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Water Resources ◆ Flood Control ◆ Water Rights

# TECHNICAL MEMORANDUM

**DATE:** June 19, 2019

**TO:** Jeff Twitchell, P.E., GEI Consultants

**FROM:** Brian Brown, P.E.

**SUBJECT:** Flood Risk to Community of Knights Landing

This memorandum documents the flood risk to Knights Landing, an unincorporated community in Yolo County, California. The community of Knights Landing is located along County Road 102/Highway 113, approximately 12 miles north of Woodland, California. Knights Landing is located on the right bank of the Sacramento River, where Highway 113 crosses the Sacramento River. The community is located in the Knights Landing Basin, an area surrounded by leveed waterways that include the Sacramento River, Knights Landing Ridge Cut, and the Yolo Bypass. The community of Knights Landing within the Basin is shown in Figure 1.

The Sacramento River carries water from Shasta Lake down the Sacramento Valley for both irrigation and flood control. The community of Knights Landing is located along the Sacramento River approximately 6 miles upstream of the Freemont Weir. The Freemont Weir is a lateral weir that allows water from the Sacramento River to flow into the Yolo Bypass in high flow events. The Yolo Bypass diverts floodwaters from the Sacramento River away from the greater Sacramento metropolitan area and other nearby riverside communities. The Knights Landing Ridge Cut is a flood diversion channel that takes water from the Colusa Basin to the Yolo Bypass.

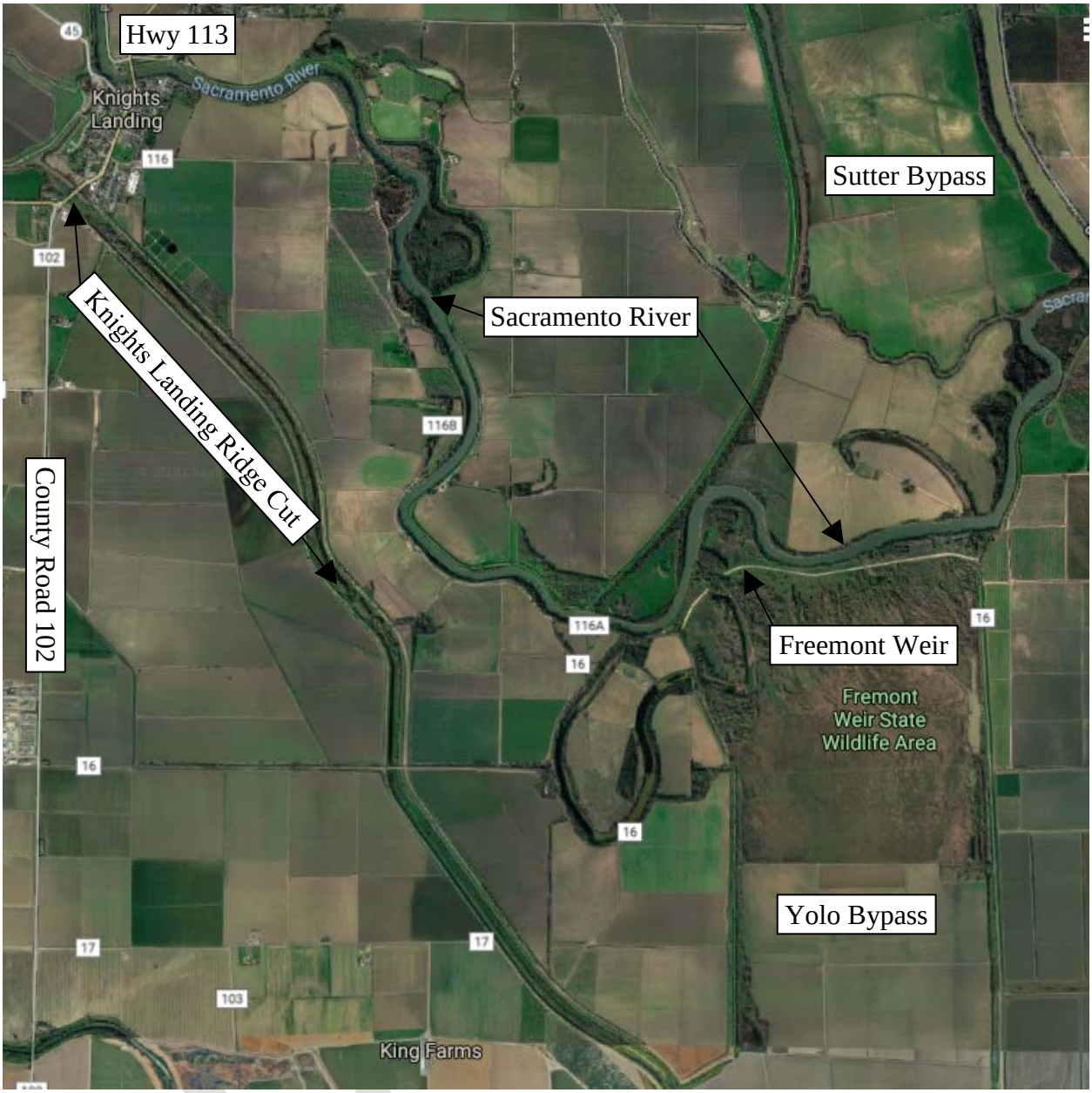


**Figure 1. Community of Knights Landing within Knights Landing Basin**

# 1. EXISTING CONDITIONS

The Knights Landing Basin is surrounded by levees that have historically provided flood protection for the community of Knights Landing. Hydraulic simulations for the 1-percent annual chance flood show that floodwaters do not overtop any of the levees surrounding the Basin.

The current FEMA Flood Insurance Study (FIS) for Yolo County is dated May 16, 2012 (FEMA, 2012). The current FIS maps the floodplain for the 1-percent annual chance floodplain on the Floodplain Insurance Rate Maps (FIRM) for Yolo County. The community of Knights Landing is shown as mapped in Zone A, shown in Figure 2. FEMA defines Zone A as "the flood insurance rate zone that corresponds to the 1-percent annual chance floodplains that are determined in the FIS by approximate methods. Because detailed hydraulic analyses are not

performed for such areas, no base flood elevations or depths are shown within this zone." Though there is not a detailed study to provide base flood elevations (BFE), the non-compliance of the levees surrounding the Knights Landing Basin leads to the Zone A determination.


**Figure 2. FEMA Flood Map for Yolo County Near Community of Knights Landing**

In accordance with FEMA criteria for the accreditation of levee systems, a minimum earthen levee freeboard of 3 feet is required in evaluating the ability of levee systems to provide protection from the 1-percent annual chance flood. If an earthen levee does not provide the specified 3-foot freeboard during a 1-percent annual chance flood, it is assumed to fail. Therefore, the floodplains in the area of such an inadequate levee reflect flood conditions as if this flood-control structure did not exist. The FEMA criteria used to evaluate protection from the 1-percent annual chance flood, as depicted in CFR 65.10, are (1) adequate design, including freeboard, (2) structural stability, and (3) proper operation and maintenance. Levees that cannot be certified to provide protection from the 1 percent annual chance flood are not considered in the hydraulic analysis of the 1-percent annual chance floodplain. The levees protecting Knights Landing have not been certified and, therefore, are not considered in the FEMA hydraulic analysis.

## 2. RESULTING FLOOD RISK

To evaluate the flood risk to the community of Knights Landing, recent hydrologic and hydraulic models were used to quantify flooding.

To represent the 1-percent annual chance flood event, hydrology based on the Central Valley Hydrology Study (CVHS) was used. The U.S. Army Corps of Engineers (USACE) completed the CVHS in 2015 for the California Department of Water Resources (DWR) (USACE, 2015). A key part of that methodology involves scaling historical flood patterns to represent desired frequencies, such as the 1-percent annual chance flood event. The CVHS event selection procedures were applied to the latitude where Knight's Landing is located in the Sacramento River System. From the event selection, it was determined that the 1997 flood pattern scaled at 95% represents the 1-percent annual chance flood for the Knights Landing Basin. The hydrograph for the 1-percent annual chance flood (1997 flood pattern scaled at 95%) in the Sacramento River at the community of Knights Landing, downstream of the Hwy 113 bridge, is shown in Figure 3.

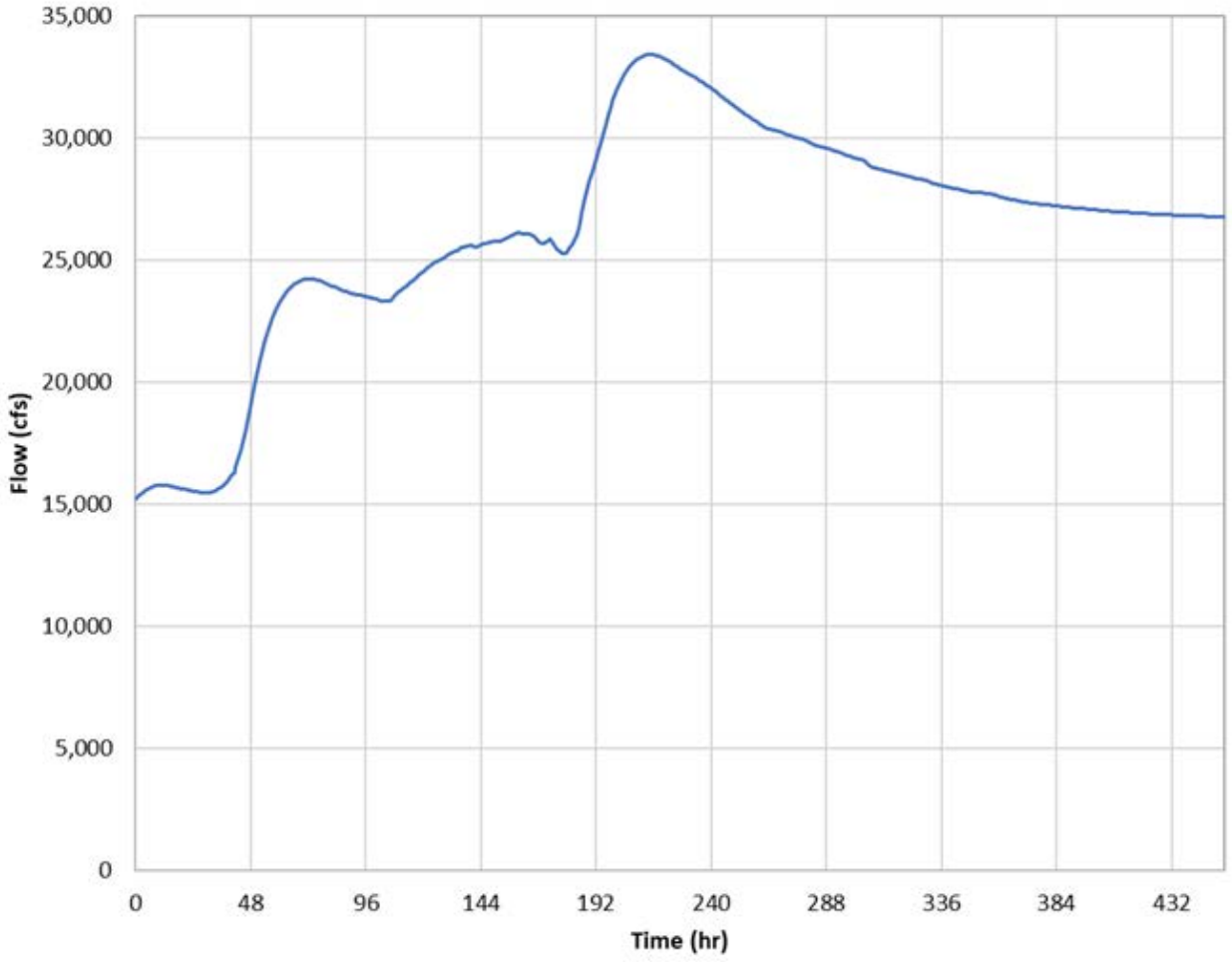


**Figure 3. Hydrograph for 1-Percent Annual Chance Flood in Sacramento River at Community of Knights Landing**

The hydraulic model used for this analysis was developed by DWR for the Central Valley Floodplain Evaluation and Delineation (CVFED) program. This HEC-RAS model contains the complete Sacramento River Flood Control System, including the Sutter and Yolo bypasses, from Shasta Lake to the San Francisco Bay. For the community of Knights Landing analysis, the Knights Landing Basin was converted to a 2-D flow area using HEC-RAS version 5.0.5. The 2-

D flow area in the hydraulic model is composed of 300’ grid cells (with CVFED LiDAR as the underlying terrain) and is shown in Figure 4. The hydraulic model can route the hydrology and levee breaches can be used to compute the resulting floodplain water surface elevation (WSE) in the Basin.

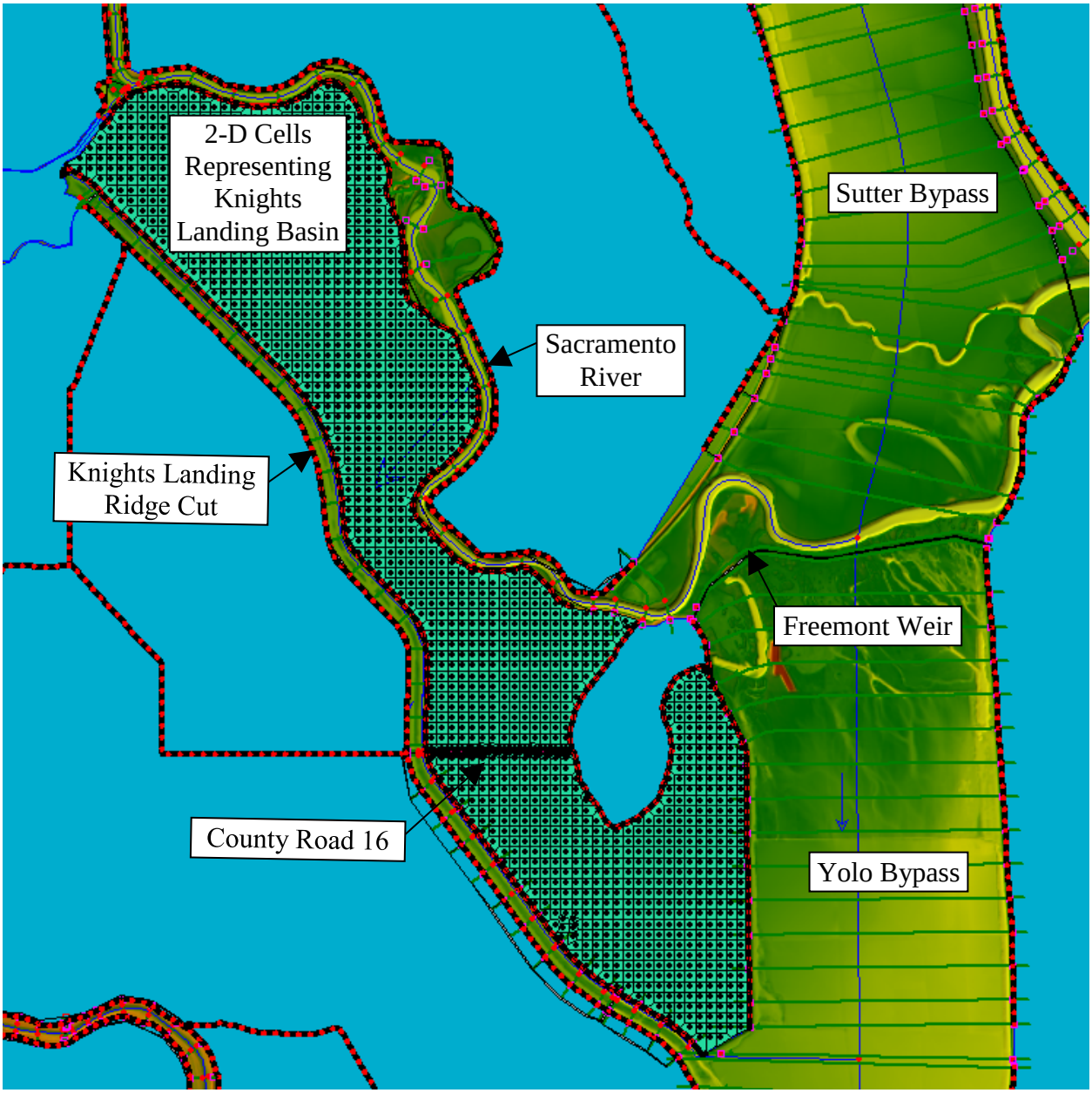


**Figure 4. 2-D Flow Area Representing Knights Landing in Hydraulic Model**

Routing the 1-percent annual chance flood through the riverine system, there was no overtopping into the Knights Landing Basin. Though there is not any overtopping, some of the levees do not have adequate freeboard. The computed WSE was compared to the California Levee Database (CLD) to determine the levee freeboard for the Basin. For the 1-percent annual chance flood the freeboard for the levees surrounding the Knights Landing Basin is shown in Figure 5.

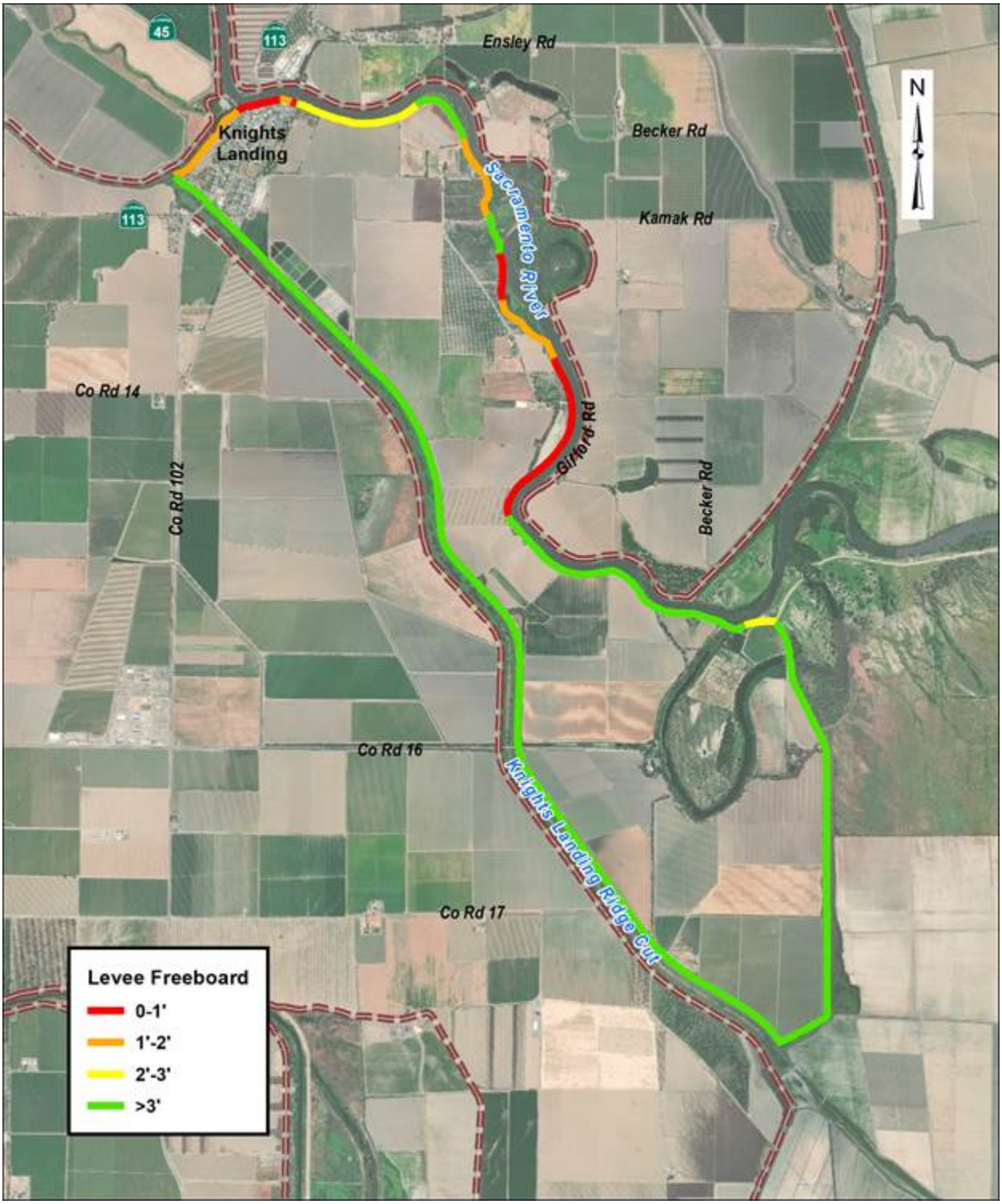


**Figure 5. 2-D Freeboard for 1-Percent Annual Chance Flood for Levees Surrounding Knights Landing Basin**

Routing the 1-percent annual chance flood through the riverine system, also allowed for comparison to the 1957 Project Design Floodplain Elevation. The computed profile compared to the 1957 Design Elevation is shown in Figure 6 for the Sacramento River and Figure 7 for the Knights Landing Ridge Cut. The 1-percent annual chance flood has higher flows than the design

profile for the Sacramento River, so the computed profile is greater than the 1957 Project Design Floodplain Elevation.

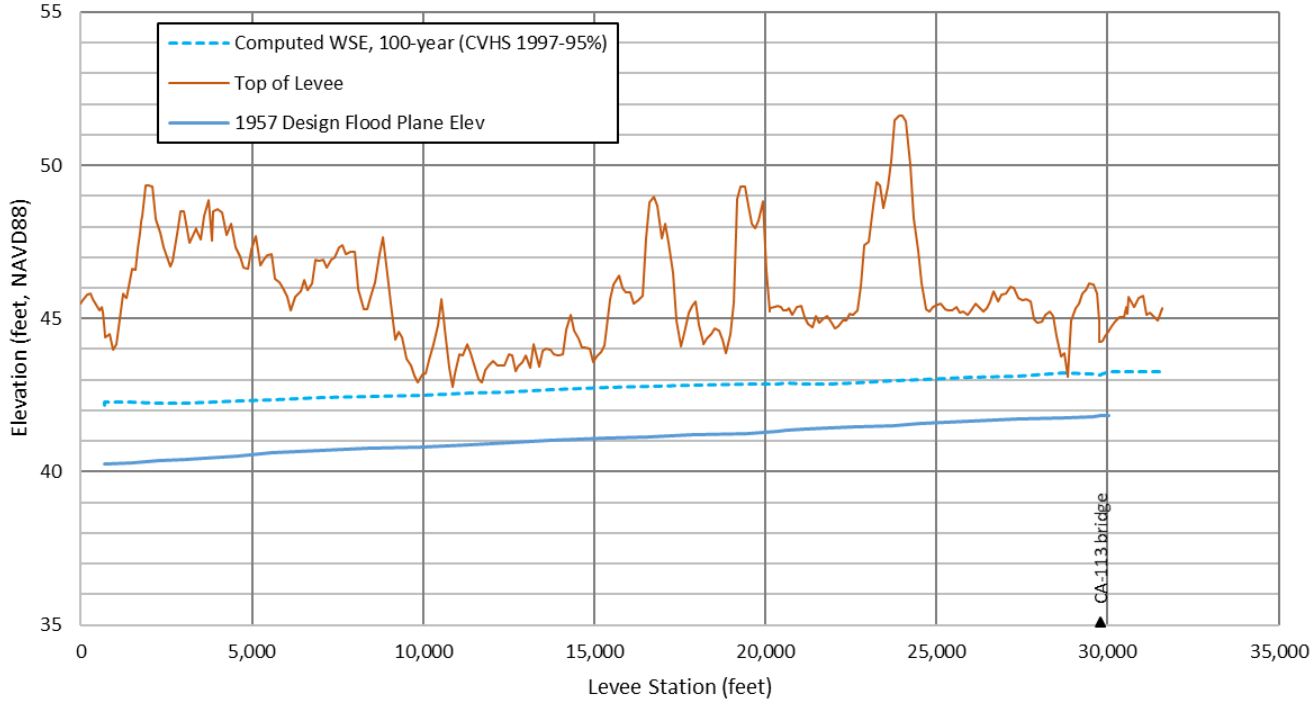


**Figure 6. 1-Percent Annual Chance Flood and 1957 Design Elevation for Sacramento River**

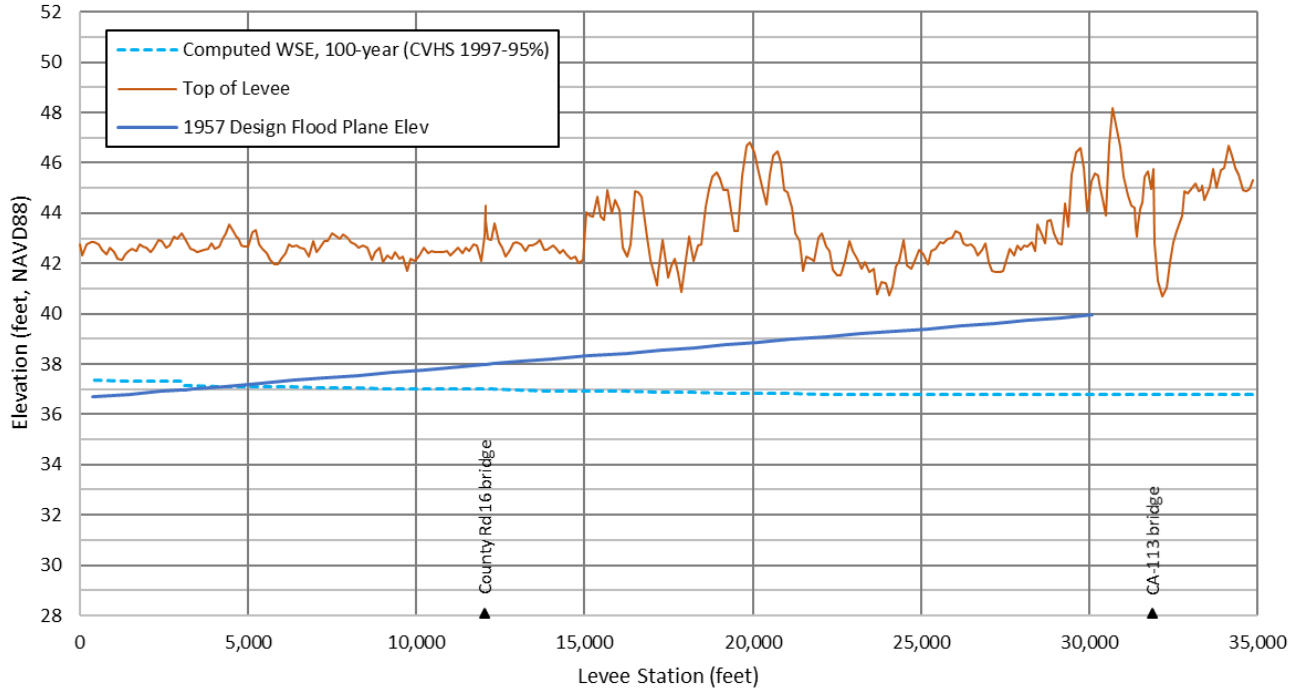


**Figure 7. 1-Percent Annual Chance Flood and 1957 Design Elevation for Knights Landing Ridge Cut**

In the feasibility study thirteen structural alternatives were evaluated and preliminary screening reduced the number of alternatives to six. The reduced array of alternatives includes three differing cross levees to provide flood protection to the community of Knights Landing. The premise behind a cross levee is that it reduces the length of existing levee that needs to be certified. The proposed cross levee can be constructed and then only the portion of the existing levee upstream of the cross levee would need to be certified to provide flood protection. The portions of levee downstream of the cross levee will not be certified, and those lands would be subject to inundation if a levee breaches. To determine the design height of cross levee, levee breaches will be used to compute the WSE in the Basin downstream of the cross levees. Figure 6 shows the three proposed cross levee configurations and the downstream levee breaches used to determine the WSE in the Basin downstream of the cross levee.

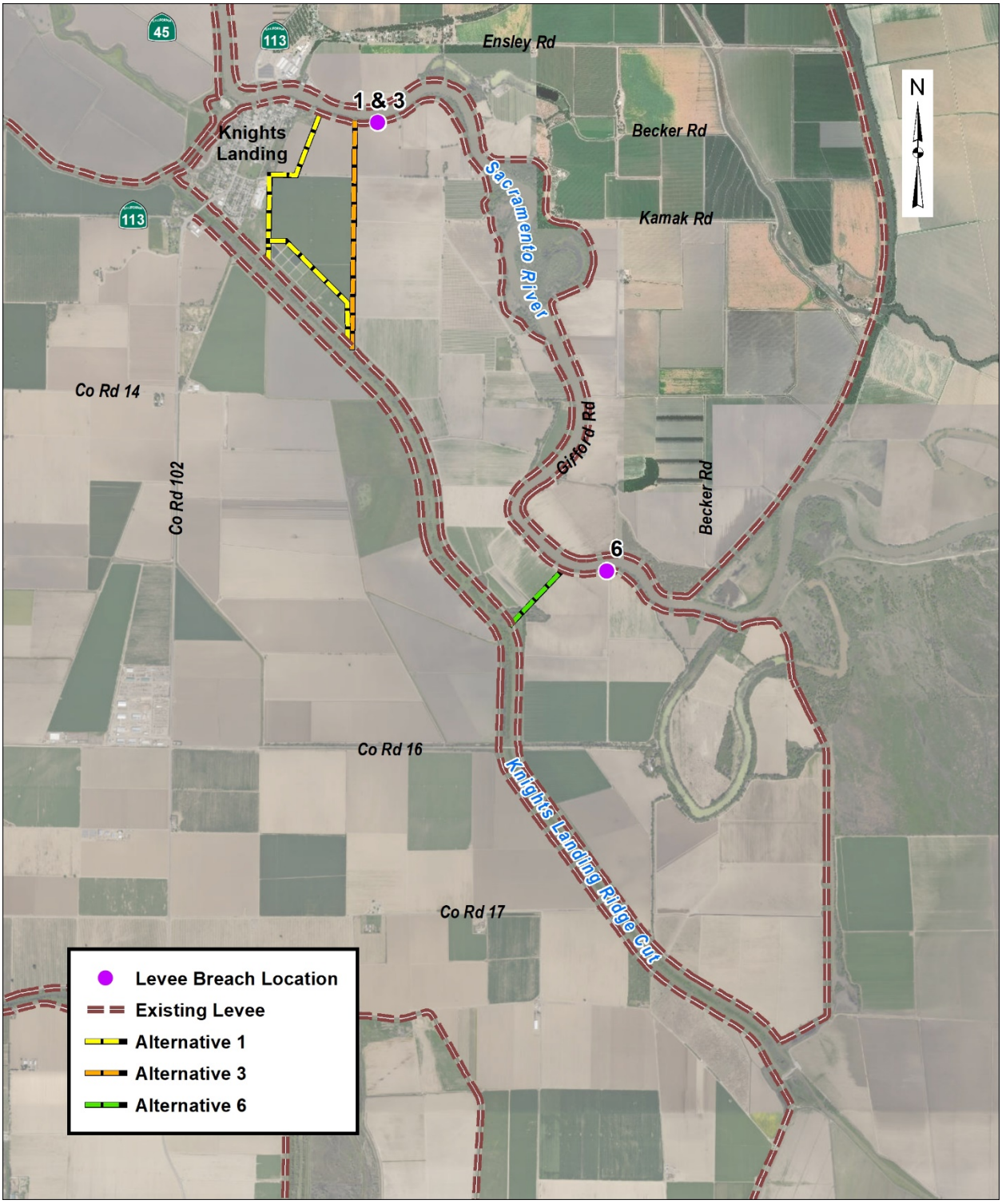


**Figure 6. Proposed Cross Levee Configurations and Downstream Levee Breach Locations**

Looking at the proposed alternatives, the Alternative 1 cross levee provides protection to the community of Knights Landing, with a secondary levee protecting the waste water treatment ponds. Alternative 3 provides protection to the community, the waste water treatment ponds, and some additional lands. Alternative 6 provides protection to the community and additional rural structures and farmland in the Basin.

Levee breaches were configured just downstream of the proposed cross levees to determine the resulting WSE in the Basin. The same levee breach location was used to evaluate Alternative 1 and Alternative 3. Levee breach parameters were based on geotechnical parameters from DWR's Urban and Non-Urban Levee Evaluation (ULE/NULE) (URS, 2014) applied using the current methodology developed for other analysis in the Sacramento River Basin. Specifically, the breach used are:

- Weir coefficient of 2.0
- Breach formation time of 6 hours
- Breach width 50 times the difference between 1-percent annual chance flood event WSE in channel and landside toe elevation
- Breach bottom elevation at the levee toe elevation
- Breach trigger elevation at the reliable levee elevation (which is the top of levee minus the geotechnical reduction height from ULE/NULE program)

Due to the flat topography in the area, the Basin acts as a bathtub, so the resulting WSE from a levee breach (which floods the entire basin including the community) is consistent throughout the Basin. The resulting Basin WSE for the breach scenarios and the average depth ponded against the proposed cross levee are listed in Table 1.

**Table 1. Breach Scenario Resulting Basin WSE and Average Depth Against Proposed Cross Levee**

| Breach Scenario | Resulting Basin WSE (NAVD 88 ft) | Average Depth Against Proposed Cross Levee (NAVD 88 ft) |
|---|---|---|
| Alternative 1 and 3 | 42.5 | 14 |
| Alternative 6 | 41.5 | 13 |

The Knights Landing Basin is inundated from when the breach initiates, throughout the simulation of the 1-percent annual chance flood event. Due to the bathtub like nature of the Basin, the Basin does not fully drain from the levee breach simulations. If any proposed development needs to establish a BFE in Knights Landing for the existing conditions, the Structural-Based Inundation Procedure from the FEMA Analysis and Mapping Procedures for Non-Accredited Levee Systems (FEMA, 2013) can be used. Using this procedure, the resulting BFE for the Basin is 42.5 feet (NAVD 88). From the start of the levee breach (peak flow ~32,000 cfs), it takes approximately 6 hours for floodwaters to inundate evacuation routes and approximately 5 hours to inundate critical facilities with one-foot of floodwater.

A relief cut along the Yolo Bypass was analyzed as a non-structural flood control measure in an effort to reduce the WSE and flood time in the Basin. The results of the relief cut analysis showed a minimal reduction in resulting WSE (about 0.3 feet) over the existing depths that are approximately 10 feet and greater. The relief cut provided some de-flooding of a couple farm fields that were adjacent to the relief cut. However, it did not provide much benefit overall and provided no benefit to lands upstream of County Road 16. With the Basin located so close to where the Sacramento River spills into the Yolo Bypass, the large flood flows in the system make a relief cut unfeasible for this low lying Basin.

# 3. FUTURE CONSIDERATIONS

In addition to looking at the current conditions, future conditions will be looked at based on climate change. The Department of Water Resources looked at climate change as part of the 2017 CVFPP Update (CVFPP, 2017), specifically addressing climate change on the hydrology of the Central Valley. The study states that median changes in annual precipitation by the end of the century for the Sacramento River Basin are projected to be about 6 percent. This conclusion is not granular enough to be applied directly to the Knights Landing Basin due to the multiple flow sources and flow splits near the Knights Landing Basin. Another component of climate change is sea level rise, which causes the tail water to increase for riverine systems discharging into the ocean. Sea level rise projections for the San Francisco bay are documented by the California Ocean Protection Council Science Advisory Team (OPC-SAT, 2017) based on recent scientific data. The Central Valley Flood Protection Board (CVFPB) and DWR are interested in sea level rise and how it could impact the leveed systems in northern California. These agencies have concluded that sea level rise does not extend far enough up the Sacramento River System to effect the Knights Landing Basin.

# 4. REFERENCES

(FEMA, 2012). *Flood Insurance Study- Yolo County, California and Incorporated Areas.* Revised May 16, 2012.

(USACE 2015). *Central Valley hydrology study.* US Army Corps of Engineers Sacramento District and David Ford Consulting Engineers. November 2015.

(URS. 2014). *Summary of January 28, 2014 Meeting Discussions*. Technical Memorandum. February 26.

(FEMA, 2013). *Analysis and Mapping Procedures for Non-Accredited Levee Systems, New Approach*. July 2013.

(CVFPP, 2017). *2017 CVFPP Update- Climate Change Analysis Technical memorandum*. State of California Department of Water Resources. March 2017.

(OPC-SAT, 2017). *2017 Rising Seas in California, An Update on Sea-Level Rise Science.* California Ocean Protection Council Science Advisory Team. April 2017.