runoff. The roadway facilities include culvert crossings that collect runoff and direct it beneath the roadway at several locations. Both the storage and flow path restrictions will affect the location and magnitude of downstream flooding. Wood Rodgers contacted Mr. Rick Estrada (Caltrans District 10) to request information for the roadway drainage features. Some older record drawings and bridge inspection reports were helpful, but they did not provide sufficient detail for modeling the drainage crossings, which will be addressed under surveys. They are included in Appendix A.

California Aqueduct

The DWR owns and operates this regional water supply conveyance channel which runs roughly parallel to Interstate 5, flowing from north to south along the eastern edge of the local coastal range (i.e., along the western edge of the San Joaquin Valley). The channel is partially elevated above existing ground with containment embankments along each bank of the channel. Because it runs perpendicular to the downhill terrain gradients, it also creates a barrier to natural runoff from Little Salado Creek and other small tributary areas. Similar to Interstate 5, there are culverts present under the aqueduct to release local runoff downstream (eastward). While the design is intended to keep local runoff and irrigation/water supply waters separate, it should be determined whether, during a flood event, flooding will overtop the channel embankments or be conveyed beneath the channel. Wood Rodgers contacted Ms. Sheree Edwards at DWR to obtain information regarding drainage conditions surrounding the facility. The record drawings that were provided by DWR are including in Appendix A. For the purpose of this analysis, it is assumed that the California

Aqueduct is not subject to failure during a 100-year storm event due to canal overtopping or embankment seepage failure.

Delta Mendota Canal

The federal Bureau of Reclamation owns the DMC (a water supply facility) which is operated and maintained by the SL&DMWA. The facility is located east of the California Aqueduct, and flows water from north to south, similar to the California Aqueduct. The canal is contained by raised embankments on both sides, with several culverts carrying adjacent runoff both under and into the canal. Wood Rodgers contacted Ms. Jaime McNeil at SL&DMWA to request information on the canal and its drainage features. Ms. McNeil provided .PDF documents containing information for the canal, drainage crossings/inlets, and rights-of-way. The provided information is included in Appendix A. It is noted that flow information provided by the SL&DMWA is inconsistent with modelled capacity as determined by the CLIPB drainage analysis. This discrepancy is discussed further under the Results section below.

Federal Emergency Management Agency (FEMA)

As an agency, FEMA does not own physical facilities in the watershed that will influence flooding; however, FEMA does perform flood studies and publish floodplain mapping which can significantly influence a project's drainage analysis solutions. The presence or absence of flooding on FEMA's maps can influence the type of analysis and regulatory review associated with a project, both before construction and after construction. **Figure 2** shows the current FEMA floodplain mapping in the project area and the immediate surrounding area. The documentation of the FEMA floodplain mapping is insufficient to determine the basis for the flooding shown on the maps, and the following is Wood Rodgers' assessment of the likely flood patterns depicted.

It is possible that the adjacent watershed (Salado Creek) influences flooding along Little Salado Creek due to overflow depicted by the Zone A flooding on the map. The mapping of Zone A is not detailed, but it does indicate that there is a flow limitation in either the Salado Creek channel capacity and/or the crossing structures. The mapping also shows significant flooding parallel to the DMC, which may indicate potential flooding emanating from the canal to lands located to the east, including the project area. While the flooding transitions from Zone A to Zone X, both of these flood zones can occur during a 100-year storm, as Zone X can denote shallow flooding of less than 1 foot during the 100-year storm event. Flooding downstream (east) of the DMC may be a combination of runoff from Little Salado Creek, Salado Creek, and the DMC. Because of these implications, Wood Rodgers analyzed the Salado Creek system between Interstate 5 and the DMC, and its potential interactions with the DMC.

FEMA's mapping also shows Zone AH flooding (with a base flood elevation of 114 feet) along State Route 33 (SR 33) at a point just downstream of the project, associated with Little Salado Creek flooding. Detailed 100-year flood mapping in this area (downstream to SR 33) was necessary for the project study in order to determine the mitigation necessary to prevent increases to existing conditions.

SURVEY INFORMATION

Wood Rodgers obtained two topographic data sets for the purpose of defining terrain and drainage paths within the watersheds affecting CLIBP. The first source of topography is the Light-Detecting and Ranging (LiDAR) data collected by DWR under the Central Valley Floodplain Evaluation and Delineation (CVFED) program, which covers most of the Central Valley. The CVFED mapping focused primarily on low-lying valley areas and did not capture the upper watershed areas west of I-5. Therefore, Wood Rodgers identified a supplemental topographic data set using Digital Elevation Model (DEM) data from the US Geological Survey (USGS) National Elevation Dataset (found online at https://www.usgs.gov/core-science-systems/ngp/tnm-delivery/gis-data-download). **Figure 3** shows the compilation of terrain data sources used for this study.

Wood Rodgers' project team includes the local surveying firm, Northstar Engineering Group, Inc. (Northstar), which surveyed culvert crossings along Little Salado Creek through the project area, on-site culverts associated with the existing airstrip layout, and the upstream crossings of I-5 and the Fink Landfill outlet structure. The new survey data is provided in Appendix A for reference. The dimensions of the culverts under the California Aqueduct were determined from record drawings provided by DWR. The dimensions and locations of the drainage culverts for the Delta Mendota Canal were provided by SL&DMWA.

EXISTING CONDITIONS

Prior to evaluating any scenarios that reflect a future development project, it is critical to define the pre-project (existing) flooding conditions. Pre-project conditions can identify existing flood hazards that may be the responsibility of others, or that may need to be removed from project areas to facilitate development. The existing conditions can also establish the target for sizing mitigation facilities by comparing future development (with drainage mitigation facilities in place) to pre-project flooding, confirming that adverse impacts are not created by the project. In order to define the pre-project conditions, it is necessary to evaluate the natural watershed hydrology, and perform detailed hydraulic calculations to accurately reflect how water flows around and through the project area.

HYDROLOGY

The hydrology affecting the project is a compilation of the contributing drainage area, the terrain slopes, the vegetative cover, the infiltration into the soil, the volume and distribution of rainfall, and the pathways by which flow moves from upstream to downstream. The compilation of these effects is best simulated using computational software programs. Wood Rodgers utilized the widely-used, free software, HEC-HMS (version 4.2), that was developed by the US Army Corps of Engineers' (USACE's) Hydrologic Engineering Center (HEC). The software is available online: https://www.hec.usace.army.mil/software/hec-hms/downloads.aspx

Watersheds

How water moves through downstream areas is heavily influenced by how water travels from upstream areas. The upstream travel times, and the storage and outflow affects created by constructed barriers and culvert restrictions, serve to slow down or speed up the travel of water. To reflect detailed evaluation of these upstream flow influences, breakdown of the watershed into sub-watersheds is necessary, allowing each site-specific influence to be properly accounted for.

Wood Rodgers combined the terrain data and the locations of culverts to help determine the watershed boundaries for existing conditions, which are shown on **Figure 4**.

Infiltration

Not all rainfall remains at the surface. The amount of water that is trapped by the terrain and prevented from flowing downstream during a storm event must be estimated as part of any hydrologic analysis. Since such volumes of water are separated and removed from the surface flow analysis, they are referred to as losses. The infiltrative capacity of the surface soils within the watershed is the biggest factor in estimating losses. The amount of water entering the soil can vary depending upon the type of soil and the moisture content of the soil at the beginning of and during the storm event. Very dry soils will have higher infiltrative capacities initially, which will diminish to some "constant" infiltration rate based on the hydraulic conductivity of the soils. The vegetative cover can also trap rainfall; however, this will be highly dependent on previous rainfall volumes and whether foliage has had time to dry. The surface soil conditions are mapped by the National Resource Conservation Service (NRCS) for many areas of the nation and are available for the watersheds in this study. These are categorized into four hydrologic soil groups (A, B, C and D) which correspond to varying levels of infiltrative capacity. The published soil data from the NRCS is available online at https://websoilsurvey.nrcs.usda.gov/app/HomePage.htm, and is shown on **Figure 5**. The influences of the soils were combined with the land use information described below to help quantify the hydrologic losses.

Land Uses

While soil and vegetation can trap rainfall, constructed features (roads, buildings, etc.) can prevent infiltration from occurring, and can increase runoff due to impervious surfaces. These types of constructed features are not naturally occurring and are the result of the effects on the landscape of different human activities (uses). Much of the contributing watershed is undeveloped. The existing land use/land cover data (raster) was extracted from the National Land Cover Database, which is developed by the Multi-Resolution Land Characteristics (MRLC) Consortium. (The MRLC Consortium is a partnership of federal agencies led by the US Geological Survey.) Data was downloaded from the MRLC website at https://www.mrlc.gov/data. These land uses are shown on **Figure 6.**

Calculation of Hydrologic Losses

The infiltration into the ground and impervious surfaces influences were quantified in the modeling using the initial abstraction and the Runoff Curve Number (CN), which is a methodology developed by the Soil Conservation Service (SCS) and in accordance with the published SCS Technical Release (TR)-55. The CN and initial abstraction values for each watershed are listed below in **Table 1**.

Table 1 - CN and Initial Abstraction Values for Each Watershed			
Basin	**Drainage Area (sq. mi.)**	**CN**	**Ia (in)**
CL01	1.10	81	0.469
CL02	1.37	84	0.381
CL03	0.13	86	0.326
CL04	0.18	72	0.778
CL05	1.15	83	0.410
CL06	1.01	85	0.353
CL07	2.79	84	0.381
I501	0.17	80	0.500
I502	0.35	82	0.439
I503	0.10	82	0.439
I504	0.07	82	0.439
LSC01	6.29	83	0.410
LSC02	0.17	81	0.469
LSC03	0.16	81	0.469
LSC04	0.94	82	0.439
LSC05	0.39	84	0.381
LSC06	3.41	84	0.381
LSC07	0.17	88	0.273
LSC08	0.21	85	0.353
LSC09	0.04	85	0.353
OS01	2.64	85	0.353
SC01	25.65	70	0.857
SC02	0.23	80	0.500
SC03	0.73	83	0.410
SC04	0.31	84	0.381

Rainfall

The amount of rainfall for design considerations is defined by the Stanislaus County Improvement Standards. The 100-year storm event is defined under Sections 4.2 and 4.3 for areas within the

County. Under Section 4.2, for retention and detention basin sizing, it directs the use of 2.88 inches of rainfall. In Section 4.3, it modifies that rainfall according to the following formula:

R = 2.88” x (M.A.P./10.9)
where,

R is the 100-year 24-hour rainfall depth in inches
M.A.P. is the Mean Annual Precipitation value applicable to the watershed, based on Plate 4-B

Evaluating the rainfall using the formula above yields a rainfall of less than 2.88 inches over the watershed because the weighted average M.A.P. is 10.4 (less than 10.9). Given the latest updated language for Section 4.2 of the County’s Standards, Wood Rodgers interprets that design precipitation for retention and detention must be a minimum of 2.88 inches and should use the higher of the two stated methods. Therefore, the 100-year storm event was modeled using 2.88 inches of applied rainfall.

The 2-year 24-hour rainfall depth values are not published within the Stanislaus County Standards, but are necessary for determining the time of concentration for each watershed. Estimating the travel time and time of concentration is based on the 2-year 24-hour rainfall event. Rainfall data published in the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 was utilized as the foundation for the velocity-based computation in determining travel times as outlined in TR-55. An average value of 1.38 inches was used as a representative value for the entire watershed (instead of using varying values). The calculation of travel times is more dependent on watershed slope and stream length values than on precipitation values. The same watershed will yield similar velocities and travel times for varying levels of rainfall. It should be noted that the NOAA Atlas 14 rainfall estimates differ from the Stanislaus County standards for the larger storm events and may yield higher runoff in some areas.

Hydrologic Routing

Channel Routing

Within a hydrologic model, the surface runoff that is generated for each sub-watershed must be moved downstream to combine with other sub-watershed runoff. This movement of water was represented using the Muskingum-Cunge method. Calculations for specific routing reaches for each watershed is provided in Appendix A.

Storage Routing

While hydrologic modeling software can model storage affects, this type of routing was not employed within the HEC-HMS platform for the portion of the routing being handled by this software. The upper watersheds do not have significant opportunities for natural storage because they have predominantly sloped terrain features and very few major roads/obstructions. The areas in the vicinity of I-5 and downstream (eastward) were modeled using HEC-RAS (hydraulic analysis – see discussion below), which allows for detailed storage and outflow characteristics to be modeled more accurately than does the HEC-HMS platform.

HYDRAULIC ANALYSIS

The topographic data, facility record drawings, and new surveys of hydraulic crossings (culverts) were used as the basis for developing the floodplain geometry in the HEC-RAS hydraulic model. The area where detailed hydraulic analysis was performed using HEC-RAS is shown on **Figure 7**. The approach taken was to quantify the channel and overflow conditions along Little Salado Creek and Salado Creek upstream of the DMC, and the flooding within the project area downstream of the DMC. The majority of the model domain is represented using interconnected 2-dimensional (2-D) surfaces with an estimated roughness coefficient of 0.06. As initial modeling progressed, the DMC was represented as a 1-D channel in the model, in order to allow for the interaction of floodwaters with the canal. The cross sections representing the DMC were derived from record information provided by SL&DMWA.

The upstream watershed runoff calculated from the HEC-HMS modeling was injected into the hydraulic model at the boundaries of the 2-D area at the locations corresponding to natural collection points in the terrain. Applying the hydrology to represent the rainfall within the 2-D area requires special consideration. HEC-RAS is primarily a hydraulic program and does not have the ability to reflect infiltration and hydrologic losses. Within the 2-D area, the rainfall excess runoff (after infiltration) from the HEC-HMS model was applied uniformly across the 2-D surface to allow the hydraulic model to "route" the surface runoff downstream.

RESULTS

The results indicate that there is no overtopping of I-5 or overtopping of the California Aqueduct during the 100-year event under existing conditions. All of the upstream runoff stores behind these facilities and flows through the existing culverts crossing these facilities. The runoff downstream of the California Aqueduct is not as contained. The channels immediately upstream of the DMC and crossings under and over the DMC do not have sufficient capacity to convey the entire 100-year storm event and, therefore, spill laterally into the floodplain upstream of the DMC. Water backs up behind the DMC high enough to spill into the DMC at several locations.

The accurate representation of the interaction of flooding with the canal requires a detailed understanding of the flow conditions in the canal prior to and during the flood event. The canal is operated as a water supply channel, so there is a potential that water supply flow could be present when a flood strikes. In addition, given the flooding interface with Salado Creek and Little Salado Creek, there is a potential that additional floodwaters from other creek crossings to the north could also enter into the canal, further exacerbating the spilling conditions into and out of the canal.

Wood Rodgers recognizes that the canal was never designed to be a flood channel. The initial results were shared with the SL&DMWA and the Bureau of Reclamation to alert them to these potential flooding conditions and to begin a dialog for dealing with flood risk within the CLIBP under proposed conditions. With input from the agencies overseeing the DMC, Wood Rodgers evaluated several scenarios with different assumed water supply flow conditions. The original design capacity of the canal is 4,299 cfs; but, based on flow measurements and their corresponding elevations and topographic data, it does not appear that the canal can flow at its stated design capacity without overtopping. Based on Wood Rodger's analysis, the maximum water supply flow that can be conveyed in the canal, while maintaining containment (no overtopping with zero freeboard) before the storm event, is approximately 3,260 cfs.

For purposes of defining a conservative estimate of flooding across the project upstream of the DMC, the DMC was assumed to be conveying 3,260 cfs of water supply flow, and further assumed to weather the storm without failure (therefore resulting in a full flow condition as the canal reaches the project area). For purposes of defining flooding across the project downstream of the DMC, the DMC was assumed to have a base flow of 3,260 cfs, and the downhill embankment was failed once additional drainage flows entering the DMC resulted in overtopping. As standard practice, wherever an uncertified embankment exists that can impound flooding, it is evaluated in both an un-failed and failed condition in order to determine worst-case flooding on both sides of the embankment. The resulting estimated maximum 100-year flooding for un-failed embankment conditions, which produces the worst-case flooding upstream of the DMC, is shown on **Figure 8**. The resulting estimated maximum 100-year flooding for failed embankment conditions (at one location), producing the worst-case conditions downstream of the DMC, is shown on **Figure 9**.

PROPOSED PROJECT

Initial Phase

The first phase of CLIBP development is referred to as Phase 1A, and entails the proposed development of 115 acres located immediately north of Fink Road, between Davis Road and Bell Road, as shown on **Figure 10**. This initial development area is located uphill of the DMC, and is significantly flooded during the 100-year storm under existing conditions, based on the analysis described above. The existing conditions CL04 watershed corresponds with the Phase 1A area and was modified to reflect development runoff conditions for the purposes of analyzing the project implementation.

The existing flooding is influenced by the DMC, but the DMC also offers an overflow outlet to limit flooding on Phase 1A. As long as the proposed development is located above existing flood levels, it should not be affected. The majority of floodwater entering the DMC in the vicinity of Phase 1A originates from Little Salado Creek overflow, not from Phase 1A land. If Little Salado Creek were to be contained, the local runoff from the Phase 1A area alone would not be large enough to overtop the canal embankment. While removing the existing off-site flood influences from Phase 1A areas would allow for its full development, it would be costly because it would force existing floodwaters onto other properties and require significant mitigation. Conversely, if flooded areas were to remain as they are today, over 40 percent of Phase 1A would be undevelopable.

With off-site alternatives being very costly and difficult to implement, the most effective solution for mitigating Phase 1A development is to construct on-site retention storage while allowing existing overflow from Little Salado Creek to pass through in a controlled fashion. Wood Rodgers proposes configuring linear storage parallel to the DMC beneath the existing floodplain, and narrowing the existing floodplain as much as possible while not impeding or increasing existing peak flow and stage conditions. Under this configuration, excavated on-site retention storage would collect Phase 1A runoff directly, well below canal levels, and safely allow for 100-percent infiltration of local runoff (under most conditions). During very large (infrequent) storm events, the corridor along the DMC would still flood and overflow into the DMC due to Little Salado Creek overflow. The local runoff from developed areas would sit below ground and store until the creek overflow receded. Infiltration would then allow for the discharge of any "trapped" runoff into the ground without impacting the DMC.

Preliminary testing of the site indicated that a minimum design infiltration rate of 0.5 inch per hour can be used to drain the retention basin. While this rate would allow for the basin to drain quickly with only Phase 1A runoff, the additional volume of water from Little Salado Creek overflow during a 100-year event would lengthen the time for drainage beyond 48 hours. These preliminary results were shared with Stanislaus County. The County then determined that, based on the relative infrequency of this event, this prolonged inundation would be acceptable.

Further percolation testing was performed by the geotechnical consultant (Engeo) and documented in their report (available upon request). A recommended design infiltration rate of 1.7 inches/hour was determined from the lowest measured stabilized rate, with no factor of safety applied. With a factor of safety of 2 (required by Stanislaus County standards), the design infiltration rate is 0.85 inches/hour. At this rate, the Phase 1A 100-year runoff of 24.5 acre-feet will drain in less than 48 hours. The proposed Phase 1A basin has a bottom area of 7.37 acres and can contain the entire 100-year Phase 1A runoff without overtopping into the DMC right-of-way. Offsite flooding originating from Little Salado Creek will increase volume entering the Phase 1A basin, but will pass downstream as it does today. Any additional volume trapped within the retention basin will infiltrate at a rate of 1.7 feet per day. The maximum water surface elevation resulting from Little Salado Creek overflow on Phase 1A land is 185.7 feet (NAVD88) during a 100-year storm event based on Stanislaus County rainfall.

The proposed Phase 1A flood mitigation and residual flooding are shown on **Figure 11**. The modeling for Phase 1A is provided in digital format in Appendix A.

Future Project Phases

In 2018, planned development for the CLIBP area was approved by the County Board of Supervisors as part of the adopted Specific Plan. As part of standard practice a complete drainage assessment for full buildout of the CLIBP should be performed. However, development of future CLIBP phases cannot be evaluated without understanding how the DMC will be operated during a 100-year flood event. All future phases beyond Phase 1A will be located downhill of the DMC and will be subject to potential flooding due to overtopping and/or embankment failure.

It is Wood Rodgers' understanding that the SL&DMWA and the Bureau of Reclamation are in the process of evaluating the current capacity of the DMC, which should involve detailed flow/capacity assessments along the entire canal reach. Assessing capacity should include identifying containment limitations (low points) along both banks, where drainage flow can potentially enter/exit the canal from a storm event. Wood Rodgers assumes that the SL&DMWA and the Bureau of Reclamation do not wish to allow uncontrolled flooding through their facility and would implement measures to protect the integrity of their water supply conveyance channel during a large storm event. The County should consider requesting a copy of the agencies' modeling and operational procedures, as they may help inform conditions for future CLIBP drainage analyses. Additional hydrologic and hydraulic analysis could be necessary to quantify inflow from other creek systems crossing the DMC.

Until the existing flood hazard associated with the DMC is fully defined, and the agencies involved have developed their approaches to address the hazard, drainage facilities to mitigate future development phases (beyond Phase 1A) cannot be determined. The CLIBP will require the assistance of the DMC agencies to analyze and mitigate the risks associated with the DMC. Fortunately, based on the County's timing for full buildout of the CLIBP, there is time for the County, the SL&DMWA, and the Bureau of Reclamation to cooperatively address this issue prior to future phases of the development.

FIGURES

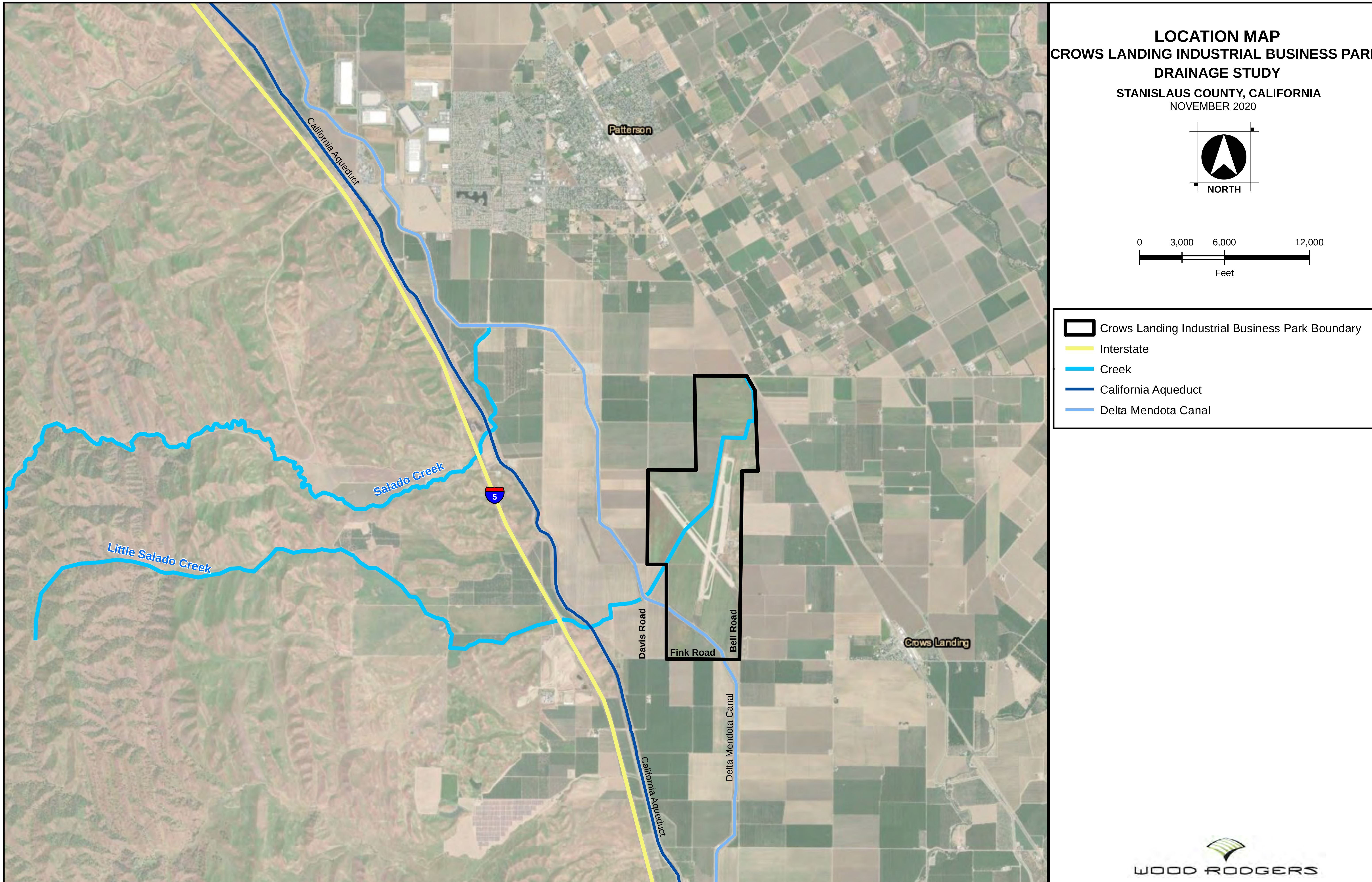

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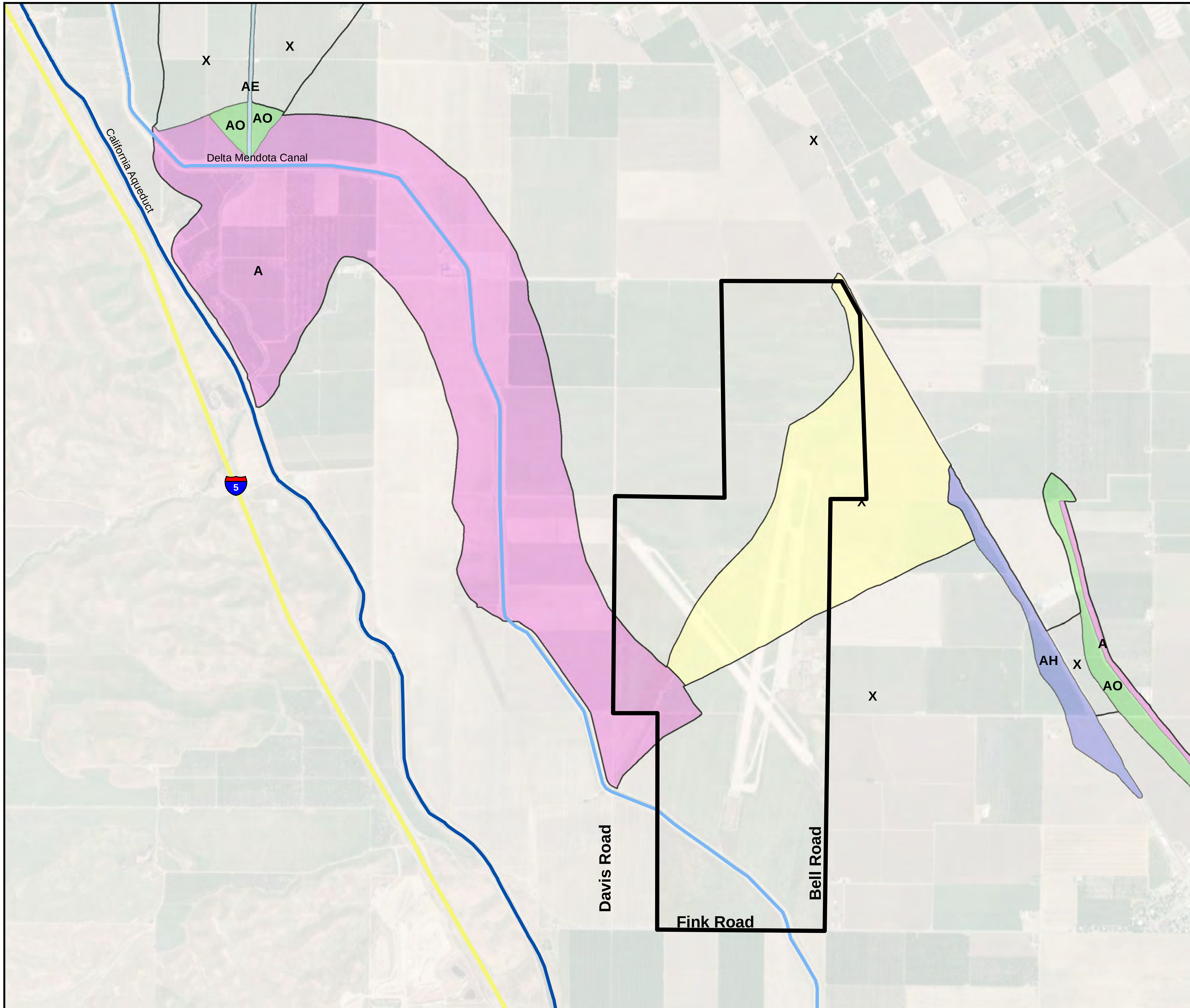
FIGURE 1



FEMA FLOODPLAIN MAPPING
CROWS LANDING INDUSTRIAL BUSINESS PARK
DRAINAGE STUDY

STANISLAUS COUNTY, CALIFORNIA

NOVEMBER 2020

NORTH

0 1,500 3,000 6,000

Feet

Interstate

California Aqueduct

Delta Mendota Canal

Crows Landing Industrial Business Park Boundary

FEMA Effective Floodplain

Zone A

Zone AE

Zone AH

Zone AO

Zone X

Zone X (Shaded)

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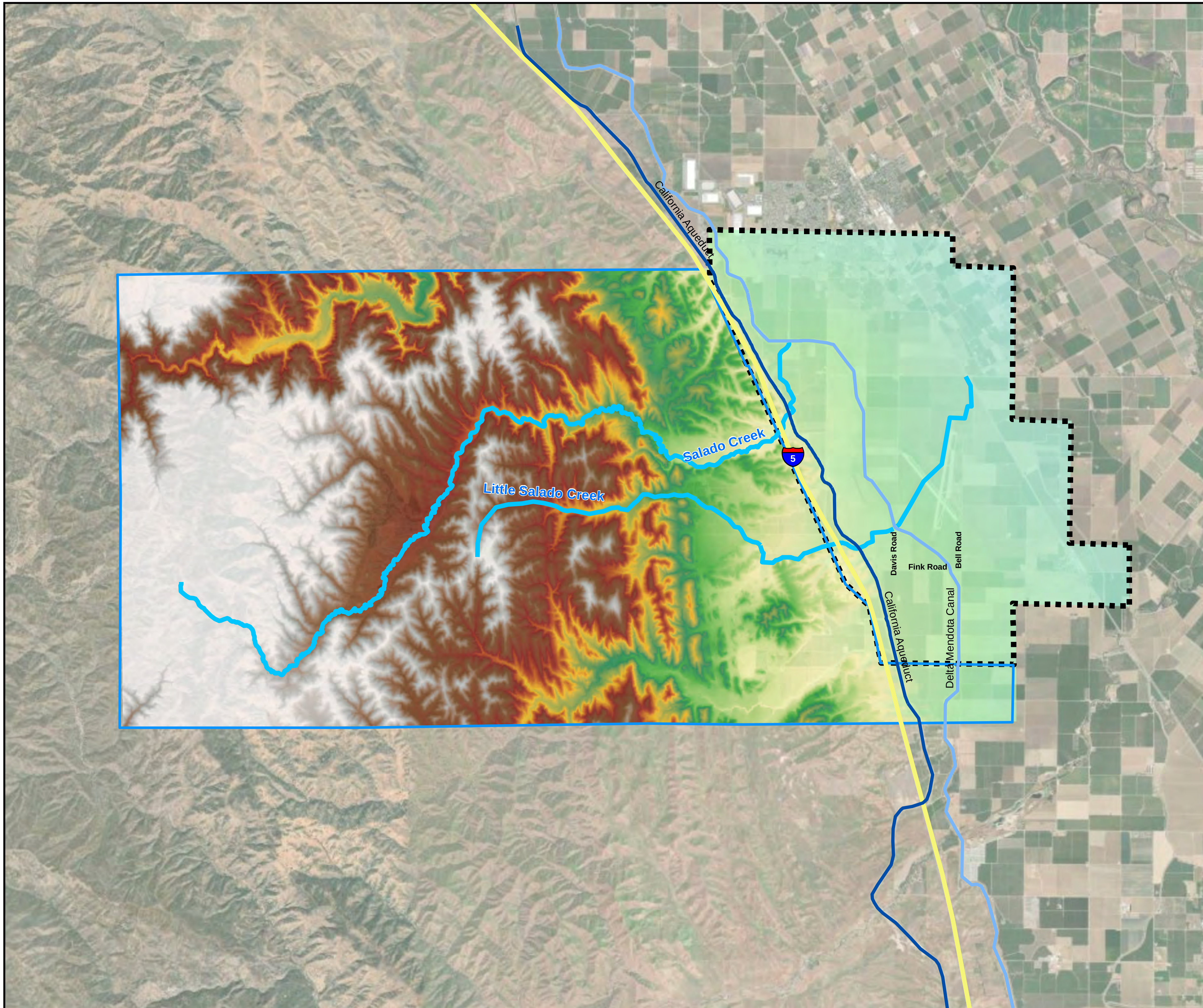
FIGURE 2



TOPOGRAPHIC DATA

CROWS LANDING INDUSTRIAL BUSINESS PARK

DRAINAGE STUDY

STANISLAUS COUNTY, CALIFORNIA

NOVEMBER 2020

NORTH

0 5,000 10,000 20,000
Feet

Legend

- California Aqueduct
- Delta Mendota Canal
- Interstate
- Creek

Topographic Data Source

- CVFED
- USGS

Value

High : 1823.97

Low : 71.7902

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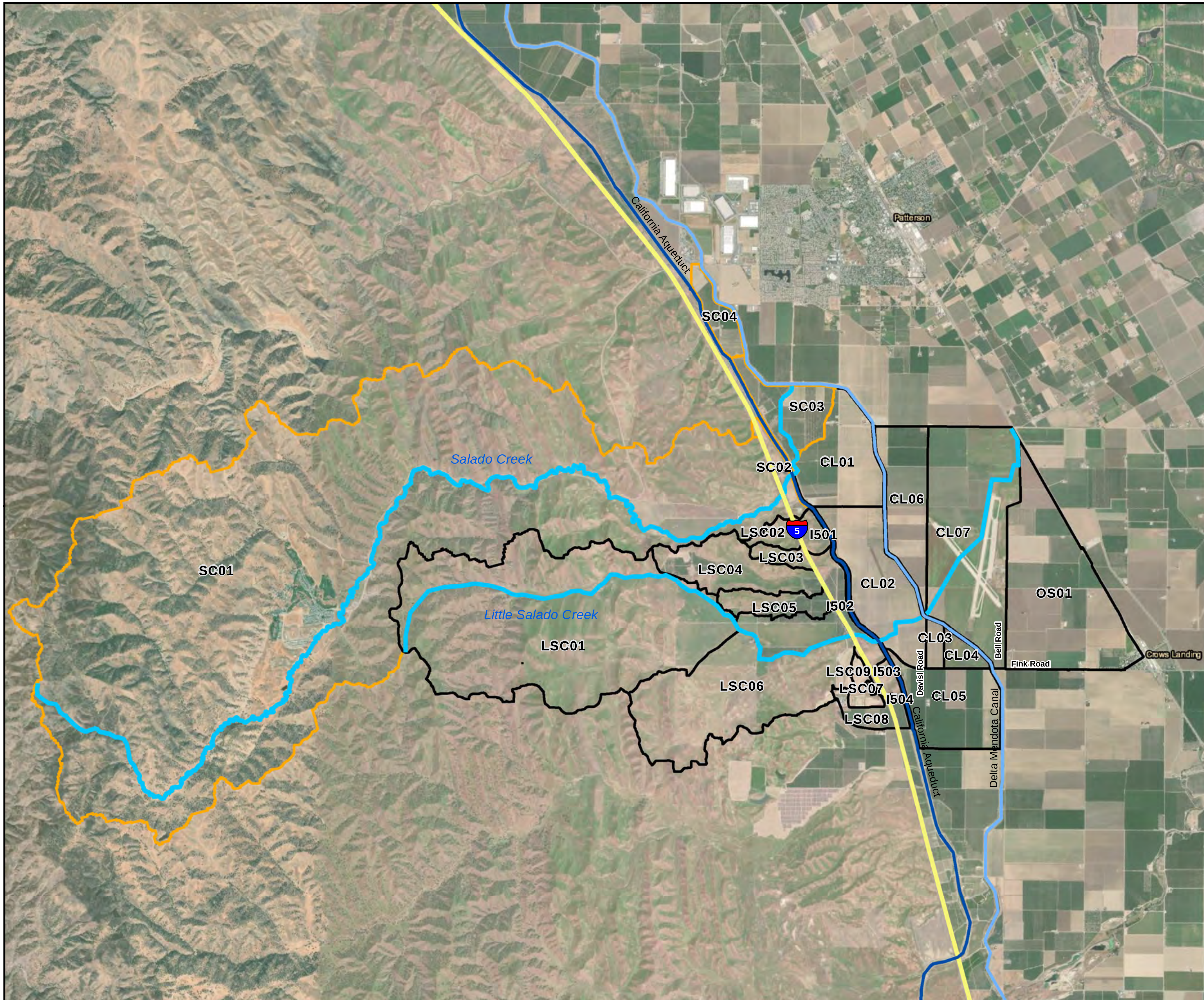
FIGURE 3



EXISTING CONDITIONS WATERSHEDS

CROWS LANDING INDUSTRIAL BUSINESS PARK

DRAINAGE STUDY

STANISLAUS COUNTY, CALIFORNIA
NOVEMBER 2020

NORTH

0 4,000 8,000 16,000
Feet

Legend

- California Aqueduct
- Delta Mendota Canal
- Interstate
- Creek

Watersheds

- Little Salado Creek and Ancillary Watersheds
- Salado Creek

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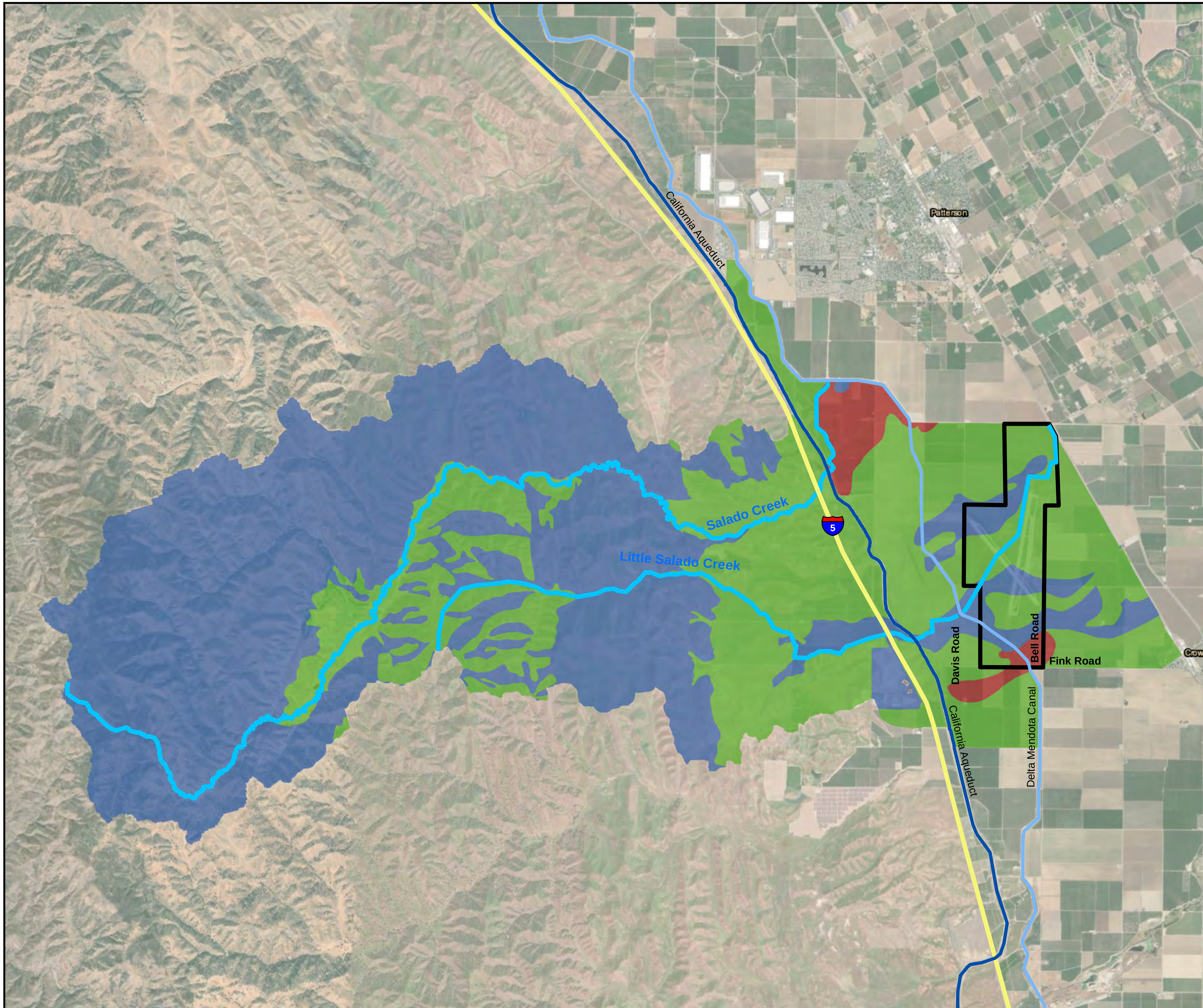
Figure 4



SOILS MAP

CROWS LANDING INDUSTRIAL BUSINESS PARK

DRAINAGE STUDY

STANISLAUS COUNTY, CALIFORNIA

NOVEMBER 2020

NORTH

0 3,000 6,000 12,000

Feet

Legend

- California Aqueduct
- Delta Mendota Canal
- Interstate
- Creek
- Crows Landing Industrial Business Park Boundary

Hydrologic Soil Group

- B
- C
- D

NOTE: Soils data provided by USDA National Resources Conservation Services

WOOD RODGERS

\\woodrodgers.loc\ProductionData\Jobs\Jobs\8682_Crows_Landing\Crows_Landing_OA\GIS\Tasks\Drain\Report\Fig05_Soils Data Fig.mxd 9/28/2020 6:38:31 PM wli

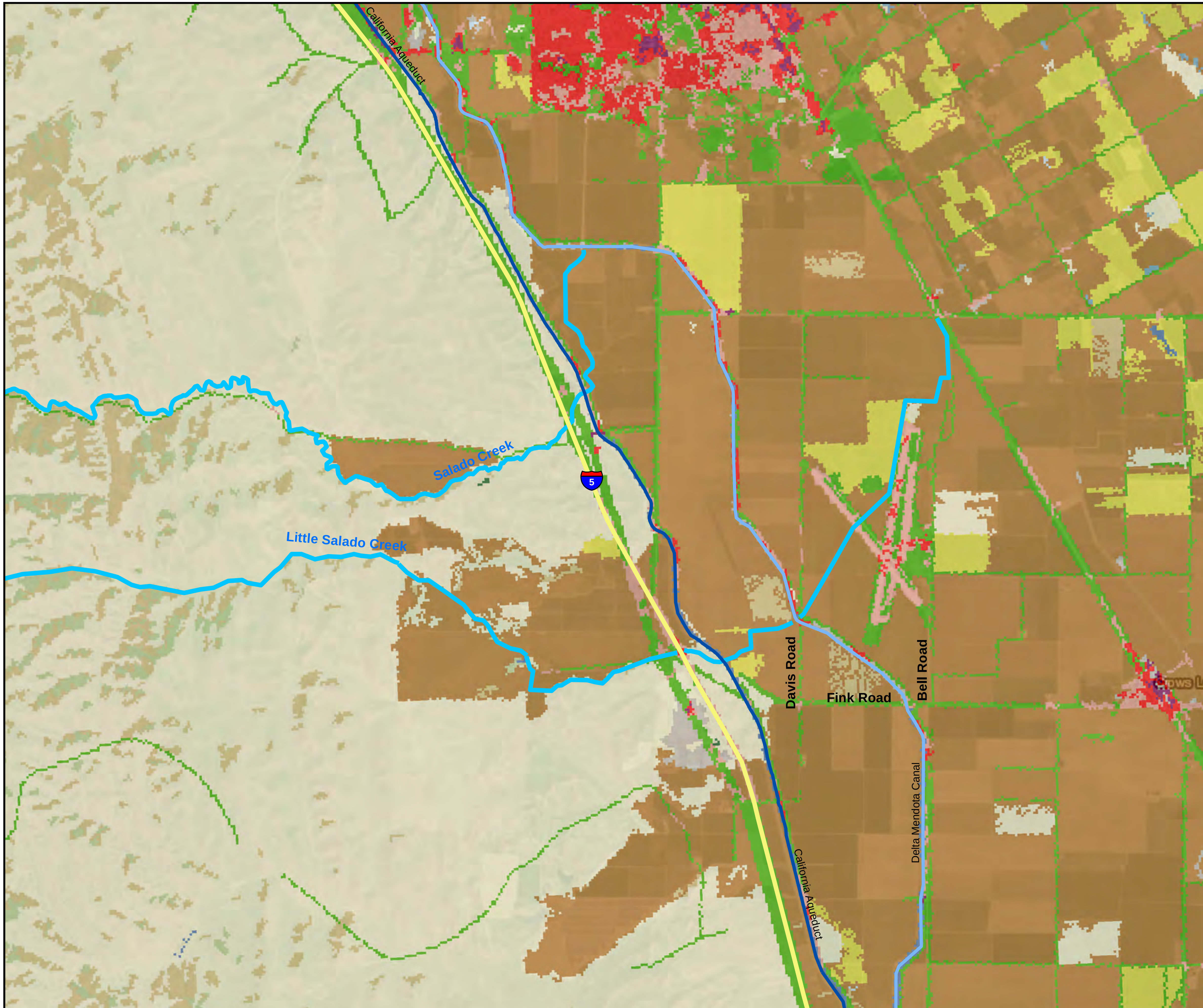
FIGURE 5

EXISTING LAND USE
CROWS LANDING INDUSTRIAL BUSINESS PARK
DRAINAGE STUDY

STANISLAUS COUNTY, CALIFORNIA
NOVEMBER 2020

NORTH

0 3,000 6,000 12,000
Feet



Legend

- California Aqueduct
- Delta Mendota Canal
- Interstate
- Creek

Land Use

- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land
- Evergreen Forest
- Mixed Forest
- Shrub/Scrub
- Herbaceuous
- Hay/Pasture
- Cultivated Crops
- Woody Wetlands
- Emergent Herbaceuous Wetlands

WOOD RODGERS

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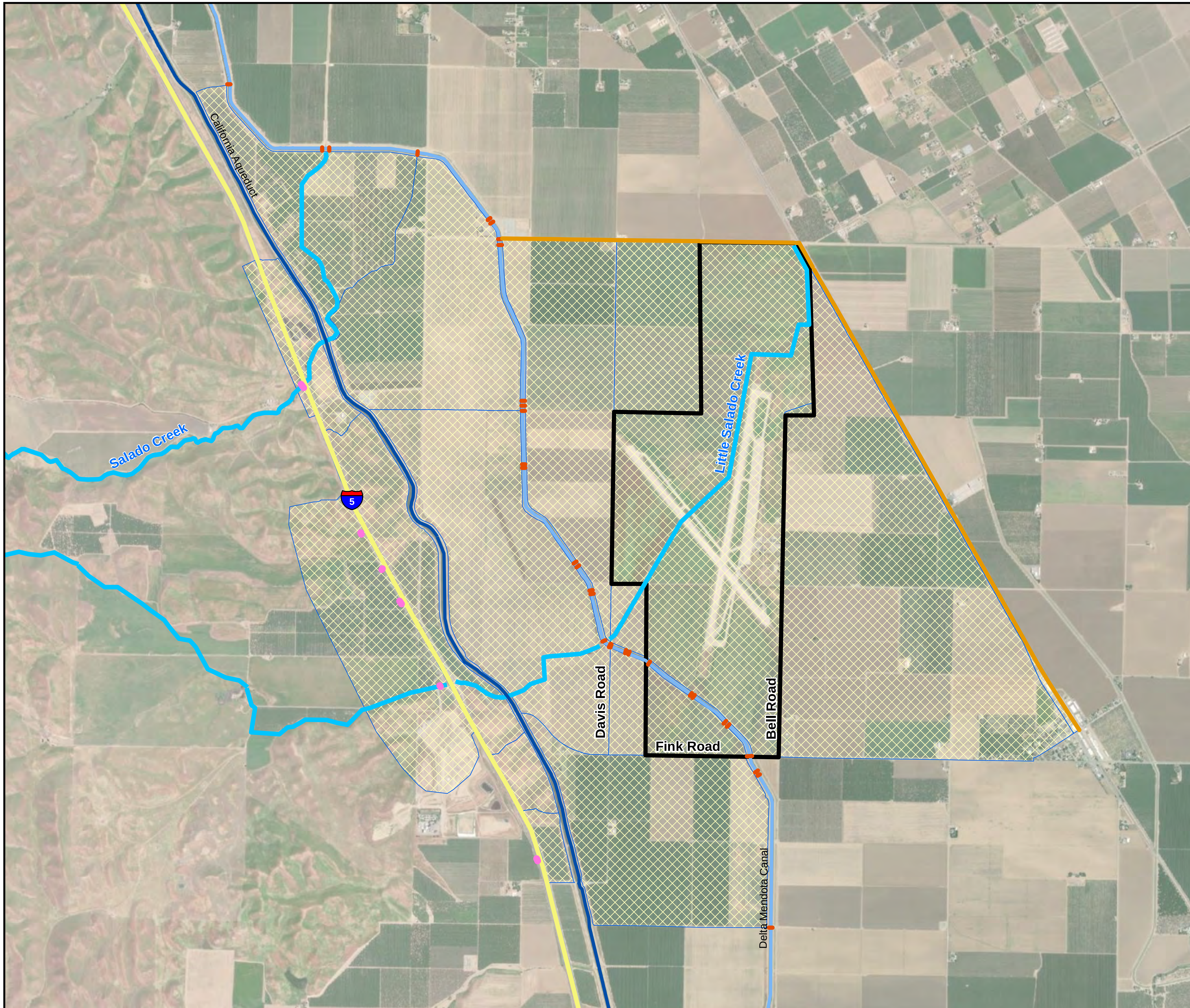
FIGURE 6



HEC-RAS MODELING DOMAIN

CROWS LANDING INDUSTRIAL BUSINESS PARK DRAINAGE STUDY

STANISLAUS COUNTY, CALIFORNIA

NOVEMBER 2020

NORTH

0 1,500 3,000 6,000

Feet

- HEC-RAS Cross Section
- California Aqueduct
- Delta Mendota Canal
- Creek
- Interstate

HEC-RAS Boundary Conditions

- Normal Depth
- Inflow Hydrograph
- HEC-RAS 2D Area
- Crows Landing Industrial Business Park Boundary

WOOD RODGERS

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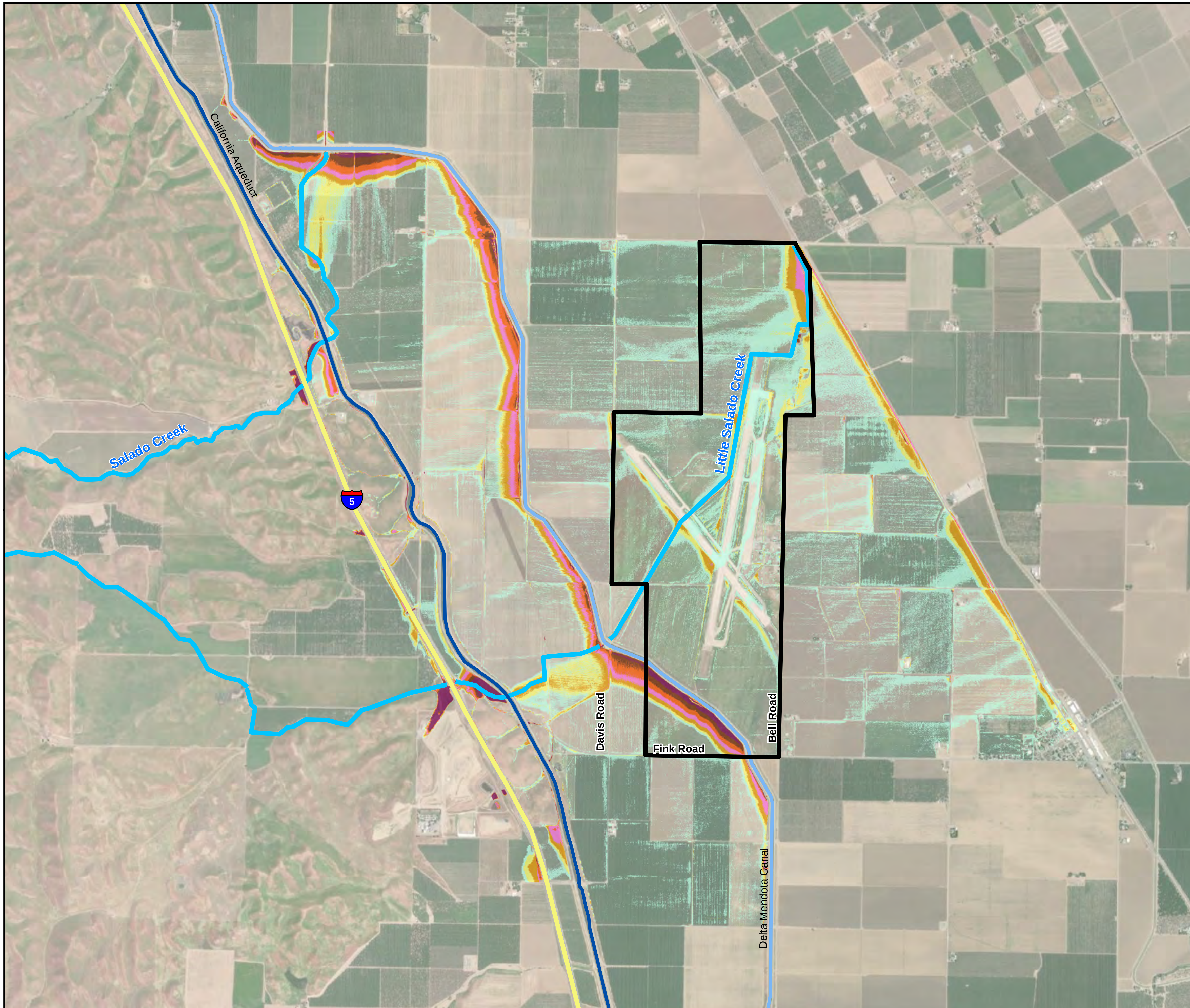
FIGURE 7



100-YEAR FLOODING
CROWS LANDING INDUSTRIAL BUSINESS PARK DRAINAGE STUDY

STANISLAUS COUNTY, CALIFORNIA
NOVEMBER 2020

NORTH

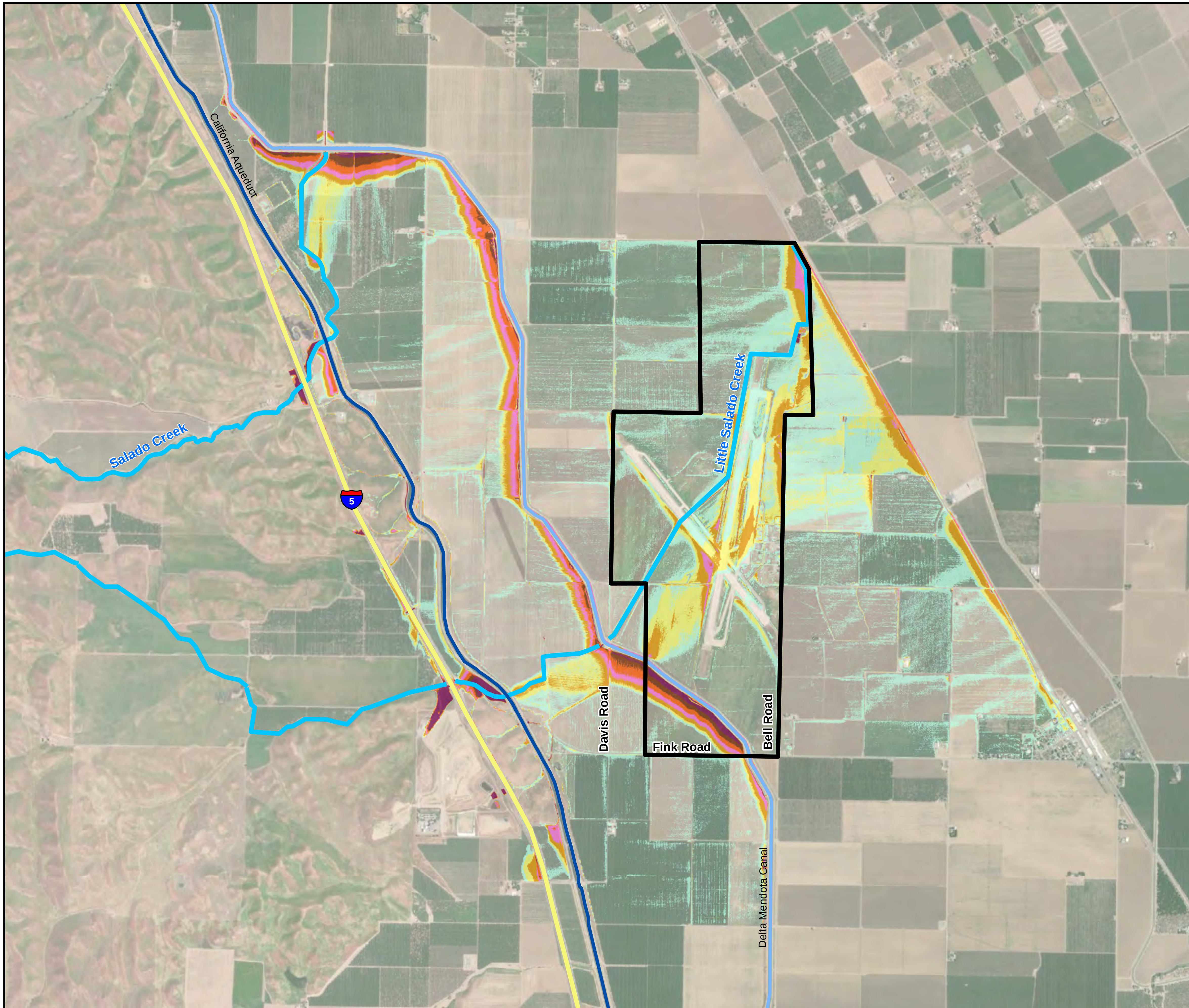
0 1,500 3,000 6,000
Feet

100-year Floodplain Depth (ft)

- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5
- California Aqueduct
- Delta Mendota Canal
- Creek
- Interstate
- Crows Landing Industrial Business Park Boundary

WOOD RODGERS

\\woodrodgers.loc\ProductionData\Jobs\Jobs\8682_Crows_Landing\Crows_Landing_OA\GIS\Tasks\Drain\Report\Fig08_100Year_FloodingMap.mxd 9/28/2020 6:35:27 PM wli



100-YEAR FLOODING WITH EMBANKMENT FAILURE

CROWS LANDING INDUSTRIAL BUSINESS PARK DRAINAGE STUDY

STANISLAUS COUNTY, CALIFORNIA

NOVEMBER 2020

NORTH

0 1,500 3,000 6,000

Feet

100-year Floodplain Depth (ft)

- 0.1 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5
- California Aqueduct
- Delta Mendota Canal
- Creek
- Interstate
- Crows Landing Industrial Business Park Boundary

\\woodrodgers.loc\ProductionData\Jobs\Jobs\8682_Crows_Landing\Crows_Landing_OA\GIS\Tasks\Drain\Report\Fig09_100Year_FloodingMap_EmbankmentFailure.mxd 9/28/2020 6:40:35 PM wli

FIGURE 9

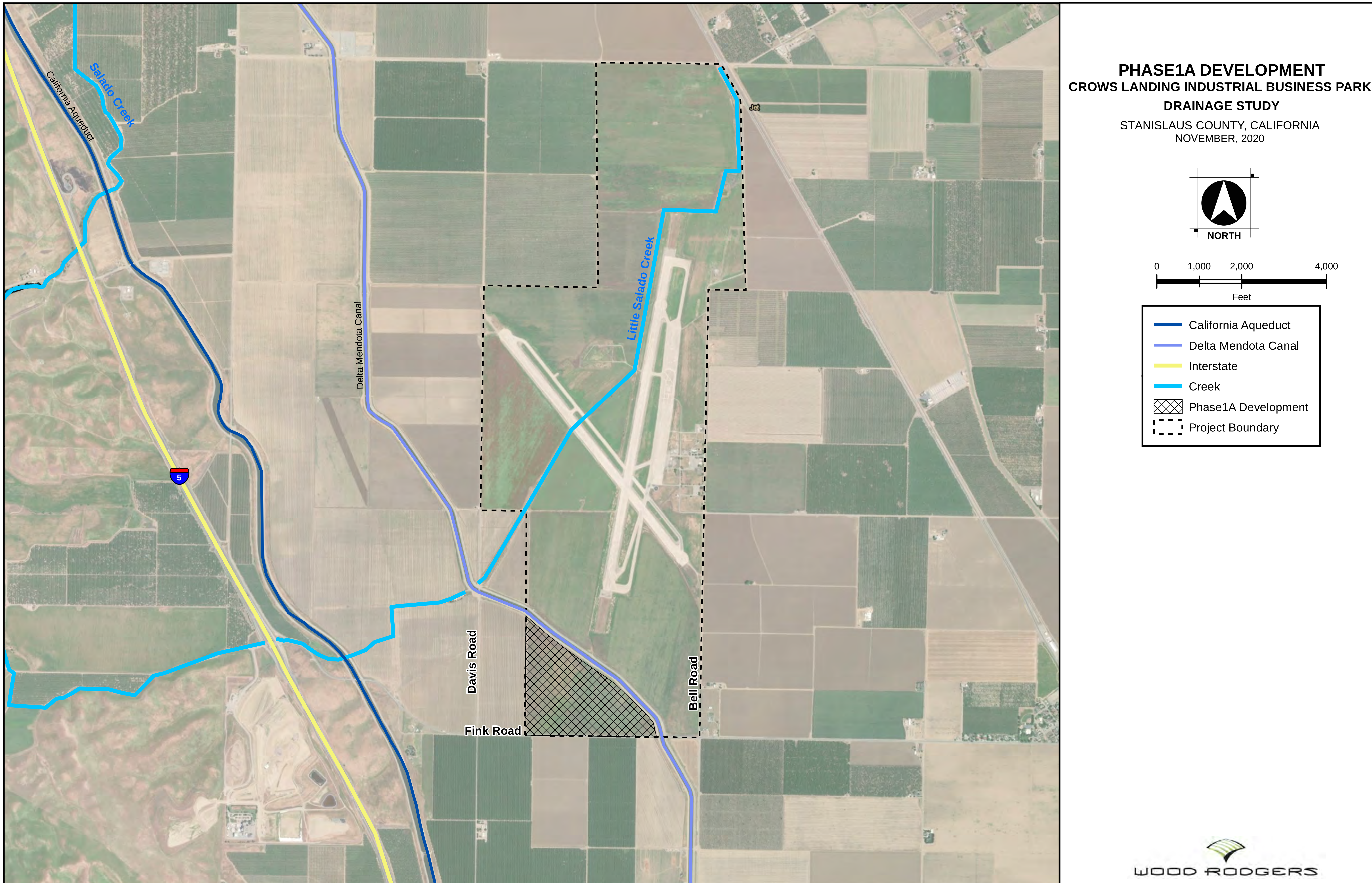


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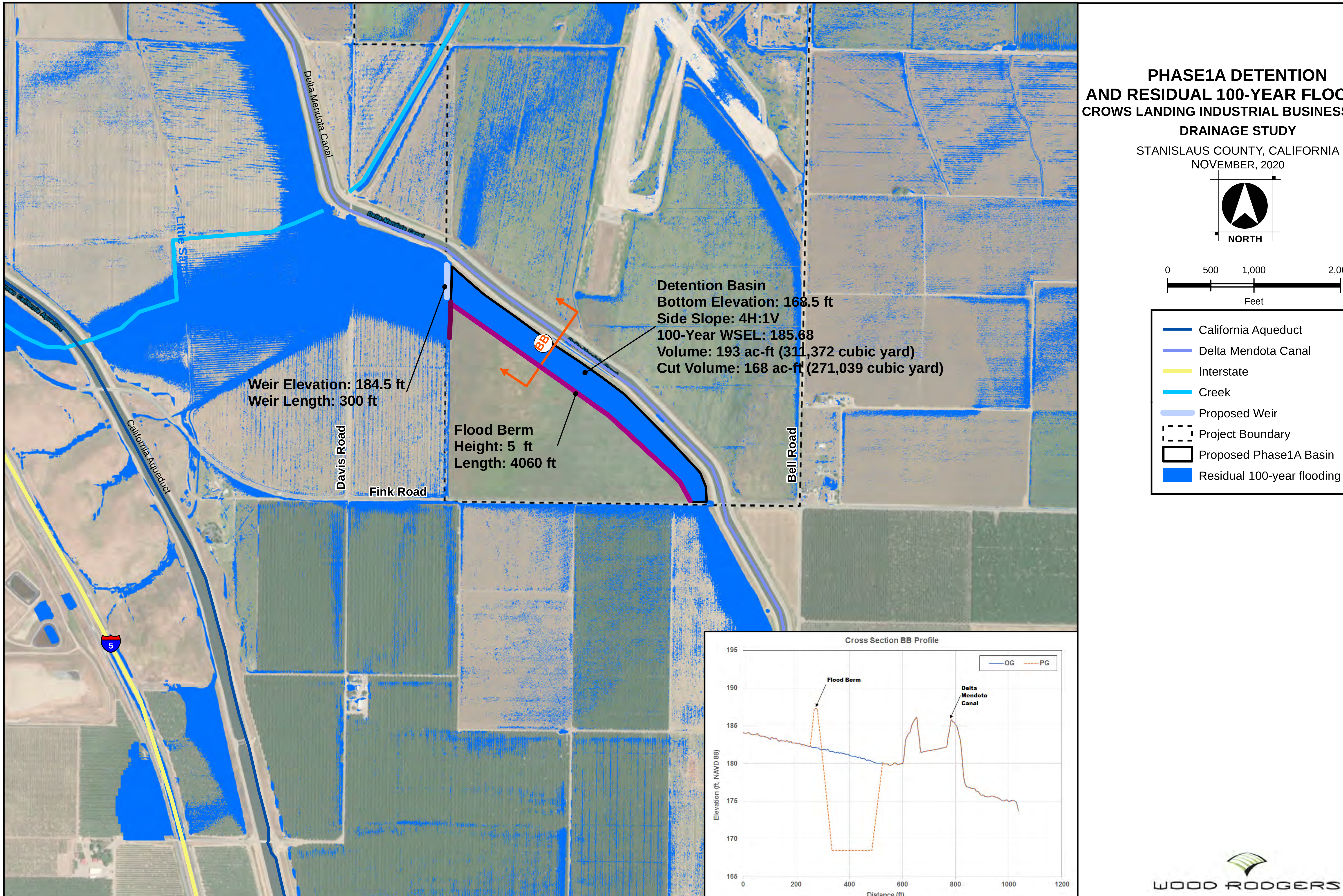
Figure 10

PHASE1A DETENTION AND RESIDUAL 100-YEAR FLOODING

CROWS LANDING INDUSTRIAL BUSINESS PARK DRAINAGE STUDY

STANISLAUS COUNTY, CALIFORNIA
NOVEMBER, 2020



WOOD RODGERS

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Figure 11