David Peterson
503 Christie Dr.
South Lake Tahoe, CA 96150

September 24, 2020

Ms. Osha Meserve
Soluri Meserve
510 8th Street
Sacramento, CA 95814

Subject: California Northstate University Medical Center Project – Flood Management Issues

Dear Ms. Meserve,

Per your request, I have reviewed the Draft EIR for the subject project plus relevant technical appendices and associated documents, and offer the following comments relative to flood management:

1. MBK prepared the 200-year floodplain maps, which show the project site mostly inundated by 3-5' of water. Depths 3' and greater trigger the requirement for Urban Level of Protection (ULOP) findings per California SB 5 (2007).
2. According to the 7/24/19 City of Elk Grove staff report (attached hereto as Exhibit 1), the Laguna West Levee to the west of the project site is currently accredited by FEMA for 100-yr flood protection. However, the City expresses concern that the dated accreditation documents may lack the detail required under current accreditation standards outlined in 44CFR65.10, particularly geotechnical underseepage calculations. The City expressed a concern in the staff report that the levee could be de-accredited in the future, and recommended that an engineering firm be hired to perform the investigations and analyses. However, I cannot tell from the documents whether the work was authorized. My interpretation was that the City's concern was lack of documentation, rather than a suspicion of levee weakness. The City should resolve this unknown.
3. In the 7/24/19 staff report, they also note that the Laguna West levee would have to be raised 3.5' to contain the 200-yr flood, and would likely also require geotechnical strengthening. The City concluded that the levee should not be improved to provide an ULOP, and noted that development in the 200-yr floodplain could only proceed if it met imposed conditions per municipal code Sec 23.42.040. The imposed conditions are not prescribed in the municipal code section; they would be assigned by City staff as part of their ULOP findings process. The State ULOP Guidelines are not specific on what should be included in the conditions either, so City staff must apply judgement. The Project EIR project description says that all habitable and mechanical facilities (except for fuel storage) will be elevated above the 200-yr floodplain, with parking underneath. Elevating is a good way to minimize risk of damages and life loss, and is a sufficient mitigation for most urban structures. However, critical facilities (City documents term these "essential public facilities") such as hospitals and other emergency services facilities must also remain fully operable during flood emergencies. For the proposed hospital, that means it would require dry ingress and egress for patients, staff, and support vehicles, including parking,

turnarounds, loading/unloading, etc. It does not appear that dry access has been included in the project description, and flood mapping shows the surrounding streets with deep inundation. The need for critical facilities to be operational during emergency events such as floods is the reason that policies such as Elk Grove General Plan policy ER 2-3 exist; they call for critical facilities to be on high ground so they can serve the community when they are most needed, in an emergency.

4. The EIR Section 2.4.1 proposes changes to the City of Elk Grove General Plan policy ER 2-3 and City Municipal Code 23.42.040 to allow construction essential public facilities in the 200-yr floodplain if constructed to minimize damages to the facilities. This propose change in language should be modified to require both minimized damages and loss of life, and augmented to require continuous operation of essential public facilities during a 200-yr flood event. Continuous operation requires reliable ingress/egress from dry land, plus utility service. Reliable ingress/egress should probably include at least 2 routes due to likelihood of traffic jamming. California learned the hard way in the Paradise fire the folly of a single ingress/egress route.

5. Based on the 200-yr floodplain maps, it appears that ingress/egress routes are impeded by floodwaters. Elk Grove Blvd is shown on the MBK maps to be subject to 3-5' depths, along with surrounding streets. I5 northbound appears to be dry, but southbound appears to be inundated. The proposed project includes a heliport, but the EIR does not discuss whether this is adequate to service an essential medical facility for the duration of inundation. Given the hospital's proposed patient capacity, it is unlikely the helipad would be sufficient to ensure ingress/egress. Further, hospital staff would have no routes available to them.

6. Alternative 3 (Lent Ranch Marketplace Alternative) would locate the essential public facility outside of the floodplain, and would obviate the need to modify policy ER 2-3 and Municipal Code 23.42.040. This site would be on high ground, and would allow for multiple all-weather ingress/egress routes. This is a much better alternative from a policy and public safety perspective. It would also be a better alternative from a City liability perspective, because changing public safety policies and codes to allow a new essential facility to be located in a flood zone instead of choosing the dry-land alternative ties the City to future consequences.

7. Under City muni cod 23.42.040, the City must make findings that the project will have an ULOP. And since the City has decided not to protect the site, it must rely on "imposed conditions", and meet EVD-2 requirements of the ULOP guidelines (see below). The second bullet requires an engineer's certification. I didn't see anything like this in the documents, so it must be added later when the City imposes conditions in making its required ULOP finding.

> **EVD-2:** Substantial evidence in the record to support a finding related to an urban level of flood protection based on imposed conditions shall include the following, at a minimum:
>
> - A list of the conditions imposed by the city or county that is consistent with existing codes and regulations, responsible entities for implementing the conditions, and a plan and schedule by which the imposed conditions will be met.

- A report prepared by a Professional Civil Engineer registered in California to document the data and analyses for demonstrating the imposed conditions will result in the property, development project, or subdivision having an urban level of flood protection.
- Any additional data and information that cities or counties use to make the finding.
- A written statement that the developer, subdivider, permittee, or their agent must satisfy the conditions imposed on or before the time of final inspection or the issuance of Certificate of Occupancy for the building to which the conditions apply.

If you have any questions or would like to discuss my comments, please let me know.

Sincerely,

David Peterson, P.E.

Attachment: Exhibit 1: 7/24/19 City of Elk Grove staff report,
Curriculum Vitae

Exhibit 1

AGENDA ITEM NO. 10.2

CITY OF ELK GROVE
CITY COUNCIL STAFF REPORT

AGENDA TITLE:	**Receive a presentation regarding an update to the 200-year floodplain study and provide direction as appropriate**
MEETING DATE:	**July 24, 2019**
PREPARED BY:	**Jeff Werner, Engineering Services Manager** **Amittoj Thandi, Engineering Services Support Manager**
DEPARTMENT HEAD:	**Robert Murdoch, P.E., Public Works Director/ City Engineer**

RECOMMENDED ACTION:

Receive a presentation regarding an update to the 200-year floodplain study and provide direction as appropriate.

BACKGROUND INFORMATION:

In 2007, the California Legislature passed Senate Bill (SB) 5, which requires all new or reconstruction projects constructed within the Sacramento-San Joaquin Valley to achieve an urban level of flood protection by 2025, which is defined as the level of flood protection necessary to withstand flooding that has a 1-in-200 chance of occurring in any given year. SB 5 and SB 1278 also requires cities and counties to amend their General Plans and Zoning Ordinances by no later than July 2016 to address 200-year flooding by requiring certain findings to be made as part of the development review process. The intent of the legislation is to strengthen the link between flood management and land use.

On July 27, 2016, the City adopted amendments to its General Plan and Elk Grove Municipal Code (EGMC) Title 23 (the Zoning Code) to comply with the requirements of SB 5 and SB 1278. These amendments included:

A. Identifying 100 and 200-year floodplains and required development standards.

B. Prohibiting approval of building permits, entitlements, tentative maps, or parcel maps for a project that is within the 200-year floodplain unless it has met one or more of the following findings:

1. The project has an Urban Level of Flood Protection (ULOP);
2. Conditions imposed on the project will provide for an ULOP;
3. Adequate progress has been made toward construction of a flood protection system to provide an ULOP for the project;
4. The project is a site improvement that would not result in the development of a new habitable structure. Improvements that qualify for the exemption include, but are not limited to, the replacement or repair of a damaged or destroyed habitable structure with substantially the same building footprint area, interior repairs or remodels to existing structures, and new nonhabitable structures.

Concurrent with these changes, the City also adopted new Flood Damage Prevention regulations (EGMC Chapter 16.50) to address design and construction requirements for projects within the 100-year floodplain consistent with federal and state regulations.

As part of the General Plan amendments, Policy SA-21 was adopted, which directs the City to work with other regional, county, and state agencies to develop mechanisms to finance the design and construction of improvements to achieve an urban level of flood protection in affected areas. Staff coordinates regularly with regional agencies including the Sacramento Area Flood Control Agency (SAFCA) and Sacramento County Department of Water Resources to identify regional projects affecting Elk Grove and potential funding opportunities.

ANALYSIS

The 200-year floodplain does not have a direct relationship with the Federal Emergency Management Agency (FEMA) National Flood Insurance Program requirements; the insurance requirements only apply to properties located in FEMA mapped 100-year floodplains. Furthermore, the Laguna West levee system has been accredited by FEMA as meeting 100-year standards and and provides properties in the Laguna West and Lakeside areas with significant flood protection.

At the January 10, 2018, Council meeting, staff provided information on the 200-year floodplain and Urban Levee Design Criteria (ULDC) and provided results from the Laguna West Levee System Problem Identification Report (PIR), prepared by MBK Engineers (MBK). Results from the PIR indicated that the Laguna West levee system would need to be raised by an average of approximately 3.5 feet in order to comply with the 200-year flood protection standard. The PIR identified an estimated cost of approximately $12.2 million to raise 4.5 miles of existing Laguna West levees by 3.5 feet, with an additional $3.0 million that may be required to extend the levees in some areas. This estimate only covers the improvements needed to raise and extend the levees. As stated in the PIR, along with the need to raise the height of the levees, there is also the potential for under-seepage and stability issues within the levee system. The potential costs to address these issues could add anywhere between $7 million and $30 million to the cost of achieving 200-year flood protection.

Upon receiving the PIR in 2018, Council directed staff to research other flood control projects being constructed in the region and their potential for lowering the 200-year water surface elevation (WSE). Staff tasked MBK with updating the flood depth map and 200-year WSEs for the Laguna West Levee system area. The updated map is included with this report as Attachment 2. As discussed in the attached Technical Memorandum (Attachment 1), MBK constructed a hydraulic model from existing models, with the most current hydrology applied and breach parameters selected, to evaluate the floodplain that has a 1-in-200 annual exceedance. The results of the study revealed that there was no significant change in the 200-year WSE from what was reported to Council in January 2018.

At this time, staff does not recommend moving forward with levee improvements, due to lack of funding. Furthermore, the City has already complied with requirements of SB 5 and 1278 by incorporating additional flood risk considerations into floodplain management and planning by amending the City's General Plan and Zoning Code to include development requirements for proposed projects within the 200-year floodplain. No further action by the City is required in order to comply with SB 5 and 1278.

There is a need to assess the condition of the existing Laguna West Levee System to determine the potential for under seepage and stability issues. As stated above these levees provide properties in the Laguna West and Lakeside areas with protection from a 100-year flood as currently defined by FEMA. Decertification of the levees due to structural deficiencies would result in these areas being entered into the 100-year floodplain, thus

requiring all properties in these areas to obtain flood insurance. The structural integrity of the levees has not been fully assessed since their construction in the 1990s. The first step in conducting a levee condition assessment is to perform geotechnical data collection and analysis of the levee system. The estimated cost of performing this geotechnical analysis is $520,000 and has been included in the City's current fiscal year budget. Staff recommends moving forward with the geotechnical analysis by conducting a consultant selection process and entering into a consultant contract for these services, which would be returned to the City Council for consideration and approval. Once the geotechnical analysis is complete, staff would return to the City Council with the results and information on whether improvements are needed to maintain the 100-year flood protection rating.

ALTERNATIVE ACTIONS:

Staff met with representatives from the Sacramento Area Flood Control Agency (SAFCA) and the County of Sacramento Department of Water Resources to discuss potential regional opportunities that may be available that could benefit the City. Staff was informed that the rural reach of the Sacramento River levee (east-side), downstream of the Beach Lake Levee could be strengthened and the improvements would need to meet FEMA and ULDC standards. Preliminary costs for this project are estimated at $15 million per mile. With approximately six to nine miles of levee needing to be improved, the total cost could range from $90 million to $135 million.

Due to the greater cost, the location of the improvements (outside of the City limits), lack of project control due to coordination with various partnering agencies and other unknown factors – most notably right-of-way acquisition – staff does not recommend pursuing this alternative.

FISCAL IMPACT:

The FY2019-2024 Capital Improvement Program (CIP) and FY2019-2020 Budget include funding for the geotechnical investigation in the amount of $520,000. Should the City Council direct staff to move forward with this effort, the funding is available for work to proceed immediately following consultant selection.

ATTACHMENTS:

1. MBK Technical Memorandum
2. 1-in-200 Year Floodplain Map

MBK ENGINEERS

Water Resources ◆ Flood Control ◆ Water Rights

TECHNICAL MEMORANDUM

DATE: March 12, 2019

TO: Amittoj Thandi, P.E., City of Elk Grove

PREPARED BY: Brian A. Brown, P.E.

REVIEWED BY: Don Trieu, P.E.

SUBJECT: Determination of 1-in-200 Year Floodplain for City of Elk Grove Laguna West Area Urban Level of Flood Protection (ULOP) Determination

1.0 INTRODUCTION

In 2007, the California legislature enacted Senate Bill 5 (SB 5) in order to strengthen the link between flood management and land use. SB 5 relied on the due diligence of cities and counties to incorporate flood risk considerations into floodplain management and land use planning. The provisions of SB 5 require cities and counties within the Sacramento-San Joaquin Valley to make findings related to an urban level of flood protection (ULOP). A finding necessary for the ULOP determination is to demonstrate that property within an urban or urbanizing area is protected from the 1-in-200 chance of flood occurrence[1].

2.0 PURPOSE

The California Department of Water Resources (DWR) developed the Urban Level of Flood Protection Criteria, in order to fulfill the requirements that were outlined in the 2007 California Flood Legislation, and later amended by subsequent legislation; specifically, California Government Code Section 65007(n):

> "Urban level of flood protection" means the level of protection that is necessary to withstand flooding that has a 1-in-200 chance of occurring in any given year using criteria consistent with, or developed by, the Department of Water Resources. Urban level of flood protection shall not mean shallow flooding or flooding from local drainage that meets the criteria of the national Federal Emergency Management Agency standard of flood protection.

To meet the requirements of SB 5, on July 27, 2016, the City adopted amendments to its General Plan. These amendments included:

[1] The flood with a 1-in-200 chance of occurring in any given year is also known as the 1-in-200 annual exceedance probability (AEP) flood or 200-year flood.

- An amendment to the Safety Element of the General Plan that prohibits the City from approving a building permit or entitlement, or approving a tentative or parcel map for a project that is within the 200-year floodplain, unless that project provides an Urban Level of Flood Protection (ULOP).
- An amendment to the Elk Grove Municipal Code (EGMC) Section 23.42.040, which will include both 100- and 200-year floodplains, and identify required development standards.
- The addition of EGMC Chapter 16.50 (Flood Damage Prevention).

As part of the Safety Element of the General Plan, a 200-year floodplain was previously developed for the City. MBK Engineers (MBK) has been tasked with updating the flood depth map and 200-year water surface elevation (WSE) for the Laguna West Levee system. This memorandum documents the analysis.

3.0 METHODOLOGY

In order to evaluate the floodplain based on a levee failure, hydrologic input; geotechnical information; and a riverine and floodplain model are needed. The hydrologic data for the rivers is needed to quantify the flows for the 1-in-200 AEP flood. The riverine model is needed to route the flow in the riverine system, and to quantify the flow that leaves the riverine system, as a result of a simulated levee breach. Overland flow hydraulics will be computed to route the levee breach flows in order to quantify the depths of flooding and the inundation extents. Geotechnical information is also needed to determine the parameters for the levee breach.

4.0 HYDROLOGY

The hydrologic inputs for the hydraulic model come from three different sources: the Central Valley Hydrology Study (CVHS), by DWR, used for the Sacramento River system; the Cosumnes River and Mokelumne River watersheds hydrology, by David Ford (Ford, 2004), used for the North Delta area; and the South Sacramento Streams Group (SSSG) Hydrology, developed by CDM in association with HDR, and the Sacramento Area Flood Control Agency (SAFCA) used for Morrison Creek (CDM, 2003). The Cosumnes River and Mokelumne River Watersheds hydrology and the SSSG hydrology are appropriate for use, as developed in a 1-in-200 AEP analysis.

Hydrologic inputs to the Sacramento River System portion of the hydraulic model are based on the CVHS. The only local application of CVHS hydrology is taken from the guidance DWR provided for the development of the SB 1278/Assembly Bill (AB) 1965 ULOP informational maps for the Sacramento area. In this guidance, storm patterns and scalings were defined for the 200-year and 500-year events for the Sacramento area, close to the confluence with the American River. The centerings do not consider the North Delta area, downstream of the Sacramento Urban Area or the Folsom Joint Federal Project (JFP). Due to these factors, the CVHS methodology had to be applied to develop CVHS based hydrology for this analysis.

To develop 200-year hydrology appropriate for the Elk Grove area that is consistent with CVHS procedures, the CVHS 1986 storm pattern was used to produce scaling factors for the Sacramento and American rivers. A scaling factor of 140% was used for the American River, and a scaling factor 90% was used for the Sacramento River. These scalings were used to

compute the Pocket Area Levee Design Water Surface Elevation (WSE) for the Sacramento Area Flood Control Agency (SAFCA) levee certification project. The hydrologic analysis used to develop the CVHS scalings, and the coincident peak analysis used to correlate the timing of the peaks to the other hydrologic input, is documented in Appendix A.

5.0 HYDRAULIC MODEL

A hydraulic model will need to be constructed from existing models, with the latest hydrology applied and breach parameters selected, to evaluate the floodplain that has a 1-in-200 AEP.

There are existing HEC-RAS models for the Sacramento River System, North Delta, and SSSG streams. HEC-RAS is a computer software program developed by the U.S. Army Corps of Engineers (USACE), specifically the Hydrologic Engineering Center (HEC), for public use. The software is designed to perform one-dimensional hydraulic calculations for a full network of natural and constructed channels. The software models riverine areas with cross sections, and overland floodplain areas with storage areas, connecting the two with lateral weirs that compute flow that overtops the riverine levees and flows into the overland floodplain.

5.1 SACRAMENTO RIVER SYSTEM MODEL

The Sacramento River System model is the Central Valley Floodplain Evaluation and Delineation (CVFED) model, developed by DWR, and used to quantify and route flows in the Sacramento River. This model contains the complete Sacramento River Flood Control System, including the Sutter and Yolo bypasses, from Shasta Lake to the San Francisco Bay. The system model was truncated to only include the reaches necessary to evaluate potential levee breaches that could inundate the Elk Grove area – specifically the Sacramento River, downstream of Verona to the confluence of Steamboat Slough; the American River; and the flow Split at the Sacramento Weir.

The truncated model was calibrated to the 2006 event, and verified to the 1997 event. The calibration used gages on the Sacramento River: at Verona, above Freemont Weir, I Street, Freeport, Snodgrass Slough, Walnut Grove, and Georgiana Slough; on the Natomas East Main Drainage Canal: at Arcade Creek and Jefferson; Georgiana Slough at the Sacramento River; Miner Slough at the Highway 84 bridge; and on Steamboat Slough at Sutter Slough. The purpose of the calibration and verification was to ensure that when truncating the large DWR system model, it could accurately reproduce historic stages above and below the confluence of the American River.

5.2 SSSG HYDRAULIC MODEL

The hydraulic model for the SSSG stream system was developed for the *SSSG Letter of Map Revision* (Wood Rodgers, 2013), updated with the Florin Creek channel widening and off-site detention basin. The model extends, from directly upstream of the Union Pacific Railroad (UPRR) tracks for each stream, to just downstream of Interstate 5 on Morrison Creek. In addition to the major streams, the model includes overbank storage areas, detention basins, and the drainage pumps that pump the storm water into the streams. The model was truncated to Franklin Road on the upstream end, in order to simplify the model, as these upstream reaches are not

needed for the study area. The output from the complete model was used at the upstream boundary conditions at the truncated locations.

5.3 NORTH DELTA HYDRAULIC MODEL

MBK Engineers developed the hydraulic model for the North Delta in 2003 for a regional study, tasked with examining flood control and ecosystem improvements. The model simulates the Cosumnes River, Dry Creek, Mokelumne River, Beach Stone Lake floodplain, and the Franklin Pond.

In 2014, MBK updated the 2003 model to reflect new topographic and bathymetry data in the region. The model was also truncated at the Cosumnes River at Highway 99 to simplify the model, as these upper reaches are not needed for the North Delta area. Once the model was truncated, the output from the 2003 model at these locations was used as an upstream boundary condition for the truncated model. The truncated model was then converted to the NAVD88 datum, and updated in order to reflect the most recent available topography in the region. The topography used includes the CVFED LiDAR (DWR, 2008), DWR digital elevation maps for the San Francisco Bay and Sacramento-San Joaquin Delta (Wang, 2012), and bathymetric surveys acquired by MBK in 2004.

The model was calibrated to the 1997 event and then verified to the 1995 event, ensuring that the model represented the terrain, prior to the Cosumnes River Mitigation Bank Project, as this regional project reflects the current condition, but was constructed after the calibration and verification events. The model was then updated with the design levee elevations for the Laguna West Levees based on as-built and improvement plans, provided by the City of Elk Grove and Sacramento County. The updated Laguna West levees are shown in Figure 1.

Figure 1. Laguna West Levees Updated Based on As-Built Plans

5.4 COMBINING HYDRAULIC MODELS FOR ANALYSIS

The individual truncated models for the Sacramento River System, North Delta area, and SSSG system described in the previous sections need to be combined to form one model for the area. The new combined hydraulic model will allow flow to be routed from a levee breach on the Sacramento River over the adjacent lands to compute a resulting WSE along the Laguna West Levees.

The first step in combining the hydraulic models was to add the truncated model of the Sacramento River System to the North Delta hydraulic model. Where both models had the same overbank storage areas, the storage areas from the North Delta model were used, as they were defined on a smaller scale than the larger overbank storage areas in the Sacramento River System model. The lateral structures in the hydraulic model, which represent the berms in the floodplain, we adjusted to ensure they accurately represented the underlying terrain and that the models had hydraulic connections between them. The truncated model for the SSSG system was then added to this hydraulic model, with lower Morrison Creek as the tie-in point for the two models. For the overlapping portion of lower Morrison Creek, in the two models the definition from the

SSSG model superseded Morrison Creek from the North Delta model. The combined hydraulic model to be used to compute the resulting WSE from the levee breaches is shown in Figure 2.

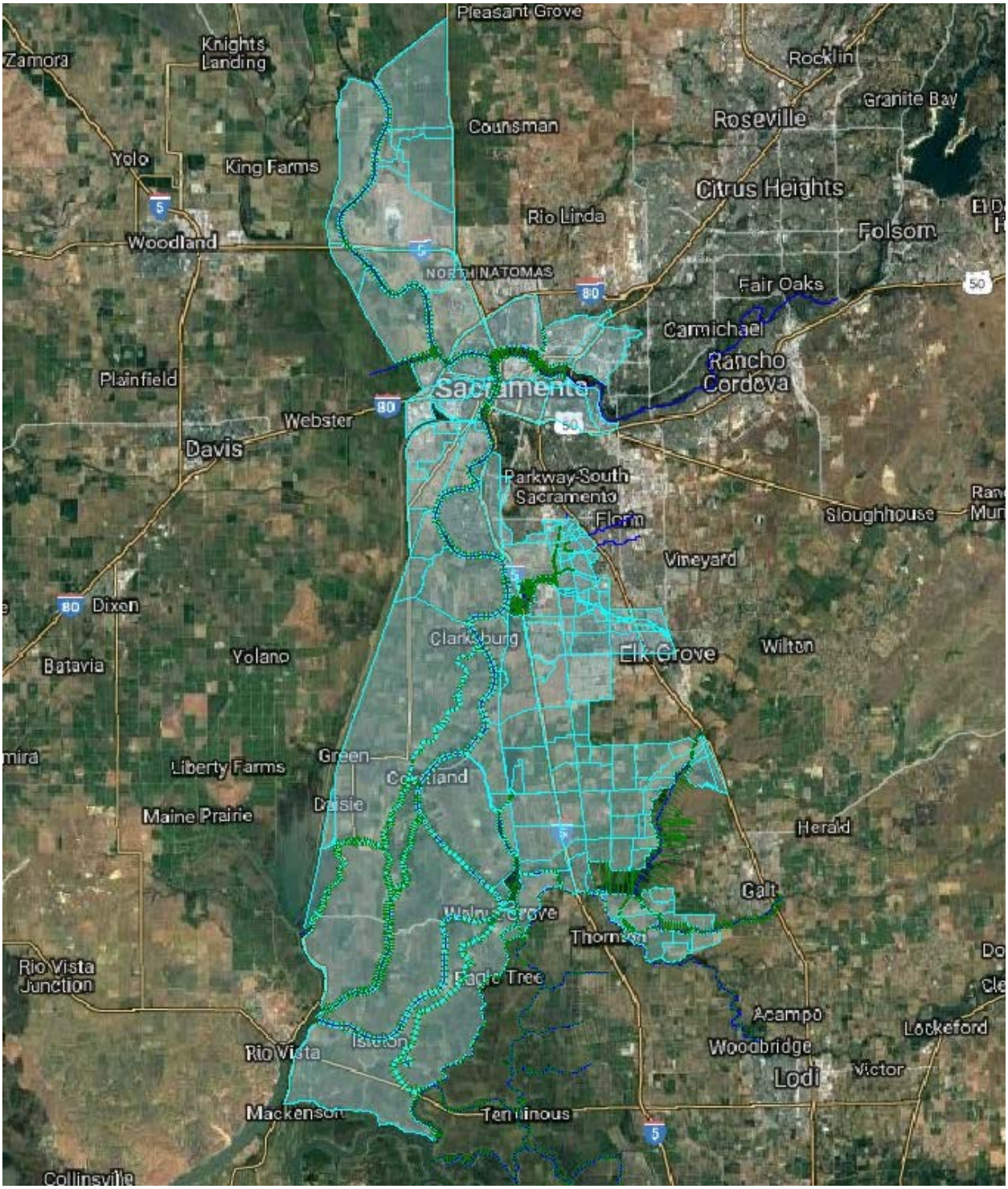

Figure 2. Combined Hydraulic Model

6.0 ANALYSIS

With the hydraulic model configured and hydrology selected, the model can be used to route the flows for a flood that has a 1-in-200 AEP. The storage area in the hydraulic model will allow flows to leave the riverine system based on a levee failure. The floodplain that has a 1-in-200 AEP will be determined for the following two scenarios:

Scenario 1: A breach on the non-urban levee of the Sacramento River levee, downstream of Freeport, with Laguna West levees overtopping without failure.

Scenario 2: A breach on the non-urban levee of the Sacramento River levee, downstream of Freeport, with Laguna West levees failing.

All other levees in the system will be assumed not to fail, and will act as weirs if overtopped.

6.1 ANALYSIS ASSUMPTIONS

The analysis assumes current conditions with consideration for Urban Levee Design Criteria (ULDC) developed by DWR. The ULDC provides guidance for design, evaluation, operation, and maintenance of levees and floodwalls that provide protection from a 1-in-200 AEP event. To be consistent with ULDC analysis the following assumptions were incorporated into the Sacramento River system model:

- Urban levees were assumed to be no less than the 200-year WSE plus 3-feet of freeboard
- The non-urban levees were assumed to be no less than the authorized height, based on the 1957 USACE design profile
- All levees were assumed to overtop without failure
- Debris loading for bridges was considered
- Sea level rise was included in the downstream boundary condition (approximately 1-foot in the San Francisco Bay [OPC-SAT, 2017])

This analysis assumes the DWR Lower Elkhorn Basin Levee Setback (LEBLS) Project is implemented, which includes setting back the north levee of the Sacramento Bypass, and the east levee of the Yolo Bypass in the Lower Elkhorn Basin. This project is currently in the design phase and is anticipated to be completed in 2022. This project will reduce flood stages on the Sacramento River, downstream of the Sacramento Weir.

This analysis assumes McCormack-Williamson Tract levees are at pre-February 2017 flood elevations. High flow rates on the Cosumnes River and stages in the Franklin Pond caused the levee along the Mokelumne River levee to breach. This breach is located downstream of the east levee of McCormack, and would not have a significant impact to the water surface elevations in the Laguna West area.

Currently, The Nature Conservancy (TNC) and DWR are undergoing a design study to construct a multi-benefit project on McCormack-Williamson Tract. The project would consist of degrading

the east and southwest levees. Degrading the levees would allow for habitat restoration and allow floodwaters to flow through the tract during large flow events. Once the project is complete, the additional floodplain storage could lower water surfaces in the region. The reduction in water surface associated with this project is unclear, as there are environmental constraints the team is working through that may limit the ability to degrade the existing east levee. Due to the uncertainty concerning what the project will accomplish (from a water surface reduction standpoint, as well as the timing of construction), this project is not included in the hydraulic analysis.

6.2 SCENARIO 1: SACRAMENTO RIVER BREACH

As part of the DWR CVFED program, DWR developed reliable levee height elevations based on geotechnical information from DWR Urban (ULE) and Non-Urban Evaluation Program (NULE). These reliable levee height elevations are defined as the height of floodwater, for which the levee meets accepted performance or design criteria. The methods for describing the levee reliability data are documented in the *Levee Reliability Technical Memorandum,* dated September 27, 2012, and the *Addendum to Levee Reliability Technical Memorandum,* dated July 9, 2013, prepared by URS for DWR. Levees that provide protection to populated areas were designated as urban, and underwent a higher level of geotechnical evaluation. Levee geotechnical reliability information was derived from levee geotechnical investigations, data, analyses, and levee performance assessments, which have been completed to date, under DWR's ULE and NULE programs.

For this mapping effort, it was assumed that the levee breach would be triggered when the water surface reached the reliable levee height. The breach trigger elevation was set from the top of levee elevation, minus the levee reduction height for each levee segment (URS, 2012; URS, 2013a). Along with this method to determine the trigger elevation, the previous levee breach methodology parameters were used for SB 1278/AB 1965 ULOP informational maps, specifically:

- Weir coefficient of 2.0
- Breach formation time of 6 hours
- Breach width 50 times the difference between top of levee 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)

The above methodology was used, with the exception of the breach width. With respect to the breach width, 50 times the difference between the computed 1-in-200 AEP peak WSE and the toe of levee was used, which is more realistic for the area, based on the levee freeboard in the 1-in-200 AEP.

Four sights along the Sacramento River were reviewed and breached, as were the subsequent, downstream breaches of the abandoned railroad embankment. The ponding from the levee

breach would likely cause the embankment downstream to fail. The location of each breach and the subsequent downstream embankment breaches are shown in Figure 3.

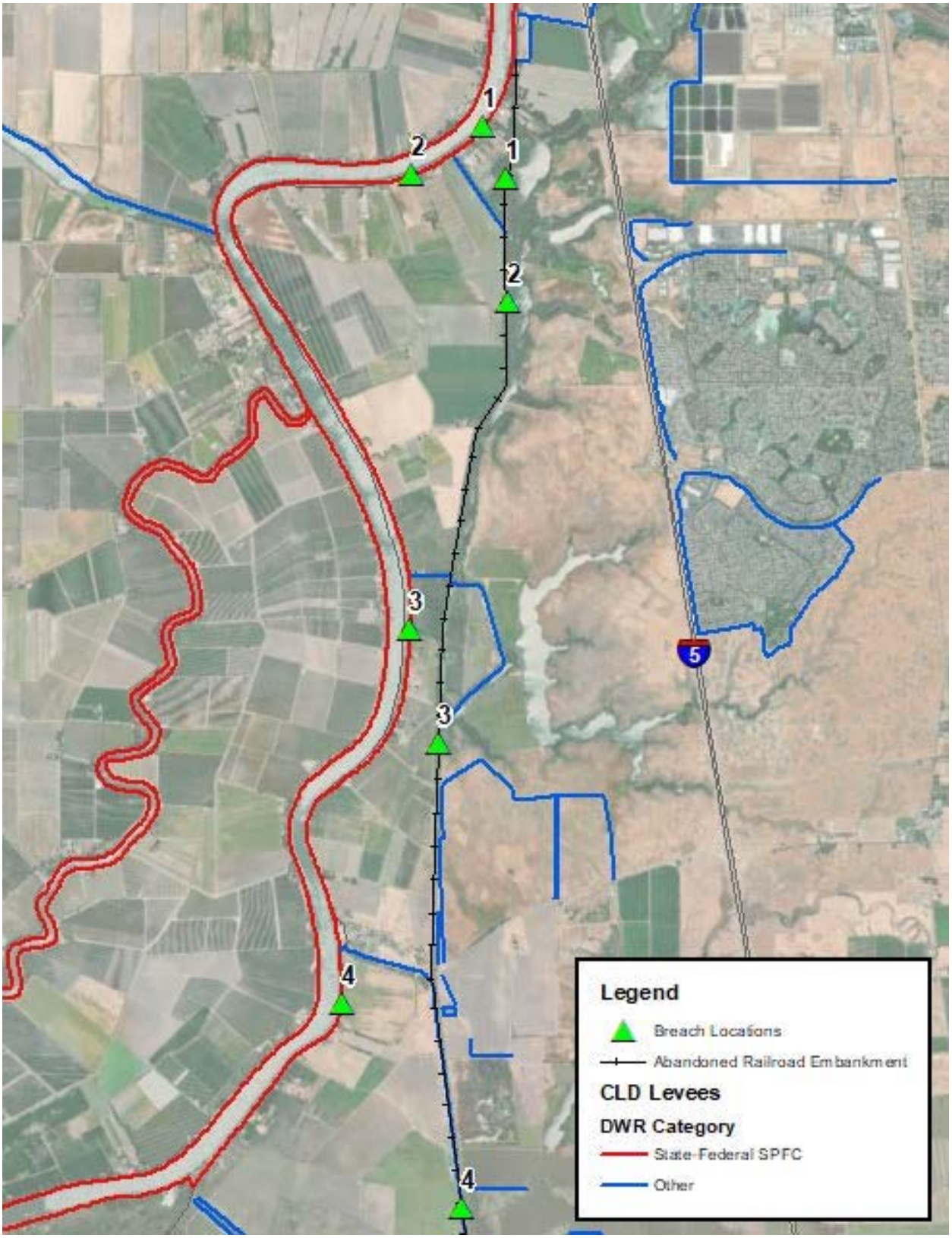

Figure 3. Sacramento Levee Breaches and Subsequent Downstream Embankment Breaches

6.3 Scenario 2: Laguna West Levee Breaches

In Scenario 2, four levee breach locations were assumed. A breach location was chosen for each representative reach of levee that had different hydraulic conditions upstream and downstream. The breach locations are shown in Figure 4.

Figure 4. Laguna West Levee Breach Location

The breach parameters used to evaluate these levees will be based on a combination of CVFED and FEMA guidance, as appropriate for the area. The breach parameters are:

- Weir coefficient of 2.0
- Breach formation time of 6 hours

- Breach width of 500 feet (minimum FEMA breach width for sand and clay levees)
- Breach trigger elevation 3-feet below top of levee (there is no ponded water on levee in existing condition)
- Breach fails to toe of levee

The parameters for the levee breaches are listed in Table 1.

Table 1. Breach Parameters for Laguna West Levees (Elevations in NAVD88)

Breach Number	Top of Levee	Toe of Levee	Trigger Elevation	Breach Width (feet)
L1	21.7	16	17.7	500
L2	21.7	16	17.7	500
L3	21.7	17	17.7	500
L4	21.7	14	17.7	500

7.0 RESULTS

The hydraulic model was configured with the hydrology, assumptions, and breach parameters described in the previous sections and simulated for Scenarios 1 and 2. For Scenario 2, each of the breach locations were simulated individually. Table 2 tabulates the maximum water surface elevation for the area behind the Laguna West levees, for all the simulation runs.

Table 2. Computed 1-in-200 AEP WSE (NAVD88)

Breach Number	200-yr WSE
Scenario 1	21.5
Scenario 2 L1	21.5
Scenario 2 L2	21.5
Scenario 2 L3	21.5
Scenario 2 L4	21.5

The analysis shows that the floodplain within Laguna West is the same for Scenario 1 (Laguna West levees overtop without failure) and Scenario 2 (failure of Laguna West levee system). This is due to the flat water surface elevation along the entire reach of the Laguna West levees and sufficient volume in Beach-Stone Lake to fill the floodplain behind the Laguna West levees in the event of overtopping, outflanking or failure of the levee. The resulting depth of flooding is shown on Exhibit 1. As per the *Urban Level of Flood Protection Criteria* (DWR, 2013), areas of flooding less than 3 feet of flood depth are exempt from SB 5.

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City of Elk Grove Laguna West Area ULOP Determination

1-in-200 Year Floodplain

0 500 1,000
Feet

Exhibit 1

R:_Flood Control\2445 City of Elk Grove\Tasks\2018_ULOP_Determination\GIS\Exhibit 1 - Inundation.mxd

Water Resources ◆ Flood Control ◆ Water Rights

TECHNICAL MEMORANDUM

DATE: August 29, 2018

TO: Don Trieu and Brian Brown

PREPARED BY: Ben Tustison, P.E.

SUBJECT: Development of 1-in-200 Year Sacramento River Centering for Elk Grove ULOP Finding

1.0 BACKGROUND

The Central Valley Hydrology Study (CVHS) was completed in 2015 (USACE, 2015). This work presented a new methodology for constructing hydrologic patterns on the Sacramento and San Joaquin River System in California's Central Valley. A key part of that methodology involved scaling historical flood events to desired frequencies, such as the 1-in-200 year flood event.

For the City of Elk Grove's (City) 1-in-200 year Urban Levee of Protection (ULOP) finding, it was determined that the failure of an event, centered on the Sacramento River System (Sacramento River centering), would provide the highest water surface for the City. This document provides the information that supports the development of that hydrologic dataset.

2.0 METHODOLOGY

2.1 SACRAMENTO RIVER - PATTERN AND MAGNITUDE

In order to construct a representative 1-in-200 year hydrologic dataset for the Sacramento River, the CVHS methodology was applied. This work was initially done on behalf of the Sacramento River Flood Control Association (SAFCA), to construct a 1-in-200 water surface profile in the Pocket Area of the Sacramento River, for an Urban Level of Protection (ULOP) finding. MBK Engineers (MBK) documented that work, and showed that a scaling factor of 140% was used for the American River, and a scaling factor 90% was used for the Sacramento River for the 1986 historical flood event. For more detail on the development of this pattern, please see the (MBK, 2016) reference at the end of this document.

2.2 COSUMNES/MOKELUMNE – MAGNITUDE

As with the Sacramento River watershed, the largest historical flood events on the Cosumnes/Mokelumne River system were the 1986 and 1997 events. This suggest that there is strong correlation between the flows in the Cosumnes/Mokelumne and Sacramento River watersheds for these large, system-wide events. Review of historical data and frequency

estimates on the Cosumnes/Mokelumne system (Ford, 2004), indicated that the 1986 and 1997 flood events were nearly or slightly in excess of 1-in-100 year; therefore, more extreme than the estimated frequencies on the Sacramento River for those events. In Consideration of these facts, the 1-in-200 year Cosumnes/Mokelumne hydrology was adopted for the Sacramento River Centering used in this analysis.

The hydrologic data from Ford (Ford, 2004) was used for the North Delta Area (Cosumnes River and Mokelumne River watersheds) in constructing the Sacramento River centering. The 1-in-200 year event, specifically, was selected because it was one of the frequencies available from this hydrologic study.

2.3 South Sacramento Streams Group – Magnitude

The South Sacramento Streams Group (SSSG) includes Morrison, Elder, Florin, and Union House creeks. These are primarily foothill fed streams, which represent much smaller drainage areas than both the Sacramento and Cosumnes/Mokelumne River systems. As such, some of the largest historical storm events for the SSSG are not necessarily the same as those occurring at other watersheds. For example, the 1995 flood event was one of the largest in the SSSG, while this event was not in the top ten historical events for the Sacramento River system. Taking this into consideration, a 1-in-100 year event was assumed on the SSSG coincident with the 1-in-200 year Sacramento River centering. The 1-in-100 year event was specifically selected, because it was one of the frequencies available from the hydrologic study used (CDM, 2003).

2.4 Relative Timing

The 1997 flood event was used as the basis relative timing between flood flows on the Sacramento River and the Cosumnes/Mokelumne system. This event was selected, because it was the largest event for which data of the adequate hourly temporal resolution was available. As shown in Figure 1, from the available data it was determined that the Sacramento River at Freeport would peak 21 hours after the Cosumnes River at Michigan Bar. As such, the constructed Sacramento River centering adopted this timing differential for the 1-in-200 year flood event that was developed.

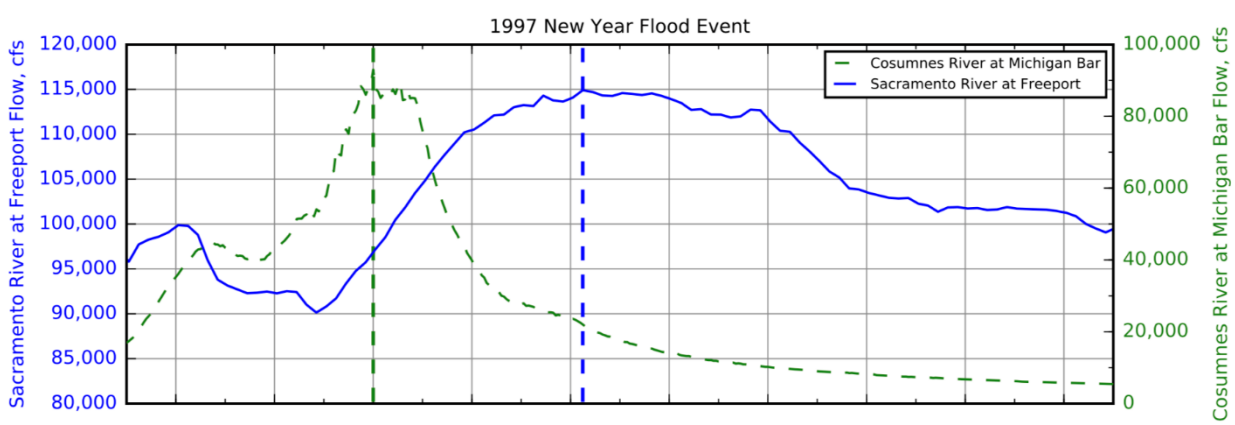

Figure 1. Comparison of flood peak timing from New Year 1997 flood event for Sacramento River at Freeport and Cosumnes River at Michigan Bar.

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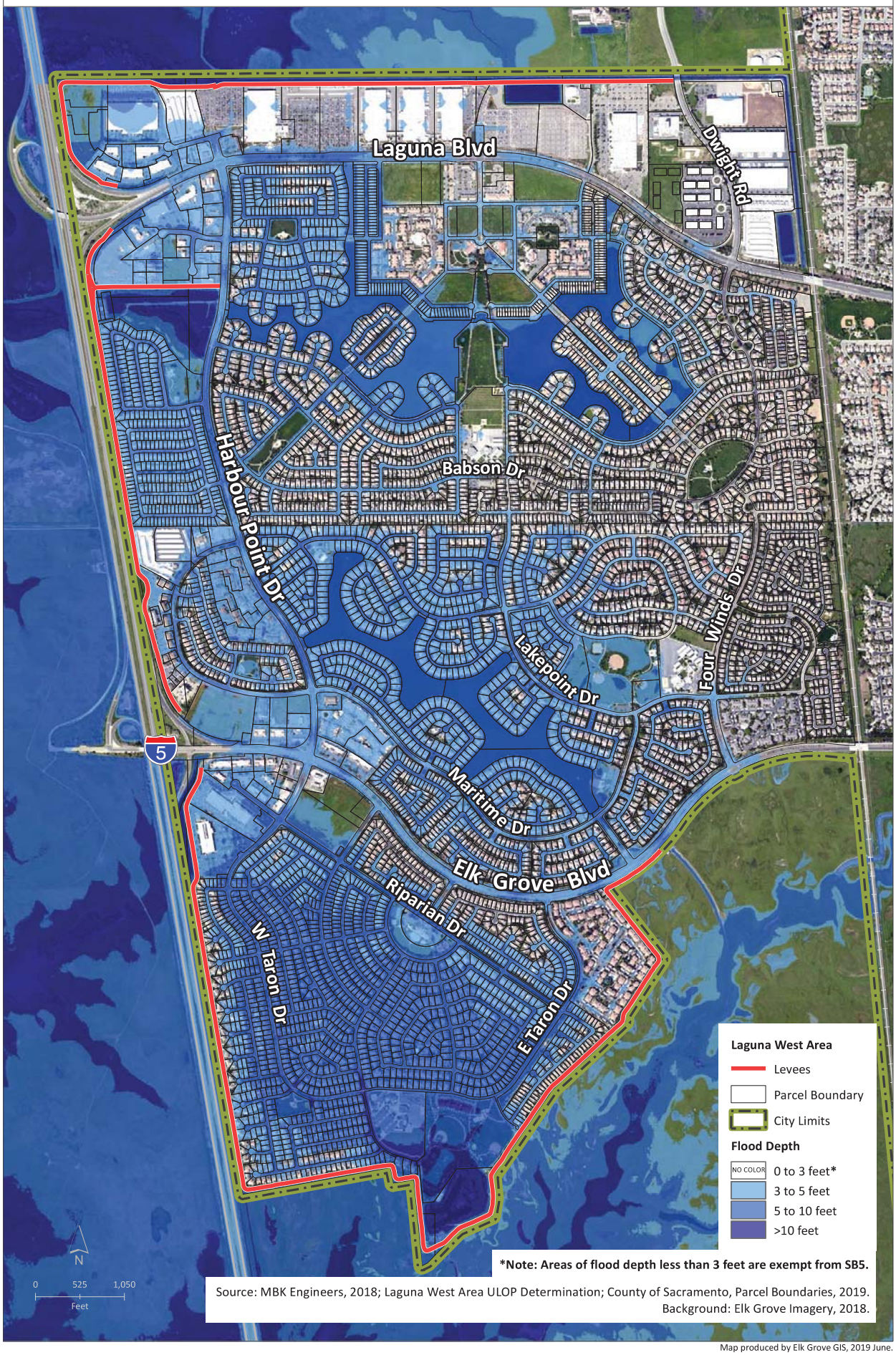
1-in-200 Year Floodplain



Source: MBK Engineers, 2018; Laguna West Area ULOP Determination; County of Sacramento, Parcel Boundaries, 2019.
Background: Elk Grove Imagery, 2018.

Map produced by Elk Grove GIS, 2019 June.

David A. Peterson, P.E.

EDUCATION

M.S., Civil Engineering, Montana State University, 1983

B.S., Civil Engineering, Montana State University, 1982

REGISTRATION

Professional Civil Engineer, 1987, California No.C-43432; 1998, Nevada No. 013110

EXPERIENCE

Mr. Peterson specializes in program management, planning, design, and implementation of water projects. He understands public involvement, the environmental process, permitting, financing, right-of-way acquisition, design, and construction of water resources, drinking water, and wastewater projects. His planning experience includes water supply plans; integrated water resources plans, river restoration, dams, water distribution, storm drains, wastewater master plans, water and wastewater treatment plant siting, water quality improvement projects, bridge hydrology/hydraulic studies, flood control plans, and FEMA flood studies. His design experience includes, gravity and pressurized pipelines, storm drainage systems, levees, floodwalls, detention basins, river restoration, erosion control, dams, spillways, canals, water tanks, pump stations, and water and wastewater treatment plants. He was a founding Principal of Peterson Brustad Inc. (PBI). Project experience includes:

DAMS AND HYDROELECTRIC FACILITIES

Forecasting of Inflows to Oroville Reservoir, Sutter Butte Flood Control Agency (SBFCA), 2017. PBI created forecasting models to estimate the water surface elevations in Oroville Reservoir during the January 2017 spillway emergency. The models used extrapolations of forecasted reservoir inflows to predict if and when Oroville's emergency spillway would overtop. Outflow data was also used as input to hydraulic models that routed the flows downstream to predict flood wave peaks and arrival times.

Oroville Reservoir Failure Analyses. Sutter Butte Flood Control Agency (SBFCA), 2017. PBI modeled scenarios for a potential emergency spillway failure on Oroville Reservoir during the January 2017 incident. Modeling included using HEC RAS 5.0 1D/2D coupled model to predict the resulting floodplain and arrival times for spillway failure scenarios of varying width and height. In addition, possible breach locations were analyzed downstream at known weak points in the Feather River west levee to determine likely worst-case scenario floodplains during a spillway failure scenario.

Folsom Dam Shutter Modifications - Sacramento Area Flood Control Agency, Sacramento, California. Principal in charge for preparation of an alternatives report on modifications to Folsom Dam's temperature shutter system. Participated in development and evaluation of feasible alternatives to provide more flexibility in the withdrawal of water from the reservoir profile. The report was used to reach an agreement between the U.S. Army Corps of Engineers (USACE) Sacramento District, U.S. Bureau of Reclamation, and local sponsor with the objective of incorporating the project into WRDA 2002 as an environmental component of authorized Folsom Dam modifications. Time was a critical factor on this project as preliminary alternatives had to be delivered to USACE within two weeks of receiving notice to proceed. Successfully met this fast-track schedule to the client's satisfaction.

Buckhorn Dam Break Analysis - East Bay Municipal Utility District, Oakland, California. Conducted a breach analysis of the proposed 145,000 acre-foot dam. The dam would be located upstream of two other dams in a densely populated section of San Francisco Bay area. Used the dynamic wave routing model, DAMBRK, to simulate a breach of the dam on the downstream dams and valley.

Trail Bridge Dam Break Analysis - Eugene Water and Electric Board, Eugene, Oregon. Project engineer for a dam breach inundation study for the existing dam on the McKenzie River using DAMBRK.

5 MW Hydropower Project on the Pit River - Muck Valley Hydro, Northern California. Provided preliminary design and cost estimates for components of this hydropower project, which includes an off-stream storage dam, reservoir, and afterbay dam. Results of the preliminary design were submitted as a license application to the Federal Energy Regulatory Commission.

Sprague River Hydropower Project - Beatty, Oregon. Provided estimates of energy production.

Middle Creek, Petrolia, Gartside, Martinsdale, South Sandstone, Red Rocks, and Cottonwood Dams - Montana Department of Natural Resources and Conservation. Performed hydrology, hydraulics, breach inundation, and dam/spillway alternative analyses for Phase II dam safety investigations (rehabilitation feasibility studies) of nine Montana dams. Also provided hydraulic design of improvements on four dams, including Gartside, Martinsdale, South Sandstone, and Cottonwood dams.

Tewaukon Dam – U.S. Fish and Wildlife Service, North Dakota. Project engineer for hydrology, hydraulics, breach inundation, and dam/spillway alternative analysis for this dam, as part of the dam safety investigation (rehabilitation feasibility studies).

WATER SUPPLY AND WATERSHED MANAGEMENT

Mokelumne River Regional Water Storage and Conjunctive Use Project, Phase 1 Reconnaissance Study – Mokelumne River Power and Water Authority, San Joaquin County, California. Project manager for preparation of studies to explore a project to capture unappropriated flows of the Mokelumne River for beneficial use. The project is needed to help solve an estimated current and future water budget deficit in eastern San Joaquin County of 150,000-200,000 acre feet per year, and will help perfect a pending water right application filed in 1990. Mr. Peterson led the HDR team while an employee of HDR for Phase 1, and then as a contractor to HDR for Phase 2 and beyond.

- **Phase 1 Reconnaissance Study.** The reconnaissance study analyzed the need for the project and identified an appropriate range of project alternatives. The approach placed special emphasis on eliminating potential alternatives that were "non starters" from an environmental or regulatory standpoint. The reconnaissance study also examined agency and stakeholder issues and considerations, and recommended an appropriate CEQA/NEPA strategy.
- **Phase 2 Operations Modeling Element.** A new Mokelumne River basin operations model was developed to analyze existing water rights, instream requirements, and storage operations, and to analyze availability of water for MRWPA direct diversion and diversion to storage alternatives.
- **Phase 3A Duck Creek Reservoir Site Suitability.** Feasibility level investigations were conducted on the proposed off-stream dam and reservoir on Duck Creek, including aerial surveys, geotechnical investigations, PMF hydrology/hydraulics for spillway sizing, embankment engineering, civil engineering preliminary design and cost estimates, environmental constraints analysis, and groundwater recharge/beneficial use facility layouts and cost estimates.

Mokelumne River Regional Water Storage and Conjunctive Use Project, Appraisal Study and Plan of Study for a Feasibility Study – U.S. Bureau of Reclamation. Mr. Peterson participated as a subconsultant to CDM Federal Services in completion

of a Federal Appraisal Study of the project, which is being used by the U.S. Bureau of Reclamation and Congress to decide whether to proceed with a federally sponsored Engineering Feasibility Study. The Appraisal Study was relied largely on Mr. Peterson's Phase 1 Reconnaissance Study.

Reservoir Sizing - U.S. Bureau of Reclamation, Sacramento, California. Wrote standardized reservoir operation model and reviewed their reservoir sizing criteria and techniques.

Tuolumne River Infiltration Gallery - Turlock Irrigation District, California. Principal-in-charge for design and construction management of a 100 cfs infiltration gallery diversion project from the Tuolumne River. The gallery functions similar to a Raney collector, except it is much shallower. Construction was concurrent with the SRP-9 element of the Tuolumne River Restoration program.

North Fork Crawford Ditch Improvements - El Dorado Irrigation District, Placerville, California. Provided hydraulic design and cost estimates for the $8 million project to repair and restore to service a 20-mile abandoned mining ditch.

Hydrologic Operations Model of the South Fork Stanislaus River - Tuolumne Utilities District, Sonora, California. Project manager for preparation of a new watershed model for the two-reservoir basin with trans-basin diversions. The model was used to evaluate changes and improvements to the water supply facilities, as well as real-time operation of the system using a forecasting algorithm. Modeling was accomplished using the Acres Reservoir Simulation Package (ARSP), with a Foxpro database preprocessor.

CALFED Water Use Efficiency Program - U.S. Department of Interior, Bureau of Reclamation, Sacramento, California. Program manager for analysis of approximately 200 quantifiable objectives (practical, cost-effective that identifies ways agricultural users can better use their water and free up water resources for other urban, agricultural, managed wetlands, and water recycling use (i.e., reduce pesticide discharges to a river, thereby improving water quality).

FLOOD PROTECTION

DWR Urban Flood Risk Reduction (UFFR) Feasibility Study for the RD17 Area, Cities of Lathrop/Manteca, CA, 2017-Present. PBI is preparing a DWR feasibility study and alternatives analysis for the provision of 200-year flood protection for the RD 17 area. The analysis of each alternative includes studying existing hydrologic conditions as well as future-with climate change conditions. Flood damages and life loss estimates are analyzed with HEC-FDA for the "without project" conditions as well as each of the "with project" conditions for each alternative. Multi-benefit alternatives will be qualitatively and quantitatively compared for consideration by stakeholders. The preferred plan will include refined conceptual drawings, phasing, cost estimates, operating rules and performance metrics. A plan will also be prepared outlining the key elements for implementation of the preferred alternative.

Urban Levee Design Criteria (ULDC) Analysis and Identification of Deficiencies for RD17 Levees, Cities of Lathrop & Manteca, San Joaquin County, California, 2014-Present. Mr. Peterson assisted the Cities of Lathrop and Manteca in developing a plan and program for Urban Level of Protection (ULOP) compliance. A key element of that plan was to develop an Engineers Report addressing the State's Urban Levee Design Criteria (ULDC). PBI was the lead consultant for this study which included detailed investigations, analyses, and documentation for the RD 17 levees to determine where ULDC was met and where deficiencies exist. The study culminated in a ULDC binder containing details on all analyses required under the ULDC, an identification of any deficiencies found, a summary of required countermeasures, and an estimated cost of these countermeasures. PBI was

responsible for developing all hydrology and hydraulics related criterion including: the design water surface profile, minimum top of levee assessment, frequently loaded levee analysis, wind/wave analysis, sea level rise analysis, and with- and without-project composite floodplains. PBI also provided the ULDC levee penetrations analysis. The remaining ULDC sections were prepared by subconsultants KSN and Engeo. PBI prepared the Engineer's Report, facilitated the selection of an independent panel of experts, facilitated the IPE review of the Engineer's Report, and prepared the Engineer's Response to the IPE Comments. These documents constitute the bulk of the materials meeting the requirements of 'substantial evidence in the record', which is required in order for local agencies to make ULOP findings. Based on the outcome of the ULDC Engineer's Report, PBI prepared a grant application for State UFRR design funds. The application was successful in securing $5M in planning and pre-design funding from the UFRR program.

Urban Levee Design Criteria (ULDC) Analysis and Identification of Deficiencies for RD2042 Levees - City of Stockton, California. Project manager for detailed investigations, analyses, and documentation for the RD 2042 (Bishop Tract) levees to determine where ULDC is met and where deficiencies exist, and documentation supporting an ULOP 'Protection Exists', or 'Adequate Progress' finding. The study is in progress and will culminate in a ULDC binder containing details on all analyses required under the ULDC, an identification of any deficiencies found, a summary of required countermeasures, and an estimated cost of these countermeasures. PBI is responsible for developing the penetration section and all H&H-related data including: the design water surface profile, minimum top of levee assessment, frequently loaded levee analysis, wind/wave analysis, and sea level rise analysis.

Urban Levee Design Criteria (ULDC) Analysis and Identification of Deficiencies for RD2126 Levees - City of Stockton, California. Project manager for detailed investigations, analyses, and documentation for the RD 2126 (Atlas Tract) levees to determine where ULDC is met and where deficiencies exist, and documentation supporting an ULOP 'Protection Exists', or 'Adequate Progress' finding. The study is in progress and will culminate in a ULDC binder containing details on all analyses required under the ULDC, an identification of any deficiencies found, a summary of required countermeasures, and an estimated cost of these countermeasures. PBI is responsible for developing the penetration section and all H&H-related data including: the design water surface profile, minimum top of levee assessment, frequently loaded levee analysis, wind/wave analysis, and sea level rise analysis.

Flood Protection Restoration Project - San Joaquin Area Flood Control Agency (SJAFCA), Stockton, California. Overall project manager for planning, design, and services during construction of more than $70 million of facilities to restore flood protection for the greater Stockton area (population 250,000), and removal of the area from the FEMA floodplain. Project features included levee and floodwall improvements to 40 miles of levee enlargements and extensions, improvements to 29 bridges, and construction of two new regional detention basins. Phase 1 included plan formulation, public involvement, and initial permitting and environmental compliance activities. Phase 2A included design aerial and ground surveys, channel mowing to reveal ground for aerial surveys, geotechnical investigation, and preliminary Environmental Impact Report (EIR) work. Phase 2B included final design, EIR, Supplemental (EIR), environmental assessment, acquisition of over 120 permits (COE 404, CDFG 1601, encroachment, etc.), coordination with Assessment District formation activities, preparation of right-of-way acquisition documents, expert witness support of condemnations, engineering services during construction, preparation of operations and maintenance manuals, conditional letter of federal

certification, FEMA letter of map revision, and in-kind services for the Corps of Engineers' 211 Reimbursement Study. Innovative features included parapet walls at bridges in lieu of raising, non-standard "cap" fill for levee raises of one-foot or less, negotiation of reduced freeboard at bridges and minor channels, a peak-shaving detention pond, floodwalls placed atop existing levees, and strip mowing prior to aerial photography to reveal ground. Construction on the fast-track project was initiated within 15 months of the start of the study phase. Services during bidding and construction provided included review of addenda and change orders, clarifications, field observations, and attendance at construction meetings.

200 Year Floodplain Modeling and Mapping – Grupe Commercial Company, Stockton, California, 2015. Developed a floodplain model using for the Stockton area using floodplain data produced by San Joaquin County and the City of Stockton. Analyzed the information, and broke it down to a fundamental level, in order to give the most accurately defined floodplain for those effected. Used the 250' X 250' grid scale to focus to a 5' X 5' grid scale within the Pixley Slough, Bear Creek, and West Lane area. This method is able to account for building pads, storm drains, and any smaller scale elevation changes that would change how a flood would affect the surrounding structures. The model also took into account several different levee breach simulations for different situations in which the surrounding levees were to become compromised.

Unionhouse Creek – Sacramento Area Flood Control Agency. Provided designs and construction management for the widening of Unionhouse Creek and the relocation of the City of Sacramento Storm Water Pump Station (Sump 201). Managed engineering, environmental and construction services for the Unionhouse Creek Improvement Project from Franklin Boulevard to Bruceville Road.

Merced IRWMP – RMC Water & Environment, Merced, California, 2012. Project manager for the flood risk management of the Merced area. Studied research by FEMA, USACE, CVFPP, Merced, Merced County, and other flood protection groups. Provided 200-year floodplain mapping, along with risk assessment for the involved areas. Produced designs for reduced flood risks, in a safer and sustainable manner for the area. Created an emergency flood procedure, and helped train and inform the public of the new plans.

Byron Tract Base Flood Elevation Refinement – Reclamation District No. 800, Discovery Bay, CA. – Project manager for the stage frequency analysis and manipulation of tide gage data to correct historical data for datum, subsidence and sea level rise to determine the base flood elevations for Byron Tract.

Nicolaus BFE Floodplain Mapping – Sutter County, California 2009. Developed BFE estimates for the Nicolaus Basin using FLO-2D and ArcGIS software. The analysis was utilized to update Sutter County floodplain GIS maps and to provide BFE estimates to FEMA.

Robbins & Meridian BFE Floodplain Mapping – Sutter County, California 2010. Developed BFE estimates for both the Robbins and Meridian Basins using HEC-RAS, FLO-2D and ArcGIS software. First, four hypothetical levee breach scenarios were simulated using HEC-RAS to produce escaping flow hydrographs. The escaping flow hydrographs were then input into FLO-2D models of the basins in order to delineate the floodplain. The analysis was utilized to update Sutter County floodplain GIS maps and to provide BFE estimates to FEMA.

Butte Sink BFE Study 2013 – Laughlin & Spence. Project manager for the assessment of floodplain mapping for Sutter County. Studies floodplain mapping from previous mapping, analyzing the data for dangers in the floodplain. The

information from the maps, as well as from surrounding bodies of water, the dangers of flooding and possible emergency procedures could be discussed.

Butte Sink BFE Floodplain Mapping – Sutter County, California 2010. Developed a HEC-RAS model that was utilized to estimate Base Flood Elevations for the Sutter County portion of the Butte Sink. The analysis utilized HEC-GeoRAS to develop the model geometry. The analysis was used to update Sutter County floodplain GIS maps and to provide BFE estimates to FEMA.

Coon Creek BFE Floodplain Mapping – Sutter County, California, 2011. Project manager for developing BFE estimates for Coon Creek, Markham Ravine, and Bunkham Slough. The study utilized CVFED LiDAR data, ArcGIS and HEC-GeoRAS to develop an existing conditions unsteady HEC-RAS model. The HEC-RAS model results were utilized to update Sutter County floodplain GIS maps and to provide BFE estimates to FEMA.

San Joaquin River Delta Base Flood Elevation Refinement – San Joaquin Area Flood Control Agency. Project manager for developing BFE estimates for the San Joaquin Delta and surrounding areas. Provided BFE estimates and floodplain mapping for the communities in the area. Created a refined study for the communities that had a flood risk, and created a detailed floodplain map to help reduce risk of flooding in these areas.

Lower Cal Provisionally Accredited Levees – San Joaquin Area Flood Control District. Project manager for the inspection and retrofit of the levees in the San Joaquin area. The levees were improved in order to reach the required levels to make up for the expected water levels based on historic data. Acquired the proper permits and accredited the levee for approval.

Mid and Upper Sacramento River Regional Flood Management Plan, California, 2014. Developed floodplain maps using HEC-RAS, FLO-2D, and ArcGIS software. The maps illustrated 100 year breach scenarios for small communities along mid and upper Sacramento River.

Provisionally Accredited Levee (PAL) Compliance Documents - San Joaquin Area Flood Control Agency (SJAFCA), Stockton, California. Principal in charge for development of PAL documents supporting accreditation of levees per 44CFR65.10:

- Walker Slough
- Calaveras River
- San Joaquin River (RD 1614)
- 14 Mile Slough
- RD 404 (interior drainage only)

FEMA Levee Accreditation for the Bear Creek and Calaveras River Systems, San Joaquin Area Flood Control Agency (SJAFCA), Stockton, California, 2014-15. PBI was the lead consultant for the submittal of 2 accreditation packages according to FEMA criteria identified in 44 CFR 65.10 for 55 miles of levees in the Bear Creek and Calaveras River systems. Specific work included HEC-RAS modeling to determine 100-year water surface profiles, levee freeboard analysis, FLO-2D modeling to determine residual floodplains due to interior drainage, and a review and evaluation of existing closure structures, embankment protection, and O&M manuals.

Smith Canal Closure Gate Design - San Joaquin Area Flood Control Agency (SJAFCA), Stockton, California. Project manager for design of a flood closure device using an inflatable Obermeyer type gate structure which would be used to

obtain FEMA 100-Year accreditation for the Smith Canal, Stockton, California. Work involved hydrologic, hydraulic, geotechnical and structural analysis, and preparation of a Conditional Letter of Map Revision for FEMA. Required the necessary environmental permits, an assessment for the cost estimate of the designs, and an application to receive the funds needed for the project. Principal in charge for preparation of a CLOMR and pre-design for the project.

Smith Canal Closure Structure - San Joaquin Area Flood Control Agency (SJAFCA), Stockton, California - Project manager for implementation of a closure structure across the mouth of Smith Canal in the Stockton Ship Channel. The structure will consist of a double sheet pile dam closing the 800' wide channel with a 50' wide operable miter gate to allow tidal action and navigation passage. Design services also include EIR, permitting, right of way acquisition, state grant funds applications, coordination with an independent panel of experts, and post project FEMA letter of map revision.

Sacramento Area Flood Control Agency (SAFCA) Levees – AECOM URS Corporation, Sacramento, California. Provided designs for construction on 2.8 miles of the Arcade Creek, the Natomas East Main Drainage Canal, and the Sacramento River East levees, in order for them to meet Urban Levee Design Criteria (ULDC) standards. Produces the plans for the removal and replacement of 45 utilities that would be effected by the renovation of the levees. PBI supplies the plans, specifications, details, and cost estimates for the replacements of the utilities and the restoration of the levees per the 200 year ULDC requirements.

Mid and Lower San Joaquin and Delta South Regional Flood Management Plan-San Joaquin Area Flood Control Agency (SJAFCA), Stockton, California. Principal in Charge and senior advisor for development of one of 6 regional plans funded by DWR as a companion to the CVFPP. The plan is intended to be a "bottom up" view of flooding problems and solutions, with local prioritization and local vision for funding.

Flood Management Program Assistance – San Joaquin County, California. Ongoing assistance to the County in its efforts to improve flood management systems and practices. The effort includes strategic advice, document reviews, and representation and/or technical assistance in matters with DWR, CVFPB, USACE, and FEMA. Principal in charge for development of a Systemwide Improvement Framework (SWIF) for the Bear Creek and Calaveras River systems, and preparation of 200-year floodplain mapping for SB 5 compliance.

Delta Stage-Frequency Analysis – San Joaquin Area Flood Control Agency (SJAFCA), San Joaquin County, California. Project manager for updating stage-frequency analyses for the Rindge Pump and Burns Cutoff tide gages in the San Joaquin River Delta near Stockton. New analysis extends the period of record to 2009, corrects for land subsidence and sea level rise, and projects sea level rise changes in stage-frequency relationships through 2100.

USACE Lower San Joaquin River Feasibility Study – San Joaquin County, California. Representing the local sponsor (SJAFCA) on the project development team. Also developed project hydrology for much of the study as an in-kind service, including HECHMS modeling of the Bear Creek, Mosher Slough, Calaveras River, and French Camp Slough watersheds. In-kind work also includes hydraulic design and civil design, and assistance with plan formulation.

U.S. Army Corps of Engineers WIK – Sutter Butte Flood Control Agency. Project manager in the coordination with the USACE on the Sutter Basin Feasibility Study. PBI assisted with project management, plan formulation, technical review, and execution of several in-kind contribution technical tasks, including Sutter Basin

FLO-2D floodplain mapping, Cherokee Canal HEC-GeoRAS modeling, Sacramento River System HEC-RAS hydraulic modeling, interior drainage analysis, regional floodplain mapping, and civil design.

USACE Sutter Basin Feasibility Study – Sutter Butte Flood Control Agency (SBFCA), Yuba City California. Representing the local sponsor (SBFCA) on the project development team; participating in all elements of project development. Provided a number of work products as in-kind services, including hydraulic design (including HECRAS modeling of levee breaks of the Feather River, Cherokee Canal, Wadsworth Canal, and Sutter Bypass and FLO2D modeling of the resulting floodplains), civil design drawings for the preferred alternative, interior drainage analysis, preparation of a Floodplain Management Plan, preparation of documents substantiating life safety risk under the Other Social Effects planning account, and preparation of documents substantiating wise use of the floodplain.

Sutter Basin Flood Management – Sutter Butte Flood Control Agency (SBFCA), Sutter and Butte Counties, California. Mr. Peterson is providing ongoing project and budget management assistance to the Sutter Butte Flood Control Agency (SBFCA). Activities include:

- Helped form SBFCA, and serving as Agency Engineer for several years. Assisted with strategy development, public outreach programs, Council and Board briefings, hiring, and funding strategies.
- Coordination with FEMA on floodplain mapping efforts, including filing of appeals, protests, and levee accreditation documents
- Coordination with DWR on their Prop 1E – funded levee investigation program. Was successful in convincing DWR to investigate the entire 70-mile Sutter Basin levee system under DWR's "Urban Investigations" program, rather than only the 5 miles adjacent to Yuba City. This increased DWR's expenditures for the basin from $1M to $14M.
- Coordination with DWR and Levee District 1 on a successful $16.3M Early Implementation Grant bid (Prop 1E) for the $20M, ¾-mile Star Bend setback levee project. This was a LD1 grant submittal, but SBFCA, Sutter County, and Yuba City had significant roles, including Board/Council resolutions, funding of the local share, preparation of several grant package sections, and fulfillment of several grant requirements related to Federal crediting and Federal approvals. Construction was completed in 2010.
- Local sponsor representative on the USACE Sutter Basin Feasibility Study. The study had been halted since 2006 due to exhaustion of funds, and Dave worked with the USACE and DWR to amend agreements for completion of the study and develop funding at the local, State, and Federal level. In early 2011, USACE HQ designated the Sutter Basin Feasibility Study as one of 2 projects to participate in a pilot program to complete feasibility studies in 18 months. PBI is assisting with on-going project management, technical review, and execution of several in-kind technical tasks.
- Coordination with DWR for Prop 13 grant. A $2.6M Proposition 13 grant is being used to fund much of the local share of the USACE Feasibility Study and pay for several in-kind contribution tasks.
- Development of a $300M early implementation project (EIP) to rehabilitate 41 miles of the west Feather River levee. This included concept development, preliminary design, developing hydraulic basis for assessment district formation and assistance with Proposition 218 process, public outreach, and preparation of Prop 1E EIP design grant documents.

- Assistance with program management of implementation of the West Feather River Levee Project. PBI's responsibilities include facilitating selection of consultants, oversight (design, right of way, CEQA/NEPA and environmental permits), performing all hydraulics, all interior drainage, securing state grant funding (several programs), and lead for FEMA, ULDC, and ULOP compliance processes.
- Project manager for the rehabilitation of the Feather River West Levee
- Assisted in construction management and provided miscellaneous other technical support for the work done on the levees
- Principal in charge for development of a Systemwide Improvement Framework (SWIF) for the Sutter Basin.

Oroville Wildlife Area Flood Stage Reduction Project – Sutter Butte Flood Control Agency, Oroville, California, 2014. Developed a floodplain model using TUFLOW and ArcGIS software to determine the hydraulic effects associated with several conceptual alternatives involving expanding the capacity of the existing system of inflow and outflow weirs in the OWA D-unit. A hydraulic analysis was performed for the 100- and 200-year storm events to determine how the proposed project improvements affect river stage, velocities, and flow into the D-unit.

Water Supply Enhancement Project EIR – Stockton East Water District. Project manager for the testing of flood impact, water quality, and geomorphological changes to the environment due to the implementation of the Water Supply Enhancement Project (WSEP). Prepared runoff analysis, river hydraulics, and data analysis to see the effects of flood-level waters on the runoff and water quality. The project tested the production and effects of the WSEP, as well as how the water quality is effected in the case of an emergency. The ideas for this process, as well as the result, will help set a strong set of rules to efficiently use this process for later projects.

Lower San Joaquin River Feasibility Study WIK – San Joaquin Area Flood Control Agency. Project manager for the gathering of data from the San Joaquin watershed systems, including Bear Creek, Mosher Slough, Calaveras River, and French Camp Slough. The project required analysis of the current water level data, as well as expected levels of water from the watershed. Project management included interpreting regulations from USACE and SJAFCA, feasibility studies, scoping assistance, budgeting, distributing resources, funding the study, and interpreting and applying watershed data.

Department of Water Resources Central Valley Flood Protection Program Lower San Joaquin Region Phase 2 – San Joaquin Area Flood Control Agency. Project manager for the initiation of the second phase of the DWR flood protection program for the San Joaquin region. The project required 19 meeting with several different groups to organize the approach to lower the risk for flooding in the central valley. Using floodplain data, maps, and a variety of other resources, a plan was created to put into place that could lower the risk for flooding for the communities in this region.

Review of Department of Water Resources Guidelines – San Joaquin Area Flood Control Agency. Project manager for the review of DWR ULDC guidelines. The guidelines were reviewed for SJAFCA in order to comply with all local and federal urban levee regulations. This work ensure that the project would meet FEMA requirements, and that it would receive the necessary funding.

200-year Freeboard Analysis and Floodplain Mapping within RD17 - Cities of Lathrop and Manteca, California. Principal in charge and QC review for a study to

analyze and delineate the 200-year floodplain in Reclamation District No. 17. It also involved the development of water surface profiles on the highly complex Lower San Joaquin River system, which were used to identify where levee freeboard deficiencies exist. HEC-RAS and FLO-2D models were used to analyze and map a composite of levee breach inundation scenarios.

Flood Management Program Assistance – Sutter County, California. Coordination with FEMA on floodplain mapping efforts, including filing of appeals and protests on draft FIRMs. Developed Base Flood Elevation maps for Yuba City, Meridian, Robbins, and Nicolas basins as a 'best available mapping" tool for County administration of A-zone building restrictions**.**

Meadowview Estates BFE – Piro Enterprises, Merced County, California. Project manager for the estimate and planning for the floodplain layout of the Meadowview area. The project required coordination with FEMA representatives to get the approval of the hydraulic designs. Provided analysis of as-built drawings, and created a hydraulic model to remove several lots from the floodplain. The project included the study of as-built designs, topographic maps, and floodplain data to predict the expected water levels and to prepare for the result.

Unionhouse Creek Channel Improvements - Sacramento, CA. Principal in Charge for the design, permitting, and construction management of a 1.6 mile long channel improvement project. Half the project consisted of excavated enlargement, and half was concrete lining.

North Area Streams SAFCA North Area Streams Levee Improvement Project – Sacramento, CA. Geotechnical improvements were needed for the Arcade Creek and Natomas East Main Drainage Canal (NEMDEC) levees. The prescribed centerline and waterside cutoff walls require removal and replacement of through-levee utilities. PBI's role in this project was to deliver plans, specs, details, and cost estimates for removing and replacing or modifications to the utilities that were impacted by construction of the cutoff walls. All pipe replacements were designed to standards set by the 200-year Urban Levee Design Criteria (ULDC). Mr. Peterson's role was as one of 3 internal technical review panelists for the AECOM team.

Phase II Stockton Metropolitan Area Flood Alternatives Study - U.S. Army Corps of Engineers, Sacramento District, Stockton, California. Principal-in-charge and technical reviewer for preparation of a preliminary and final alternatives report for alternatives that would reduce flood damages in the Stockton Metropolitan area. Mr. Peterson also made presentations to the public and elected officials on this project. (Completed 2002).

Stockton Metro California Section 211 Study - U.S. Army Corps of Engineers, Sacramento District, Stockton, California. Provided technical assistance to USACE staff on special report satisfying the reimbursement requirements of WRDA 98 Section 211(f). Report determined B/C ratios and Federal interest, audited local expenditures, and determined allowable Federal cost share for the various channel segments of the SJAFCA project. Federal share is being reimbursed to SJAFCA through appropriations. (Completed 2001).

Stockton Metro California Limited Reevaluation of Eligibility for Federal Reimbursement for 2 Reaches of Project Authorized by Section 211 WRDA 98 - U.S. Army Corps of Engineers, Sacramento District, Stockton, California. Principal-in-charge and technical reviewer for limited reevaluation report to determine B/C ratios and Federal interest for the Mosher Slough and Upper Calaveras River reaches of the SJAFCA project, both of which had previously been disqualified because they were below the 800 cfs threshold for Federal interest. (Completed 2004).

North Wilson Way Specific Plan CLOMR Review – San Joaquin County, California. Provided review of the draft CLOMR prepared by the project proponent on behalf of the County.

Mariposa Lakes Off-Site and On-Site Drainage Review – City of Stockton, California. Provided review of the draft off-site drainage report, which included HEC-1 modeling of the Littlejohns and Duck Creek drainages of San Joaquin County, and the on-site development drainage concepts prepared by the project proponent on behalf of the City.

Upper Penitencia Creek Bypass - Santa Clara Valley Water District, San Jose, California. Principal-in-charge and technical reviewer for planning and design of a new 4,100 cfs bypass channel (Reach 1 Bypass) to relieve flood flows from the natural channel in Upper Penitencia Creek. The Reach 1 Bypass will consist of a 2,600' long 28'x14' box culvert, a side weir diversion structure from Upper Penitencia Creek, two crossings, and an outlet structure to Coyote Creek. Crossings over the box include King Road and Union Pacific Railroad's San Jose Industrial Lead railroad line.

Pixley Slough Relocation - A.G. Spanos Land Company, Stockton, California. Project manager for hydrology, hydraulics, and geotechnical investigation for relocation of about a half-mile of a 700 cfs channel. The previous channel had discharged to Disappointment Slough in the Sacramento-San Joaquin Delta. The realigned channel now discharges to Bear Creek, which discharges to Disappointment Slough. This diversion raised flood levels in Bear Creek both upstream and downstream of the confluence with Pixley Slough. It also raised flood levels in Pixley Slough upstream of the diversion. Existing U.S. Army Corps of Engineers hydrology was used for the project. Water surface profiles were computed using HEC-2. The hydraulic analyses were used to define required channel geometry, scour protection, and levee elevations on both Pixley Slough and Bear Creek. Project also involved coordination with a local consulting firm for final design of the improvements, wetland mitigation area design, the U.S. Army Corps of Engineers 404 permit, FEMA letter of map revision, and the State Reclamation Board permit.

Flooding at Calmat's Sand and Gravel Facility - Zurich American Insurance Group, Fresno, California. Project manager for evaluation of repair costs to the Calmat sand and gravel operations adjacent to the San Joaquin River. The January 1997 flood caused the river to inundate the facility, which breached numerous levees and berms, destroyed a river crossing, damaged plant equipment, and washed away stockpiles. Designed repairs to the levees, berms, crossing, and several eroded areas, and received bids for the work as backup to Zurich's counter claim.

Flooding at Martori Farms/Eagle Produce Facility - Zurich American Insurance Group, Aguila, Arizona. Project manager for evaluation of repair costs to Martori Farms/Eagle Produce facility. The facility was inundated by local drainage in the September 1997 flood, damaging field ditches, leveled arable farm fields, leveled drip system fields, main and lateral pipelines, and flood control dikes. Designed repairs to the damaged facilities, and received bids for the work as backup to Zurich's counter claim.

CLOMR for Proposed Avenal Business Park - City of Avenal, California. Project manager for preparation of a flood protection plan and FEMA conditional letter of map revision (CLOMR). The study defined levees and setbacks required to remove most of the parcel from the 100-year floodplain.

Levee Breach Inundation Study - Sacramento County, California. Analyzed and mapped the potential flooding from 16 hypothetical levee breaks. Flat topography in

the area made the analysis challenging from a hydraulic modeling standpoint. Drawdown in the river at the breach could cause water to actually flow upstream in the river following a breach. Water discharging through a breach varied because of river stage, weir submergence, and width of the breach. All of these parameters were time variant and interrelated. Also, floodwater exiting the breach tended to spread out in two dimensions. Creative, site-specific solution methodologies were developed, which included hand calculations, spreadsheet calculations, BASIC programming, DAMBRK, HEC-1, and HEC-2. The final product consisted of maps that show progression of the initial flood wave, with superimposed tables of water surface elevation versus time at several cross sections.

American River Inundation Study - Sacramento County, California. Principal in Charge and technical reviewer for a study to analyze and map the potential flooding from American River levee breaks upstream of the Mayhew Drain. The study defined inundation and evacuation zones. UNET was used for the analysis.

Lake Las Vegas Flood Damage Assessment - Reliance National Insurance Company, Las Vegas, Nevada. Investigated damage to the Lake Las Vegas intake and bypass, reservoir, and dam caused by a 50- to 100-year storm. Results of the investigation were used to check the reasonableness of Lake Las Vegas' damage claim. Included in the investigation were two permit required confined space entries.

Replacement of Nine Bridges - Calaveras, San Benito, Madera, Riverside, Ventura, Orange and Lassen Counties, California. Conducted bridge hydrology and hydraulics studies. These studies included flood hydrology using HEC-1 and regression analyses, water surface profile calculations using HEC-2, and sedimentation or scour estimates. The largest of nine bridges was the State Route 126 (SR-126) bridge over the Santa Clara River (Q100 = 175,000 cfs), which had failed from scour several times in the past and required deep caisson construction and bank protection on the replacement project.

Lower San Joaquin River Feasibility Study Preliminary Screening Analysis – San Joaquin Area Flood Control Agency/United States Army Corps of Engineers, San Joaquin County, California, 2012. In an effort to reduce the duration and the cost of the Lower San Joaquin River Feasibility Study (LSJRFS), a Preliminary Screening Analysis was conducted to identify levee reaches that were highly unlikely to justify a Federal interest and could therefore be "screened out" of the LSJRFS. The analysis included simulating levee breach scenarios in HEC-RAS and FLO-2D, mapping the resultant floodplains in ArcGIS and computing expected flood damages in HEC-FDA. A 200-year improvement scenario was identified for each levee system and costs were estimated for these improvements. Screening decisions were made based on the benefit/cost ratios for each levee reach.

Flood Studies on Crooked Creek, Lone Tree Creek, Alkali Creek, and the Jocko River - Various Clients, Montana. Provided flood hydrology using HEC-1 and regression analyses, water surface profile calculations using HEC-2, and mapping of the 100-year floodplain.

Storm Drain Master Plan - City of Winters, California. Project manager for preparation of the city's storm drain master plan. About half of the project addressed regional flood control. Flooding from off-site sources to the north placed much of the existing city and growth area in the Federal Emergency Management Agency (FEMA) 100-year flood plain. Analyses involved HEC-1 modeling of a complex system that was characterized by undersized channels with altered courses. These channels overflowed in major flood events, and the water escaped across farmland sloping gently away from the channels. Flooding across the agricultural land was greatly affected by elevated roads and ditch banks. HEC-2 was used to estimate channel capacities and overflow rating curves. Flood protection alternatives were

then developed to remove the city's 20-year sphere of influence from the floodplain. Alternatives included detention storage, channel improvements, bridge improvements, confinement levees, and a new outfall to Putah Creek.

Foresthill Sawmill Erosion Control Plan - Georgia-Pacific Corporation, Foresthill, California. Project manager for preparation of a drainage and erosion control plan following closure of the 150-acre sawmill. Provided hydrologic analyses of existing conditions using HEC-1, and made recommendations for improvements.

WATER TREATMENT, DISTRIBUTION, AND STORAGE

New 30 mgd Surface Water Treatment Facility - City of Fresno, California. Project manager for a major (40%) subconsultant to MWH during conceptualization, siting, environmental documentation (CEQA), public outreach, design, and construction engineering services for a new 30 mgd surface water treatment plant. Mr. Peterson's responsibilities included portions of the sanitary survey, the raw water supply, treated water distribution and blending, and key portions of the treatment plant. Raw water facilities designed include a new intake, pipeline, and pump station. Process facilities designed include flashmix, ACTIFLO clarification, and filter backwash handling. Treated water facilities designed includes a clearwell, high service pump station, distribution system piping, and off-site pressure sustaining valve stations. Solids handling included a backwash equalization basin and pump station, a lamella plate settler used to thicken the solids and reduce the backwash volume, and four earthen lagoons/drying beds used to store solids over the winter for drying in the summer.

Stockton Delta Water Supply Project – City of Stockton, California. Consultant to the City to lead the financing team, review the work of the environmental consulting firm, assist with obtaining new water rights, assist with the design/build procurement process, and advise the City on overall decisions relating to the project. The project will be a new intake from the San Joaquin River Delta, treatment plant, and associated raw water and treated water pipelines. Initial capacity of the limiting components will be 30 mgd (estimated cost $175M), with ultimate system capacity of 160 mgd.

Full Surface Water Implementation Study – City of Lodi, California. Project manager for an analysis of alternatives for utilization of the City's 6,000 acre feet of water purchased from WID. Alternatives investigated included treatment for potable use, raw water delivery to public turf areas, and groundwater recharge.

Lake of the Pines – Low Ball & Lynch, Nevada County, California. Project manager for the design and construction of a new water supply project for the Nevada Irrigation District (NID). The project required the predesign of two booster pumps, a 600,000 gallon storage tank, over 1,000 feet of piping, and a hydropneumatic tank system. Provided review of NID documents, inspection of the geologic conditions, and surveying for the proposed areas of construction. Required laboratory testing and analysis to test the nature of the soil and the effects on the proposed construction. The project needed positive results from all of these different areas in order for the construction process to be approved to begin.

New Potable Water System for Tracy Pumping Plant - U.S. Bureau of Reclamation, Tracy, California. Preliminary design of a new water system for the Tracy Pumping Plant. The system included two 100,000-gallon storage tanks, distribution piping, and a new packaged treatment plant.

Grand Island – United States Army Corps of Engineers, Sacramento, California, 2013. Project manager for the feasibility of an existing pipe at the USACE facility in

Sacramento. The project concluded that the pipeline would need to be removed, and also required a design for the removal of the pipe in the report.

Farmington Water System – Stockton East Water District. Project manager for the assessment of the Farmington water system. Provided an environmental evaluation of the impact from the system, as well as a preliminary report for the system. Provided designs for the replacement of the Farmington water system and managed the construction. Provided a design report, environmental assessment, and acquired the permits for the construction process.

Northwest Reservoir and Pump Station - City of Stockton, California. Project manager of the predesign portion of the 10 MG potable water reservoir and pump station.

Fresno Water Storage Reservoir and Pump Station - City of Fresno, California. Project manager for planning, siting, design, and services during construction for a new 2 MG potable water reservoir and pump station. Project included a partially buried prestressed concrete reservoir, operations building, and about 1,000 feet of 24-inch piping. The operations building houses an office, chlorination room, emergency generator, motor control center, pump station, storage room, and an open room that will house six granular activated carbon (GAC) filters for future wellhead treatment. The project was planned as a three-phase development, eventually including a second 2 MG reservoir and pump station and a second GAC facility.

Water Reservoir Study - City of Clovis, California. Predesign for a new 1 MG concrete potable water reservoir and pump station.

Watsonville Water Distribution System Analyses and Planning - City of Watsonville, California. Performed water system analyses using NETWK modeling. Improvements were identified to correct system deficiencies.

Hillsborough Water Distribution System Model - Town of Hillsborough, California. Provided senior review for development of a new model for water distribution system.

Eugene Water Distribution System Analyses and Planning - City of Eugene, Oregon. Performed water system analyses of eight pressure zones using NETWK modeling. Improvements were identified to correct system deficiencies.

Tuscaloosa Water Distribution System Analyses and Planning - City of Tuscaloosa, Alabama. Performed water system analyses of five pressure zones using NETWK modeling. Improvements were identified to correct system deficiencies.

Water System Analysis - Oakdale Irrigation District, California. Project manager on water system study for a small subdivision. The study analyzed operation and recommended improvements to correct pressure and reliability deficiencies.

Bi-directional Pipeline Investigation - South San Joaquin Irrigation District, Manteca, California. Project manager for a study that investigated alternatives for a three-mile, 30 to 50 cfs bi-directional pipeline inter-tie between South San Joaquin Irrigation District and Oakdale Irrigation District.

New Water System Model - City of Stockton, California. Project manager for development of a new water system model, including approximately 1,300 pipes and 800 nodes. Since the original creation of the model, oversaw the addition and analyses of five major developments and a county island to the model. Provided follow-on services to the city in assessing various “what if” scenarios.

PROFESSIONAL ENDEAVORS

Peterson Brustad Inc., 8/05 to Present

David A. Peterson, P.E.

Peterson Engineering, 6/05 to 8/05

West Yost and Associates, Inc., 7/04 to 6/05

HDR Engineering, Inc., 4/94 to 7/04

CH2M Hill, Inc., 1987 to 1994

HKM Associates, 1983 to 1987

PROFESSIONAL AFFILIATIONS

San Juan Water District; Board of Directors 2003-2014

Association of California Water Agencies; currently serving on Finance Committee, Water Management Committee, and Chair of Flood Control Subcommittee. Formerly on Board of Directors, and former Region 4 Board Chair.

ACWA Health Benefits Authority; former Board of Trustees

National Water Resources Association; former Board of Directors

Water for the West Foundation; charter Board of Directors

Floodplain Management Association

PUBLICATIONS AND PRESENTATIONS

Contributing author, "Handbook of Public Water Systems," Source Water Development chapter, John Wiley & Sons, Inc., New York, NY, 2001.

Peterson, D., “Experts Help Keeps Flood Water Bounded,” Erosion Control, July/August 1998.

Peterson, D., and Callahan, M., “SJAFCA Flood Protection Restoration Project”, presented at Floodplain Managers Association Conference, September 1996.

Peterson, D., and Burmeister, B., "Fresno/Clovis Water Management Plan," presented at ASCE Water Resources Planning and Management Division Conference, May 1993.

Peterson, D., "Levee Breach Inundation Study for Sacramento County, California," presented at ASCE national Hydraulic Engineering Conference, July 1993.

Peterson, D., and Elwell, G.E., "Common Hydrologic and Hydraulic Methods of Analysis," presented at HKM Associates' seminar, Practical Applications in Stormwater Management for the 1980's, Billings, Montana, 1986.

Peterson, D., "Small Scale Hydropower Design Optimization and Analysis of Hydrologic Sensitivity." Master's Thesis, Montana State University, Bozeman, 1983.

Peterson, D., and Cunningham, A.B., "A Procedure for Estimating Flow-Duration Curves for Ungaged Mountainous and High Plains Streams in Montana," Montana Joint Water Resources Research Institute, Montana State University, Bozeman, 1983.

Peterson, D., "Electrical Requirements of Small Hydropower Facilities," Montana State University Department of Civil Engineering, Bozeman, 1983.

Peterson, D., "Simulation of the Operation of Small-Scale Hydropower Facilities," Montana State University Department of Civil Engineering, Bozeman, 1982.