June 2014

West Sacramento General Reevaluation Report

US Army Corps of Engineers ®
Sacramento District

Central Valley Flood Protection Board

WSAFCA
West Sacramento Area Flood Control Agency

Draft Report Documentation

Economic Appendix

Cover Photo: Sacramento River, West Sacramento, and Yolo Bypass, March 2011

Photo courtesy of Chris Austin.

WEST SACRAMENTO PROJECT, CALIFORNIA
GENERAL REEVALUATION REPORT

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Economic Appendix

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1 - INTRODUCTION

1.1 PURPOSE AND SCOPE

This Appendix documents the economic analysis performed for the West Sacramento General Reevaluation Report (GRR). The main purposes of this report are to:

- Describe the framework of the economic analysis, including the major assumptions, data, methodologies, and analytical tools used.
- Describe the flood risk, in terms of probability of flooding and consequence of flooding, associated with the without-project condition, which assumes that two previously authorized projects (the Joint Federal Project (JFP), and the Folsom Dam Raise) are in place and functional.
- Describe the residual flood risk, which is the remaining flood risk once improvements are completed, associated with each alternative.
- Summarize the results of the net benefit and benefit-to-cost analyses for each alternative.
- Identify the National Economic Development (NED) Plan, which is the alternative that reasonably maximizes net benefits.

1.2 BACKGROUND

Surrounded by water during the winter months, the city of West Sacramento depends on levees for the safety of its residents (Figure 1 below). In 2002, the U.S. Army Corps of Engineers (Corps) completed levee improvements authorized through the *West Sacramento Project* that were intended to protect the city from a flood having greater than a 1% chance of occurring in any given year. Unfortunately, these levee improvements, recommended as part of *the Sacramento Metropolitan Area, California, General Reevaluation Report (*February 1992), did not consider the under seepage deficiencies facing many of the levees which protect the city. Although the levee improvements authorized for construction were redesigned to address under seepage, the levees not included in the authorization and which also protect the city were not reevaluated to determine whether they were adequate to withstand the design flood event. Further, the geotechnical engineering and risk analysis standards being applied to urban levees in the post-Katrina environment have raised additional doubt regarding the actual level of protection afforded to the city by the existing flood protection infrastructure.

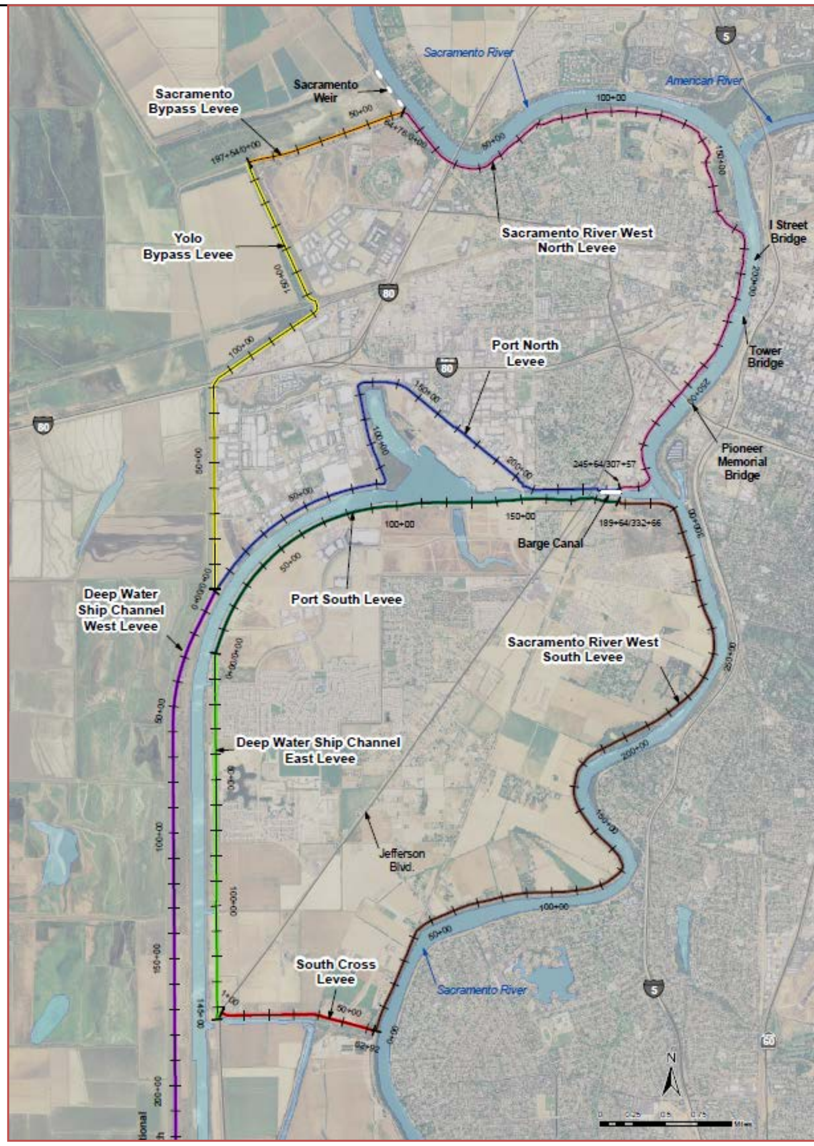


Figure 1: Levees Surrounding the City of West Sacramento

As a result, the West Sacramento Area Flood Control Agency (WSAFCA) has initiated a thorough, State and locally-funded review of its flood risk management system. Based on the current Federal standards, multiple deficiencies have been found in the Federal levee system that protects the city, with the predominant dangers being seepage, stability, and erosion. Recognizing the need for more work, the city has moved proactively to address this challenge, with city residents recently voting to assess a tax on themselves for up to $40 million of the needed funds. The city is seeking additional assistance and funding from private, state, and Federal agencies to implement the levee improvements necessary to reduce the flood risk facing their community.

1.3 STUDY AREA

Sacramento Watershed

The West Sacramento study area is part of the larger Sacramento River watershed, which is comprised of 26,300 square miles in the northern half of California's Central Valley. The watershed is approximately

240 miles long and up to 150 miles wide bounded by the Sierra Nevada on the east, the Coastal Range on the west, the Cascade and Trinity Mountains in the north, and the Delta in the south. Major tributaries of the Sacramento River include the Feather and American Rivers (Figure 2).

The Sacramento River watershed typically receives the greatest runoff as a result of winter and spring rainfall. A majority of the Sacramento River is perched, meaning the river channel is at a higher elevation than the adjacent lower lying basins. This effect is amplified as flows combine with tides near the bottom of the watershed to strongly influence flood water levels in the Delta. This often causes backwater effects on the Sacramento River and its tributaries in and near the Delta.

Between Lake Shasta and Red Bluff, the Sacramento River is relatively narrow and entrenched, with little floodplain and a narrow riparian corridor. Shasta Dam regulates most of the flood flows entering the reach. From Red Bluff to Chico Landing, the river is relatively free to erode and deposit bank material as it meanders within its floodplain. This reach does not have major levees or other flood management facilities and includes the most extensive riparian habitat of any reach of river. Downstream from Chico Landing, a system of levees, weirs, bypasses, and natural overbank areas convey flow to the Delta. The Sutter Bypass and finally the Yolo Bypass carry the bulk of flood flows to the Delta.

Riparian forests in the Sacramento River watershed are considerably smaller than they were historically, but still support a variety of wildlife. The vegetation includes Valley oak riparian, Great Valley cottonwood riparian, Great Valley mixed riparian elderberry savanna, oak woodland, freshwater marsh, seasonal wetlands, grasslands, and agricultural lands. Ecosystem functions, such as periodic inundation of habitat along the river, have also been reduced from the historical condition, resulting in a reduction of ecosystem diversity and productivity.

In the early 1900s, the Federal and State governments began construction of system-wide flood management facilities, including levees, weirs, and bypass channels. This included constructing new facilities and reconstructing existing private facilities to meet the Federal engineering standards that existed at the time. The effort focused on protecting lives and property by increasing the conveyance of flood waters through the system. The design goal of the facilities was to aid navigation and flush sediment remaining from the hydraulic mining conducted late in the 19th century. These conveyance facilities improved flood protection and navigation and allowed continued agricultural and urban development. They also constrained the river to specific alignments, significantly reducing channel meandering and further isolating the rivers from their historic floodplain.

The Corps constructed new levees or reconstructed private levees in order to complete the Sacramento River Flood Control Project. This project, authorized by the Flood Control Act of 1917, encompasses approximately 1,100 miles of levee along the Sacramento River and its primary tributaries from Collinsville in the Sacramento and San Joaquin River Delta upstream to Ord Ferry in Glenn County. The non-Federal partner for this flood control system is the Central Valley Flood Protection Board (formerly the Reclamation Board), which accepted the responsibility to operate and maintain the system under authority granted in the Flood Control Act of 1944. In accordance with State law, most of these responsibilities have been delegated to local levee and reclamation districts.

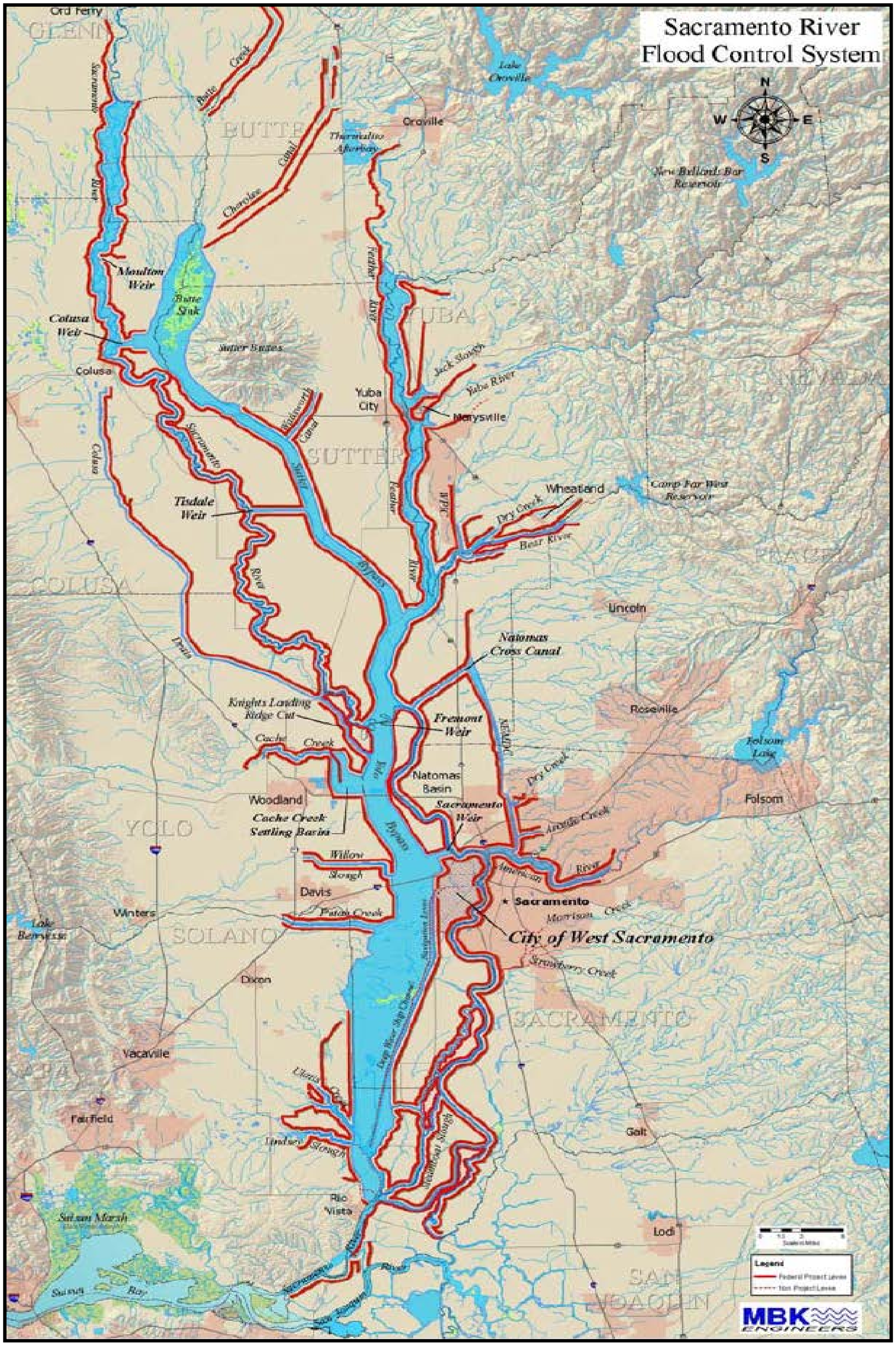


Figure 2: Study Area

West Sacramento Study Area

The study area is located in eastern Yolo County in the north central region of California's Central Valley (See Figure 2). The study area corresponds approximately with the city limit of West Sacramento, which is comprised of an estimated 13,000 acres of mixed-use land and an estimated population of 44,000 residents. The city of West Sacramento is located directly across the Sacramento River from the city of Sacramento, the state's capital.

The study area is almost completely bound by floodways and levees, making it vulnerable to multiple sources of flood risk. These sources include the Yolo Bypass to the west, the Sacramento Bypass to the north, and the Sacramento River to the east. Further, the City is bifurcated by the Sacramento River Deep Water Ship Channel (DWSC) and Barge Canal. The associated levee system currently protecting the study area includes nearly 50 miles of levees in Reclamation District (RD) 900, RD 537, Maintenance Area 4, and along the DWSC and Barge Canal. The sub-basins and the levee reaches within each sub-basin include:

Northern Sub-Basin – The northern sub-basin, representing approximately 6,100 acres, is bounded by the Port North Levee and the DWSC to the south, the Sacramento River West-North Levee to the north and east, the Sacramento Bypass Levee to the north, and the Yolo Bypass Levee to the west. Land in this area varies in elevation from 34.0 feet near Raley Field to 16.0 to 18.0 feet adjacent to the DWSC. The north bank of the DWSC is generally about elevation 19.5 feet. This area is traversed by the right bank of the Sacramento River from river mile (RM) 63.0 to RM 57.5.

- **Sacramento River West-North Levee** extends for approximately 5.5 miles along the Sacramento River right bank levee from the Sacramento Bypass south to the confluence of the Barge Canal and the Sacramento River.
- **Sacramento Bypass Levee** extends for approximately 1.1 miles along the Sacramento Bypass left bank levee from the Sacramento Weir west to the Yolo Bypass Levee.
- **Yolo Bypass Levee** extends for approximately 3.7 miles along the Yolo Bypass levee left bank from the confluence of the Sacramento Bypass and the Yolo Bypass south to the Navigation Levee (DWSC West).
- **Port North Levee** extends for approximately 4.9 miles along the DWSC right bank levee from the Barge Canal west to the bend in the Navigation Levee.

Southern Sub-Basin – The southern sub-basin encompasses approximately 6,900 acres and varies from elevation 18.0 feet to elevation 8.0 feet. The area is bounded by the Port South Levee and the DWSC to the north, the Sacramento River West-South Levee to the east, the South Cross Levee to the south, and the DWSC East Levee to the west. The south bank of the DWSC from Lake Washington to the Sacramento River is generally at elevation 19.5 feet. The right bank of the Sacramento River extends from RM 57.7 to RM 51.5.

- **Port South Levee** extends for approximately 4 miles along the DWSC left bank levee from the Barge Canal west past the bend in the DWSC.

- **DWSC West** extends for approximately 21.4 miles along the DWSC right bank levee from the bend in the DWSC at the intersection of Port North Levee and Yolo Bypass Levee south to Miners Slough.
- **DWSC East** extends for approximately 2.8 miles along the DWSC left bank levee from the end of Port South Levee south to South Cross Levee.
- **Sacramento River West South Levee** extends approximately 5.9 miles along the Sacramento River right bank levee from the confluence of the Barge Canal and the Sacramento River south to the South Cross Levee.
- **South Cross Levee** extends along the South Cross levee for approximately 1.2 miles from Jefferson Boulevard to the Sacramento River where it intersects the southern end of Sacramento River West-South Levee.

A majority of the levees within the study area are part of the Sacramento River Flood Control Project. The few exceptions are the Port North and Port South Levees, the DWSC West levee and the South Cross Levee. The Port North, Port South, and DWSC West levees were constructed as part of the Port of Sacramento. The South Cross Levee is a private levee. Although the DWSC West levee was constructed as part of the navigation project supporting the Port of Sacramento, this levee provides significant flood benefits to portions of both the northern and southern sub-basins. During the 200-year flood event, the water surface elevation in the Yolo Bypass is more than 12-feet higher than the water surface elevation in the DWSC at the northern limit of the DWSC West levee. This difference in water surface elevation is still greater than 10-feet between these two water courses downstream near the South Cross Levee. Based on these differences in water surface elevation, a failure of the DWSC West levee within this reach would result in higher flood damages within the study area for a 200-year flood event.

1.4 SUMMARY OF PRIOR REPORTS ASSOCIATED WITH WEST SACRAMENTO

The list below provides a summary of prior reports associated with the West Sacramento study area.

- **Sacramento River Flood Control Project: Sacramento Urban Area Levee Reconstruction, Basis of Design—USACE (November 1989)**

  The Corps completed a basis of design (BOD) to present the results of engineering studies and investigations prior to preparing plans and specification for remedial construction of select levees in the cities of Sacramento and West Sacramento. The BOD includes discussion of previous studies, geology of the region, discussion of subsurface characteristics, design considerations, alternative comparison and cost estimates.

- **Sacramento Metropolitan Area, California, Feasibility Report and Environmental Impact Statement/Environmental Impact Report—USACE (February 1992)**

  The Corps developed a feasibility report to assess the need for additional flood protection, to identify potential alternatives to increase flood protection and to determine Federal interest on the alternatives. The Corps study determined that there was a need for additional flood protection and then provided several potential alternatives which would provide varying levels of flood protection. The selected alternative recommended raising the south bank of the Sacramento Bypass and the east bank of the Yolo Bypass from the Sacramento Bypass south to the Navigation Levee.

- **West Sacramento Project, West Sacramento, California: Design Memorandum and Environmental Assessment/Initial Study – USACE (May 1995)**
  The Corps prepared a design memorandum for the flood protection improvements recommended in the Sacramento Metropolitan Area, California, Feasibility Report and Environmental Impact Statement/Environmental Impact Report authorized by Congress in 1992. The memorandum addressed necessary revisions to this feasibility report which had assumed that a flood control only dam near Auburn would be constructed. The memorandum presented and described the process for construction and mitigation as well as associated costs.

- **Sacramento River Bank Protection Project, California - USACE (On-Going)**

  Authorized by the Flood Control Act of 1960, the Sacramento River Bank Protection Project (SRBPP) is a continuing construction project that maintains the existing levee and flood control facilities of the Sacramento River Flood Control Project (SRFCP). The SRBPP provides a continuing long-range program of bank stabilization and erosion control to maintain the integrity of the SRFCP through bank protection and setback levees. As the authority for Phase II draws to a close, the Corps is initiating a GRR to study alternative means to preserve the integrity of the SRFCP. The SRBPP has historically repaired erosion sites in the West Sacramento area.

- **Sacramento and San Joaquin River Basins, California, Comprehensive Study (Interim Report) - USACE (December 2002)**

  Following the floods that occurred in January 1997, the Corps and the State of California Reclamation Board (currently known as the Central Valley Flood Protection Board) prepared an Interim Report along with Technical Study Documentation which documented the existing flood management system and potential modifications to it for flood risk management and ecosystem restoration along the Sacramento and San Joaquin Rivers. This report also reflects that the public's safety and economic prosperity should not conflict with conserving natural systems. This report goes into more detail on developing a comprehensive and effective plan for flood risk management, how the system functions, and how it can be improved. The major undertaking of the study was developing the necessary analytical tools to evaluate how changes to the system affected the performance of the system as a whole with respect to reducing flood damages, protecting public safety, and restoring degraded ecosystems. The study laid the groundwork for future potential modifications to the system for the purpose of reducing flood damages and restoring affected ecosystems.

1.5 FUTURE WITHOUT-PROJECT CONDITION

For this current GRR effort, the future without-project condition assumes that previously authorized projects, including the Joint Federal Project (JFP) and Folsom Dam Raise are in place and functional. The future without-project condition also assumes that the Sacramento Bypass levee improvements (i.e., CHP Academy) are also completed. System-wide risk reduction was estimated by comparing the economic outputs of each alternative evaluated to the future without-project condition.

1.6 ORGANIZATION AND CONTENT

This report is organized around four main chapters. The contents of each chapter are summarized in Figure 3 below.

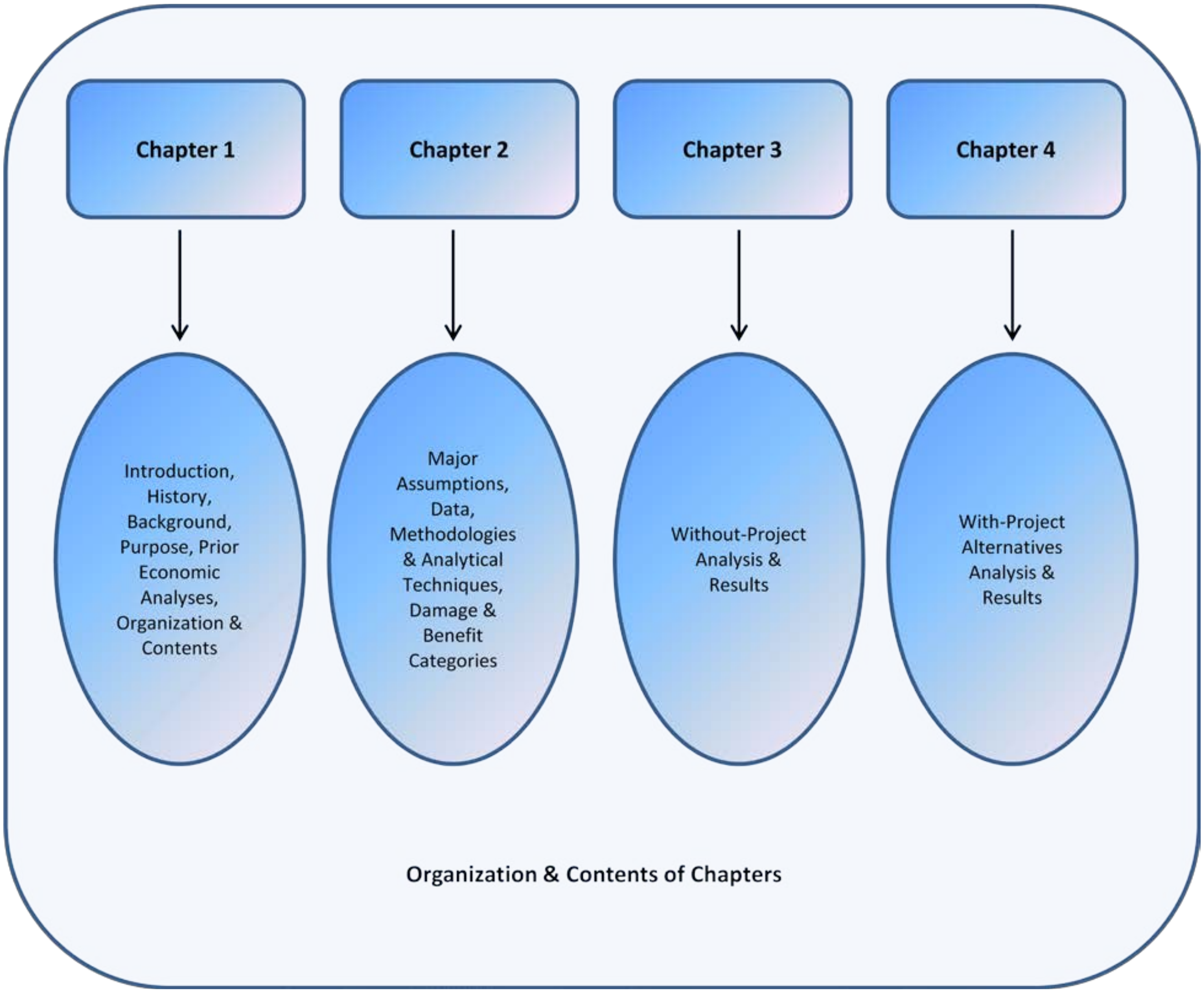


Figure 3: Organization and Contents

2 - FRAMEWORK OF ECONOMIC ANALYSIS

2.1 CONSISTENCY WITH CURRENT REGULATIONS & POLICIES

The analysis presented in this document was performed using the most up-to-date guidance and is consistent with current regulations and policies. Various references were used to guide the economic analysis, including:

- The *Planning Guidance Notebook* (ER 1105-2-100, April 2000, with emphasis on Appendix D, Economic and Social Considerations, Amendment No. 1, June 2004) serves as the primary source for evaluation methods of flood risk management (FRM) studies
- EM 1110-2-1619, *Engineering and Design – Risk-Based Analysis for Flood Damage Reduction Studies* (August 1996)
- ER 1105-2-101, *Planning Risk-Based Analysis for Flood Damage Reduction Studies* (Revised January 2006)
- Economic Guidance Memorandum (EGM) 01-03, *Generic Depth-Damage Relationships* (2000)
- Economic Guidance Memorandum (EGM) 04-01, *Generic Depth-Damage Relationships for Residential Structures with Basements* (2003)
- Economic Guidance Memorandum (EGM) 09-04, *Generic Depth-Damage Relationships for Vehicles* (2009)

2.2 PRICE LEVEL, PERIOD OF ANALYSIS, AND DISCOUNT RATE

Values listed in this document are based on an October 2013 price level. Annualized benefits and costs were computed using a 50-year period of analysis and a current federal discount rate of 3.50%. Unless otherwise noted, annualized values are presented in thousands ($1,000s) of dollars.

2.3 MAIN ASSUMPTIONS

Several main assumptions were relied upon in order to reasonably and efficiently study the problem (i.e., flooding) and its potential solutions (i.e., flood risk management alternatives), and then ultimately reach a conclusion using the limited resources available. The analysis assumes that:

- The Joint Federal Project (JFP) and Folsom Dam Raise are in place and functional; this assumption is reflected in the hydrologic (inflow-outflow operations at Folsom Dam used in the hydraulic analysis), hydraulic (floodplains and rating curves) and geotechnical (levee fragility curves) engineering data used in the economic analysis
- The future without-project operations at Folsom Dam assume a target release of 160,000 cubic feet per second (cfs) for the 200-year event
- The with-project operations at Folsom Dam assume a target release of 160,000 cfs for the 200-year event
- The hydrologic, hydraulic, and geotechnical conditions within the study area would remain the same between the without-project and the most likely future without-project conditions. Most

likely future (without-project) hydrologic, hydraulics, and geotechnical engineering data for input into the economic modeling were assumed to be the same as the base without-project condition

- Future development (mostly in the South Basin) were not included in the inventory and therefore without-project damages or with-project benefits associated with new structures (built after 2008) were not claimed
- For the alternatives analysis, the engineering performance (and therefore the damages, residual damages, and benefits) at index points 5 and 6 on the Sacramento River for Alternative 5 are the same as those for Alternative 1 since it is believed that there is minimal difference in hydraulics between Alternative 1 (improve levee on Sacramento River – South) and Alternative 5 (set back levee on Sacramento River – South); refinements to the hydraulic modeling will be completed for future analyses.

2.4 METHODOLOGIES, TECHNIQUES, & ANALYTICAL TOOLS

Various methodologies, analytical techniques, and tools were used to perform the economic analysis. The majority of those used for this analysis is standard to many Corps of Engineers studies and are described in the appropriate sections throughout this document. Several of the main ones used in this analysis are described below.

2.4.1 Economic Analytical Tool: HEC-FDA Software

The main analytical tool used to perform the economic analysis was the Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA v.1.2.5) software. This program stores the engineering data (hydrologic, hydraulic, and geotechnical) and the economic data (structure/content inventory and depth-percent damage curves), and is used to model the flooding problem and potential alternative solutions in the study area.

By relating the economic inventory data to the floodplain data, the HEC-FDA software computes economic stage-damage curves. Through integration of the main engineering relationships (exceedance probability-discharge curves, hydraulic rating curves, and geotechnical levee fragility curves) and the main economic relationship (stage-damage curves), the HEC-FDA software computes project performance statistics and expected annual damages/benefits.

The results of the economic modeling are then used as input into the net benefit and benefit-to-cost analyses and may also aid in plan formulation, all of which are performed external to the HEC-FDA software.

2.4.2 Floodplain Data in HEC-FDA Using FLO-2D Model Output

The SPK Hydraulic Design Section developed floodplains using the FLO-2D model, which produces interior water surface elevations by grid cell. The model generates suites of FLO-2D floodplains (0.5, 0.1, 0.04, 0.02, 0.01, 0.005, and 0.002 exceedance probability events); suites were developed for each index point. (See Section 2.6 for discussion of representative index points).

Importing the FLO-2D data into the HEC-FDA models required file formatting. The FLO-2D files were formatted so that the HEC-FDA program would import them as a HEC-RAS water surface profile (WSP) output file. Instead of using river station numbers like in a typical HEC-RAS WSP, assignment of water surface elevations by frequency event were completed using grid cell numbers (output of FLO-2D); the grid cell assignments represent actual floodplain water surface elevations by frequency event as opposed to in-channel water surface elevations.

2.4.3 Computing Stage-Damage Curves in HEC-FDA

The formatted WSPs included every grid cell that contained a structure and the water surface elevations in each grid cell for each frequency event. The suite of floodplains along with the imported structure inventory was used in HEC-FDA to compute stage-damage curves.

Once the formatted floodplain data were imported into HEC-FDA, a row was inserted at the top of the WSP which included the in-channel stages associated with the index point. This step allowed for the linkage between the two-dimensional floodplain data and the in-channel stages. Importing formatted floodplain data and assigning water surface elevations to grid cells eliminated the need for creating interior-exterior relationships, which is another way to link exterior (river) stages to interior (floodplain) stages within HEC-FDA.

2.4.4 Multiple-Source Flooding into Single Consequence Area

Multiple sources of flooding within a single consequence area complicate the economic risk analysis in terms of estimating the chance of flooding and the consequences of flooding in that consequence area. Additional analytical complexity is introduced if one considers that the probability of flooding along a particular flooding source also varies (i.e., not only is the probability of flooding between various water sources not uniform but the probability of flooding along a specific water source is also not uniform), and that the same area is flooded from levee breaches at different locations but at varying magnitudes (i.e., different floodplains) depending on the location of the breach.

The risk analysis was performed using eight representative index points, with each point tied to a specifics source of flooding within the study area. The same index points were used for both the without-project and with-project analyses. Section 2.6 below describes in more detail the index points used and their locations.

2.5 ECONOMIC IMPACT AREAS (EIA)

The study area was divided into two sub-economic impact areas (EIA) primarily to facilitate the economic modeling and economic data collection. These sub-areas allow for the direct computation and reporting of consequences that result from flooding from a specific source under both the without-project and with-project conditions. The two sub-EIAs are:

- West Sacramento – North Basin
- West Sacramento – South Basin

Since both sub-EIAs experience flooding and therefore damages from levee breaches occurring at all eight of the representative index points used in the analysis (see Section 2.6 below for a discussion regarding index points), damages/benefits are reported for the two areas combined and not by sub-basin. Figure 4 shows the two sub-EIAs.

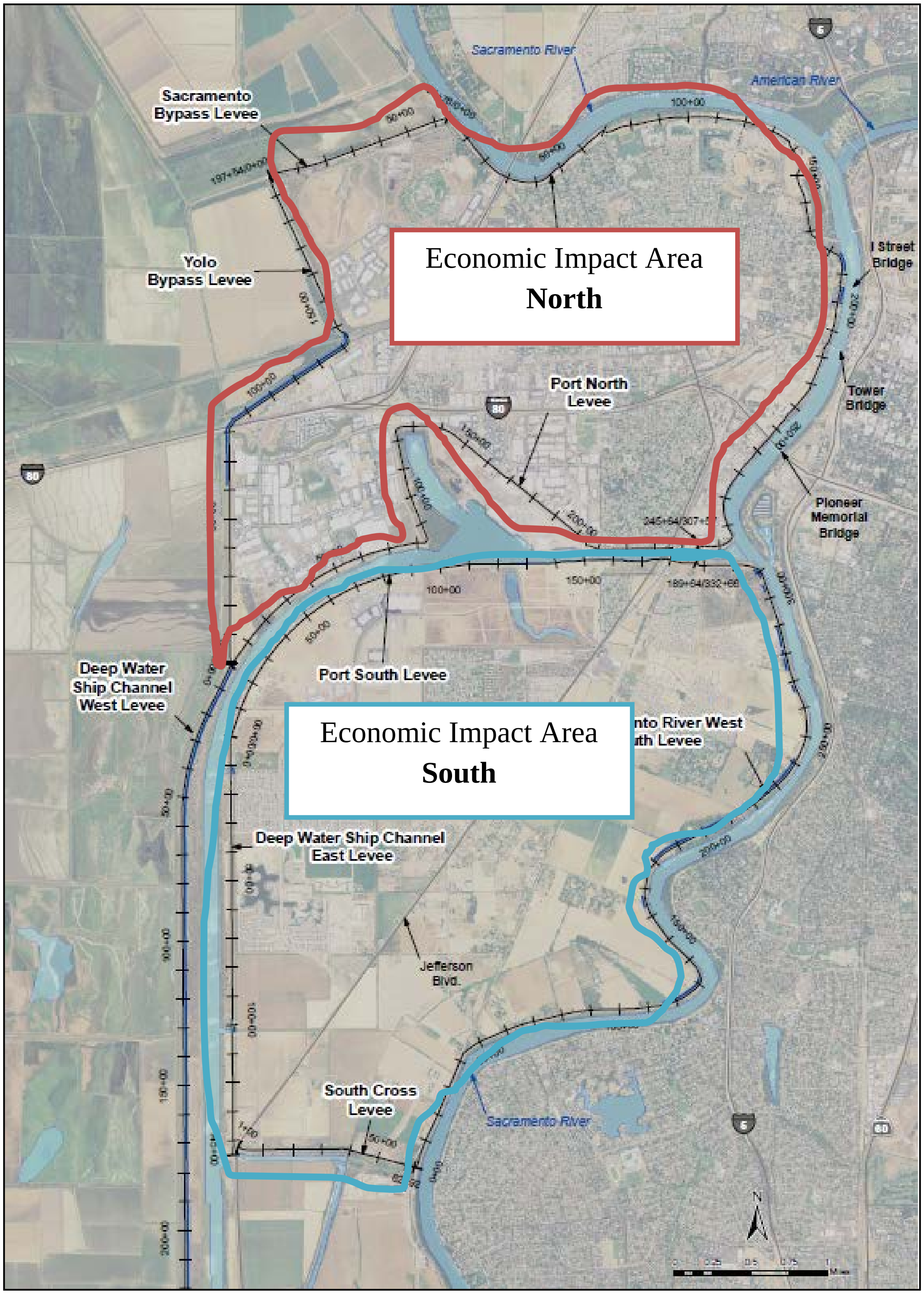


Figure 4: Economic Impact Areas (EIA)

2.6 HYDRAULIC REACHES & REPRESENTATIVE INDEX POINTS

Chapter 1 (Section 1.3) briefly noted that West Sacramento is at risk of flooding from multiple sources. For example, the North Basin sub-EIA could be potentially flooded from either the Yolo Bypass or the Sacramento River. Additionally, along each source of flooding, the condition of the levee could vary from one location (hydraulic reach) to the next, with the probability of flooding from a particular reach varying correspondingly.

In terms of economic analysis, levee reaches are used to focus-in on those areas deemed most pertinent for developing engineering data, which feed into the economic modeling. Data are generated at representative index points within each reach and are used to estimate project performance statistics under both without-project and with-project conditions. The engineering data is also used in conjunction with economic data to estimate expected damages and benefits. Both sets of results are then used together to describe the flood risk in the study area.

The project delivery team (PDT) selected eight hydraulic/geotechnical reaches, with each containing one index point, for which to generate engineering data for use in the economic modeling. These index points were selected to aid in a more accurate description of residual flood risk in the study area. The eight index points used in the economic analysis are shown in Figure 5 and listed below.

- Index Point 1, Sacramento River, River Mile (RM) 61.7
- Index Point 2, Sacramento River, RM 60.2
- Index Point 3, Yolo Bypass, RM 43.1
- Index Point 4, Sacramento Bypass, RM 1.6
- Index Point 5, Sacramento River, RM 56.7
- Index Point 6, Sacramento River, RM 53.1
- Index Point 7, Deep Water Ship Channel (DWSC), RM 41.2
- Index Point 8, DWSC, RM 43.5

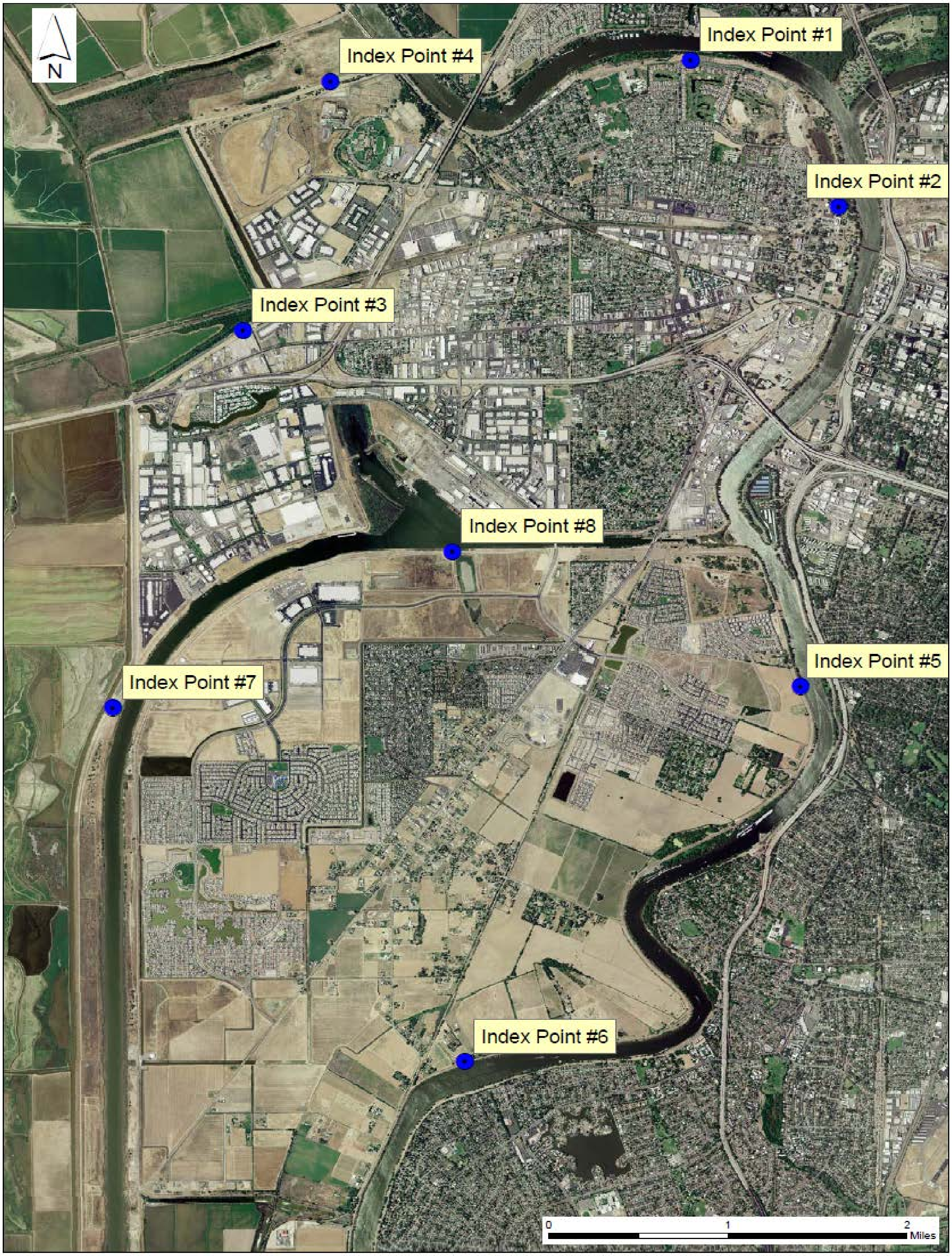


Figure 5: Index Points Used in the Economic Analysis

2.7 DESCRIPTION OF ECONOMIC DATA & UNCERTAINTIES

The economic data used in the analysis are described in the following sub-sections. These data lay the groundwork for the without-project damage and with-project benefit analyses that are described in Chapters 3 and 4, respectively.

2.7.1 Structure Inventory

A base geographic information system (GIS) inventory with parcel attribute data for Yolo County was provided by the non-federal partner. Building attribute data were used to determine land use and valuation of structures and contents. Numerous field visits were taken to collect the base inventory data using standard USACE practices. The data collected included number of stories, foundation heights, building use (commercial, industrial, public, residential), occupancy types (more specific building use, such as commercial restaurant or single-family residential), class (per Marshall & Swift Valuation Service's grades of construction), construction rating (per Marshall & Swift's categories of "low cost" to "excellent" construction), and condition ("poor" to "new" condition).

Structure counts for the four main building categories are listed in Table 1 below, and represent those structures falling within the 500-year floodplain. There are over 18,000 structures at risk of flooding.

Table 1: Number of Structures by Category in 0.2% Exceedance Probability Floodplain

DAMAGE CATEGORY/BUILDING TYPE	STRUCTURE COUNT
COMMERCIAL	485
INDUSTRIAL	484
PUBLIC	99
RESIDENTIAL	17,419
TOTAL	**18,487**

Figure 6 below shows the land-use types in the West Sacramento study area.

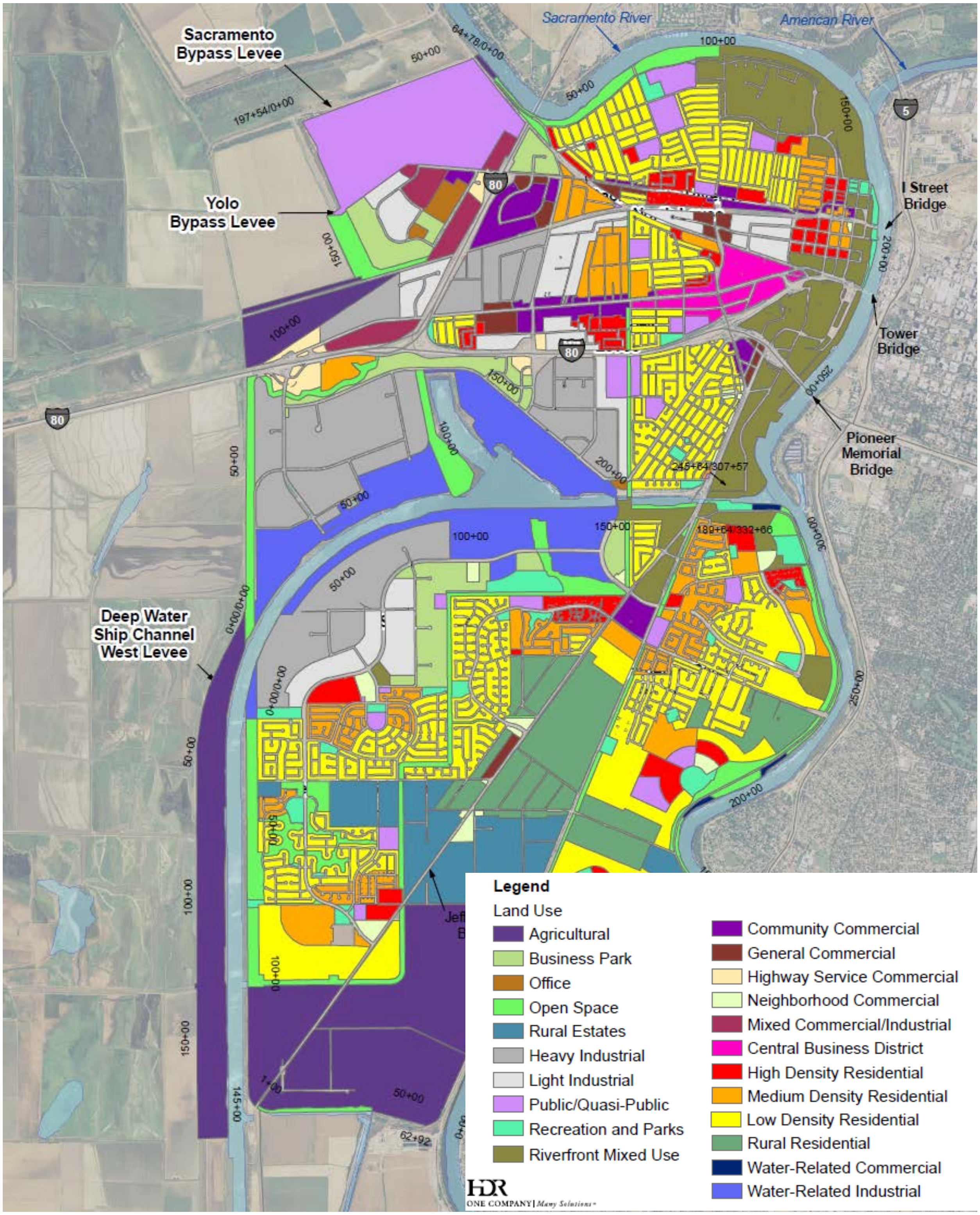


Figure 6: Land Use in West Sacramento

2.7.2 Structure and Content Values

Structure attribute data collected during field visits and obtained from the non-federal partner were used to determine valuation of structures and contents.

2.7.2.1 Structure Value

Depreciated replacement value of structures were estimated based on building square footage, estimated cost per square foot (from the Marshall & Swift Valuation Handbook), and estimated depreciation. Values per square foot were based on building use, class, and type as outlined in the Marshall and Swift Valuation Handbook.

For structures, the value of property at risk was estimated based on depreciated replacement values. The USACE flood risk management projects require that structures be valued using replacement costs minus depreciation. These values may differ from assessed values, sales or market values, reproduction costs or values determined by income capitalization. Depreciated replacement cost does not include land values. Depreciated replacement values were calculated using the formula,

Depreciated Replacement Value = (Square Footage of Structure)*(Cost per Square Foot)*(Remaining Value)

Remaining value is simply 100% minus the estimated depreciation (in percent).

2.7.2.2 Content Value

For SFR residential structures, depth-percent damage curves developed by the USACE Institute for Water Resources (IWR) and presented in Economic Guidance Memorandum (EGM) 01-03 and 04-01, were used. Since the percentage damages in these generic depth-percent damage curves were developed as a function of structure value, it was unnecessary to explicitly derive content values for input into the HEC-FDA model; the model computes content damages by applying the percentages in the content-percent damage curves to structure values. For report purposes and to estimate content value for residential structures, a content-to-structure value ratio of 50% was used, which is consistent with the ratio used in other USACE studies.

For non-residential categories, an expert elicitation was performed to develop content values and content depth-percent damage curves for specific occupancy types for the 2008 American River Watershed, Folsom Dam Raise and Modification Economic Reevaluation Report (ERR). Although the values and curves were developed specifically for structures in the American River Watershed study area, the results of the expert elicitation were extended to the West Sacramento study area in light of its proximity to Sacramento and the similarity of its structure types/construction types to those in Sacramento. In total, there were 22 different occupancy types with values ranging from $22 to $235 per square foot with uncertainty. Content values for non-residential structures were generated as a function of building use, damageable square footage, and content value per square footage per occupancy type.

Table 2 displays the value of damageable property for structures, contents, and combined. Estimated value of damageable property is over $4.7 billion.

Table 2: Value of Damageable Property - Structures and Contents

CATEGORY	TOTAL VALUE OF DAMAGEABLE PROPERTY (OCTOBER 2013 PRICE LEVEL, IN $1,000)		
	STRUCTURES	CONTENTS	TOTAL
COMMERCIAL	406,000	284,000	690,000
INDUSTRIAL	695,000	556,000	1,251,000
PUBLIC	159,000	72,000	231,000
RESIDENTIAL	1,692,000	846,000	2,538,000
TOTAL	**2,952,000**	**1,758,000**	**4,710,000**

2.7.3 First-Floor Elevation of Structures

For structure and content damages, depth of flooding relative to the structure's first floor is the primary factor in determining the magnitude of damages. The current analysis uses HEC-FDA's internal processes for the determination of structural inundation. The process combined a geographic information system (GIS) database containing spatially-referenced polygons for each parcel in the study area with depth of flooding data (per grid cell) from the FLO-2D modeling. Parcels/structures were then tied to a specific grid cell in which the parcel was located.

Foundation heights for each structure were estimated during numerous field visits. First-floor elevations were computed in HEC-FDA using the foundation height and an assumed ground elevation of zero feet. During the field inventory, first floor estimations were made by visual inspection and assigned to structures in one half-foot increments. For example, the average SFR built on slab without any fill might be listed as having a foundation height of 0.5 foot to 1.0 foot; structures on raised foundations may have foundation heights greater than 1.5 feet.

Using the ground elevation and foundation height data from the economic structure inventory in conjunction with the depth of flooding (in feet) data from the WSP, depths of flooding above the first floor of each structure for each exceedance probability event were computed within HEC-FDA. As explained previously, depths of flooding from the FLO-2D modeling were provided for each grid cell for the 0.5, 0.1, 0.04, 0.02, 0.01, 0.005, and 0.002 exceedance probability events and were imported into the HEC-FDA model in the form of a water surface profile.

2.7.4 Automobiles

Damages to automobiles were developed based on a function of average value, number of vehicles, depth of flooding, and depth-percent damages loss. Values were determined for average used cars ($7,988 and updated to current price of $8,300) based on information from the U.S. Department of Transportation, Bureau of Transportation Statistics. The number of cars per residential unit (1.93) was based on the total number of automobiles and trucks registered in the Sacramento Area (source: California Department of Finance) divided by the number of households. It was assumed that, based on short evacuation time[1], about 50% of residential-based vehicles would be removed from the flood area

[1] The 50% assumption (percentage of autos moved out of the floodplain) used for automobiles was made based on the potential short warning time, the large number of people who live in the area, the relatively small number of major routes

prior to a flood event. Table 3 below shows the estimated value of automobiles at risk of flooding in the study area.

Table 3: Value of Automobiles Potentially at Risk of Flooding

CATEGORY	VALUE OF DAMAGEABLE PROPERTY (OCTOBER 2013 PRICE LEVEL, IN $1,000S)
AUTOMOBILES	144,735

2.7.5 Depth-Percent Damage Curves

The depth of flooding is the primary factor in determining potential damages to structures, contents, and automobiles. Depth-percent damage functions were used in the HEC-FDA models to estimate the percent of value lost for these categories. Residential depth-damage curves (structures and contents) were taken from Economic Guidance Memorandum (EGM) 01-03, *Generic Depth-Damage Relationships,* and 04-01, *Generic Depth-Damage Relationships for Residential Structure with Basements,* for use on both single-family and multi-family residential structures. Structures were identified as 1-story, 2-story, or split-level. Mobile home curves were taken from the May 1997 Final Report, *Depth Damage Relationships in Support of Morganza to the Gulf, Louisiana Feasibility Study*. Non-residential structure curves were based on revised Federal Emergency Management Agency (FEMA) Flood Insurance Administration (FIA) curves. Since flood inundation in the area is deep and durations are long (exceeding three days), these curves were based on prior American River Watershed Studies (Natomas Basin) and the 1997 Morganza Study, areas where flooding is also deep and of long duration. As previously described in Section 2.7.2.2, non-residential content depth-percent damage curves for 22 occupancy types were developed based on an expert elicitation; these curves were developed specifically for building types in the Sacramento area and for American River Watershed analyses but used for this study.

Depth-percent damage functions for automobiles were based on averages from curves developed by the Institute for Water Resources (IWR) and provided in EGM 09-04, *Generic Depth-Damage Relationships for Vehicles*.

All of the depth-percent damage curves used in the analysis can be found in the West Sacramento GRR HEC-FDA models.

2.7.6 Economic Uncertainties

The valuation of residential and non-residential structures and contents along with automobile losses were estimated with uncertainty. In the estimation of structure value, three variables were considered to have a possible range of values: 1) dollar per square foot 2) building square footage and 3) percent of estimated depreciation. Using triangular distributions to describe the range of these three variables, a Monte Carlo simulation was run on typical structures by category and the mean and standard deviations were compared to derive coefficients of variation (COV) for structure values by category. Content value uncertainties were based on data from expert elicitation mentioned previously. The program Best Fit was used to determine what would be a reasonable distribution, and using the model data, it was

(highways) for evacuation, and EGM 09-04 which recommends a removal rate of 50.6% for areas where the warning time is less than 6 hours.

determined that a normal distribution best described uncertainty in the structure and content valuation. These uncertainty parameters for valuation were imported into the HEC-FDA program.

Several factors contributed to the uncertainty associated with automobile damages. These factors include the average unit value, the number of vehicles per residence/dealership assumed, and the evacuation rate. It was assumed that the average number or automobiles per residential unit was about 2 and the evacuation rate was 50%. An average value of an automobile was determined to be $8,300. While uncertainty in these variables was not considered, uncertainty in the percent damage by depth (as reflected in the depth-percent damage curve) was taken into account.

Uncertainty in first floor elevation was also included in the model. During the field inventory, first floor (foundation height) estimates were made by visual inspection and assigned to structures in one half-foot increments. Based on this level of precision, it was assumed that 0.5 foot standard deviation would capture the potential uncertainty in this first floor elevation.

The uncertainty associated with the percent damages at specific depths of flooding for automobiles and structures/contents were entered into the HEC-FDA model. Residential structure and content depth-percent damage curves are normally distributed and include standard deviations of percent damages by depth of flooding. Non-residential content depth-percent damage curves are triangularly distributed and include a minimum, most likely, and maximum percent damage by depth of flooding.

All of the value and depth-percent damage uncertainty associated with structures, contents and automobiles can be found in the West Sacramento GRR HEC-FDA models. A summary of the uncertainty values by category is displayed in Table 4 below.

Table 4: Uncertainty Parameters Used in HEC-FDA Analysis

USE CATEGORY	UNCERTAINTY IN VALUE (INPUT TO HEC-FDA), IN PERCENT	
	STRUCTURE SD/MEAN	CONTENT SD/MEAN
Residential (SFR & MFR)	17	--
Mobile Homes	14	--
Office 2-Story	15	14
Office 1-Story	15	16
Retail	13	18
Retail-Furniture	13	20
Auto Dealerships	12	16
Hotel	11	3
Food Stores	11	27
Restaurants	15	3
Restaurants-Fast Food	12	13
Medical	12	46
Shopping Centers	10	23
Large Grocery Stores	11	4
Service (Auto)	15	4
Warehouse	15	31
Light Industry	16	19
Heavy Industry	13	31
Government	14	16
Schools	12	33
Religious	12	40
Recreation	13	13
Automobiles	15	N/A

2.8 DESCRIPTION OF ENGINEERING DATA & UNCERTAINTIES

The following sub-sections briefly describe the engineering data used in the economic analysis. More details about each discipline-specific engineering analysis can be found in the Hydrology, Hydraulics, and Geotechnical Appendices.

2.8.1 Hydrologic Engineering Data Used in HEC-FDA

The Sacramento District Hydrology Section provided all hydrologic data used in the HEC-FDA modeling. This includes the equivalent record length for each index point (1-8) and frequency-discharge curves for index point 2, 3, 4, 5, 6, and 7. For index points 1 and 8, only frequency-stage (and not frequency-discharge curves) were provided due to the difficulty in modeling discharges along these reaches. (The hydrologic data was provided to the Hydraulic Design Section for use in channel modeling using HEC-RAS program; frequency-stage curves were then developed and provided to the Economics and Risk Analysis Section by the SPK Hydraulic Design Section for use in the HEC-FDA models.) The hydrologic data and curves used in the economic analysis can be found in the West Sacramento GRR HEC-FDA models.

2.8.2 Hydraulic Engineering Data Used in HEC-FDA

The SPK Hydraulic Design Section used the HEC-RAS model to determine stages in the channel, to model levee breakout locations, and to develop breakout hydrographs; it used the FLO-2D model to determine water surface elevations in the floodplain (i.e., develop suites of floodplains). More details about the data and assumptions used by the Hydraulic Design Section for their HEC-RAS and FLO-2D modeling efforts can be found in the Hydraulics Appendix.

For this analysis, a suite of floodplains was generated for each of the eight index points. For each index point, the Hydraulic Design Section provided data for input into the HEC-FDA model. These include:

- Discharge-stage (rating) curves with uncertainty for the without-project and with-project conditions for six index points (Index Points 2-7)
- Exceedance probability-stage curves with uncertainty for the without-project and with-project conditions for two index points (Index Points 1 and 8)
- Suites of floodplains for each index point; these were formatted from FLO-2D water surface elevation data for direct import into HEC-FDA

The hydraulic data and curves used in the economic analysis can be found in the West Sacramento GRR HEC-FDA models.

2.8.3 Geotechnical Engineering Data Used in HEC-FDA

A geotechnical levee fragility curve shows the probabilities of failure at different water surface elevations against a levee. Fragility curves are a main component of the economic modeling and in determining the performance of a project, which is often described in terms of annual exceedance probability (AEP) or the chance of flooding in any given year.

For this analysis, eight sets of geotechnical levee fragility curves were used in the economic analysis, one set for each index point located on a levee reach, with each set including a without-project and with-project curve. Details about the development of the geotechnical fragility curves can be found in the Geotechnical Appendix. The geotechnical data and curves used in the economic analysis can be found in the West Sacramento GRR HEC-FDA models.

2.8.4 Engineering Uncertainties in HEC-FDA

There were three main engineering uncertainties incorporated into the HEC-FDA modeling:

- Uncertainty in within-channel discharges was computed in HEC-FDA using data provided by the District's Water Management Section. This data was in the form of an equivalent record length. The data is entered into HEC-FDA, which uses the data to compute uncertainty in discharge for a range of exceedance probability events.
- Uncertainty in stages (in-channel) was captured in the hydraulic rating curves, which were entered into HEC-FDA. Stage uncertainty was provided by the District's Hydraulic Design Section.

All of the data used to describe the uncertainty in the main engineering relationships can be found in the West Sacramento GRR HEC-FDA models.

3 - WITHOUT-PROJECT ANALYSIS & RESULTS

3.1 FUTURE WITHOUT-PROJECT CONDITION

Expected annual damages (EAD) and engineering project performance results for the without-project condition, which assumes that the Joint Federal Project (JFP), the Folsom Dam Raise Project, and the levee improvements along the Sacramento Bypass (CHP Academy) are in place and operational, are summarized in this chapter. The without-project condition serves as the baseline for which all with-project alternatives are measured against. The with-project alternatives analysis is presented in Chapter 4.

3.2 FLOODING CHARACTERISTICS

The without-project analysis and results are based predominantly on estimates of the flooding extent, the depth of flooding, and the property that may be damaged from flooding within a particular area. Table 5 displays key characteristics of flooding associated with specific annual chance exceedance events for the West Sacramento study area; characteristics are broken out by north and south basins. The flooding characteristics of a particular area for a particular exceedance probability event may differ depending on the assumed levee breach location (reach/index point). For example, the inundation extent and depth of flooding from a levee breach at Index Point 8 on the Deep Water Ship Channel will differ from the extent and depth from a breach at Index Point 3 on the Yolo Bypass. In general, flooding from any of the sources of risk (i.e., Sacramento River, Sacramento Bypass, Yolo Bypass, and Deep Water Ship Channel) would be deep and potentially catastrophic.

It is important to note that it would be incorrect to sum the number of structures inundated per index point to derive a total number of structures at risk (Table 5 below); this would result in double counting. The same structures may in fact be at risk from flooding from more than one location (index point). Estimates of the total number of structures at risk from flooding in each basin were presented in Chapter 2.

Table 5: Flooding Characteristics – West Sacramento Study Area

REACH/INDEX POINT	AVERAGE DEPTH OF FLOODING ABOVE 1ST FLOOR BY INDICATED ANNUAL CHANCE EXCEEDANCE (ACE) EVENT (IN FEET)			ESTIMATE OF NUMBER OF STRUCTURES INUNDATED BY INDICATED ANNUAL CHANCE EXCEEDANCE (ACE) EVENT		
	0.04	**0.01**	**0.002**	**0.04**	**0.01**	**0.002**
1 NORTH	4.7	7.7	11.3	6,499	6,635	6,669
1 SOUTH	4.4	12.5	15.8	6,577	7,095	7,096
2 NORTH	5.3	9.1	12.0	6,564	6,659	6,673
2 SOUTH	6.6	14.1	16.4	6,862	7,095	7,096
3 NORTH	10.1	12.0	13.5	6,661	6,668	6,679
3 SOUTH	15.9	17.4	18.5	7,096	7,100	7,100
4 NORTH	8.1	11.8	13.7	6,645	6,667	6,677
4 SOUTH	13.0	16.4	17.8	7,095	7,096	7,100
5 NORTH	6.9	9.9	10.9	6,580	6,652	6,669
5 SOUTH	13.4	16.4	17.4	7,095	7,100	7,100
6 NORTH	1.8	7.0	8.9	3,812	6,617	6,654
6 SOUTH	9.3	13.8	15.6	7,082	7,095	7,096
7 NORTH	2.3	7.0	9.4	5,233	6,617	6,654
7 SOUTH	8.2	13.6	15.9	7,068	7,095	7,096
8 NORTH	0	0	3.0	0	0	6,012
8 SOUTH	0	0	2.5	0	0	5,976

3.3 FLOOD RISK: PROBABILITY & CONSEQUENCES

Risk can be described in terms of the chance of some undesirable event occurring and the potential consequences should that undesirable event occur. In FRM National Economic Development (NED) analysis, risk is described in terms of the chance of flooding (the undesirable event) and the potential damages (consequences) from flooding. The following sections describe the flood risk associated with the without-project condition.

3.3.1 Annual Chance Exceedance (ACE) Event Damages

Annual chance exceedance (ACE) event damages, sometimes referred to as single-event damages, were computed in HEC-FDA. Single-event damages assume that a breach from a specific probability event occurs; it does not take into account the likelihood of this event actually happening. Single-event damages are useful in that they show the magnitude of consequences, within a particular consequence area, *should* a specific flood event occur in that area. Table 6 below shows the damages that may occur for a range of events within the West Sacramento study area; damages are displayed for each index point. These damage values include automobiles, structures, and contents.

Table 6: Annual Chance Exceedance (ACE) Event Damages by Index Point

INDEX POINT/REACH	ACE EVENT DAMAGES (IN $1,000s, OCTOBER 2013 PRICE LEVEL)						
	50%	10%	4%	2%	1%	0.5%	0.2%
1	1,049,353	1,455,924	2,294,502	2,600,304	3,267,255	3,509,772	3,625,157
2	1,217,337	2,268,607	2,611,998	2,828,239	3,440,803	3,597,358	3,685,232
3	1,470,145	3,239,104	3,580,671	3,654,576	3,724,909	3,770,528	3,820,014
4	109,940	2,668,044	3,345,850	3,529,303	3,675,331	3,735,549	3,804,217
5	1,252,397	3,111,848	3,257,936	3,349,896	3,563,669	3,588,213	3,643,764
6	879,527	1,290,274	2,136,922	2,673,978	3,285,973	3,419,807	3,483,323
7	0	532,996	2,223,259	2,842,560	3,276,901	3,441,088	3,532,101
8	0	0	0	0	0	254,088	1,678,117

3.3.2 Expected Annual Damages (EAD)

Expected annual damage (EAD) is the metric used to describe the consequences of flooding on an annual basis considering a full range of flood events – from high frequency/small events to low frequency/large events over a long time horizon (years). It is the main economic statistic used to describe the flooding problem in the study area; it is also used as the baseline to measure potential benefits of proposed FRM alternatives. (Expected annual damages, under existing without-project conditions, were estimated for each damage category and all impact areas. Note that without-project EAD is used as the metric in this analysis and not without-project *equivalent* annual damage. Equivalent annual damage reflects the damage value associated with the without-project condition over the period of analysis and under *changing* hydrology, hydraulic, and economic conditions in the study area. Essentially, equivalent annual damages are expected annual damages that have been converted to a single present worth value and then amortized over the analysis period using an appropriate discount rate. For purposes of this analysis, the study area is assumed to be fully built out, which implies future conditions are the same as existing conditions; therefore expected annual damages are equal to equivalent annual damages.)

Table 7 displays the EAD results for each index point and by major damage category. Since the economic incremental analysis is being performed from a system-wide/basin perspective, the EAD results for Index Point 3 on the Yolo Bypass (highlighted in Table 3) was used as the starting point without-project damages for which to measure with-project outputs; the greatest risk to West Sacramento, in terms of consequences, is associated with a breach at Index Point 3. Expected annual damages associated with a levee breach along the Yolo Bypass are estimated to be approximately $288 million.

Table 7: Expected Annual Damages (EAD) by Index Point

INDEX POINT	WITHOUT-PROJECT EXPECTED ANNUAL DAMAGES (EAD) (IN $1,000s, OCTOBER 2013 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)					
	AUTO	COM	IND	PUB	RES	TOTAL
1	3,756	17,666	35,822	5,191	34,523	**96,960**
2	1,147	3,943	7,772	1,264	13,788	**27,914**
3	11,733	41,299	82,815	12,850	139,565	**288,263**
4	10	38	72	12	123	**255**
5	2,985	9,558	19,487	2,987	36,993	**72,012**
6	2,564	7,008	13,956	1,940	32,582	**58,050**
7	7,093	19,551	41,001	5,963	93,541	**167,150**
8	443	2,005	3,883	525	4,172	**11,028**

3.3.3 Annual Exceedance Probability (AEP) by Index Point

Annual exceedance probability (AEP) is a statistic used to describe the chance of flooding in any given year within a consequence area. It is often used to describe one aspect of flood risk, with the other being the consequences (e.g., damages and loss of life) of flooding. Annual exceedance probability is computed in HEC-FDA using engineering data at an index point; these input data include exceedance probability-discharge, stage-discharge, and geotechnical levee failure relationships.

Table 8 below displays the AEP values associated with each index point. Annual exceedance probability values differ depending on the location along the levee due primarily to the differing geotechnical conditions of the levees protecting the consequence area. Each area is considered to be protected by a system of levees, and flooding to the area could potentially occur from various sources. For example, in West Sacramento, flooding can occur from the Sacramento River, Sacramento Bypass, Yolo Bypass, or Deep Water Ship Channel; further, the risk of flooding along either water source varies depending on the location along the source. In this respect, the AEP values listed in Table 8 for each index point represent the probability of a flood event occurring when considering only one failure location (one failure mechanism). Generally, evaluating AEP information at multiple points at which flooding into an area could occur typically provides a more complete characterization of the chance of flooding for that particular area.

Table 8: Annual Exceedance Probability (AEP) Results by Index Point

INDEX POINT	SOURCE	AEP	1/AEP
1	Sacramento River	0.055	1 in 18
2	Sacramento River	0.008	1 in 119
3	Yolo Bypass	0.089	1 in 11
4	Sacramento Bypass	0.000	N/A
5	Sacramento River	0.024	1 in 42
6	Sacramento River	0.041	1 in 25
7	DWSC	0.123	1 in 8
8	DWSC	0.012	1 in 83

3.3.4 Long-Term Risk by Index Point

Another statistic that the HEC-FDA program computes is long-term risk. Long-term risk describes the chance of flooding over a given time period, such as 30 years; HEC-FDA computes long-term risk statistics for 10-, 30-, and 50-year periods. Table 9 displays the without-project long-term risk results for each index point.

Table 9: Long-Term Risk Results by Index Point

INDEX POINT	SOURCE	LONG-TERM RISK (%)		
		10 YEARS	30 YEARS	50 YEARS
1	Sacramento River	43	82	94
2	Sacramento River	8	22	35
3	Yolo Bypass	61	94	99
4	Sacramento Bypass	0	0	0
5	Sacramento River	21	51	70
6	Sacramento River	34	72	88
7	DWSC	75	98	100
8	DWSC	12	31	46

3.3.5 Assurance

Assurance, previously referred to as conditional non-exceedance probability (CNP), describes the likelihood of a stream/river being able to pass a specific flow event, for example the 100-year flow. The assurance statistics provide relevant information to decision makers in that it helps describe both how well the flood system currently performs and how well the system could potentially perform under various with-project scenarios.

The assurance statistics for each index point under the without-project condition are listed in Table 10 below. Taking Index Point 3 as an example, the information indicates that there is a 72% chance of passing the 10% flow event, but only a 23% chance of passing the 1% flow event.

Table 10: Assurance Results by Index Point

INDEX POINT	SOURCE	ASSURANCE (%)					
		10%	4%	2%	1%	0.4%	0.2%
1	Sac River	94	84	80	75	49	24
2	Sac River	100	93	91	88	65	31
3	Yolo BP	72	39	31	23	13	9
4	Sac BP	100	100	100	100	100	100
5	Sac River	96	89	87	85	72	65
6	Sac River	93	91	91	90	89	86
7	DWSC	53	22	17	12	9	9
8	DWSC	100	89	82	70	47	28

4 - WITH-PROJECT ALTERNATIVES ANALYSES

4.1 WITH-PROJECT ANALYSIS: BASIN AS BASIC ANALYTICAL UNIT

Without-project expected annual damages were computed at eight representative index points throughout the study area. As was explained in Chapter 2, the project delivery team (PDT) selected these index points, which are located on the main flood sources, in order to be able to reasonably characterize the flood risk associated with the West Sacramento basin by accounting for the multiple sources of flooding in the basin.

Similarly, with-project damages reduced (benefits) associated with various project alternatives were also computed at each representative index point for each basin. If the flood risk in a basin (or any other consequence area) could be attributed to one and only one flood source, then the total benefits computed at an index point along a particular flood source would represent the benefits of building a project on that flood source. However, this is not the case for the West Sacramento study area since flood risk in the basin/consequence area comes from more than one source. Under this scenario, benefits were computed first at each index point (source), and then estimated for the whole basin by comparing the risk at each index point and using the highest EAD/residual EAD. Table 11 below summarizes the method used to estimate benefits for the West Sacramento basin.

Table 11: Method of Benefit Calculation by Basin

BASIN	INDEX POINT	METHOD USED TO ESTIMATE BENEFITS
West Sacramento North and South Basins	1 (Sacramento River)	Compare risk at multiple index points and use highest EAD/residual EAD to estimate benefits
	2 (Sacramento River)	
	3 (Yolo Bypass)	
	4 (Sacramento Bypass)	
	5 (Sacramento River)	
	6 (Sacramento River)	
	7 (DWSC)	
	8 (DWSC)	

4.2 DESCRIPTION OF ALTERNATIVES

Summary descriptions of each alternative are presented below:

- **Alternative 1 –** This alternative improves levees in place. The FRM features of this alternative are summarized in Table 12 by reach.

Table 12: Alternative 1 FRM Features

Levee Reach	Seepage Measures	Stability Measures	Overtopping Measures	Erosion Protection Measures
NORTH BASIN				
Sacramento River North	Cutoff Wall	Cutoff Wall	Levee Raise	Bank Protection
Port North	---	---	Flood Wall	---
Yolo Bypass	Cutoff Wall	Cutoff Wall	---	---
Sacramento Bypass Training Levee	---	---	---	Bank Protection
SOUTH BASIN				
Sacramento River South	Cutoff Wall, Seepage Berm	Cutoff Wall	---	Bank Protection
South Cross	Relief Wells	Stability Berm	Levee Raise	---
Deep Water Ship Channel East	Cutoff Wall	Cutoff Wall	Levee Raise	---
Deep Water Ship Channel West	Cutoff Wall	Cutoff Wall	Levee Raise	Bank Protection
Port South	Cutoff Wall	Cutoff Wall	Levee Raise	---

- **Alternative 3 –** Alternative 3, just like Alternative 1, improves levees in place. The FRM features of this alternative mirror those of Alternative 1, except this alternative also includes a control structure on the DWSC near the area where the South Cross Levee ties into the east levee of the DWSC. Table 13 summarizes the features of Alternative 3.

Table 13: Alternative 3 FRM Features

Levee Reach	Seepage Measures	Stability Measures	Overtopping Measures	Erosion Protection Measures
NORTH BASIN				
Sacramento River North	Cutoff Wall	Cutoff Wall	Levee Raise	Bank Protection
Port North	Closure Structure	Closure Structure	Closure Structure	Closure Structure
Yolo Bypass	Cutoff Wall	Cutoff Wall	---	---
Sacramento Bypass Training Levee	---	---	---	Bank Protection
SOUTH BASIN				
Sacramento River South	Cutoff Wall, Seepage Berm	Cutoff Wall	---	Bank Protection
South Cross	Relief Wells	Stability Berm	Levee Raise	---
Deep Water Ship Channel East	Cutoff Wall	Cutoff Wall	Levee Raise	---
Deep Water Ship Channel West	Cutoff Wall, Closure Structure	Cutoff Wall, Closure Structure	Levee Raise, Closure Structure	Bank Protection
Port South	Closure Structure	Closure Structure	Closure Structure	Closure Structure

- **Alternative 5 –** This alternative includes essentially the same features as Alternative 1, except a setback levee along the Sacramento River south reach replaces improving levees in place. Table 14 below summarizes the features of Alternative 5 by reach.

Table 14: Alternative 5 FRM Features

Levee Reach	Seepage Measures	Stability Measures	Overtopping Measures	Erosion Protection Measures
NORTH BASIN				
Sacramento River North	Cutoff Wall	Cutoff Wall	Levee raise	Bank Protection
Port North	---	---	Floodwall	---
Yolo Bypass	Cutoff Wall	Cutoff Wall	---	---
Sacramento Bypass Training Levee	---	---	---	Bank Protection
SOUTH BASIN				
Sacramento River South	Setback Levee, Cutoff Wall, Seepage Berm,	Setback Levee, Cutoff Wall, Seepage Berm	---	Setback Levee, Bank Protection
South Cross	Stability Berm, Relief Wells	---	Levee Raise	---
Deep Water Ship Channel East	Cutoff Wall	Cutoff Wall	Levee Raise	Bank Protection
Deep Water Ship Channel West	Cutoff Wall	Cutoff Wall	Levee Raise	---
Port South	Cutoff Wall	Cutoff Wall	Levee Raise	---

4.3 WITH-PROJECT RESULTS: RESIDUAL EAD AND BENEFITS BY INDEX POINT AND ALTERNATIVE

The following tables show the without-project EAD and with-project residual EAD results computed in HEC-FDA for each index point/breach location. The benefits shown for each alternative in each table are the damages reduced at a respective index point/breach location, and represent the benefits to the basin if improvements were to occur on the source of flooding where the index point is located and if there were no other sources of flood risk.

For example, in Table 15, the benefits of Alternative 1 (with levee raises) are approximately $70 million. All of these benefits could be claimed if improvements to the Sacramento River (right bank) were made, and if there were no other sources of flood risk. While the first condition (improvements to the levees) would be met under this scenario, the second condition under this scenario has not yet been met – there is still flood risk from other water sources. Since there is still flood risk from other sources, the full $70 million in benefits cannot be claimed for the entire basin. (In the next section, the benefits for the basin as a whole are estimated by considering all sources of flood risk.)

Tables 15 through 22 display both the without-project and with-project data per index point. The first set is associated with outputs derived from improvements, except for any levee raises, made under Alternatives 1, 3, and 5, which for most index points are the same across each alternative; the second set is associated with outputs derived from improvements made under Alternatives 1, 3, and 5, which do include proposed levee raises; and the third set is associated with outputs derived from Alternative 3's control structure, whose impacts are measured at Index Point 8.

Table 15: Without-Project EAD and With-Project Residual EAD (IP1, right bank Sacramento River)

DAMAGE CATEGORY	INDEX POINT 1 – WEST SACRAMENTO BASIN (IN $1,000s, OCTOBER 2013 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	ALTERNATIVES 1/3/5 (NO LEVEE RAISES)		ALTERNATIVES 1/3/5 (WITH LEVEE RAISES)		ALTERNATIVE 3 CONTROL STRUCTURE	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	3,756	1,090	2,666	1,048	2,708	N/A	N/A
Commercial	17,666	5,094	12,572	4,949	12,717	N/A	N/A
Industrial	35,822	10,198	25,624	9,915	25,907	N/A	N/A
Public	5,191	1,523	3,668	1,476	3,715	N/A	N/A
Residential	34,523	10,667	23,856	10,147	24,376	N/A	N/A
TOTAL IP	**96,960**	**28,571**	**68,389**	**27,147**	**69,813**	N/A	N/A

Table 16: Without-Project EAD and With-Project Residual EAD (IP2, right bank Sacramento River)

DAMAGE CATEGORY	INDEX POINT 2 – WEST SACRAMENTO BASIN (IN $1,000s, OCTOBER 2013 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	ALTERNATIVES 1/3/5 (NO LEVEE RAISES)		ALTERNATIVES 1/3/5 (WITH LEVEE RAISES)		ALTERNATIVE 3 CONTROL STRUCTURE	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	1,147	485	662	400	747	N/A	N/A
Commercial	3,943	1,712	2,231	1,401	2,542	N/A	N/A
Industrial	7,772	3,344	4,428	2,744	5,028	N/A	N/A
Public	1,264	552	712	451	813	N/A	N/A
Residential	13,788	1,718	12,070	4,848	8,940	N/A	N/A
TOTAL IP	**27,914**	**11,045**	**16,869**	**9,843**	**18,071**	N/A	N/A

Table 17: Without-Project EAD and With-Project Residual EAD (IP3, left bank Yolo Bypass)

DAMAGE CATEGORY	INDEX POINT 3 – WEST SACRAMENTO BASIN (IN $1,000s, OCTOBER 2013 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	ALTERNATIVES 1/3/5 (NO LEVEE RAISES)		ALTERNATIVE 1/3/5 (WITH LEVEE RAISES)		ALTERNATIVE 3 CONTROL STRUCTURE	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	11,733	1,280	10,453	1,280	10,453	N/A	N/A
Commercial	41,299	4,327	36,972	4,327	36,972	N/A	N/A
Industrial	82,815	8,705	74,110	8,705	74,110	N/A	N/A
Public	12,850	1,366	11,484	1,366	11,484	N/A	N/A
Residential	139,565	15,725	123,840	15,725	123,840	N/A	N/A
TOTAL IP	**288,263**	**31,404**	**256,859**	**31,404**	**256,859**	N/A	N/A

Table 18: Without-Project EAD and With-Project Residual EAD (IP4, left bank Sacramento Bypass)

DAMAGE CATEGORY	INDEX POINT 4 – WEST SACRAMENTO BASIN (IN $1,000s, OCTOBER 2013 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	ALTERNATIVES 1/3/5 (NO LEVEE RAISES)		ALTERNATIVES 1/3/5 (WITH LEVEE RAISES)		ALTERNATIVE 3 CONTROL STRUCTURE	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	10	0	10	N/A	N/A	N/A	N/A
Commercial	38	0	38	N/A	N/A	N/A	N/A
Industrial	72	0	72	N/A	N/A	N/A	N/A
Public	12	0	12	N/A	N/A	N/A	N/A
Residential	123	0	123	N/A	N/A	N/A	N/A
TOTAL IP	**255**	**0**	**255**	N/A	N/A	N/A	N/A

Table 19: Without-Project EAD and With-Project Residual EAD (IP5, right bank Sacramento River)

DAMAGE CATEGORY	INDEX POINT 5 – WEST SACRAMENTO BASIN (IN $1,000s, OCTOBER 2013 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	ALTERNATIVES 1/3/5 (NO LEVEE RAISES)		ALTERNATIVES 1/3/5 (WITH LEVEE RAISES)		ALTERNATIVE 3 CONTROL STRUCTURE	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	2,985	149	2,836	N/A	N/A	N/A	N/A
Commercial	9,558	501	9,057	N/A	N/A	N/A	N/A
Industrial	19,487	1,005	18,482	N/A	N/A	N/A	N/A
Public	2,987	158	2,829	N/A	N/A	N/A	N/A
Residential	36,993	1,852	35,141	N/A	N/A	N/A	N/A
TOTAL IP	**72,012**	**3,665**	**68,347**	N/A	N/A	N/A	N/A

Table 20: Without-Project EAD and With-Project Residual EAD (IP6, right bank Sacramento River)

DAMAGE CATEGORY	INDEX POINT 6 – WEST SACRAMENTO BASIN (IN $1,000s, OCTOBER 2013 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	ALTERNATIVES 1/3/5 (NO LEVEE RAISES)		ALTERNATIVES 1/3/5 (WITH LEVEE RAISES)		ALTERNATIVE 3 CONTROL STRUCTURE	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	2,564	444	2,120	444	2,120	N/A	N/A
Commercial	7,008	1,357	5,651	1,357	5,651	N/A	N/A
Industrial	13,956	2,708	11,248	2,708	11,248	N/A	N/A
Public	1,940	380	1,560	380	1,560	N/A	N/A
Residential	32,582	5,521	27,061	5,521	27,061	N/A	N/A
TOTAL IP	**58,050**	**10,412**	**47,638**	**10,412**	**47,638**	N/A	N/A

Table 21: Without-Project EAD and With-Project Residual EAD (IP7, right bank DWSC)

DAMAGE CATEGORY	INDEX POINT 7 – WEST SACRAMENTO BASIN (IN $1,000s, OCTOBER 2013 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	ALTERNATIVES 1/3/5 (NO LEVEE RAISES)		ALTERNATIVES 1/3/5 (WITH LEVEE RAISES)		ALTERNATIVE 3 CONTROL STRUCTURE	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	7,093	687	6,406	687	6,406	N/A	N/A
Commercial	19,551	1,813	17,738	1,813	17,738	N/A	N/A
Industrial	41,001	3,778	37,223	3,778	37,223	N/A	N/A
Public	5,963	557	5,406	557	5,406	N/A	N/A
Residential	93,541	9,321	84,220	9,321	84,220	N/A	N/A
TOTAL IP	**167,150**	**16,156**	**150,994**	**16,156**	**150,994**	N/A	N/A

Table 22: Without-Project EAD and With-Project Residual EAD (IP8, left bank DWSC)

DAMAGE CATEGORY	INDEX POINT 8 – WEST SACRAMENTO BASIN (IN $1,000s, OCTOBER 2013 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	ALTERNATIVES 1/5 (NO LEVEE RAISES)		ALTERNATIVES 1/5 (WITH LEVEE RAISES)		ALTERNATIVE 3 CONTROL STRUCTURE	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	443	434	9	N/A	N/A	0	443
Commercial	2,005	1,902	103	N/A	N/A	0	2,005
Industrial	3,883	3,757	126	N/A	N/A	0	3,883
Public	525	499	26	N/A	N/A	0	525
Residential	4,172	4,112	60	N/A	N/A	0	4,172
TOTAL IP	**11,028**	**10,704**	**324**	N/A	N/A	**0**	**11,028**

4.4 RANGE OF BENEFITS BY INDEX POINT & ALTERNATIVE

The following tables present ranges of benefits for each alternative and at each index point. HEC-FDA computes damages reduced (benefits) at specific probabilities (25%, 50%, and 75%); the intersection of the probability and the dollar value in the table can be read as, "There is an X chance that damages reduced (benefits) exceeds Y." The benefits in these tables provide a broader picture of the possible range in benefits that may be realized considering all of the hydrologic, hydraulic, geotechnical, and economic uncertainty.

Table 23: Range of Benefits at IP1 (In $1000s, October 2013 Price Level, 50-Year Period of Analysis)

PLAN	WITHOUT-PROJECT EAD	WITH-PROJECT EAD	EXPECTED BENEFITS	PROBABILITY BENEFITS EXCEED INDICATED VALUE		
				75%	50%	25%
No action	96,960	--	--	--	--	--
Alts. 1/3/5 (no raises)	96,960	28,571	68,388	54,781	66,461	77,733
Alts. 1/3/5 (with raises)	96,960	27,536	69,435	55,417	67,448	79,061

Table 24: Range of Benefits at IP2 (In $1000s, October 2013 Price Level, 50-Year Period of Analysis)

PLAN	WITHOUT-PROJECT EAD	WITH-PROJECT EAD	EXPECTED BENEFITS	PROBABILITY BENEFITS EXCEED INDICATED VALUE		
				75%	50%	25%
No action	27,914	--	--	--	--	--
Alts. 1/3/5 (no raises)	27,914	12,022	15,891	9,068	12,377	19,703
Alts.1/3/5 (with raises)	27,914	9,843	18,071	10,483	15,529	22,732

Table 25: Range of Benefits at IP3 (In $1000s, October 2013 Price Level, 50-Year Period of Analysis)

PLAN	WITHOUT-PROJECT EAD	WITH-PROJECT EAD	EXPECTED BENEFITS	PROBABILITY BENEFITS EXCEED INDICATED VALUE		
				75%	50%	25%
No action	288,263	--	--	--	--	--
Alts. 1/3/5 (no raises)	288,263	31,404	256,860	174,800	238,691	317,595
Alt. 1/3/5 (with raises)	288,263	31,404	256,860	174,800	238,691	317,595

Table 26: Range of Benefits at IP4 (In $1000s, October 2013 Price Level, 50-Year Period of Analysis)

PLAN	WITHOUT-PROJECT EAD	WITH-PROJECT EAD	EXPECTED BENEFITS	PROBABILITY BENEFITS EXCEED INDICATED VALUE		
				75%	50%	25%
No action	255	--	--	--	--	--
Alts. 1/3/5	255	0	255	255	255	255

Table 27: Range of Benefits at IP5 (In $1000s, October 2013 Price Level, 50-Year Period of Analysis)

PLAN	WITHOUT-PROJECT EAD	WITH-PROJECT EAD	EXPECTED BENEFITS	PROBABILITY BENEFITS EXCEED INDICATED VALUE		
				75%	50%	25%
No action	72,012	--	--	--	--	--
Alts. 1/3/5	72,012	3,665	68,347	45,267	65,738	87,491

Table 28: Range of Benefits at IP6 (In $1000s, October 2013 Price Level, 50-Year Period of Analysis)

PLAN	WITHOUT-PROJECT EAD	WITH-PROJECT EAD	EXPECTED BENEFITS	PROBABILITY BENEFITS EXCEED INDICATED VALUE		
				75%	50%	25%
No action	58,050	--	--	--	--	--
Alts. 1/3/5 (no raises)	58,050	10,412	47,640	29,841	37,847	56,034
Alts. 1/3/5 (with raises)	58,050	10,412	47,640	29,841	37,847	56,034

Table 29: Range of Benefits at IP7 (In $1000s, October 2013 Price Level, 50-Year Period of Analysis)

PLAN	WITHOUT-PROJECT EAD	WITH-PROJECT EAD	EXPECTED BENEFITS	PROBABILITY BENEFITS EXCEED INDICATED VALUE		
				75%	50%	25%
No action	167,150	--	--	--	--	--
Alts. 1/3/5 (no raises)	167,150	16,156	150,994	86,873	143,795	203,370
Alts. 1/3/5 (with raises)	167,150	16,156	150,994	86,873	143,795	203,370

Table 30: Range of Benefits at IP8 (In $1000s, October 2013 Price Level, 50-Year Period of Analysis)

PLAN	WITHOUT-PROJECT EAD	WITH-PROJECT EAD	EXPECTED BENEFITS	PROBABILITY BENEFITS EXCEED INDICATED VALUE		
				75%	50%	25%
No action	11,028	--	--	--	--	--
Alts. 1/5	11,028	10,704	325	58	223	513
Alt. 3	11,028	0	11,028	2,130	5,250	12,387

4.5 WITH-PROJECT RESULTS: BENEFITS BY BASIN AND ALTERNATIVE

Table 31 below displays the benefits of each alternative from the perspective of looking at the West Sacramento area as one complete FRM system. The benefit values in these tables reflect improvements made to each source of flood risk within the basin. For example, FRM improvements are implemented to reduce flood risk associated with the Yolo Bypass, the Sacramento River, and the DWSC. This table reflects benefits that would be realized in the basin (i.e., in a single consequence area) by thinking of the flood problem from a broader system perspective rather than from just individual, isolated (index points/reaches) sources of flood risk.

As the results in Table 31 indicate, when looking at the West Sacramento basin (north and south) as one system, the benefits of each alternative are essentially the same. The rationale for this outcome is that under each alternative, all improvements are assumed to be made. Making this assumption results in the same residual flood risk (remaining risk) under each alternative (again, when looking at the West Sacramento area as a whole); this residual risk is associated with the “weakest link” in the system after all improvements are made, which under each alternative turns out to be Index Point 3 on the Yolo Bypass. The residual EAD at this location is approximately $31 million.

Table 31: Average Annual Benefits by Alternative (In $1,000s, October 2013 Price Level, 50-Year Period of Analysis)

BASIN	WITHOUT-PROJECT EAD	WITH-PROJECT EAD	AVERAGE ANNUAL BENEFITS
ALTERNATIVE 1/5 (NO LEVEE RAISES)	288,263	31,404 (residual EAD from IP 3)	256,859
ALTERNATIVE 1/5 (WITH LEVEE RAISES)	288,263	31,404 (residual EAD from IP 3)	256,859
ALTERNATIVE 3 (NO LEVEE RAISES)	288,263	31,404 (residual EAD from IP 3)	256,859
ALTERNATIVE 3 (WITH LEVEE RAISES)	288,263	31,404 (residual EAD from IP 3)	256,859

If looked at from a single index point/reach perspective, residual risk in terms of consequences and chance of flooding differs across index points/reaches. This can be seen in Tables 16 to 23 above for consequences and Tables 32 to 34 (in the next section) for chance of flooding.

4.6 WITH-PROJECT PERFORMANCE RESULTS: AEP, LONG-TERM RISK, & ASSURANCE

Tables 32 to 34 present the performance statistics under both without-project and with-project conditions for each index point and alternative.

The AEP values under with-project conditions indicate that each alternative provides significant risk reduction in terms of the chance of flooding in any given year. For example, at Index Point 3 on the Yolo Bypass, without-project AEP is about 1 in 11. With improvements, flood risk as estimated at IP3 is reduced to about a 1 in 111 for all Alternatives.

The long-term risk statistics indicate that the chance of flooding over specified time periods is also reduced. For example, at IP3 the chance of flooding over a 10-year and 30-year period improves significantly with a project in place, going from a 61% and 94% chance for a 10-year and 30-year period without a project, respectively, to a 9% and 24% chance with a project in place.

The assurance results describe the chance a specified flow event would be contained within the channels of a water source (at a specific index point location). For example, for IP3 the chance of containing the 1% flow event under the without-project condition is about 23%. With improvements made to the Yolo Bypass, the chance of containing the 1% flow event increases to about 93% (all alternatives).

Table 32: Without-Project and With-Project Conditions

INDEX POINT	ANNUAL EXCEEDANCE PROBABILITY (AEP)[1]				
	WITHOUT	ALTS. 1 and 5 (NO LEVEE RAISES)	ALTS. 1 and 5 (WITH LEVEE RAISES)	ALT. 3 (NO LEVEE RAISES)	ALT. 3 (WITH LEVEE RAISES)
1	0.055	0.006	0.006	0.006	0.006
2	0.008	0.004	0.003	0.004	0.003
3	0.089	0.009	0.009	0.009	0.009
4	0.000	0.000	0.000	0.000	0.000
5	0.024	0.001	0.001	0.001	0.001
6	0.041	0.003	0.003	0.003	0.003
7	0.129	0.003	0.003	0.003	0.003
8	0.012	0.007	0.007	0.000	0.000

[1]Engineering performance results at index points 5 and 6 on the Sacramento River were assumed the same for Alternatives 1 and 5; additional hydraulic modeling of Alternative 5 will occur in the future.

Table 33: Long-Term Risk -- Without-Project and With-Project Conditions

INDEX POINT	LONG-TERM RISK[1]									
	WITHOUT		ALTS. 1 AND 5 (NO LEVEE RAISES)		ALTS. 1 AND 5 (WITH LEVEE RAISES)		ALT. 3 (NO LEVEE RAISES)		ALT. 3 (WITH LEVEE RAISES)	
	10 Years	30 Years	10 Years	30 Years	10 Years	30 Years	10 Years	30 Years	10 Years	30 Years
1	43	82	5	15	5	15	5	15	5	15
2	8	22	4	10	3	9	4	10	3	9
3	61	94	9	24	9	24	9	24	9	24
4	0	0	0	0	0	0	0	0	0	0
5	21	51	1	3	1	3	1	3	1	3
6	34	72	3	10	3	10	3	10	3	10
7	75	98	3	9	3	9	3	9	3	9
8	12	31	7	20	7	20	0	0	0	0

[1]Engineering performance results at index points 5 and 6 on the Sacramento River were assumed the same for Alternatives 1 and 5; additional hydraulic modeling of Alternative 5 will occur in the future.

Table 34: Assurance -- Without-Project and With-Project Conditions

INDEX POINT	ASSURANCE[1]														
	WITHOUT			ALTS. 1 AND 5 (NO LEVEE RAISES)			ALTS. 1 AND 5 (WITH LEVEE RAISES)			ALT. 3 (NO LEVEE RAISES)			ALT. 3 (WITH LEVEE RAISES)		
	4%	1%	.2%	4%	1%	.2%	4%	1%	.2%	4%	1%	.2%	4%	1%	.2%
1	84	75	24	97	96	28	97	96	28	97	96	28	97	96	28
2	93	88	31	98	97	48	98	97	63	98	97	48	98	97	63
3	39	23	9	93	93	92	93	93	92	93	93	92	93	93	92
4	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
5	89	85	65	99	98	97	99	98	97	99	98	97	99	98	97
6	91	90	86	98	98	97	98	98	97	98	98	97	98	98	97
7	22	12	9	96	93	90	96	93	90	96	93	90	96	93	90
8	89	70	28	96	79	33	96	79	33	99	99	99	99	99	99

[1]Engineering performance results at index points 5 and 6 on the Sacramento River were assumed the same for Alternatives 1 and 5; additional hydraulic modeling of Alternative 5 will occur in the future.

4.7 SCREENING-LEVEL COST ESTIMATES: BY ALTERNATIVE & SOURCE OF FLOOD RISK

Preliminary, screening-level cost estimates were provided by the District's Cost Engineering Section. The costs were broken out by stream/reach/feature for this economic analysis and are summarized in Tables 35 to 37 below.

Table 35: Alternative 1 – Costs

REACH IMPROVEMENTS	RISK SOURCE THAT IMPROVEMENTS PROTECT AGAINST	ALTERNATIVE 1 (IN $1,000s, OCTOBER 2013 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS, 3.50% DISCOUNT RATE)			
		Project Costs	Average Annual Costs	O&M Costs	Total Average Annual Costs
Sacramento Bypass Training Dike	Sacramento Bypass	7,753	331	N/A	331
Yolo Bypass	Yolo Bypass	18,547	791	N/A	791
DWSC West - Yolo Bypass to DWSC Structure	Yolo Bypass	69,657	2,969	N/A	2,969
DWSC West - DWSC Structure South 18 miles	Yolo Bypass	277,460	11,828	N/A	11,828
DWSC East	Yolo Bypass	114,170	4,867	N/A	4,867
DWSC East - Structure to South Levee	Yolo Bypass	N/A	N/A	N/A	N/A
Port North Levee	Sacramento River	45,453	1,938	N/A	1,938
Port South Levee	Sacramento River	24,731	1,054	N/A	1,054
Sacramento River North Levee - IMPROVE LEVEES	Sacramento River	571,547	24,365	N/A	24,365
Sacramento River South Levee - IMPROVE LEVEES	Sacramento River	539,592	23,003	N/A	23,003
Sacramento River South Levee – SET BACK LEVEES	Sacramento River	N/A	N/A	N/A	N/A
Stone Lock	Sacramento River	39,129	1,668	N/A	1,668
South Cross Levee	Yolo Bypass	68,272	2,910	N/A	2,910
DWSC Structure	Yolo Bypass	N/A	N/A	N/A	N/A
Total	--	**1,776,311**	**75,724**	**106**	**75,830**

Table 36: Alternative 3 - Costs

REACH IMPROVEMENTS	RISK SOURCE THAT IMPROVEMENTS PROTECT AGAINST	ALTERNATIVE 3 (IN $1,000s, OCTOBER 2013 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS, 3.50% DISCOUNT RATE)			
		Project Costs	Average Annual Costs	O&M Costs	Total Average Annual Costs
Sacramento Bypass Training Dike	Sacramento Bypass	8,692	371	N/A	371
Yolo Bypass	Yolo Bypass	20,776	886	N/A	886
DWSC West - Yolo Bypass to DWSC Structure	Yolo Bypass	77,646	3,310	N/A	3,310
DWSC West - DWSC Structure South 18 miles	Yolo Bypass	N/A	N/A	N/A	N/A
DWSC East	Yolo Bypass	N/A	N/A	N/A	N/A
DWSC East - Structure to South Levee	Yolo Bypass	42,745	1,822	N/A	1,822
Port North Levee	Sacramento River	N/A	N/A	N/A	N/A
Port South Levee	Sacramento River	N/A	N/A	N/A	N/A
Sacramento River North Levee – IMPROVE LEVEES	Sacramento River	628,838	26,807	N/A	26,807
Sacramento River South Levee – IMPROVE LEVEES	Sacramento River	601,844	25,657	N/A	25,657
Sacramento River South Levee – SET BACK LEVEES	Sacramento River	N/A	N/A	N/A	N/A
Stone Lock	Sacramento River	43,711	1,863	N/A	1,863
South Cross Levee	Yolo Bypass	76,022	3,241	N/A	3,241
DWSC Structure	Yolo Bypass	517,724	22,071	N/A	22,071
Total	**--**	**2,017,997**	**86,027**	**1,306**	**87,333**

Table 37: Alternative 5 - Costs

REACH IMPROVEMENTS	RISK SOURCE THAT MPROVEMENTS PROTECT AGAINST	ALTERNATIVE 5 (IN $1,000s, OCTOBER 2013 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS, 3.50% DISCOUNT RATE)			
		Project Costs	Average Annual Costs	O&M Costs	Total Average Annual Costs
Sacramento Bypass Training Dike	Sacramento Bypass	7,770	331	N/A	331
Yolo Bypass	Yolo Bypass	18,587	792	N/A	792
DWSC West - Yolo Bypass to DWSC Structure	Yolo Bypass	69,799	2,976	N/A	2,976
DWSC West - DWSC Structure South 18 miles	Yolo Bypass	278,053	11,853	N/A	11,853
DWSC East	Yolo Bypass	114,388	4,876	N/A	4,876
DWSC East - Structure to South Levee	Yolo Bypass	N/A	N/A	N/A	N/A
Port North Levee	Sacramento River	45,538	1,941	N/A	1,941
Port South Levee	Sacramento River	24,773	1,056	N/A	1,056
Sacramento River North Levee - IMPROVE LEVEES	Sacramento River	572,570	24,409	N/A	24,409
Sacramento River South Levee - IMPROVE LEVEES	Sacramento River	N/A	N/A	N/A	N/A
Sacramento River South Levee – SET BACK LEVEES	Sacramento River	373,669	15,930	N/A	15,930
Stone Lock	Sacramento River	39,211	1,672	N/A	1,672
South Cross Levee	Yolo Bypass	68,411	2,916	N/A	2,916
DWSC Structure	Yolo Bypass	N/A	N/A	N/A	N/A
Total	**--**	**1,612,768**	**68,752**	**106**	**68,858**

In addition to project first costs, interest during construction (IDC), which is an economic cost, was also factored into the net benefit/BCR analyses. Interest during construction for each alternative was calculated by the Sacramento District's Economic & Risk Analysis Section. A gross assumption was made in regard to the construction period (number of years) used to calculate IDC. It was assumed that approximately $100 million dollars would be spent each year until the project was complete. Based on this assumption, the construction period for Alternative 1 is estimated to be 18 years; the construction period for Alternative 3 is estimated to be 21 years; and the construction period for Alternative 5 is estimated to be 17 years. Total NED costs, which include IDC, are shown in Table 38 for each alternative.

Table 38: NED Costs by Alternative with IDC

Alternative	Costs (IN $1,000s, OCTOBER 2013 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS, 3.50% DISCOUNT RATE)					
	Project Costs	IDC	Total Costs	Average Annual Costs (AAC)	O&M Costs	Total AAC
Alt 1	1,776,311	734,889	2,511,200	107,052	106	107,158
Alt 3	2,017,997	1,030,020	3,048,017	129,937	1,306	131,243
Alt 5	1,612,768	646,916	2,259,684	96,330	106	96,436

4.8 NET BENEFIT AND BENEFIT-TO-COST ANALYSES: FROM SINGLE FRM FEATURE/REACH/INDEX POINT PERSPECTIVE

When evaluating the feasibility of a specific FRM feature, the costs and benefits of the feature can be compared to one another within a narrowly-defined perspective that addresses the flood risk reduction associated with building only that single FRM feature. This narrow perspective assumes that the benefits (i.e., damage reduction in a consequence area) of a particular feature are fully realized because there are no other sources of risk to be concerned with; that is, once this particular feature is built, the area's flood risk is reduced so significantly that no other measures are necessary.

In reality, the West Sacramento consequence area is vulnerable to multiple sources of flood risk. So while the area may benefit from making improvements to just one source of risk, the area does not realize full benefits until other FRM features are built since the area would still be vulnerable from other sources of risk. In this context, consequence areas having multiple sources of risk must rely on various FRM improvements located in various geographic locations and implemented over a period of time (phases) that work together. Analyzing a consequence area as one unit having multiple sources of flood risk underlies the rationale for performing incremental net benefit/BCR analyses. An incremental analysis allows for the demonstration, in a logical manner, of the incremental risk reduction that is achieved in the area of concern as various FRM components come on line through to the point at which the entire FRM system is finally addressed. Table 39 displays the FRM features, the sources of risk that the features protect against, and the index point used in the incremental benefit/cost analysis.

The incremental analysis is presented in Section 4.9.

Table 39: FRM Features, Sources of Risk, and Index Points Used in the Economic Analysis

Feature	Source of Risk FRM Feature Protects Against	Associated IP Used to Estimate Net Benefits Provided by Feature
Yolo Bypass	Yolo Bypass	IP3
DWSC West - Yolo Bypass to DWSC Structure	Yolo Bypass	IP7
DWSC West - DWSC Structure South 18 miles	Yolo Bypass	IP7
DWSC East	Yolo Bypass/DWSC	IP7, IP8
DWSC East - Structure to South Levee	Yolo Bypass/DWSC	IP7, IP8
Port North Levee	Yolo Bypass/DWSC	IP7, IP8
Port South Levee	Yolo Bypass/DWSC	IP7, IP8
Sacramento River North Levee - IMPROVE LEVEES	Sacramento River	IP1, IP2
Sacramento River South Levee - IMPROVE LEVEES	Sacramento River	IP5, IP6
Sacramento River South Levee – SET BACK LEVEES	Sacramento River	IP5, IP6
South Cross Levee	Yolo Bypass	IP7
DWSC Structure	Yolo Bypass	IP7, IP8

4.9 INCREMENTAL NET BENEFIT AND BENENFIT-TO-COST ANALYSES: FROM A BASIN-WIDE PERSPECTIVE BASED ON MAJOR SOURCE OF FLOOD RISK AND FRM MEASURE

Incremental net benefit/benefit-to-cost analyses were performed using the major sources of flood risk as the incremental unit. The cost information presented in Tables 35 to 37 was used to perform the analyses, which are presented in Table 40 below.

Addressing in tandem all sources of flood risk as part of an overall system is necessary in order to significantly reduce risk to the city of West Sacramento. Since the city is surrounded by levees, until all sources of risk are addressed West Sacramento would still face a relatively significant chance of flooding and incur catastrophic consequences (damages and possible loss of life) should flooding to the area take place. Table 40 shows how an alternative can be broken down into increments in order to attribute benefits to specific features of an alternative and to show how each feature of the West Sacramento FRM system works as one unit – with each feature progressively reducing residual risk to the area as they come on line. The analyses presented in Table 42 are intended to show how parts of the system work together, how residual risk is incrementally reduced as weak links in the system are strengthened, and how the alternatives differ from one another in terms of incremental net benefits.

Table 40: Incremental Net Benefit and Benefit-to-Cost Analyses for Alternatives 1, 3, and 5 (Values in $1,000s, October 2013 Price Level, 50-Year Period of Analysis, 3.50% Discount Rate)

Increment	Without-Project EAD/Resid EAD	Increm. Average Annual Benefits (AAB)	Cumulat. AAB	Increm. Average Annual Costs (AAC)	Cumulat. AAC	Increm. Net Benefits	Cumulat. Net Benefits	Increm. Benefit-to-Cost Ratio (BCR)	Cumalat. BCR
Alternative 1: Improve Levees									
0 -- No Action	288,263	0	0	0	0	0	0	N/A	N/A
1 – Yolo Bypass, Sac Bypass Training Dike	167,150	121,113	121,113	2,083	2,083	119,030	119,030	58.2	58.2
2 - DWSC-W, DWSC-E, Port North, Port South, South Cross Levee	96,960	70,190	191,303	43,266	45,348	26,924	145,955	1.6	4.2
3 - Sac River North, Stone Lock, Sac River South IMPROVE LEVEES	31,404	65,556	256,859	61,704	107,052	3,852	149,807	1.1	2.4
Total			**256,859**	**107,052**	**107,052**	**149,807**	**149,807**		**2.4**
Alternative 3: Improve Levees + Control Structure									
0 -- No Action	288,263	0	0	0	0	0	0	N/A	N/A
1 – Yolo Bypass, Sac Bypass Training Dike	167,150	121,113	121,113	2,587	2,587	118,526	118,526	46.8	46.8
2 - DWSC-W limited, DWSC-E limited, South Cross Levee, DWSC Control Structure	96,960	70,190	191,303	55,982	58,570	14,208	132,733	1.3	3.3
3 - Sac River North, Stone Lock, Sac River South IMPROVE LEVEES	31,404	65,556	256,859	71,367	129,937	(5,811)	126,922	0.9	2.0
Total			**256,859**	**129,937**	**129,937**	**126,922**	**126,922**		**2.0**
Alternative 5: Improve Levees; Set Back Levee on Sacramento River (South)									
0 -- No Action	288,263	0	0	0	0	0	0	N/A	N/A
1 – Yolo Bypass, Sac Bypass Training Dike	167,150	121,113	121,113	2,016	2,016	119,097	119,097	60.1	60.1
2 - DWSC-W, DWSC-E, Port North, Port South, South Cross Levee	96,960	70,190	191,303	41,878	43,894	28,312	147,409	1.7	4.4
3 - Sac River North, Stone Lock, Sac River South SET BACK LEVEES	31,404	65,556	256,859	52,436	96,330	13,120	160,529	1.3	2.7
Total			**256,859**	**96,330**	**96,330**	**160,529**	**160,529**		**2.7**

The reaches were grouped into increments and the increments, as displayed in Table 40, were determined by assessing the without-project and with-project HEC-FDA AEP and EAD results. Walking through the increments, Table 40 shows that the first one, under all alternatives, would be to improve the Yolo Bypass levees since the economic HEC-FDA modeling indicates that this is the weakest point of the system in terms of the chance and consequences of flooding. Following the Yolo Bypass levee improvements, the next increment would be to either address the DWSC levee/South Cross Levee/Port improvements that provide protection against inundation water originating from the Yolo Bypass (Alternatives 1 and 5) or constructing the DWSC control structure (Alternative 3) that would also protect against inundation water originating from the Yolo Bypass. Once these improvements are made, the final increment would be to address the levees along the Sacramento River (all alternatives).

4.10 IDENTIFICATION OF NATIONAL ECONOMIC DEVELOPMENT (NED) PLAN

Based on the analysis presented above, all alternatives provide positive net benefits. Alternative 5 provides the most net benefits ($160 million) and therefore would be considered the NED Plan. The net benefit analysis for each alternative is summarized in Table 41 below; the net benefit curve is shown in Figure 7. Whichever alternative is recommended, additional refinements would have to be completed during future phases of this study in order to more fully optimize the return on investment (i.e., net benefits).

Table 41: Net Benefit and Benefit-to-Cost Analyses by Alternative (Values in $1,000s, October 2013 Price Level, 50-Year Period of Analysis, 3.50% Discount Rate)

Alternative	Average Annual Benefits	Average Annual Costs (AAC)	Annual O&M Costs	Total AAC	Net Benefits	Benefit-to-Cost Ratio (BCR)
Alt. 1 IMPROVE LEVEES	256,859	107,052	106	107,158	149,701	2.4
Alt. 3 IMPROVE LEVEES + Control Structure	256,859	129,937	1,306	131,243	125,616	2.0
Alt. 5 IMPROVE LEVEES + Set Back Levee on Sac River South	256,859	96,330	106	96,436	160,423	2.7

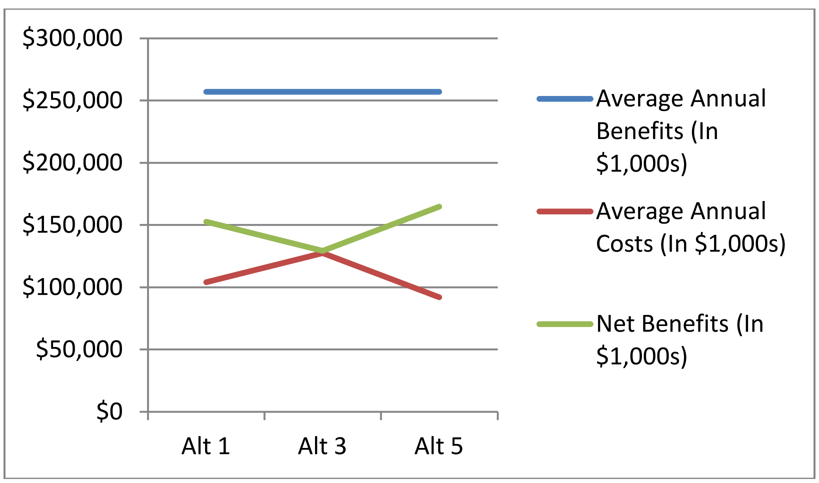


Figure 7: Net Benefit Curve (Green)

West Sacramento GRR
Economic Appendix

Attachments – Supporting Data

ATTACHMENT
WEST SACRAMENTO GRR
ECONOMICS APPENDIX
OTHER SOCIAL EFFECTS (OSE) & REGIONAL ECONOMIC DEVELOPMENT (RED)
JULY 2014

A. INTRODUCTION

In the past, planning studies at the Corps of Engineers have focused primarily on the National Economic Development (NED) account to formulate and evaluate water resource infrastructure projects. In recent years, however, there has been a renewed emphasis on considering the Other Social Effects (OSE), Regional Economic Development (RED), and Environmental Quality (EQ) accounts when making investment decisions, as can be seen in the publication of Engineering Circular (EC) 1105-2-409, “Planning in a Collaborative Environment.” EC 1105-2-409 encourages the use of all four accounts in order to develop water resource solutions that are more holistic and acceptable, and which take into account both national and local stakeholder interests.

The following sections describe the OSE and RED assessments developed for the West Sacramento GRR. (The EQ assessment is described in the main planning document.)

B. OTHER SOCIAL EFFECTS (OSE)

Purpose and Methodology

The OSE assessment is intended to provide a portrait of the social landscape of the West Sacramento study area and offer a glimpse into the potential vulnerability of the people that live there. In essence, the questions the OSE account tries to answer are:

How are social connectedness, community social capital, and community resiliency likely to change in the absence of a solution to a water resource issue? How are vulnerable populations likely to be affected?

The metrics commonly used to answer these questions include:

- Social connectedness, which can be described using gender, race and ethnicity, age, rural versus urban communities, rental versus owner-occupied dwellings, and occupation
- Community social capital, which can be described using education, family structure, rural vs. urban communities, and population growth
- Community resilience, which can be described using income, political power, neighborhood prestige, employment loss, residential property characteristics, infrastructure and lifelines, family structure, and medical services

The assessment compares the other social effects associated with the without-project and with-project conditions. The 1% annual chance exceedance (ACE) floodplain serves as the baseline to assess effects.

References

- *Planning Guidance Notebook* (ER 1105-2-100)
- *Handbook on Applying "Other Social Effects" Factors in Corps of Engineers Water Resources Planning* (IWR 09-R4)
- *Planning in a Collaborative Environment*, (EC) 1105-2-409
- *Levee Screening Tool: Methodology and Application* (November 2011, RMC-CPD-1)
- *Social Vulnerability to Environmental Hazards (* Social Science Quarterly, Volume 84, Number 2, June 2003)

Early History of the West Sacramento Area

The surrounding land and water provided abundant natural resources to the Patwin Indians, who were the first inhabitants of the area at around 500 AD. European settlers began arriving in the 1800's, and established the first permanent settlement in 1844. In 1849 the Town of Washington (which is now the Broderick area of West Sacramento) was established. During the early years, the area supported successful fishing, farming, and dairy industries. Over time the area continued to grow, prosper, and develop; from 1900 to 1920, the population in the area doubled from about 1,398 to about 2,638. In 1963, the Port of Sacramento opened to deep sea traffic with the completion of the Deep Water Ship Channel.

Current Social Landscape

Describing the social landscape of the area provides an understanding of who lives in the study area, who has a stake in the problem or issue, and why it is important to them. A demographic profile of the area is performed using social statistics, and the information is presented in a meaningful way through the use of comparisons and rankings. It is important to note that the profile itself is not an OSE analysis but rather a data collection step that provides a basic level of understanding about the social conditions in the area; the data provides input into a more in-depth analysis that targets areas of special concern or relevance to the water resources issue at hand. The basic social statistics discussed below and listed in Table 1 are indicators used to portray basic information about the social life and the processes of the study area.

The West Sacramento study area is home to more than 48,000 people. The area has seen tremendous growth over the last 10 to 15 years as an influx of people have come from across the region to take advantage of the relatively affordable home prices as well as the many amenities available nearby. Between 2000 and 2010, the area has seen a population increase of about 54%, many of whom represent various races and ethnicities, bringing extraordinary diversity to the area. Also, based on the 2010 Census, the people that have settled in West Sacramento over the past decade have more formal education, with a quarter of the residents holding at least a bachelor's degree (compared to only about 10% in 2000). Finally, the median household income in the area has increased significantly from 2000 ($31,718) to 2010 ($54,179), indicating an increase level of economic activity for the area and the region. In comparison, the median household income for California as a whole stayed about the same between 2000 and 2010.

Key demographics are presented in Table 1 below.

Table 1: Basic Social Characteristic of West Sacramento Study Area - 2000 and 2010 Census Data

Social Statistic	West Sacramento			California		
	2000	2010	% Δ	2000	2010	% Δ
Population	31,615	48,744	+54%	33,871,648	37,253,956	+10%
Age						
Median	34	33.6	-1.2%	33.3	35.2	+5.7%
% >65	12.7%	9.5%	-25%	10.6%	11.4%	+7.5%
% <18	29.8%	26.7%	-10.4%	27.3%	25.0%	-8.4%
Race & Ethnicity						
Asian	7.2%	10.5%	+46%	10.9%	12.8%	+17.4%
Black	2.6%	4.8%	+85%	6.7%	5.8%	-13.4%
Hispanic	30%	31.4%	+4.7%	32.4%	37.6%	+16%
White	54.6%	36.8%	-33%	46.7%	40.1%	-14.1%
Other	5.6%	16.5%	+195%	4.3%	3.7%	+86%
Education						
% HS Graduates	69.9%	81.2%	+16.2%	81%	80.8%	-0.2%
% College Graduates	9.8%	23.5%	+39.8%	30.5%	30.2%	-0.9%
Income and Poverty						
% Unemployed	5.4%	12.2%	+126%	4.3%	7.1%	+65%
Median Household Income	$31,718	$54,179	+71%	$61,400	$61,632	0%
% Below Poverty	22.3%	18.8%	-15.7%	15.3%	14.4%	-5.9%
Housing						
% Own	54.5%	58.7%	+7.7%	56%	55.9%	0%
% Rent	45.5%	41.3%	-9.2%	44%	44.1%	0%
Quality of Life						
Avg. Household Size	2.75	2.78	-1.1%	2.98	3.45	+16%
Language Other than English Spoken at Home	38.4%	37.4%	-2.6%	43.5%	43.2%	-0.7%
Mean Travel Time to Work (in minutes)	21.2	22.7	+7.1%	27.1	27	-0.4%

Social Effects Assessment

A social effects assessment considers the social vulnerability and resiliency of a population. Social vulnerability refers to the sensitivity of a population to natural hazards, whereas social resiliency refers to the population's ability to respond to and recover from the impacts of a natural hazard. The characteristics that are recognized as having an influence on social vulnerability and resiliency generally include age, gender, race, and socioeconomic status as well as population segments with special needs or those without the normal social safety nets typically necessary to recover from a disaster. The quality of human settlements (e.g., housing type and construction, infrastructure, and lifelines) and the built environment also play an important role in assessing social vulnerability and resiliency, especially as these characteristics influence potential economic losses, injuries, and fatalities from natural hazards. Table 2 provides a discussion of factors that may influence social vulnerability and resiliency and also provides a qualitative assessment of the West Sacramento study area based on indicator statistics from the 2010 U.S. Census. The discussion column in Table 2 is from the article, *Social Vulnerability to Environmental Hazards*, which was published in the June 2003 edition of Social Science Quarterly.

Table 2: Social Vulnerability and Resiliency Indicators – West Sacramento Assessment

Indicator	Discussion	Assessment
Income, political power, and prestige	This measure focuses on the ability to absorb losses and enhance resilience to hazard impacts. Wealth enables communities to absorb and recover from losses more quickly due to insurance, social safety nets, and entitlement programs.	The median household income of the area is below the median for the state of California; however, the community is in very close proximity to the state Capitol and the significant amount of political resources available there.
Gender	Women can have a more difficult time during recovery than men, often due to sector-specific employment, lower wages, and family care responsibilities.	Women make up 51.2% of the work force while men make up 48.8%; the median earnings for women in the area is $34,046, which is just 83% of the median earnings for men.
Race and Ethnicity	Race and ethnicity may impose language and cultural barriers that affect access to post-disaster funding	The area is highly diverse in terms of race and ethnicity. About one-third of the residents speak a language other than English at home; this may contribute to the vulnerability and possibly the resiliency of the community.
Age	Extremes on the age spectrum inhibit the movement out of harm's way. Parents lose time and money caring for children when daycare facilities are affected; the elderly may have mobility constraints or mobility concerns increasing the burden of care and lack of resilience.	Those age 65 and over make up a slightly lower percentage of the community's population as compared to the percentage for the same age category and for the state as a whole; the percentage of residents younger than 18 (26.7%) is slightly higher than the stage statistic (25%).
Employment Loss	The potential loss of employment following a disaster exacerbates the number of unemployed workers in a community, contributing to a slower	The latest Census indicates that the current unemployment rate in the area may be significantly higher than the state's. A flood event

	recovery from the disaster.	which causes additional unemployment may exacerbate the current unemployment rate.
Rural/Urban	Rural residents may be more vulnerable due to lower incomes, and may be more dependent on locally-based resource extraction economies (farming and fishing). High-density areas (urban) complicate evacuation from harm's way.	The area is highly urbanized and close to many resources.
Residential Property	The value, quality, and density of residential construction affect potential losses and recovery. For example, expensive homes are costly to replace, while mobile homes are easily destroyed and less resilient to hazards.	The area is comprised of average quality homes. Medium density neighborhoods are typical. There is not a significant percentage of prestige homes; there is not a significant percentage of mobile homes.
Infrastructure and Lifelines	Loss of sewers, bridges, water, communications, and transportation infrastructure may place an insurmountable financial burden on the smaller communities that lack the financial resources to rebuild.	The West Sacramento community is well-established and would most likely have access to the many resources available within the city itself as well as within the greater metropolitan area, which includes, Davis, Sacramento, Folsom, Elk Grove, Dixon, and other cities.
Renters	People that rent typically do so because they are either transient or do not have the financial resources for home ownership. They often lack access to information about financial aid during recovery. In the most extreme cases, renters lack sufficient shelter options when lodging becomes uninhabitable or too costly to afford.	The number of rentals in the area is fairly high (greater than 40%), but is still lower than the state average of about 44%. The high rental population may contribute to communication cohesion issues; research indicates that renters do not have the same level of community pride as owners do, which may lead to more challenges in redeveloping a community after a flood event.
Occupation	Some occupations, especially those of resource extraction, may be severely impacted by a hazard event. Self-employed fishermen suffer when their means of production is lost and may not have the requisite capital to resume work in a timely fashion and thus will seek alternative employment. Migrant workers engaged in agriculture and low skilled service jobs (e.g., housekeeping, childcare, and gardening) may similarly suffer, as disposable income fades and the	The number of people that live in the area and work in resource extraction occupations is fairly low the 2010 Census indicates that around 300 people work in the farming, fishing, and forestry occupations.

	need for services decline. Immigration status also affects occupational recovery.	
Family Structure	Families with large numbers of dependents or single-parent households often have limited finances to outsource care for dependents, and thus must juggle work responsibilities and care for family members. All affect the resilience to recover from hazards.	The literature indicates that families having greater than four persons have more financial difficulty than smaller families. Accordingly, community planners need to be aware of issues that may arise.
Education	Education is strongly linked to socioeconomic status, with higher educational attainment resulting in greater lifetime earnings. Lower education constrains the ability to understand warning information and access to recovery information.	Over 80% of the population has graduated from high school and almost a quarter hold a bachelor's degree.
Population Growth	Counties experiencing rapid growth lack available quality housing; its social services network may not have had time to adjust to increased populations. New migrants may not speak the language and not be familiar with bureaucracies for obtaining relief or recovery information, all of which increases vulnerability.	West Sacramento has grown significantly over the past fifteen years, with a majority of the growth taking place between 2000 and 2010. The growth rate between 2000 and 2010 was 54%. Rapid growth is highly correlated with low community cohesion. The sense of belonging, cooperation, and community pride are dynamic factors which help with community resilience but which may not be as strong in cities that have experienced rapid growth.
Medical Services	Health care providers, including physicians, nursing homes, and hospitals are important post-event sources of relief. The lack of proximate medical services will lengthen immediate relief and result in longer recovery from disasters.	The residents of West Sacramento would have access to nearby medical facilities in the cities of Davis, Woodland, Sacramento, Elk Grove, Folsom, El Dorado Hills, Roseville, Rocklin, Dixon, and others

Life Safety Evaluation

The Sacramento District's Levee Safety Section uses the Levee Screening Tool (LST) to assess levees within the District's geographic boundary. The LST provides an initial quantitative risk estimate to assist local, state, and federal stakeholders in identifying and prioritizing the funding needs for levees of concern. The information and data entered into the LST are collected from existing information/data. Life loss estimates are computed in the LST based on the information/data entered and for various scenario/conditions, including life loss during the day time, life loss during the night time, life loss assuming a levee breach prior to overtopping, and life loss assuming no breach until overtopping. Additional information about the levee screening tool and its computation processes can be found in, *Levee Screening Tool: Methodology and Application,* as listed in the reference section.

The results of the levee screenings performed for the West Sacramento study area were used in this OSE assessment to make preliminary estimates of life loss. The results of two scenarios modeled in the LST, levee breach prior to overtopping and no levee breach until overtopping, are presented here. For this assessment, the levee breach prior to overtopping scenario was assigned to the without-project condition and the no levee breach until overtopping was assigned to the with-project (Alternative 5) condition. A comparison of potential fatalities under each condition is displayed in Table 3 below.

Table 3: Statistical Life Loss Estimates

Levee Segment	Estimated Life Loss					
	Without-Project (Assumes Breach Prior to Overtopping)			Alternative 5 (Assumes No Breach Until Overtopping)		
	Day	Night	Weighted	Day	Night	Weighted
Sacramento River – North Levee	124	90	106	41	30	35
Sacramento River – South Levee	124	90	106	41	30	35
Yolo Bypass – North of DWSC	124	90	106	41	30	35

In addition to life loss estimates, other metrics were used to assess the vulnerability of individuals living in the study area, as listed in Table 4 below. These include:

Table 4: Description of Metrics Used to Evaluate Life Safety

Evaluation Metric	Description
Population at Risk (People)	Number of people within the 1% ACE floodplain based on the 2010 census block GIS data.
Critical Infrastructure (Facilities)	Number of fire stations, police stations, hospitals, senior living facilities, and jails that are of life safety significance; also includes substations, schools, power plants, chemical industry, colleges, intermodal shipping, heliports, petroleum bulk plants, and broadcast communication which may be of regional significance
Evacuation Routes (Number of Routes)	Assesses the vulnerability of populations with regard to the number of escape routes available during flood events.
Wise Use of Floodplains (Acres)	Potentially developable land within the 0.2% ACE floodplain. Acres of land with 1% ACE flood depths less than 3 feet.

Table 5 displays the comparison for the without-project and with-project (Alternative 5) conditions as they relate specifically to the life safety metrics summarized in Table 4.

Table 5: Summary of Life Safety Metrics

Evaluation Metric	Alternative	
	Without-Project	Alternative 5
Population at Risk (People)	48,000	0
Critical Infrastructure (Facilities)	76	41
Evacuation Routes (Number of Routes)	0	11
Wise Use of Floodplains (Acres)	0	3,896

Population at Risk: The population at risk of flooding from a 1% ACE flood event is about 48,000 for the without-project condition. Most of this population would be removed from the 1% ACE floodplain under Alternative 5. Of special concern is the population segment over the age of 65 living within the study area since these individuals have been shown to be at higher risk of life loss from flood events. The West Sacramento community actually has a lower percentage (9.5%) of seniors over 65 as compared to the senior population of the state of California (11.4%).

Critical Infrastructure: A significant amount of critical infrastructure is located within the West Sacramento study area. Critical infrastructure is a term used by governments to describe assets that are essential for the functioning of a society and economy from a national perspective. Most commonly associated with the term are fire stations, police stations, hospitals, senior living facilities, and prisons. Alternative 5 removes a significant proportion of the critical infrastructure from the floodplain.

Evacuation Routes: The City of West Sacramento's evacuation maps were last updated in 2009. In their plan they have identified flood stage actions, public notification procedures, temporary shelters for children and special needs adults, and an evacuation checklist. The City has provided maps detailing evacuation routes and temporary shelter locations. The City of West Sacramento distributes quarterly news letters to its residents to keep them informed of all current emergency information.

Flood preparedness is a common topic in local media. The local emergency management offices often send out information about what to do in preparation for an emergency. The City of West Sacramento's public website provides emergency preparedness information, emergency evacuation procedures, and links to the appropriate County, State and Federal agencies responsible for emergency preparedness.

There are several evacuation routes out of the city of West Sacramento. Interstate 80, three lanes in each direction, can be taken either east (to Sacramento) or west (towards Davis). Business 80/State Highway 50, which are four lanes in each direction, can be taken east (to Sacramento). The I Street and Tower Bridges (one and two lanes in each direction, respectively) can be taken east (to Sacramento). North Harbor Boulevard, one lane in each direction, can be taken northwest across the Sacramento Weir to the area north of the Sacramento Bypass. Jefferson Boulevard or South River Road, both one lane in each direction, can be taken south to the area south of the cross levee. In total, there are 16 assigned lanes going out of West Sacramento, which is a large number compared to other locations in the Central Valley of California.

Wise Use of Floodplains: A determination must be made as to whether the increase in potentially developable floodplain area is acceptable under Corps policy, or can be avoided or mitigated to an acceptable level within a justified cost. It is important to remember that the floodplain metric used in this assessment is a simple index based on physical parameters. The metric does not attempt to forecast future population growth, economic conditions, or government decisions that will constrain future floodplain development. Those factors should be considered in conjunction with the metric.

Without-Project and With-Project Comparison

An assessment of the beneficial and adverse effects associated with the without-project condition and the tentatively selected plan (with-project condition) was made. The social effects of the alternatives have both direct and indirect effects. Direct effects come from construction of the projects, whereas indirect effects come from the effects of the project on the existing social landscape. The alternatives are characterized using descriptors related to magnitude (number of individuals affected), location (concentration of effects), timing and duration (when the effects will start and how long they are expected to last), and associated risks. Table 6 provides a description of the effects of the without-project condition and Alternative 5.

Table 6: Effects of Alternatives

	Without-Project	**Alternative 5**
Alternative Description		
	No project is constructed by the Federal government	Improvements to the Yolo Bypass (east levee), DWSC (west levee), Sacramento River (north and south levees), South Cross Levee, and port (north and south levees) are made
Other Social Effects (OSE)		
Summary	Continued flood risk and high potential consequences in the West Sacramento study area	Life safety residual risk is significantly reduced
Population at Risk (PAR)	Approximately 48,000 people are at high risk from a 1% ACE flood	The risk from a 1% ACE flood is significantly reduced for all of the approximately 48,000 West Sacramento residents
Loss of Life	Potential loss of life: 106	Potential loss of life: 35
Critical Infrastructure	76 critical infrastructure at risk	41 critical infrastructure at risk
Evacuation Routes	No evacuation routes available if flood event occurs	11 evacuation routes available in the event of a flood
Wise Use of Floodplains	0 available acres	About 3,900 acres of land would be available for future development
Social Vulnerability	The community may be characterized as having a medium level of social vulnerability based on the social vulnerability indicators presented in Table 2	Flood risk to the West Sacramento community is reduced, and social vulnerability is minimized due to the decrease in chance of a flood occurring
Residual Risk and Consequences	Residual risk remains high throughout the study area.	Residual risk for life safety is significantly reduced.

C. REGIONAL ECONOMIC DEVELOPMENT (RED)

Purpose and Methodology

The U.S. Army Corps of Engineers (USACE) *Planning Guidance Notebook* (ER 1105-2-100) states that while the National Economic Development (NED) and Environmental Quality (EQ) accounts are required, display of the Regional Economic Development (RED) effects are discretionary. The Corps' NED procedures manual affirms that RED benefits are real and legitimate; however, the concern (from a Federal perspective) is that they are often offset by RED costs in other regions. Nevertheless, for the local community these benefits are important and can help them in making their preferred planning decisions.

Although the RED account is often examined in less detail than NED, it remains useful. For example, Hurricane Katrina caused a significant economic hardship to not just the immediate Gulf Coast but for entire counties, watersheds, and the state of Louisiana. Besides the devastating damage to homes (which are often captured by the NED account), hundreds of thousands of people lost their jobs, property values fell, and tourism and tax revenues declined significantly and were transferred to other parts of the U.S. In this example, the RED account can provide a better depiction of the overall impact to the region.

The distinction between NED and RED is a matter of perspective, not economics. A non-federal partner may consider the impacts at the state, regional, and local levels to be a true measure of a project's impact or benefit, whereas from the Corps' perspective, this may not constitute a national benefit. Gains in RED to one region may be partially or wholly offset by losses elsewhere in the nation. For example, if a Federal project enables a firm to leave one state to relocate to a newly-protected floodplain of another state, the increase in regional income for the project area may come at the expense of the former area's loss. In this case, there is no net increase in the value of the nation's output of goods and services and should be excluded from NED computations.

The following sections describe the impacts of Alternative 5 from a regional perspective. The impacts were evaluated using the Corps' certified RECONS software.

Key RED Concepts

Econometric analysis allows for the evaluation of a full range of economic impacts related to specific economic activities by calculating effects of the activities in a specific geographic area. These effects are:

- Direct effects, which consist of economic activity contained exclusively within the designated sector. This includes all expenditures made by the companies or organizations in the industry and all employees who work directly for them.
- Indirect effects, which define the creation of additional economic activity that results from linked business, suppliers of goods and services, and provisions of operating inputs.
- Induce effects, which measure the consumption expenditures of direct and indirect sector employees.

Input-output (I/O) models are characterized by their ability to evaluate the effects of industries on each other. Unlike most typical measures of economic activity that examine only the total output of an industry or the final consumption demand provided by a given output, I/O models provide a much more comprehensive view of the interrelated economic impacts. I/O analysis is based on the notion that there is a fundamental relationship between the volume of output of an industry and the volume of the various inputs used to produce that output. Industries are often grouped into production, distribution, transportation, and consumption categories. Additionally, the I/O model can be used to quantify the multiplier effect, which refers to the idea that an increase in spending can lead to an even greater increase in income and consumption, as monies circulate (or multiply) throughout the economy.

Flood Risk Management RED Considerations

There are particular effects for each type of project improvement as they relate to the RED account. The estimation of RED flood-related effects can be very complex. At a minimum, the RED analysis should include a qualitative description of the types of businesses at risk from flooding, particularly those that could have a significant adverse impact (output, employment, etc.) upon the community or regional economies if their operations should be disrupted by flooding and how this would be affected by the recommended project. The potential RED effects to flood risk management projects are summarized in Table 7 below.

Table 7: Potential RED Effects to Flood Risk Management

RED Factor	Potential RED Effects
Construction	Additional construction related activity and resulting spillovers to suppliers
Revenues	Increased local business revenues as a consequence of reduced flooding, particularly from catastrophic floods
Tax Revenues	Increased income and sales taxes from the direct project and spillover industries
Employment	Short-term increase in construction employment; with catastrophic floods, significant losses in local employment (apart from the debris and repair businesses, which may show temporary gains)
Population Distribution	Disadvantage groups may benefit from the creation of a flood-free zone
Increased Wealth	Potential increase in wealth for floodplain residents as less is spent on damaged property, repairs, etc.; potential increase in property values.

RECONS Software

A variety of software programs are available to measure the RED impacts of a project. The Corps of Engineers' Institute for Water Resources (IWR) along with the Louis Berger Group has developed a regional economic impact modeling tool called Regional Economic System (RECONS) that computes estimates of regional and national job creation, retention, and other economic measures. The expenditures made by the USACE for various services and products generate economic activity that can be measured in jobs, income, sales, and gross regional product. The software automates calculations and generates estimates of economic measures associated with USACE's annual civil works program spending. RECONS was built by extracting multipliers and other economic measures from more than 1,500 regional economic models that were built specifically for USACE's project locations by the Minnesota IMPLAN Group. These multipliers were then imported into a database. The software ties various spending profiles to the matching industry sectors by location to produce economic impact estimates. The RECONS program is used to document the performance of direct investment spending of the USACE, and allows users to evaluate project and program expenditures associated with annual expenditures.

RECONS Inputs and Outputs

The economic impacts presented below show the West Sacramento study area and the state of California's interrelated economic impacts resulting from an injection of flood risk management construction funds. For this assessment, the study area and the state of California were both used as the geographic designation to assess the overall impacts to the regional economy from constructing Alternative 5. This places a frame around the economic impacts where the activity is internalized; leakages, which are payments made to imports or value added sectors that do not in turn re-spend the dollars within the area, are not included in the total impacts.

Table 8 summarizes the complex nature of the regional economy of the Sacramento/Arden/Arcade/Roseville, CA Metropolitan Statistical Area (MSA), which includes El Dorado, Placer, Sacramento, and Yolo counties and a population of approximately 2.2 million. There are approximately 1.2 million people employed in the MSA who provide an output to the nation worth over $158 billion annually.

Table 8: Regional Profile – Sacramento/Arden/Arcade/Roseville, CA MSA (Dollar Values in $Millions, October 2013 Price Level)

Industry	Output	Labor Income	GRP	Employment
Accommodations and Food Service	$4,522	$1,562	$2,384	75,155
Administrative and Waste Management Services	$4,072	$2,145	$2,665	67,557
Agriculture, Forestry, Fishing and Hunting	$1,526	$388	$671	11,783
Arts, Entertainment, and Recreation	$1,594	$489	$751	21,054
Construction	$12,733	$5,471	$5,999	82,970
Education	$4,254	$3,367	$3,811	66,272
Finance, Insurance, Real Estate, Rental and Leasing	$23,202	$5,878	$14,551	118,760
Government	$21,059	$17,612	$19,940	241,383
Health Care and Social Assistance	$10,710	$6,058	$7,029	103,062
Imputed Rents	$12,558	$2,011	$8,153	65,011
Information	$7,646	$1,442	$3,075	20,698
Management of Companies and Enterprises	$2,040	$876	$1,172	10,242
Manufacturing	$19,269	$3,263	$4,460	39,136
Mining	$562	$129	$344	1,087
Professional, Scientific, and Technical Services	$12,918	$6,688	$7,771	89,771
Retail Trade	$9,491	$4,062	$6,519	123,095
Transportation and Warehousing	$3,686	$1,470	$2,176	27,064
Utilities	$1,103	$243	$672	1,635
Wholesale Trade	$5,344	$2,022	$3,467	30,383
Total	**$158,286**	**$65,176**	**$95,610**	**1,196,119**

Input Costs: The total remaining costs of Alternative 5 is $1,430,768,000 (none of the costs have been expended). The RED analysis requires the adjustment of costs for two items: (1) interest during construction (IDC) and (2) purchase of land. Interest during construction is used in the NED analysis to estimate the opportunity cost of using money for one economic endeavor (e.g., building a FRM project) instead of another (e.g., building a bullet train); IDC is not actually expended within the region and therefore is not included in the RED analysis. Similarly, the purchase of land, not including administrative costs, is considered a transfer payment from one party to another and therefore is also not included in the RED analysis.

Table 9 is based on the average annual regional expenditures that are expected over the construction period. The construction period for Alternative 5 is assumed to be 17 years. Over that period, a total of about $1.43 billion is anticipated to be spent in the West Sacramento study area in order to build Alternative 5. The average construction expenditure is $84 million, which is the anticipated amount ($1.43 billion) divided by the number of years of construction (17).

Table 9: Inputs Assumptions, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2013 Price Level)

Category	Spending	Spending Amount	Local Percentage Capture		
		Alternative 5	Local	State	National
Aggregate Materials	10%	140,215,264	70	77	97
Other Materials	1%	17,169,216	99	100	100
Equipment	35%	500,768,800	69	99	100
Construction Labor	54%	772,614,720	100	100	100
Total	100%	1,430,768,000	NA	NA	NA

<u>RECONS Outputs</u>: Direct expenditures expected for construction of earthen levees are spent primarily in two sectors of the economy, construction labor and equipment. Both accounts for 89% of the total project expenditures. Local capture rates are computed in RECONS to show where the output from expenditures is realized. As indicated in Table 9, all of the construction labor is expected to occur within the Sacramento/Arden/Arcade/Roseville MSA; 69% of the equipment is expected to be provided from within the study area and 99% from within the state of California.

Table 10 summarizes the overall economic impacts for this analysis. The USACE is planning to expend approximately $1.4 billion on the project. Of this total project expenditure, approximately $1.2 billion will be captured within the regional impact area. The rest will be leaked out to the state of California or the nation. The expenditures made by the USACE for various services and products are expected to generate additional economic activity, which can be measured in jobs, income, sales, and GRP as summarized in Tables 10.

Table 10: Summary of Economic Impacts, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2013 Price Level)

Total Spending		Alternative 5		
		Regional	State	National
		$1,430,768,000	$1,430,768,000	$1,430,768,000
Direct Impact	**Output**	$1,235,141,897	$1,393,626,327	$1,425,636,669
	Jobs	19,500	20,070	20,285
	Labor Income	$901,354,589	$944,258,549	$958,194,300
	GRP	$1,019,915,998	$1,107,995,027	$1,125,752,934
Total Impact	**Output**	$2,270,119,496	$2,803,213,863	$3,764,418,117
	Jobs	27,035	30,022	35,423
	Labor Income	$1,254,412,176	$1,429,427,754	$1,741,319,203
	GRP	$1,647,818,323	$1,948,927,779	$2,483,073,305

Table 11: Economic Impacts – Regional Level, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2013 Price Level)

Industry Sector		Alternative 5			
		Sales	Jobs	Labor Income	GRP
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$54,698,742	407	$20,261,641	$26,294,772
	Wholesale trade businesses	$1,519,623	9	$579,093	$1,147,878
	Transport by rail	$3,293,446	9	$1,118,262	$1,819,889
	Transport by water	$616,712	1	$124,820	$276,789
	Transport by truck	$38,718,199	310	$17,239,150	$20,846,459
	Construction of other new nonresidential structures	$17,018,212	102	$6,860,910	$8,663,727
	Commercial & industrial machinery & equipment rental/leasing	$346,662,242	1,156	$82,555,993	$188,251,765
	Labor	$772,614,720	17,507	$772,614,720	$772,614,720
Total Direct Effects		$1,235,141,897	19,501	$901,354,589	$1,019,915,998
Secondary Effects		$1,034,977,599	7,534	$353,057,587	$627,902,325
Total Effects		**$2,270,119,496**	**27,035**	**$1,254,412,176**	**$1,647,818,323**

Table 12: Economic Impacts – State Level, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2013 Price Level)

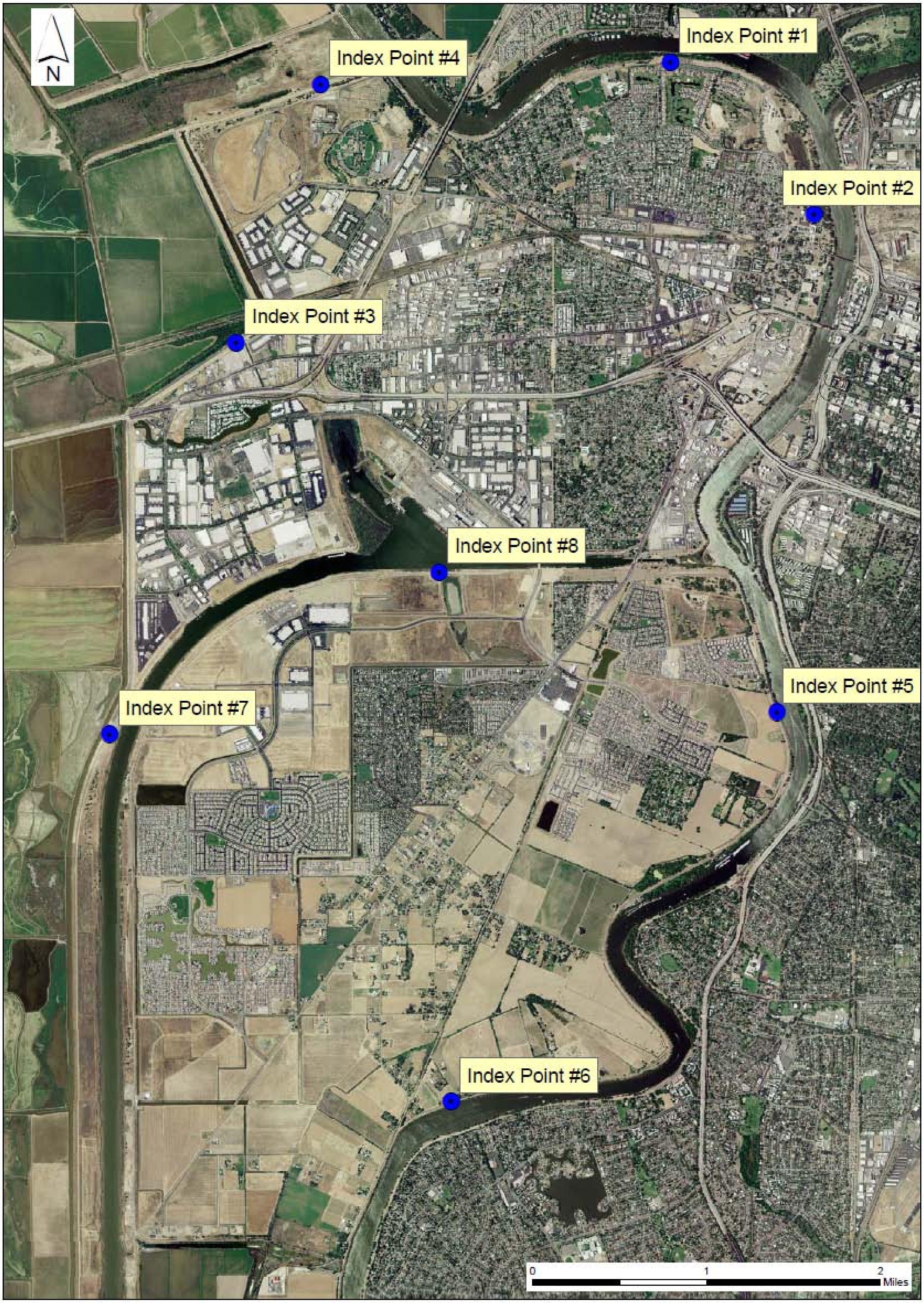
Industry Sector		Alternative 5			
		Sales	**Jobs**	**Labor Income**	**GRP**
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$54,698,742	407	$20,261,641	$26,294,772
	Wholesale trade businesses	$2,103,300	12	$835,886	$1,602,354
	Transport by rail	$3,293,446	9	$1,118,262	$1,819,889
	Transport by water	$1,089,916	2	$220,806	$489,169
	Transport by truck	$47,325,797	379	$21,141,407	$25,538,950
	Construction of other new nonresidential structures	$17,169,216	102	$6,922,666	$8,741,323
	Commercial & industrial machinery & equipment rental/leasing	$495,331,189	1,651	$121,143,162	$270,893,850
	Labor	$772,614,720	17,507	$772,614,720	$772,614,720
Total Direct Effects		$1,393,626,327	20,071	$944,258,549	$1,107,995,027
Secondary Effects		$1,409,587,536	9,952	$485,169,205	$840,932,752
Total Effects		**$2,803,213,863**	**30,023**	**$1,429,427,754**	**$1,948,927,779**

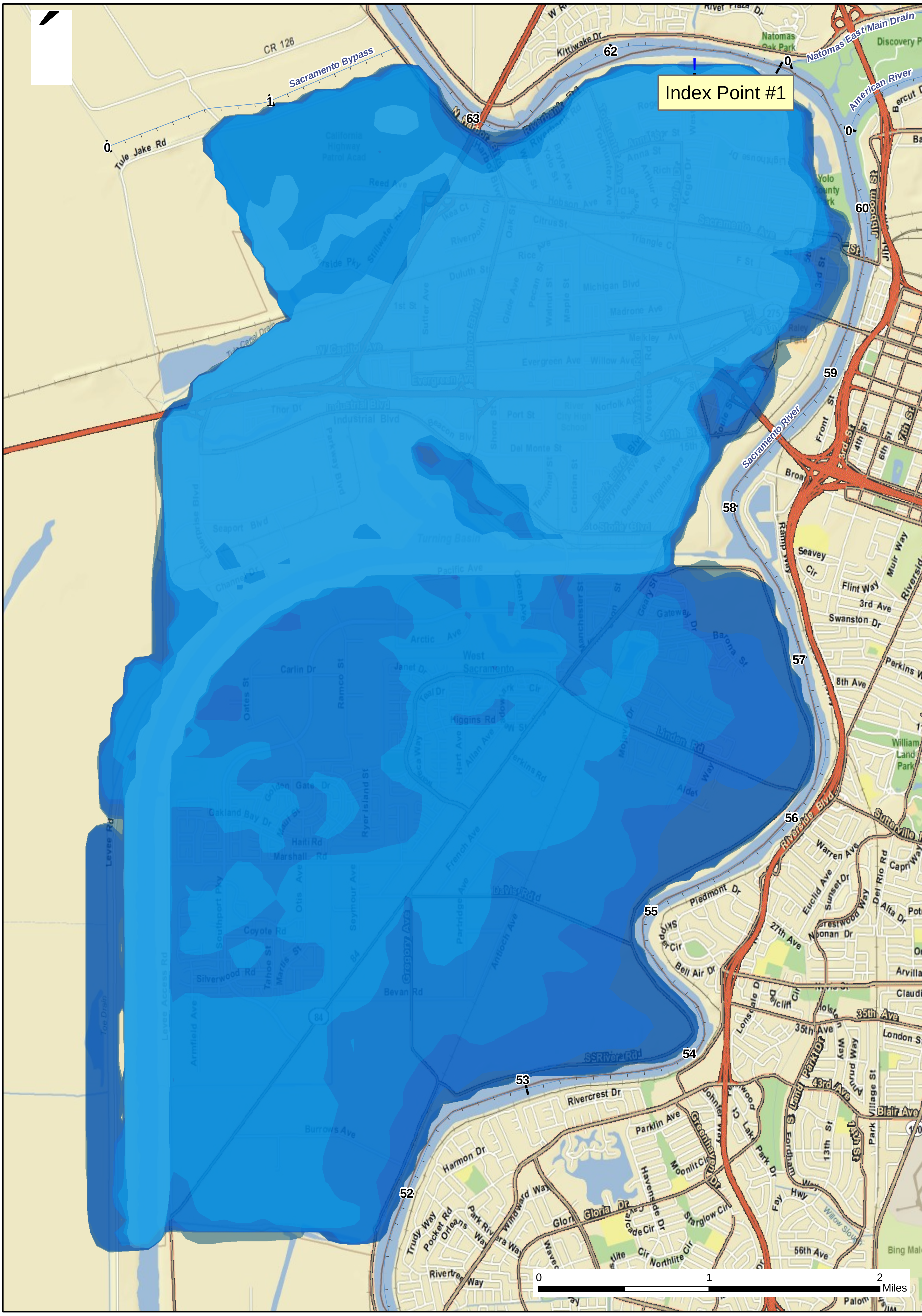
Table 13: Economic Impacts – National Level, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2013 Price Level)

Industry Sector		Alternative 5			
		Sales	**Jobs**	**Labor Income**	**GRP**
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$77,830,897	580	$30,917,751	$39,196,808
	Wholesale trade businesses	$2,131,818	13	$848,432	$1,624,559
	Transport by rail	$4,077,955	12	$1,384,636	$2,253,392
	Transport by water	$1,578,561	3	$321,845	$708,479
	Transport by truck	$50,196,275	402	$22,442,739	$27,103,811
	Construction of other new nonresidential structures	$17,169,216	103	$6,922,666	$8,741,323
	Commercial & industrial machinery & equipment rental/leasing	$500,037,227	1,667	$122,741,512	$273,509,842
	Labor	$772,614,720	17,507	$772,614,720	$772,614,720
Total Direct Effects		$1,425,636,669	20,285	$958,194,300	$1,125,752,934
Secondary Effects		$2,338,781,448	15,138	$783,124,903	$1,357,320,371
Total Effects		**$3,764,418,117**	**35,423**	**$1,741,319,203**	**$2,483,073,305**

The creation of jobs in the study area is important to note. In 2010, the unemployment rate in the study area (12.4%) was higher than the state (7.1%) average; the number of jobs gained within the region demonstrates the multiplier effect of the infusion of construction funds for this project.

ENCLOSURE 1
FLOODPLAINS





Legend

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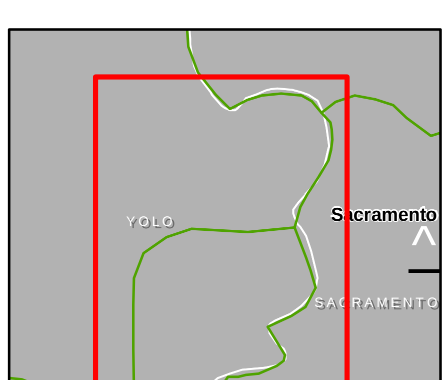
10-yr Sac Break IP 1	200-yr Sac Break IP 1
25-yr Sac Break IP 1	500-yr Sac Break IP 1
50-yr Sac Break IP 1	

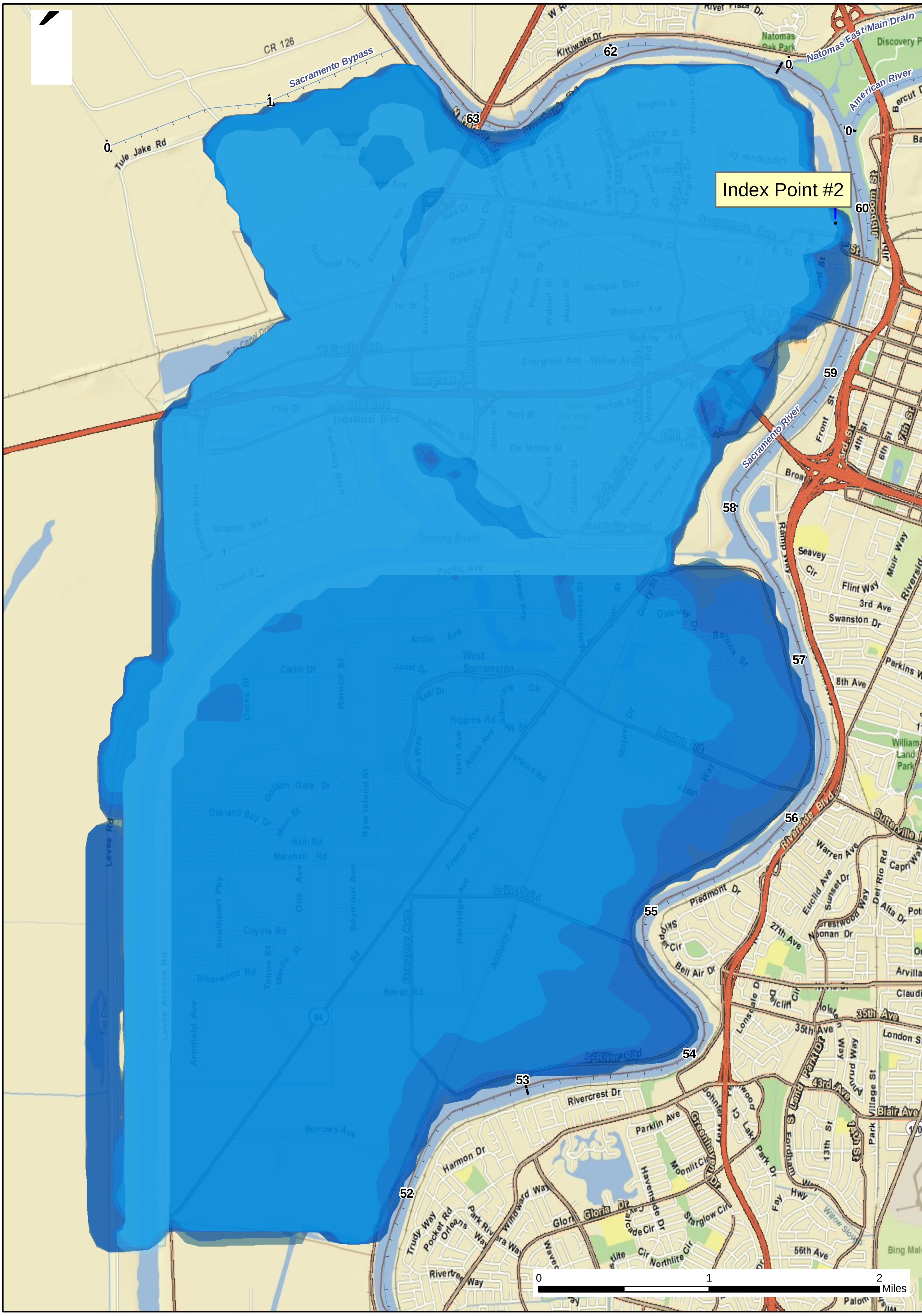


West Sacramento GRR
Yolo, Solano Counties, California

2-Yr Thru 500-yr Floodplains
Index Point 1
Sacramento River RM 61

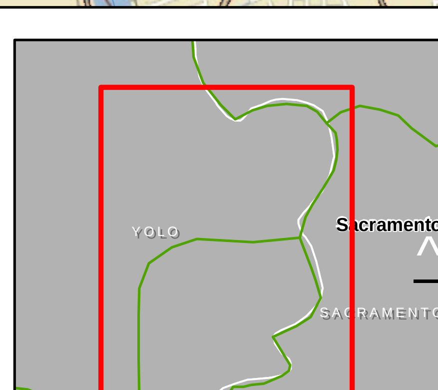
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2011 Prepared by J.S.M and J.J.S. PLATE 1



Legend

2-yr Sac Break IP 2	100-Yr Sac Break IP 2
10-Yr Sac Break IP 2	200-Yr Sac Break IP 2
25-Yr Sac Break IP 2	500-Yr Sac Break IP 2
50-Yr Sac Break IP 2	



West Sacramento GRR
Yolo, Solano Counties, California

2-Yr Thru 500-yr Floodplains
Index Point 2
Sacramento River RM 60

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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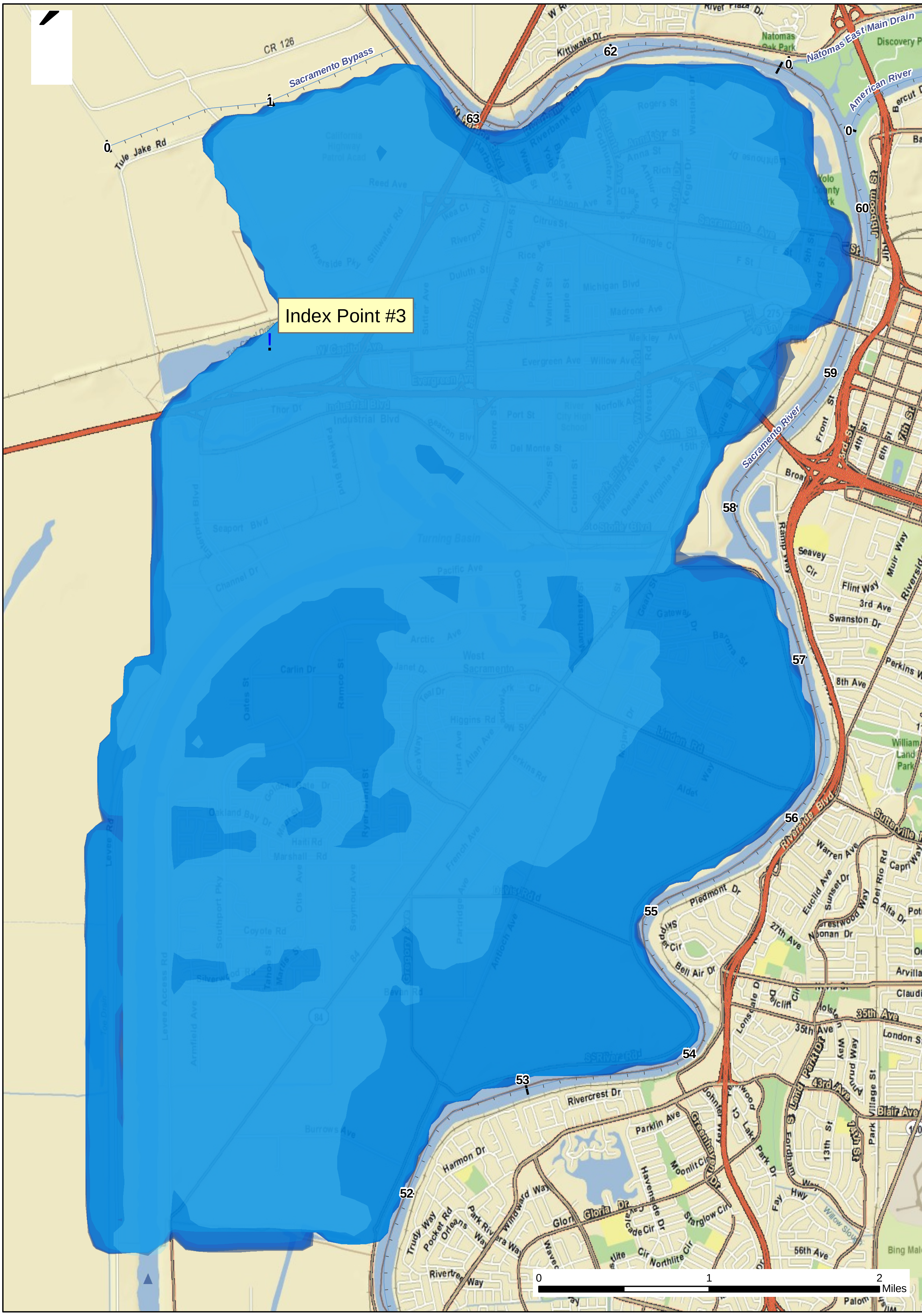
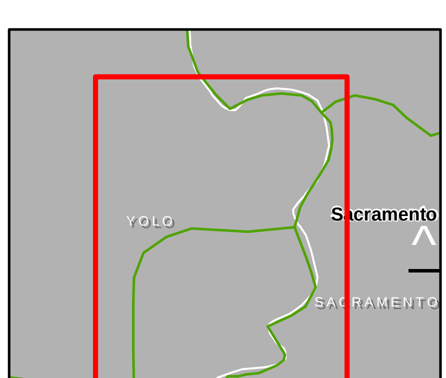


Legend

2-Yr Yolo Break IP 3	100-Yr Yolo Break IP 3
10-Yr Yolo Break IP 3	200-Yr Yolo Break IP 3
25-Yr Yolo Break IP 3	500-Yr Yolo Break IP 3
50-Yr Yolo Break IP 3	



West Sacramento GRR
Yolo, Solano Counties, California

2-Yr Thru 500-yr Floodplains
Index Point 3
Yolo Bypass RM 42.6

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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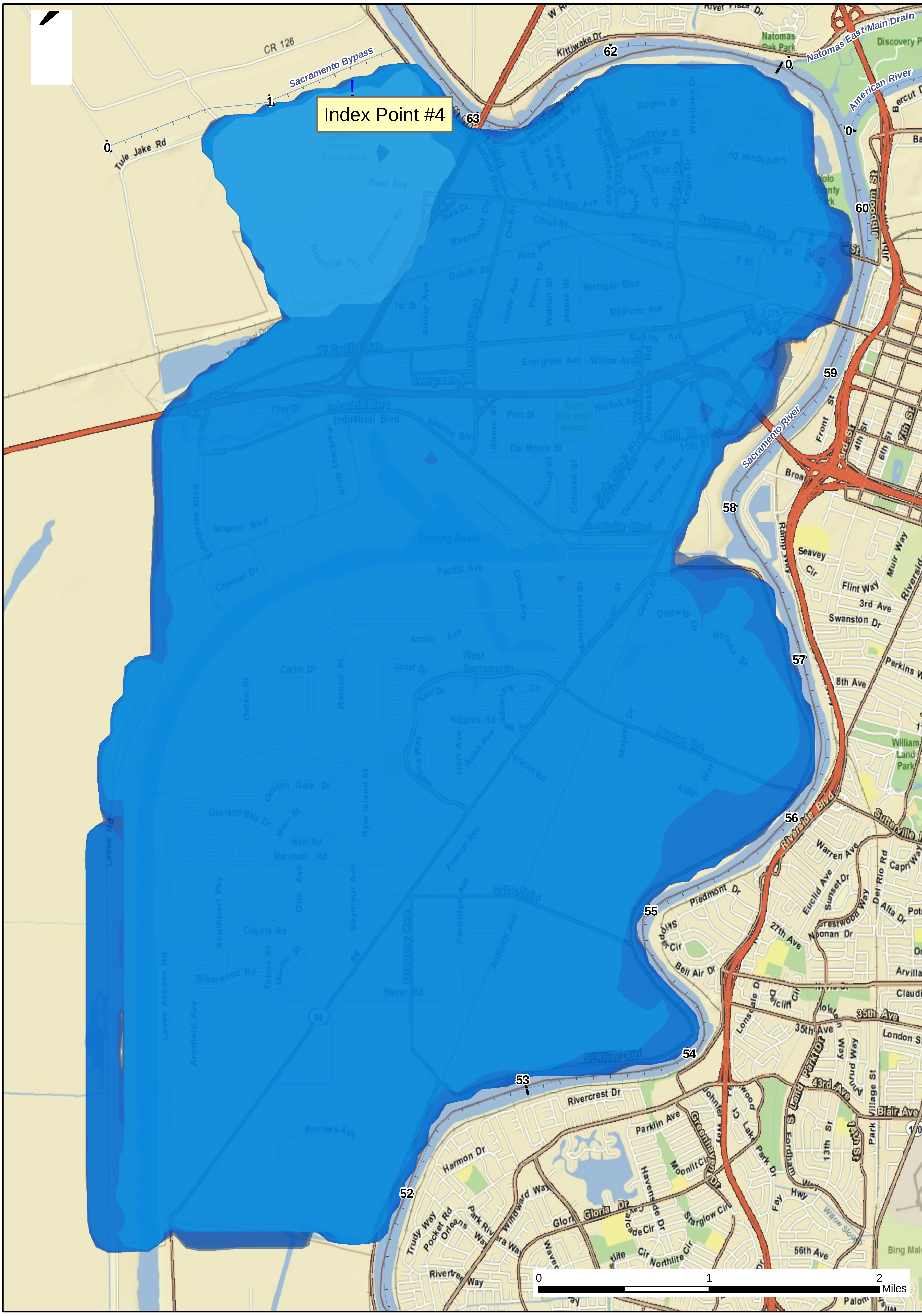

Legend

2-Yr Sac Byp Break IP 4	100-Yr Sac Byp Break IP 4
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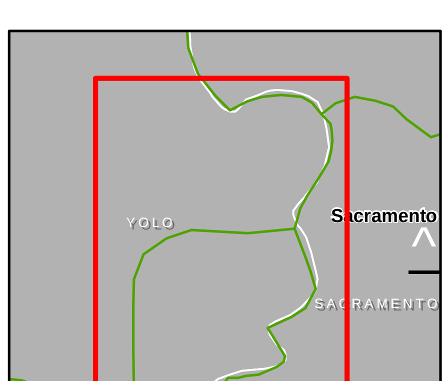
25-Yr Sac Byp Break IP 4	500-Yr Sac Byp Break IP 4
50-Yr Sac Byp Break IP 4	



West Sacramento GRR
Yolo, Solano Counties, California

2-Yr Thru 500-yr Floodplains
Index Point 4
Sacramento Bypass RM 1.49

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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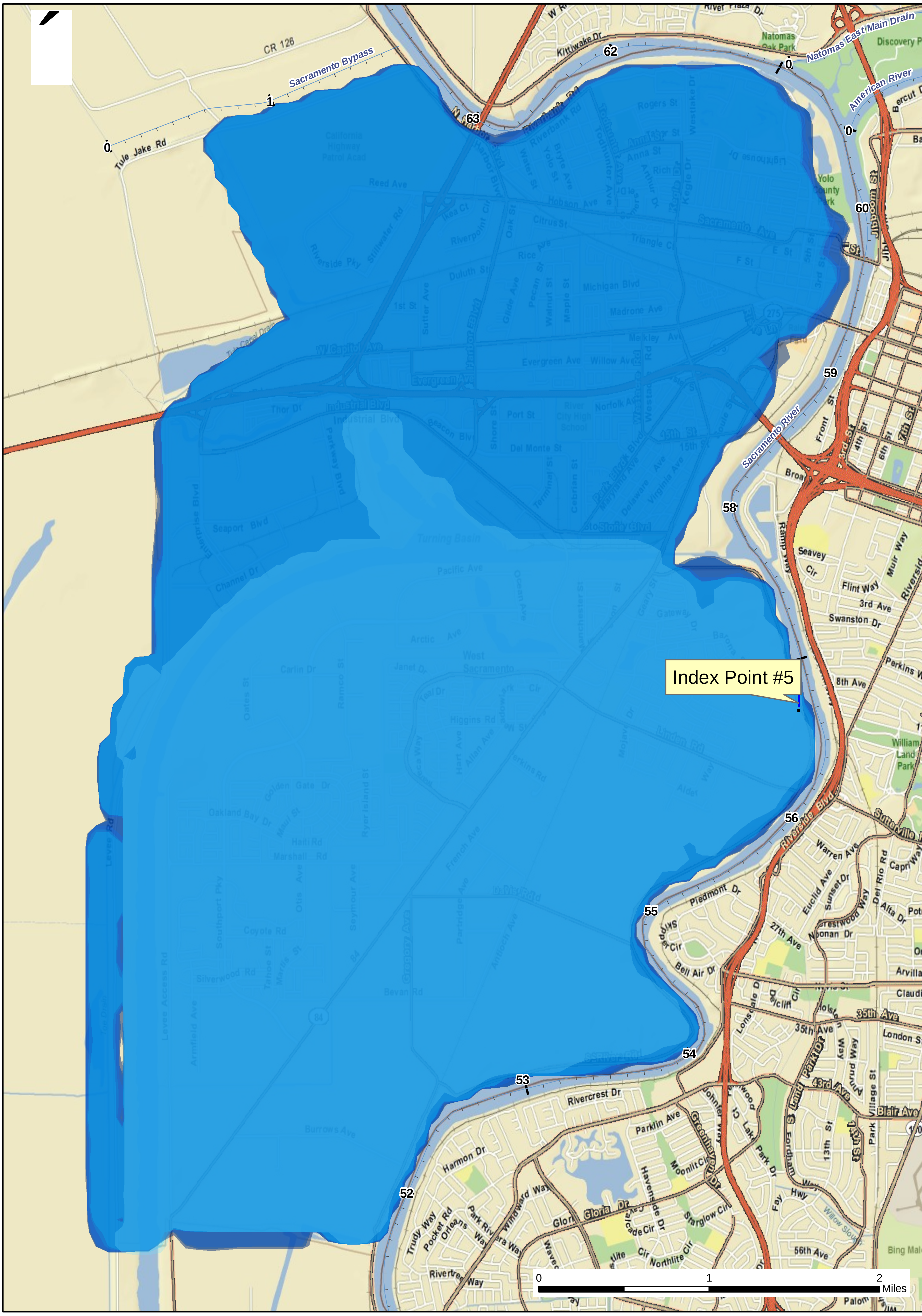
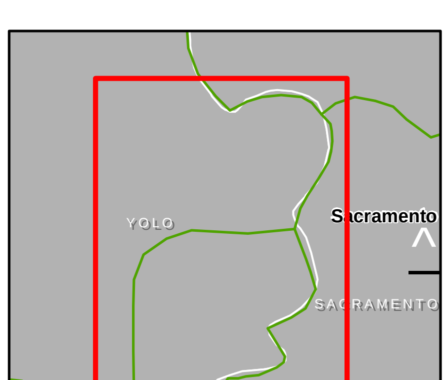


Legend

- 2-yr Sac Break IP 5
- 10-yr Sac Break IP 5
- 25-yr Sac Break IP 5
- 50-yr Sac Break IP 5
- 100-yr Sac Break IP 5
- 200-yr Sac Break IP 5
- 500-yr Sac Break IP 5

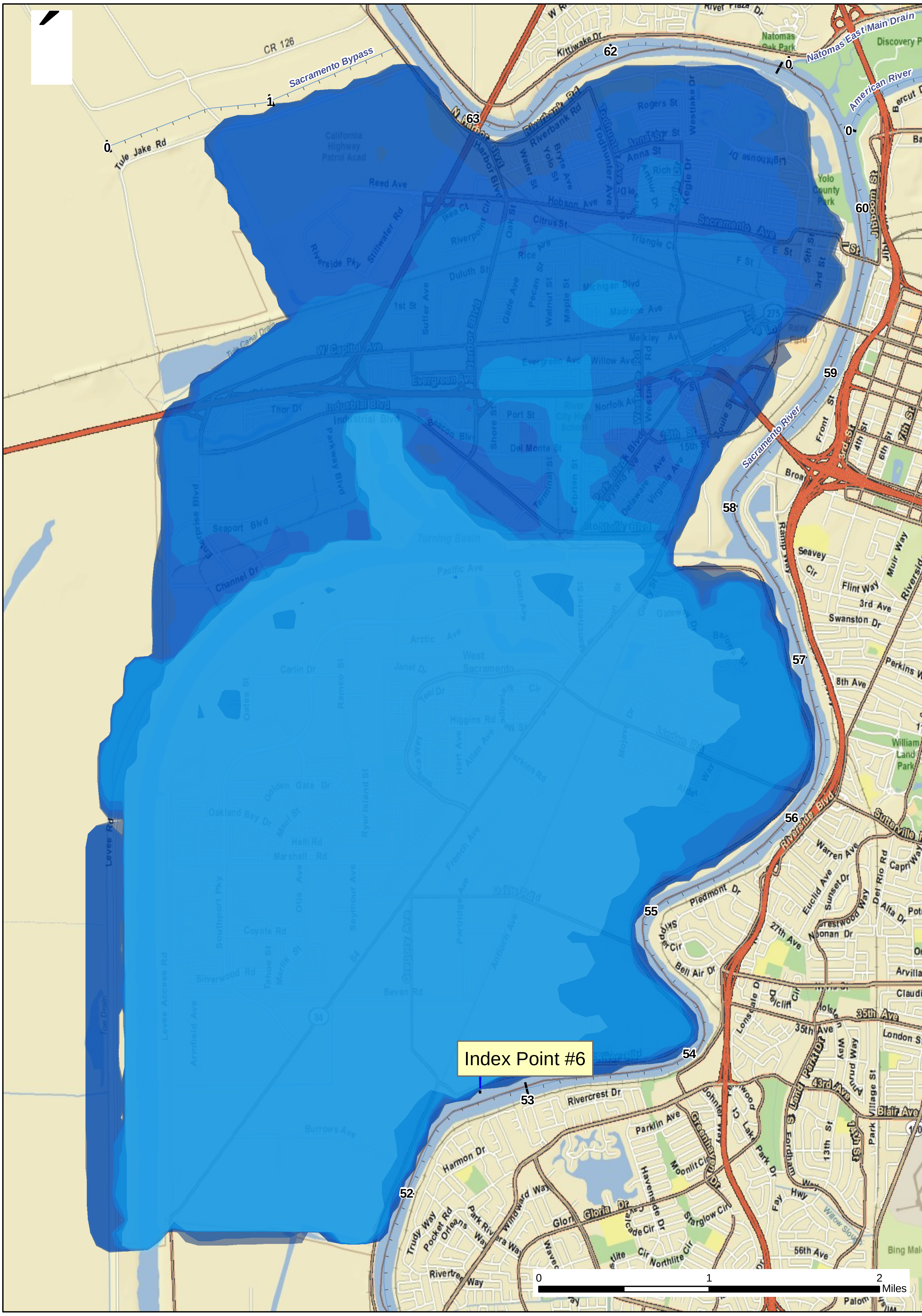


West Sacramento GRR
Yolo, Solano Counties, California

2-Yr Thru 500-yr Floodplains
Index Point 5
Sacramento River RM 56.75

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2011 Prepared by J.S.M and J.J.S.



Legend

- 2-Yr Sac Break IP 6
- 10-Yr Sac Break IP 6
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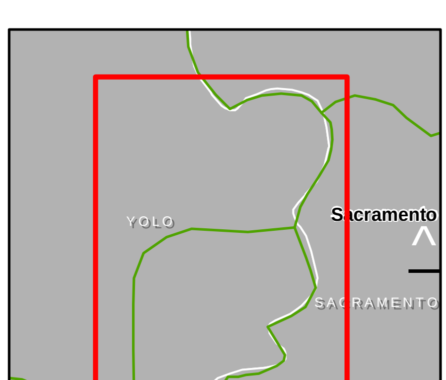
- 500-Yr Sac Break IP 6

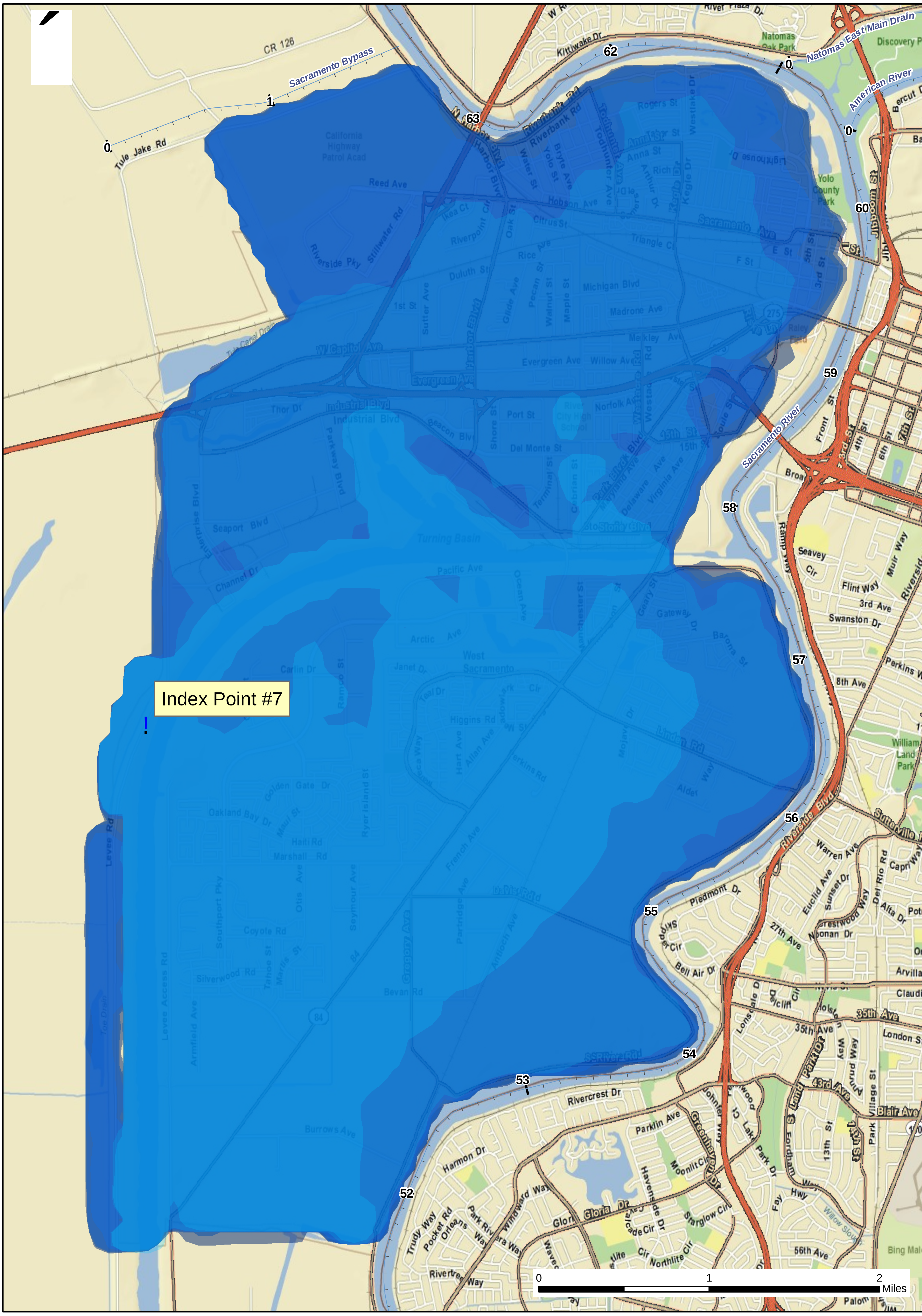


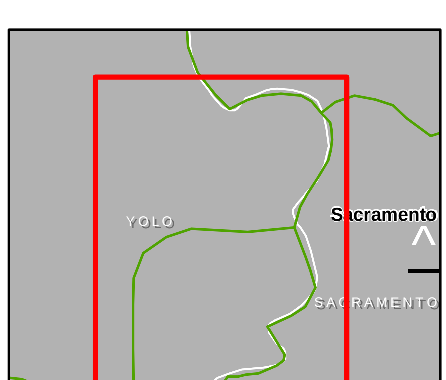
West Sacramento GRR
Yolo, Solano Counties, California

2-Yr Thru 500-yr Floodplains
Index Point 6
Sacramento River RM 52.7

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2011 Prepared by J.S.M and J.J.S. PLATE 1





Legend

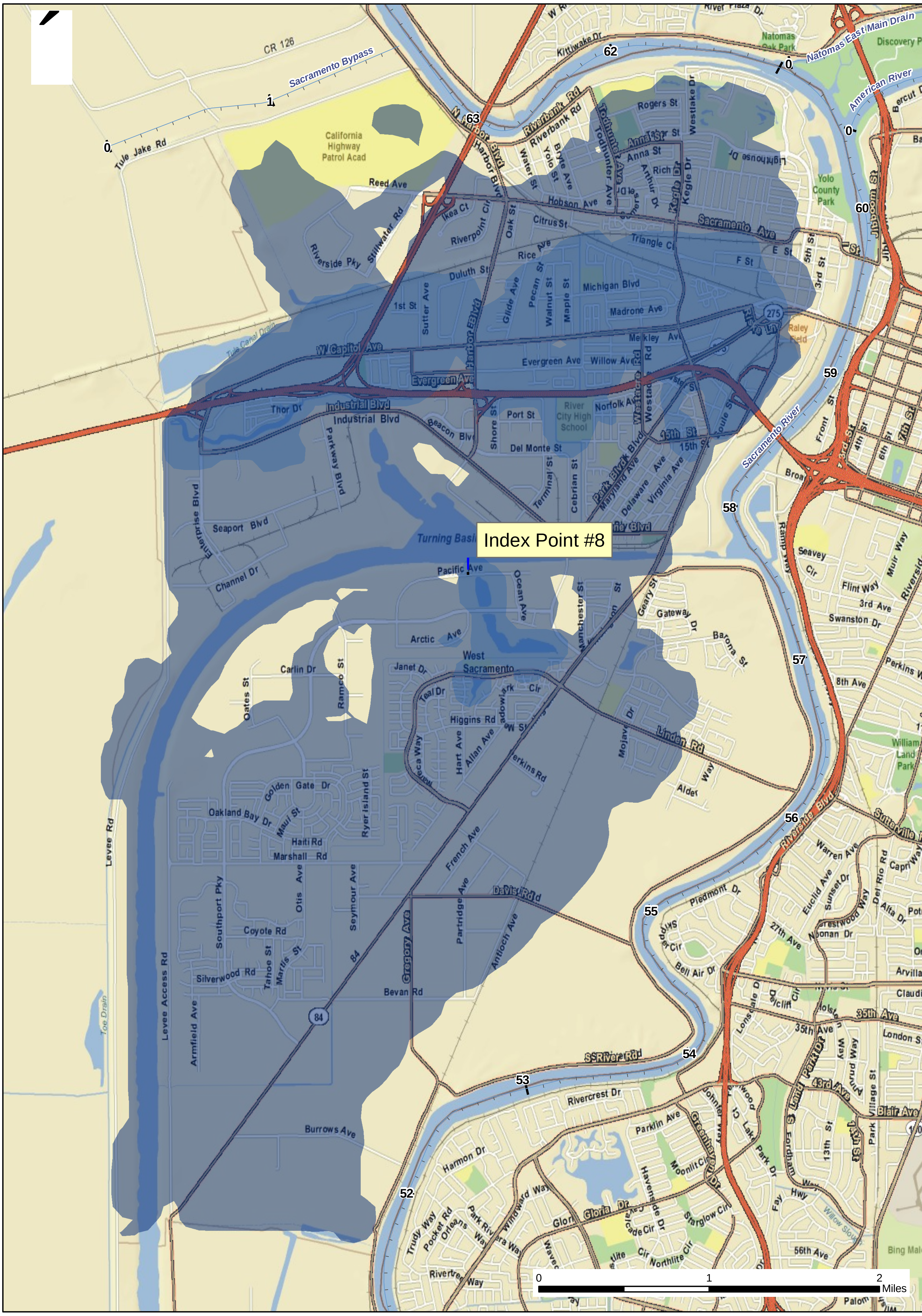
10-Yr Yolo Break IP 7	100-yr Yolo Break IP 7
25 Yr Yolo Break IP 7	200-Yr Yolo Break IP 7
50-Yr Yolo Break IP 7	500-Yr Yolo Break IP 7

West Sacramento GRR
Yolo, Solano Counties, California

2-Yr Thru 500-yr Floodplains
Index Point 7
Yolo Bypass RM 40.95

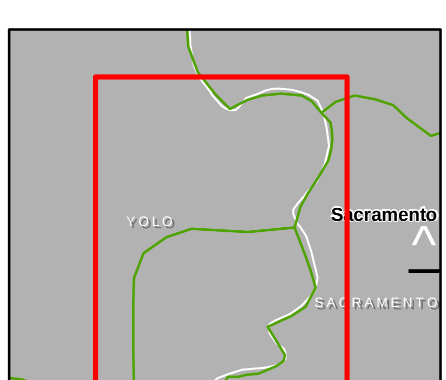
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2011 Prepared by J.S.M and J.J.S. PLATE 1



Legend

(dark blue)	500-Yr Sac DWSC Break IP 8
(blue)	200-Yr Sac DWSC Break IP 8



West Sacramento GRR
Yolo, Solano Counties, California

2-Yr Thru 500-yr Floodplains
Index Point 8
Sacramento DWSC RM 43.75

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

FEB 2011 Prepared by J.S.M and J.J.S. PLATE 1

West Sacramento Without Project Condition Risk Inputs ("n"YRSAC_NA3_3)

IP:1 Sac Riv, RM 61.4986 (Model TOL = 43.2')				
Without Project				
Frequency	Inflow	Adjusted Outflow	Q Total (Model)	Stage NAVD '88
1yr = .999	N/A	N/A		27.00
2yr = .5	N/A	N/A	66936.3	29.63
10yr = .1	N/A	N/A	26073.52	30.78
25yr = .04	N/A	N/A	-1223.5	33.49
50yr = .02	N/A	N/A	792.87	34.03
100yr = .01	N/A	N/A	4573.9	34.71
200yr = .005	N/A	N/A	-16234.2	36.17
500yr = .002	N/A	N/A	-71592.7	38.20
Equivalent Record Length = 71				

LEVEE PERFORMANCE CURVE	
NAVD 88 Elevation	Pr(f)
26	0
29	0.039
32	0.077
35	0.239
38	0.536
41	0.953

IP:4 Sac Bypass, RM 1.49 (Model TOL =36.82')				
Without Project				
Frequency	Inflow	Adjusted Outflow	Q Total (Model)	Stage NAVD '88
1yr = .999	141500	0		20.65
2yr = .5	197300	0	100	21.61
10yr = .1	328800	35858	65841	28.59
25yr = .04	448700	76374	107329	31.87
50yr = .02	475700	101301	111202	32.52
100yr = .01	545800	117399	115011	33.28
200yr = .005	635700	156687	138930	34.69
500yr = .002	911400	180775	183293	36.41
Equivalent Record Length = 71				

LEVEE PERFORMANCE CURVE	
NAVD 88 Elevation	Pr(f)
21.97	0
29.97	0
35.97	0
37.97	0.012
39.97	0.042
42.37	0.459

IP:7 Yolo Bypass, RM 40.95 (Model TOL = 32.83)				
Without Project				
Frequency	Inflow	Adjusted Outflow	Q Total (Model)	Stage NAVD '88
1yr = .999	139200	0		20.43
2yr = .5	200100	107259	105596	21.11
10yr = .1	343600	272803	297133	26.44
25yr = .04	458700	410491	443123	29.21
50yr = .02	492200	483135	482828	29.96
100yr = .01	552000	552770	534892	30.85
200yr = .005	646600	631168	602885	31.89
500yr = .002	928700	692678	673392	32.92
Equivalent Record Length = 72				

LEVE PERFORM
NAVD 88 Elevation
9.5
15.5
19.5
24.5
29.5
34.5

IP:2 Sac R, RM 59.9979 (Model TOL = 42.4 ')				
Without Project				
Frequency	Inflow	Adjusted Outflow	Q Total (Model)	Stage NAVD '88
1yr = .999	166900	80000		26.38
2yr = .5	224300	91314	94639	29.23
10yr = .1	359600	98397	101171	30.55
25yr = .04	525300	103479	115649	33.3
50yr = .02	551700	113351	118221	33.85
100yr = .01	666700	121560	121799	34.54
200yr = .005	939900	143491	131092	36.02
500yr = .002	1133400	180634	158047	38.12
Equivalent Record Length = 73				

LEVEE PERFORMANCE CURVE	
NAVD 88 Elevation	Pr(f)
28	0
32	0.039
34	0.077
36	0.183
38	0.437
40	0.922

IP:5 Sac Riv, RM 56.75 (Model TOL = 41.74)				
Without Project				
Frequency	Inflow	Adjusted Outflow	Q Total (Model)	Stage NAVD '88
1yr = .999	166900	80000		24.52
2yr = .5	224300	91306	94631	27.82
10yr = .1	359600	98329	100694	29.13
25yr = .04	525300	103421	115584	31.84
50yr = .02	551700	113323	118179	32.42
100yr = .01	666700	121448	121792	33.09
200yr = .005	939900	135024	130652	34.54
500yr = .002	1133400	146336	148644	36.51
Equivalent Record Length = 73				

LEVEE PERFORMANCE CURVE	
NAVD 88 Elevation	Pr(f)
19.63	0
27.63	0.024
30.63	0.034
34.63	0.223
38.63	0.493
40.63	0.687

IP:8 Sac DWSC, RM 43.412 (MODEL TOL = 22)				
Without Project				
Frequency	Inflow	Adjusted Outflow	Q Total (Model)	Stage NAVD '88
1yr = .999	N/A	N/A	N/A	7.37
2yr = .5	N/A	N/A	N/A	7.68
10yr = .1	N/A	N/A	N/A	12.97
25yr = .04	N/A	N/A	N/A	17.7
50yr = .02	N/A	N/A	N/A	18.64
100yr = .01	N/A	N/A	N/A	19.78
200yr = .005	N/A	N/A	N/A	20.87
500yr = .002	N/A	N/A	N/A	22.27
Equivalent Record Length = 73				

LEVE PERFORM
NAVD 88 Elevation
13
14
16
18
20
21.67

IP:3 Yolo Bypass, RM 42.62 (Model TOL = 34.9')				
Without Project				
Frequency	Inflow	Adjusted Outflow	Q Total (Model)	Stage NAVD '88
1yr = .999	139200	0		20.67
2yr = .5	200100	107711	105994	21.38
10yr = .1	343600	273031	297332	26.86
25yr = .04	458700	410938	443816	29.74
50yr = .02	492200	483545	483412	30.50
100yr = .01	552000	553424	535272	31.41
200yr = .005	646600	631918	603455	32.55
500yr = .002	928700	693250	673943	33.65
Equivalent Record Length = 72				

LEVEE PERFORMANCE CURVE	
NAVD 88 Elevation	Pr(f)
8.12	0
14.12	0
20.12	0.01
26.12	0.169
32.12	0.891
38.12	0.999

IP:6 Sac Riv, RM 52.7474 (Model TOL = 40.03)				
Without Project				
Frequency	Inflow	Adjusted Outflow	Q Total (Model)	Stage NAVD '88
1yr = .999	166900	80000		22.94
2yr = .5	224300	91303	94628	26.23
10yr = .1	359600	98255	100688	27.53
25yr = .04	525300	103394	115489	30.19
50yr = .02	551700	113302	118158	30.77
100yr = .01	666700	121342	121789	31.44
200yr = .005	939900	135009	130614	32.85
500yr = .002	1133400	145927	148530	34.62
Equivalent Record Length = 73				

LEVEE PERFORMANCE CURVE	
NAVD 88 Elevation	Pr(f)
19.02	0
23.02	0.02
27.02	0.04
35.02	0.165
37.02	0.273
39.02	0.425

West Sacramento Alternative 1: Fix In Place Risk Inputs ("n"YR_SAC_W-PRJ_Raised_Levees)
West Sacramento Alternative 3: Fix Levees and DWSC Closure Structure In Place Risk Inputs ("n"YR_SAC_W-PRJ_Raised_Levees)

IP:1 Sac Riv, RM 61.4986 (Model TOL = 43.2')				
Alternative 1 & 3				
Frequency	Inflow	Adjusted Outflow	Q Total (Model)	Stage NAVD '88
1yr = .999	N/A	N/A		27.00
2yr = .5	N/A	N/A	66903.02	29.63
10yr = .1	N/A	N/A	26077.77	30.78
25yr = .04	N/A	N/A	-1222.78	33.48
50yr = .02	N/A	N/A	803.9	34.03
100yr = .01	N/A	N/A	4574.56	34.71
200yr = .005	N/A	N/A	-28105	36.54
500yr = .002	N/A	N/A	-99340	39.04
Equivalent Record Length = 71				

LEVEE PERFORMANCE CURVE	
NAVD 88 Elevation	Pr(f)
26	
29	
32	
35	
38	
41	

IP:4 Sac Bypass, RM 1.49 (Model TOL =36.82')				
Alternative 1 & 3				
Frequency	Inflow	Adjusted Outflow	Q Total (Model)	Stage NAVD '88
1yr = .999	141500	0		20.65
2yr = .5	197300	0	100	21.61
10yr = .1	328800	35858	65843	28.59
25yr = .04	448700	76374	107318	31.87
50yr = .02	475700	101301	111170	32.51
100yr = .01	545800	117399	115016	33.28
200yr = .005	635700	156687	148940	34.98
500yr = .002	911400	180775	206912	37.00
Equivalent Record Length = 71				

LEVEE PERFORMANCE CURVE	
NAVD 88 Elevation	Pr(f)
22	
29	
36	
38	
40	
42.4	

IP:7 Yolo Bypass, RM 40.95 (Model TOL = 32.83)				
Alternative 1 & 3				
Frequency	Inflow	Adjusted Outflow	Q Total (Model)	Stage NAVD '88
1yr = .999	139200	0		20.43
2yr = .5	200100	107259	105590	21.11
10yr = .1	343600	272803	297134	26.44
25yr = .04	458700	410491	442953	29.21
50yr = .02	492200	483135	482620	29.96
100yr = .01	552000	552770	534852	30.85
200yr = .005	646600	631168	610023	31.99
500yr = .002	928700	692678	687476	33.13
Equivalent Record Length = 72				

LEVEE PERFORMANCE CURVE	
NAVD 88 Elevation	Pr(f)
10	
15	
20	
25	
30	
34.5	

IP:2 Sac R, RM 59.9979 (Model TOL = 42.4 ')				
Alternative 1 & 3				
Frequency	Inflow	Adjusted Outflow	Q Total (Model)	Stage NAVD '88
1yr = .999	166900	80000		26.38
2yr = .5	224300	91314	94610	29.22
10yr = .1	359600	98397	101171	30.55
25yr = .04	525300	103479	115657	33.29
50yr = .02	551700	113351	118223	33.85
100yr = .01	666700	121560	121798	34.54
200yr = .005	939900	143491	134255	36.40
500yr = .002	1133400	180634	179092	39.03
Equivalent Record Length = 73				

LEVEE PERFORMANCE CURVE	
NAVD 88 Elevation	Pr(f)
28	
32	
34	
36	
38	
40	

IP:5 Sac Riv, RM 56.75 (Model TOL = 41.74)				
Alternative 1 & 3				
Frequency	Inflow	Adjusted Outflow	Q Total (Model)	Stage NAVD '88
1yr = .999	166900	80000		24.52
2yr = .5	224300	91306	94603	27.82
10yr = .1	359600	98329	100694	29.13
25yr = .04	525300	103421	115596	31.84
50yr = .02	551700	113323	118180	32.41
100yr = .01	666700	121448	121791	33.09
200yr = .005	939900	135024	133374	34.92
500yr = .002	1133400	146336	159123	37.29
Equivalent Record Length = 73				

LEVEE PERFORMANCE CURVE	
NAVD 88 Elevation	Pr(f)
19	
27	
31	
35	
39	
41	

IP:8 Sac DWSC, RM 43.412 (MODEL TOL = 22)				
Alternative 1 & 3				
Frequency	Inflow	Adjusted Outflow	Q Total (Model)	Stage NAVD '88
1yr = .999	N/A	N/A	N/A	7.37
2yr = .5	N/A	N/A	N/A	7.68
10yr = .1	N/A	N/A	N/A	12.97
25yr = .04	N/A	N/A	N/A	17.72
50yr = .02	N/A	N/A	N/A	18.64
100yr = .01	N/A	N/A	N/A	19.78
200yr = .005	N/A	N/A	N/A	20.91
500yr = .002	N/A	N/A	N/A	22.66
Equivalent Record Length = 73				

LEVEE PERFORMANCE CURVE	
NAVD 88 Elevation	Pr(f)
13	
14	
16	
18	
20	
21.7	

IP:3 Yolo Bypass, RM 42.62 (Model TOL = 34.9')				
Alternative 1 & 3				
Frequency	Inflow	Adjusted Outflow	Q Total (Model)	Stage NAVD '88
1yr = .999	139200	0		20.67
2yr = .5	200100	107711	106012	21.38
10yr = .1	343600	273031	297332	26.86
25yr = .04	458700	410938	443711	29.73
50yr = .02	492200	483545	483253	30.50
100yr = .01	552000	553424	535233	31.41
200yr = .005	646600	631918	610692	32.66
500yr = .002	928700	693250	688445	33.88
Equivalent Record Length = 72				

LEVEE PERFORMANCE CURVE	
NAVD 88 Elevation	Pr(f)
8	
14	
20	
26	
32	
38	

IP:6 Sac Riv, RM 52.7474 (Model TOL = 40.03)				
Alternative 1 & 3				
Frequency	Inflow	Adjusted Outflow	Q Total (Model)	Stage NAVD '88
1yr = .999	166900	80000		22.94
2yr = .5	224300	91303	94600	26.23
10yr = .1	359600	98255	100688	27.53
25yr = .04	525300	103394	115493	30.19
50yr = .02	551700	113302	118153	30.76
100yr = .01	666700	121342	121789	31.44
200yr = .005	939900	135009	133257	33.20
500yr = .002	1133400	145927	159087	35.23
Equivalent Record Length = 73				

LEVEE PERFORMANCE CURVE	
NAVD 88 Elevation	Pr(f)
19	
23	
27	
35	
37	
39	

NOTE 1: Stage and flow data (2yr to 500yr) were obtained from RAS results - Without-Project "n"YR_SAC_NA3_3

NOTE 2: (Values in Red) Stage and flow data for 1yr and 2yr (along Sacramento and American Rivers) was obtained from gage data and rating curves. The stage was determined by taking the difference in water surface elvations from the gage and index point and adding or subtracting (depending if the gage is upstream or downstream of the index point) from the 1yr and 2yr stage at the gage station. The flow was determined by interpolation of the rating curve (since the stage was already determined). See Rating Curve Tab. NEMDC, RM 1 is considered American River here.

NOTE 3: Stage data for 2yr NEMDC (except RM 1) is obtained from RAS results- With-Project, Selected Levee Raise (SLR). The 1yr stage is land-side levee toe at location of index point. See NEMDC Toe Elev Tab.

NOTE 4: Reaches B, C, and I require flow and stage data. All other Natomas reaches only require stages (stage-frequency curves will be used)

NOTE 5: Data for Non Natomas (blue) reaches should be checked and updated as necessary.

NOTE 6: Values for 1yr and 2yr, Sac River 79.0022 taken from WO-PRJ_Risk_Inputs.xls.

NOTE 7: Standard Deviation taken from SD_Data.xls

NOTE 8: For the NEMDC, RM 1 (1yr and 2yr) the flow was increased to account for flow with the NEMDC. Flow in the American is for the 2-yr and 10-yr events is 10 times that of the NEMDC, so this value was used to derive the additional flow in the NEMDC. (Rating for the stages generated for the American portion only). Because flow ends up greater than the inflow, outflow was set equal to inflow.

30,110
10,415

NOTE 9: Inflow taken from Inflows.xls.

NOTE 10: Values in blue extrapolated using process as in West Report (B-5). Original value for 70.2464 was 93721 for the 500-yr event and had to be adjusted for FDA.

NOTE 11: Values in green are greater than stage from dominant centering and therefore were adjusted. Must be a difference of at least greater .05 ft to make adjustment.

Other Notes

Need to extrapolate above top of levee?
Sensitivities - ERL, Standard Deviations (Flow & Stage), SD sig digits, Extrapolated Values, 1yr & 2yr on NEMDC

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

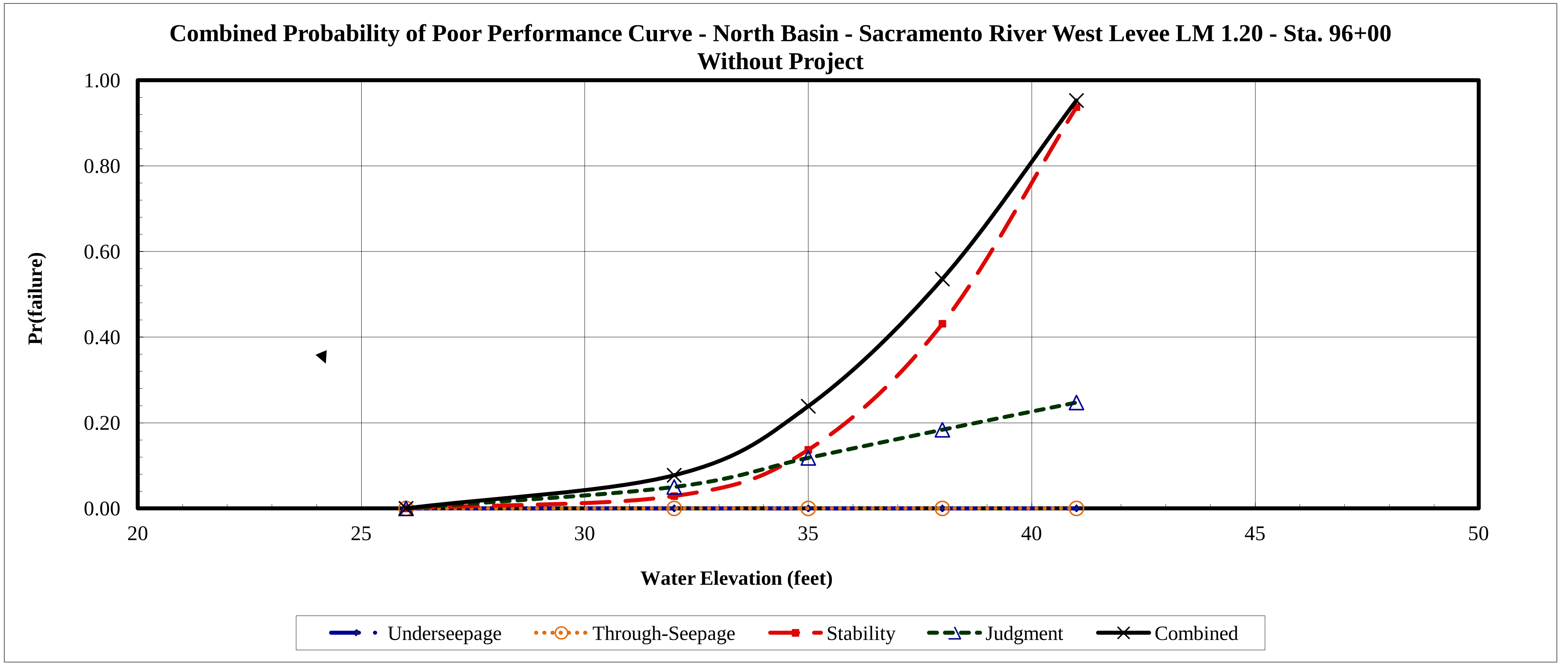
Project: West Sacramento GRR
Study Area: Sacramento River
River Section: North Basin - Sacramento River W

Levee Mile: 1.20 - Sta. 96+0(
River Mile: 61.67
Analysis Case: Without Project

Crest Elev.: 41.00
L/S Toe Elev.: 26.00
W/S Toe Elev.: 28.20

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/22/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
26.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
32.00	0.0000	1.0000	0.0000	1.0000	0.0288	0.9712	0.0500	0.9500	0.0773	0.9227
35.00	0.0000	1.0000	0.0000	1.0000	0.1369	0.8631	0.1179	0.8821	0.2386	0.7614
38.00	0.0000	1.0000	0.0000	1.0000	0.4313	0.5687	0.1837	0.8163	0.5358	0.4642
41.00	0.0001	0.9999	0.0000	1.0000	0.9372	0.0628	0.2473	0.7527	0.9528	0.0472



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

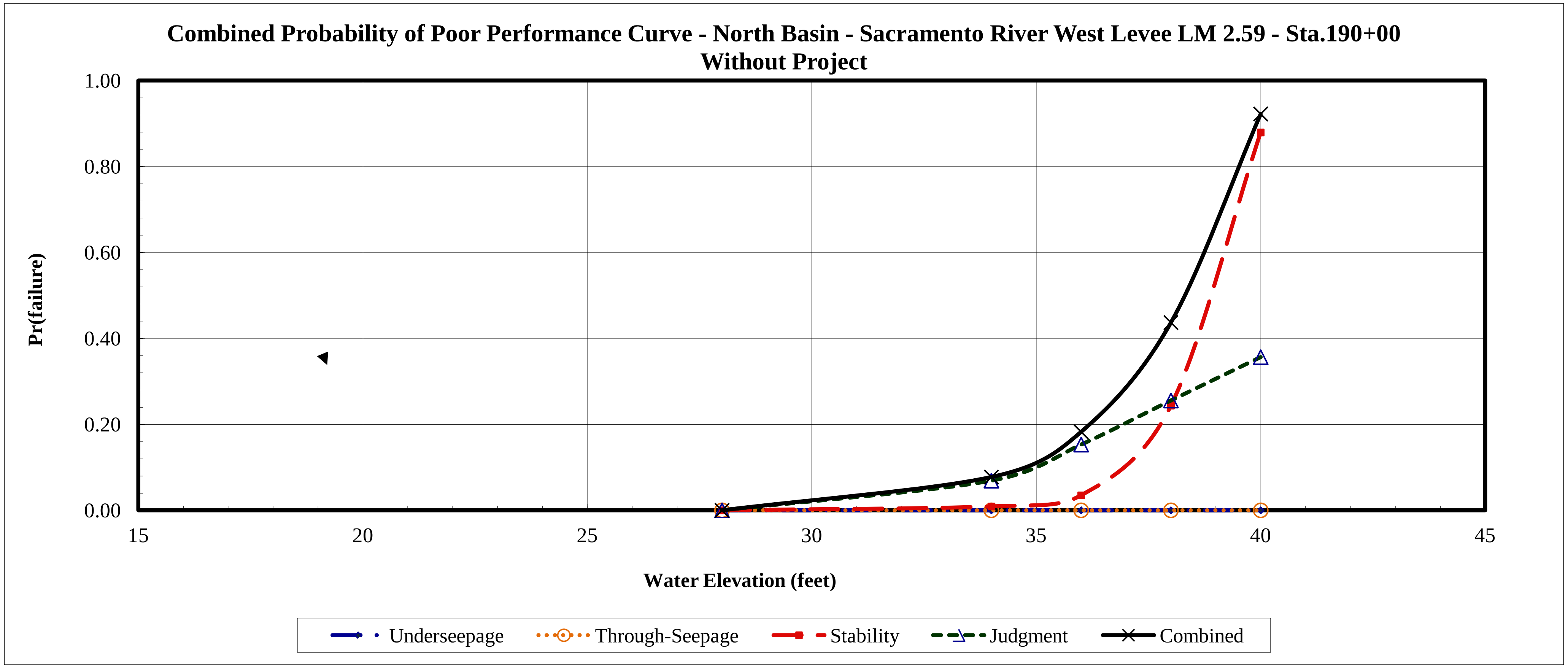
Project: West Sacramento GRR
Study Area: Sacramento River
River Section: North Basin - Sacramento River W

Levee Mile: 2.59 - Sta.190+0
River Mile: 60.20
Analysis Case: Without Project

Crest Elev.: 40.00
L/S Toe Elev.: 28.00
W/S Toe Elev.: 28.00

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/23/2013

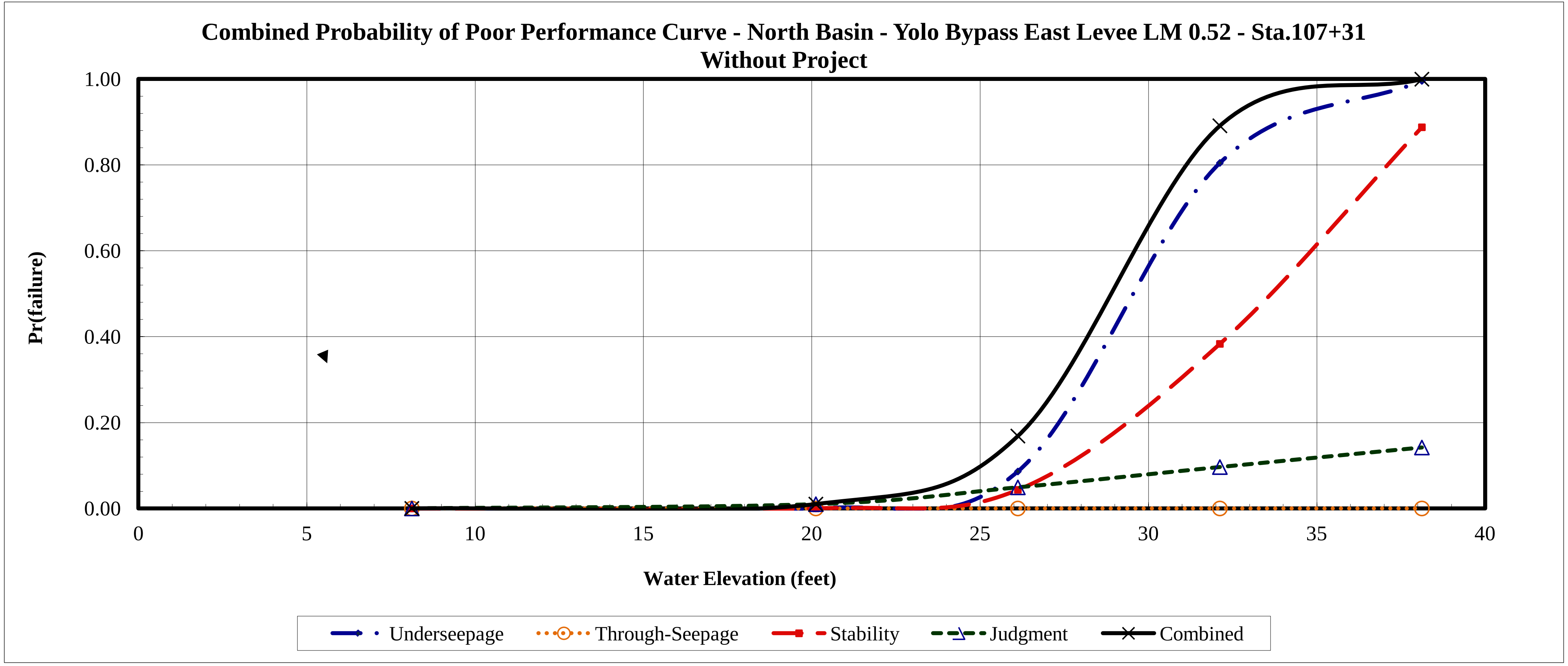
Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
28.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
34.00	0.0000	1.0000	0.0000	1.0000	0.0090	0.9910	0.0690	0.9310	0.0774	0.9226
36.00	0.0000	1.0000	0.0000	1.0000	0.0349	0.9651	0.1529	0.8471	0.1825	0.8175
38.00	0.0000	1.0000	0.0000	1.0000	0.2436	0.7564	0.2555	0.7445	0.4368	0.5632
40.00	0.0000	1.0000	0.0000	1.0000	0.8793	0.1207	0.3564	0.6436	0.9223	0.0777



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

Project: West Sacramento GRR
Study Area: Yolo Bypass
River Section: North Basin - Yolo Bypass East L
Levee Mile: 0.52 - Sta.107+3
River Mile: 43.10
Analysis Case: Without Project
Crest Elev.: 38.12
L/S Toe Elev.: 8.12
W/S Toe Elev.: 8.12
Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/23/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
8.12	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
20.12	0.0000	1.0000	0.0000	1.0000	0.0001	0.9999	0.0100	0.9900	0.0101	0.9899
26.12	0.0861	0.9139	0.0000	1.0000	0.0433	0.9567	0.0491	0.9509	0.1686	0.8314
32.12	0.8046	0.1954	0.0000	1.0000	0.3832	0.6168	0.0964	0.9036	0.8911	0.1089
38.12	0.9957	0.0043	0.0000	1.0000	0.8876	0.1124	0.1419	0.8581	0.9996	0.0004



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

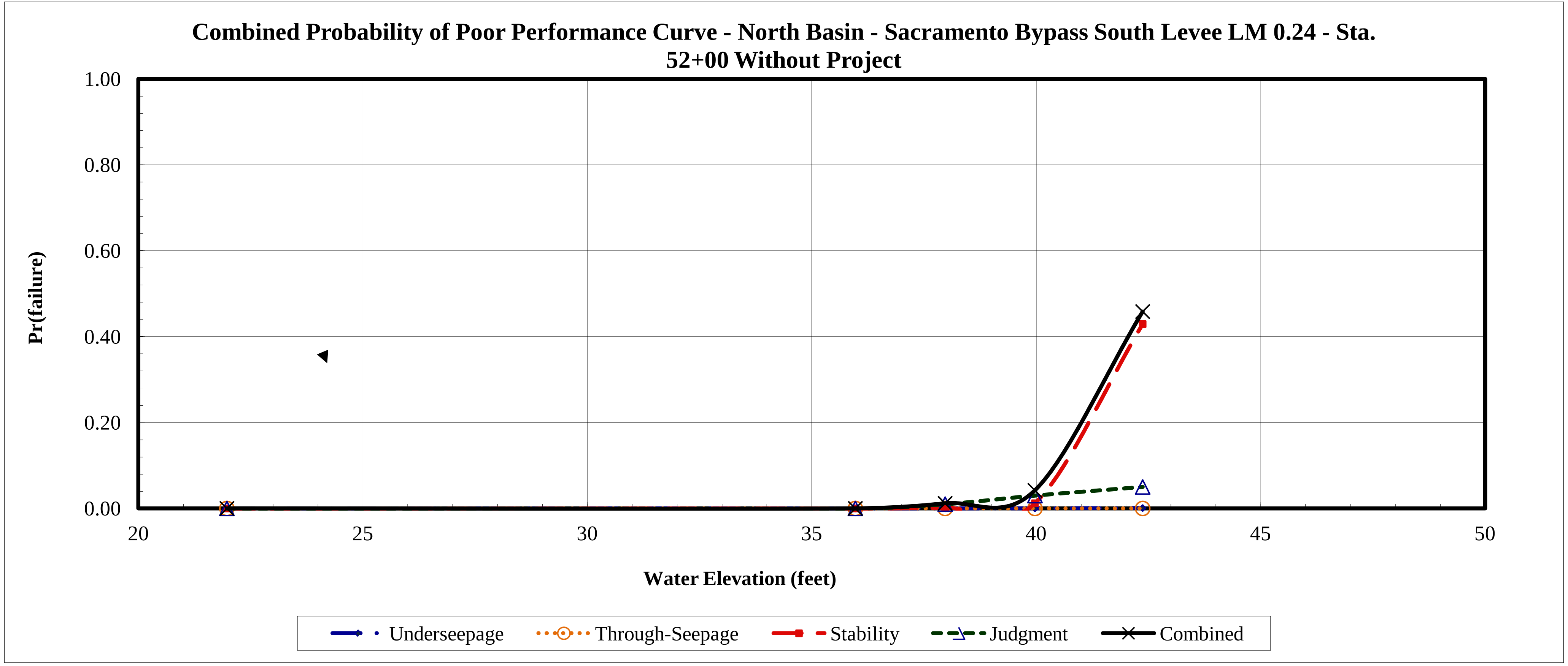
Project: West Sacramento GRR
Study Area: Sacramento Bypass
River Section: North Basin - Sacramento Bypass

Levee Mile: 0.24 - Sta. 52+0(
River Mile: 1.60
Analysis Case: Without Project

Crest Elev.: 42.37
L/S Toe Elev.: 21.97
W/S Toe Elev.: 22.17

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/22/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
21.97	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
35.97	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
37.97	0.0000	1.0000	0.0000	1.0000	0.0018	0.9982	0.0100	0.9900	0.0119	0.9881
39.97	0.0003	0.9997	0.0000	1.0000	0.0122	0.9878	0.0300	0.9700	0.0421	0.9579
42.37	0.0010	0.9990	0.0000	1.0000	0.4294	0.5706	0.0500	0.9500	0.4585	0.5415



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

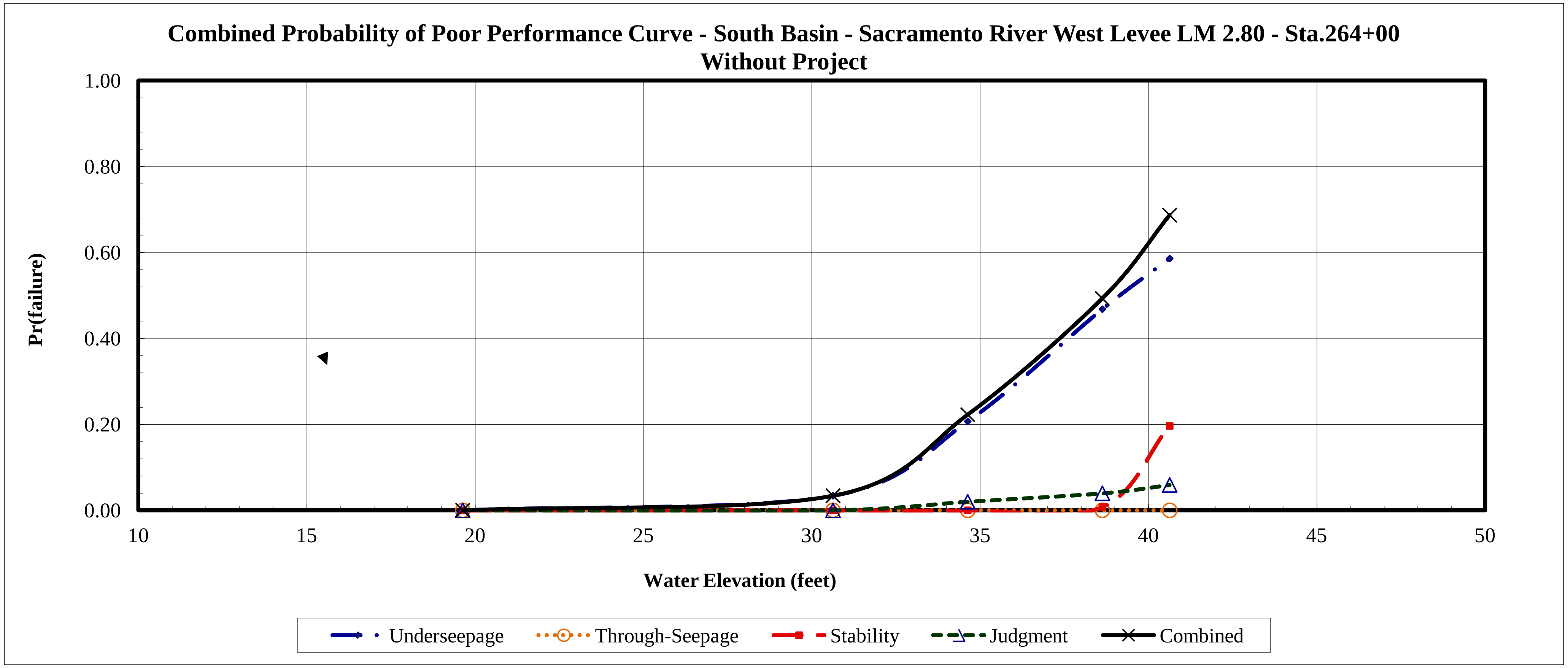
Project: West Sacramento GRR
Study Area: Sacramento River
River Section: South Basin - Sacramento River W

Levee Mile: 2.80 - Sta.264+0
River Mile: 56.74
Analysis Case: Without Project

Crest Elev.: 40.63
L/S Toe Elev.: 19.63
W/S Toe Elev.: 19.63

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/24/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
19.63	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
30.63	0.0339	0.9661	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0339	0.9661
34.63	0.2069	0.7931	0.0000	1.0000	0.0000	1.0000	0.0199	0.9801	0.2227	0.7773
38.63	0.4680	0.5320	0.0000	1.0000	0.0079	0.9921	0.0396	0.9604	0.4931	0.5069
40.63	0.5859	0.4141	0.0000	1.0000	0.1965	0.8035	0.0591	0.9409	0.6869	0.3131



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

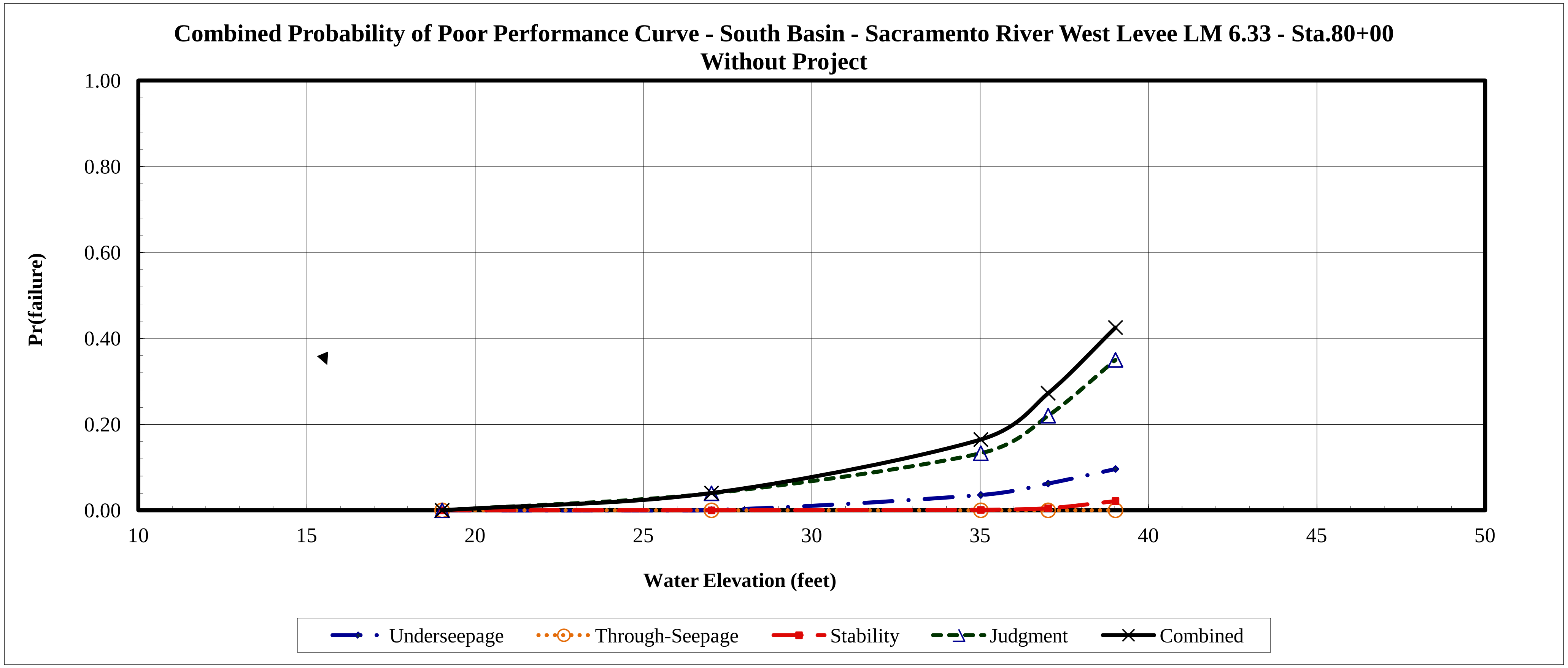
Project: West Sacramento GRR
Study Area: Sacramento River
River Section: South Basin - Sacramento River W

Levee Mile: 6.33 - Sta.80+00
River Mile: 53.08
Analysis Case: Without Project

Crest Elev.: 39.02
L/S Toe Elev.: 19.02
W/S Toe Elev.: 19.02

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/24/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
19.02	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
27.02	0.0007	0.9993	0.0000	1.0000	0.0000	1.0000	0.0396	0.9604	0.0403	0.9597
35.02	0.0358	0.9642	0.0000	1.0000	0.0010	0.9990	0.1330	0.8670	0.1648	0.8352
37.02	0.0625	0.9375	0.0000	1.0000	0.0047	0.9953	0.2203	0.7797	0.2725	0.7275
39.02	0.0962	0.9038	0.0000	1.0000	0.0216	0.9784	0.3502	0.6498	0.4254	0.5746



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

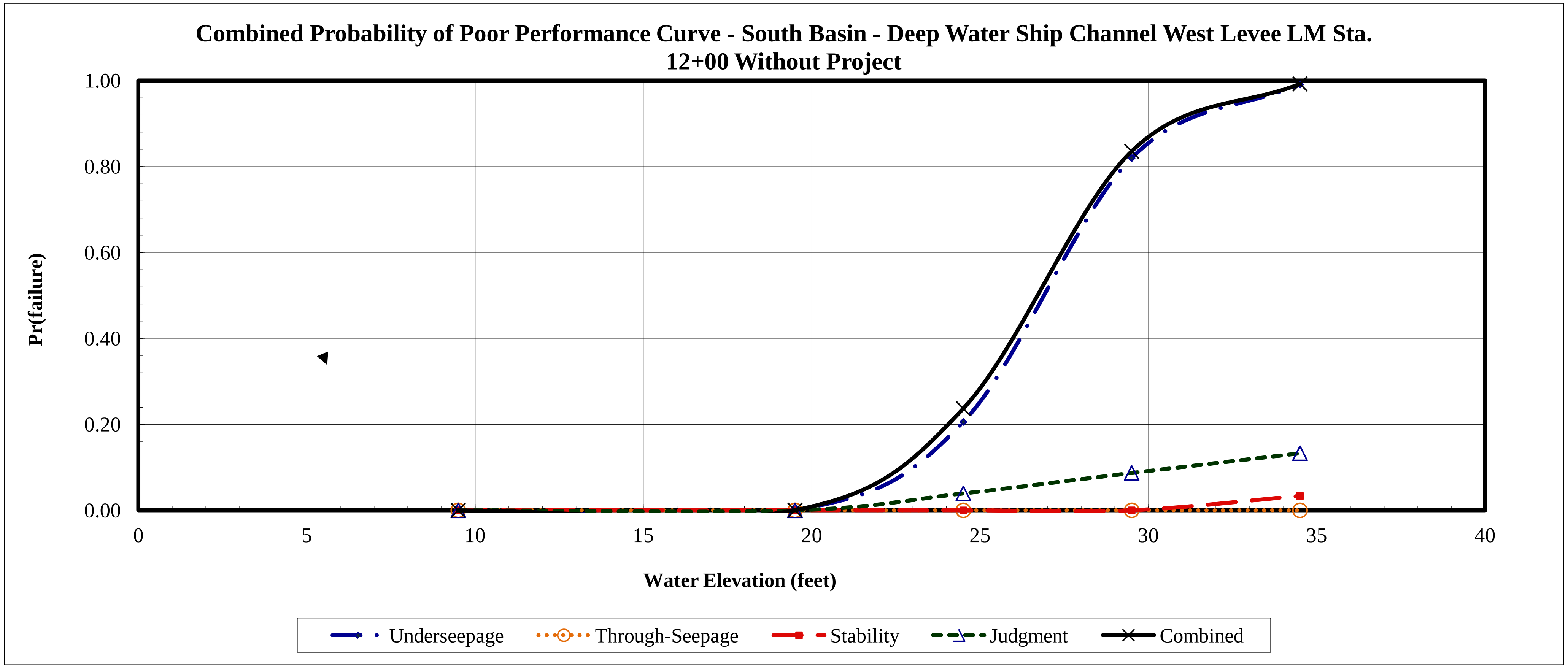
Project: West Sacramento GRR
Study Area: Deep Water Ship Channel
River Section: South Basin - Deep Water Ship Ch

Levee Mile: Sta. 12+00
River Mile: 41.21
Analysis Case: Without Project

Crest Elev.: 34.50
L/S Toe Elev.: 9.50
W/S Toe Elev.: 9.50

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/26/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
9.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
19.50	0.0005	0.9995	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0005	0.9995
24.50	0.2057	0.7943	0.0000	1.0000	0.0000	1.0000	0.0394	0.9606	0.2370	0.7630
29.50	0.8196	0.1804	0.0000	1.0000	0.0001	0.9999	0.0870	0.9130	0.8353	0.1647
34.50	0.9907	0.0093	0.0000	1.0000	0.0335	0.9665	0.1330	0.8670	0.9922	0.0078



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

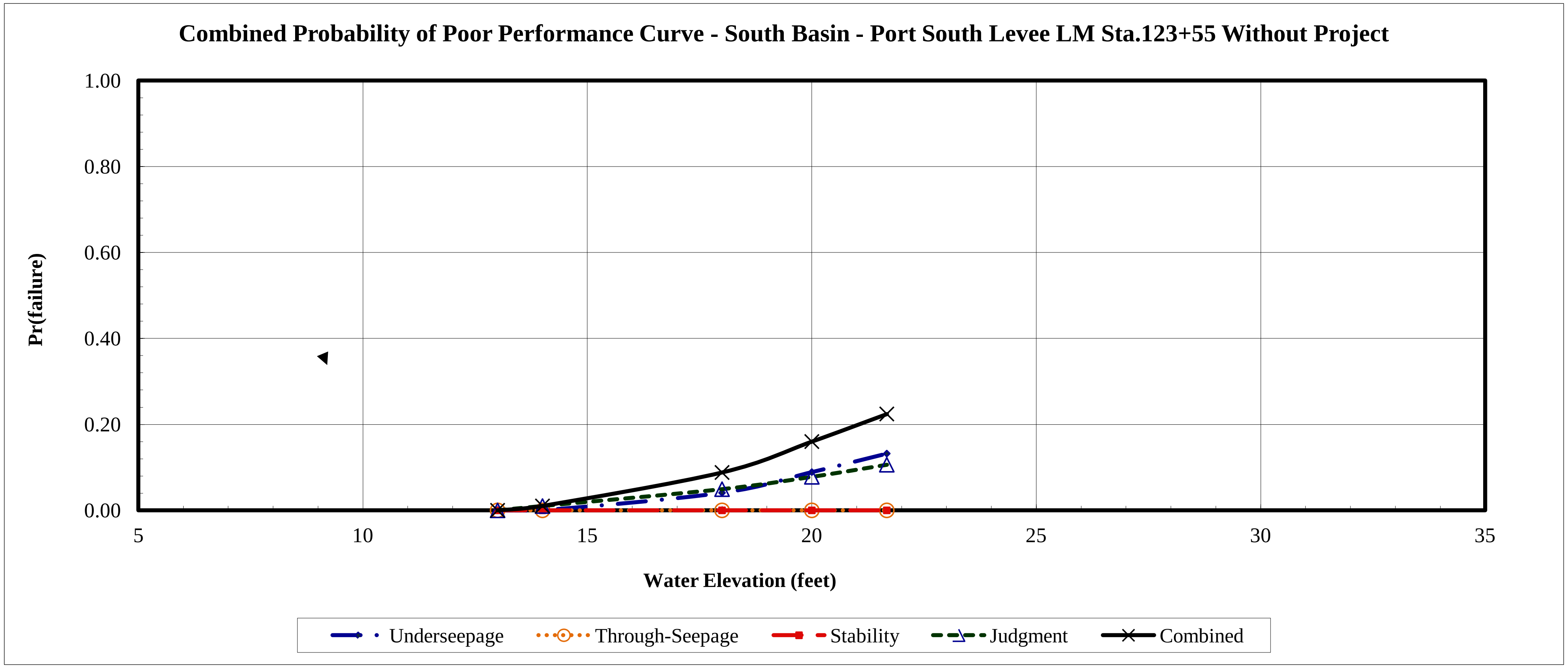
Project: West Sacramento GRR
Study Area: Deep Water Ship Channel
River Section: South Basin - Port South Levee

Levee Mile: Sta.123+55
River Mile: 43.45
Analysis Case: Without Project

Crest Elev.: 21.67
L/S Toe Elev.: 13.00
W/S Toe Elev.: 13.00

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/24/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
13.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
14.00	0.0002	0.9998	0.0000	1.0000	0.0000	1.0000	0.0100	0.9900	0.0102	0.9898
18.00	0.0409	0.9591	0.0000	1.0000	0.0000	1.0000	0.0493	0.9507	0.0882	0.9118
20.00	0.0890	0.9110	0.0000	1.0000	0.0000	1.0000	0.0780	0.9220	0.1601	0.8399
21.67	0.1322	0.8678	0.0000	1.0000	0.0000	1.0000	0.1061	0.8939	0.2243	0.7757



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

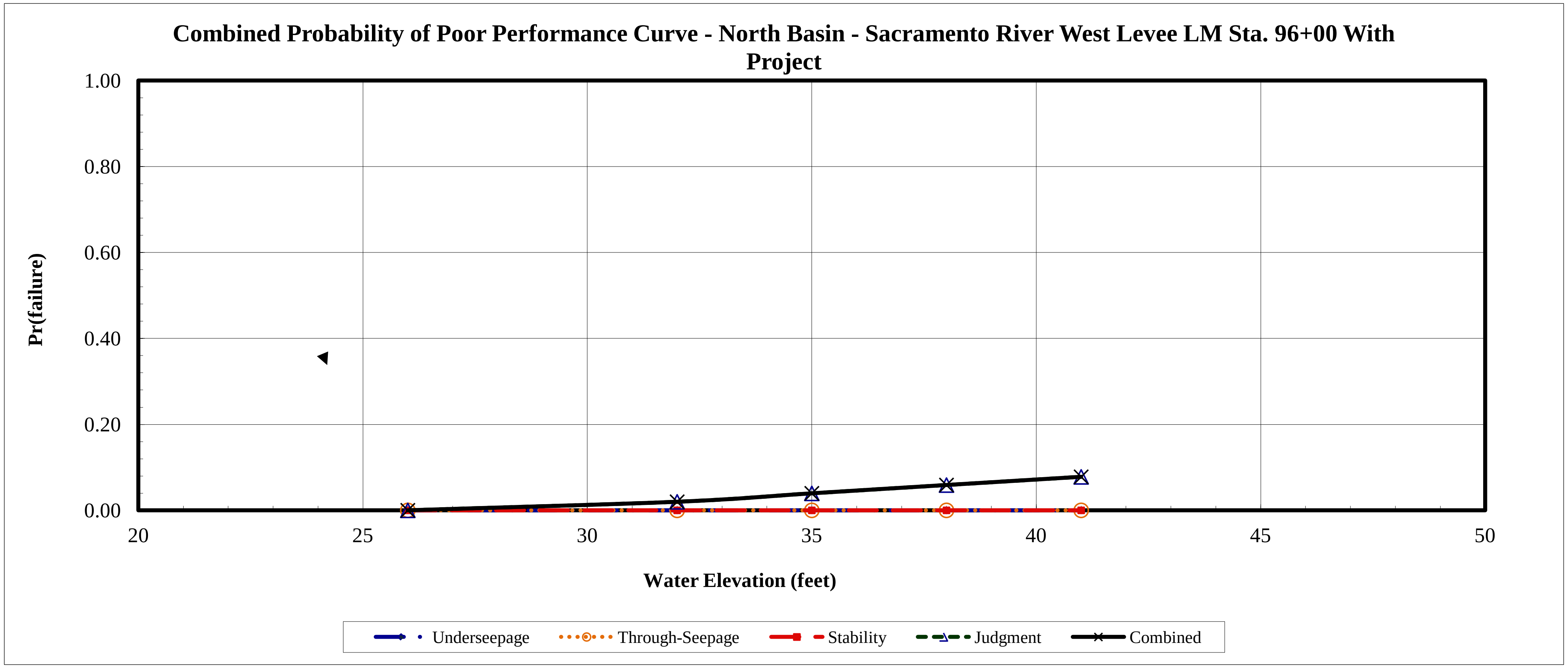
Project: West Sacramento GRR
Study Area: Sacramento River
River Section: North Basin - Sacramento River W

Levee Mile: Sta. 96+00
River Mile: 61.67
Analysis Case: With Project

Crest Elev.: 41.00
L/S Toe Elev.: 26.00
W/S Toe Elev.: 28.20

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/22/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
26.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
32.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0199	0.9801	0.0199	0.9801
35.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0395	0.9605	0.0395	0.9605
38.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0588	0.9412	0.0588	0.9412
41.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0779	0.9221	0.0779	0.9221



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

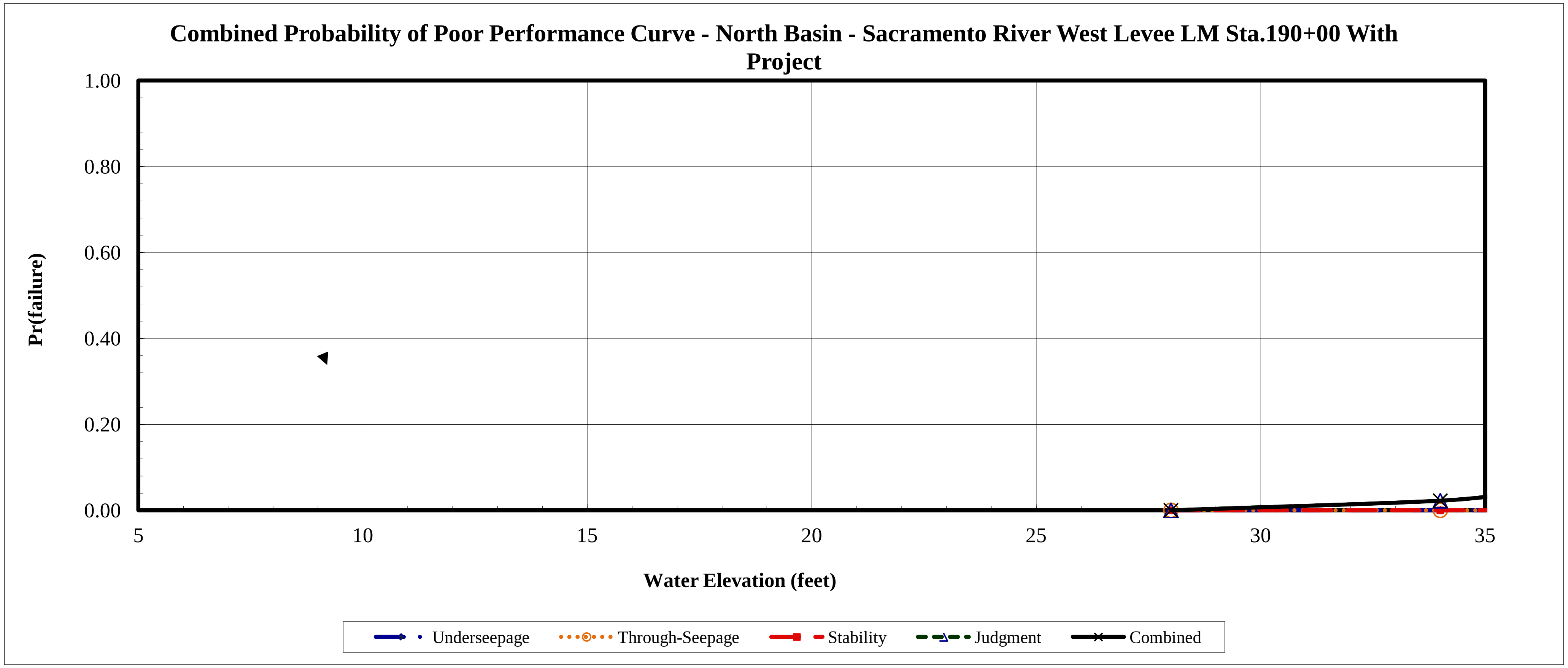
Project: West Sacramento GRR
Study Area: Sacramento River
River Section: North Basin - Sacramento River W

Levee Mile: Sta.190+00
River Mile: 60.20
Analysis Case: With Project

Crest Elev.: 40.00
L/S Toe Elev.: 28.00
W/S Toe Elev.: 28.00

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/23/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
28.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
34.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0223	0.9777	0.0223	0.9777
36.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0443	0.9557	0.0443	0.9557
38.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0659	0.9341	0.0659	0.9341
40.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0871	0.9129	0.0871	0.9129



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

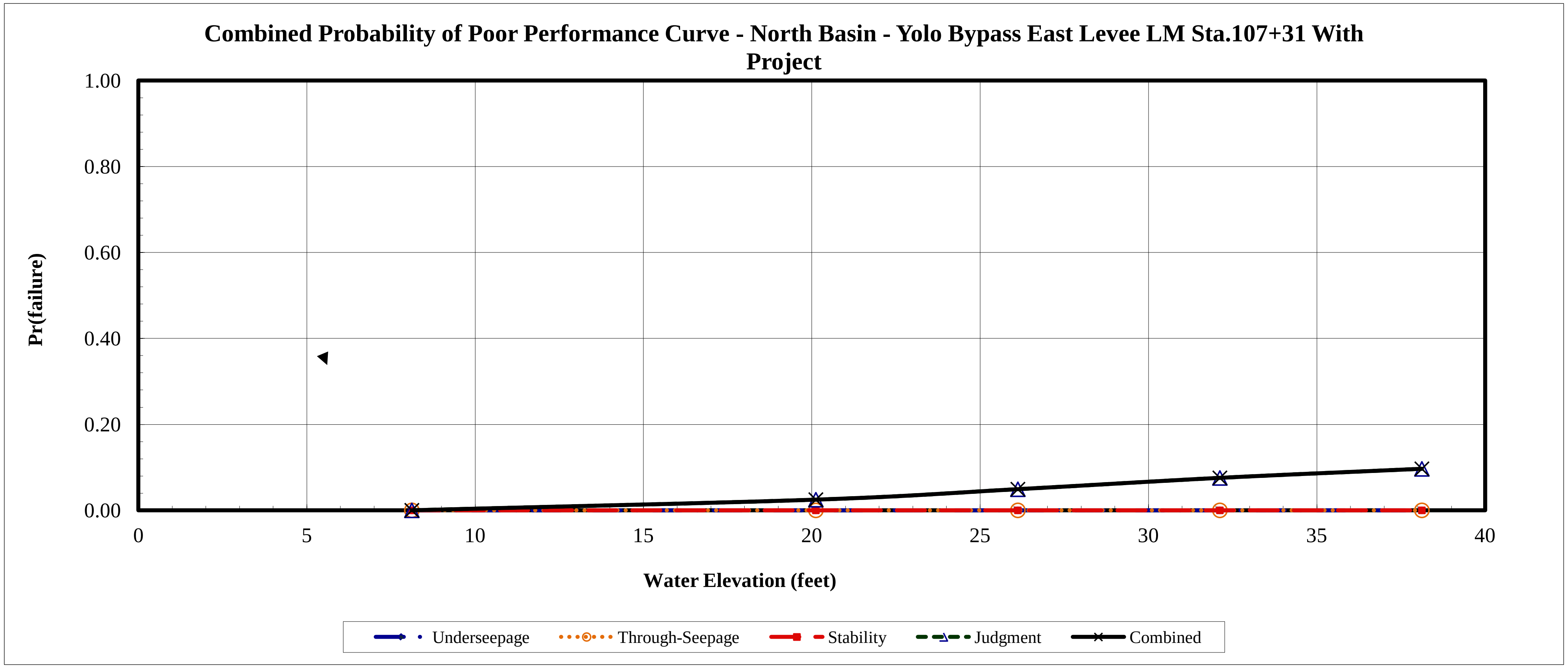
Project: West Sacramento GRR
Study Area: Yolo Bypass
River Section: North Basin - Yolo Bypass East L

Levee Mile: Sta.107+31
River Mile: 43.10
Analysis Case: With Project

Crest Elev.: 38.12
L/S Toe Elev.: 8.12
W/S Toe Elev.: 8.12

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/23/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
8.12	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
20.12	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0248	0.9752	0.0248	0.9752
26.12	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0491	0.9509	0.0491	0.9509
32.12	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0754	0.9246	0.0754	0.9246
38.12	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0965	0.9035	0.0965	0.9035



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

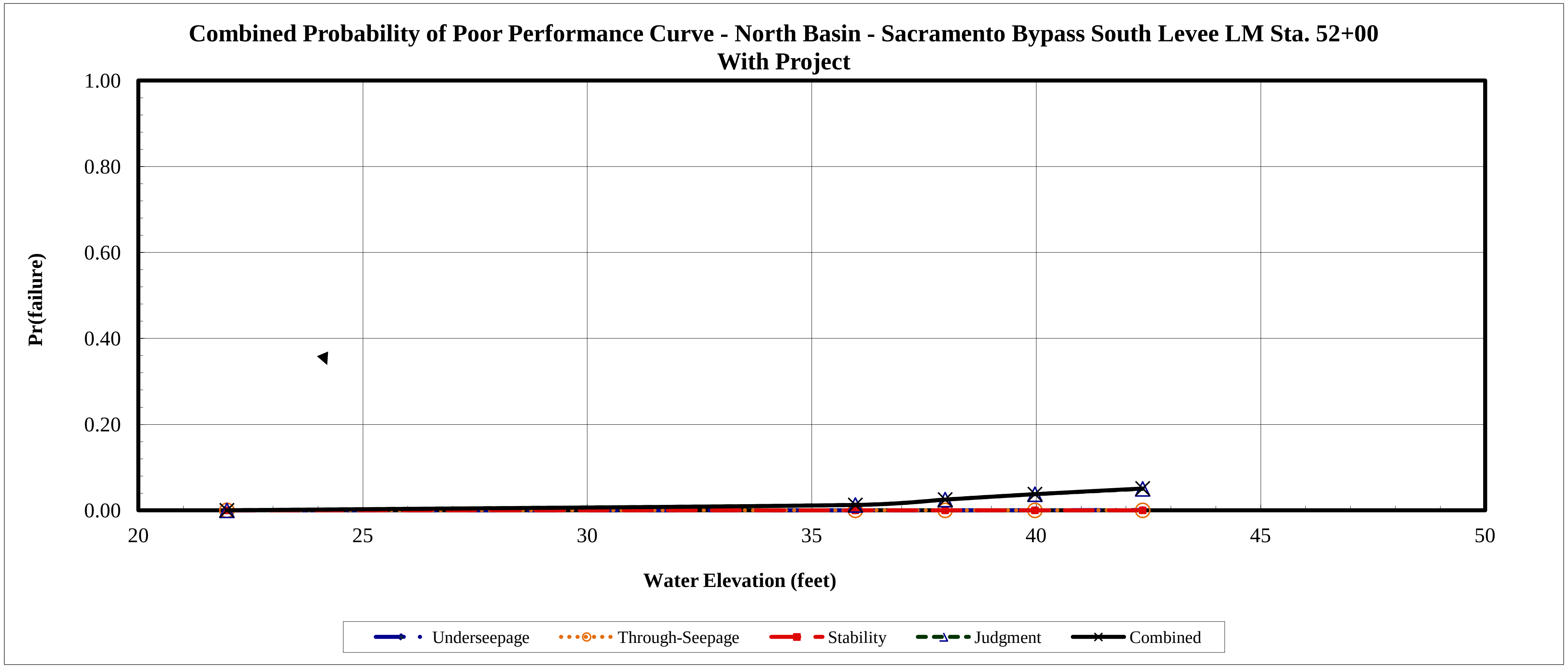
Project: West Sacramento GRR
Study Area: Sacramento Bypass
River Section: North Basin - Sacramento Bypass

Levee Mile: Sta. 52+00
River Mile: 1.60
Analysis Case: With Project

Crest Elev.: 42.37
L/S Toe Elev.: 21.97
W/S Toe Elev.: 22.17

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/22/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
21.97	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
35.97	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0125	0.9875	0.0125	0.9875
37.97	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0250	0.9750	0.0250	0.9750
39.97	0.0003	0.9997	0.0000	1.0000	0.0000	1.0000	0.0375	0.9625	0.0377	0.9623
42.37	0.0010	0.9990	0.0000	1.0000	0.0000	1.0000	0.0500	0.9500	0.0509	0.9491



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

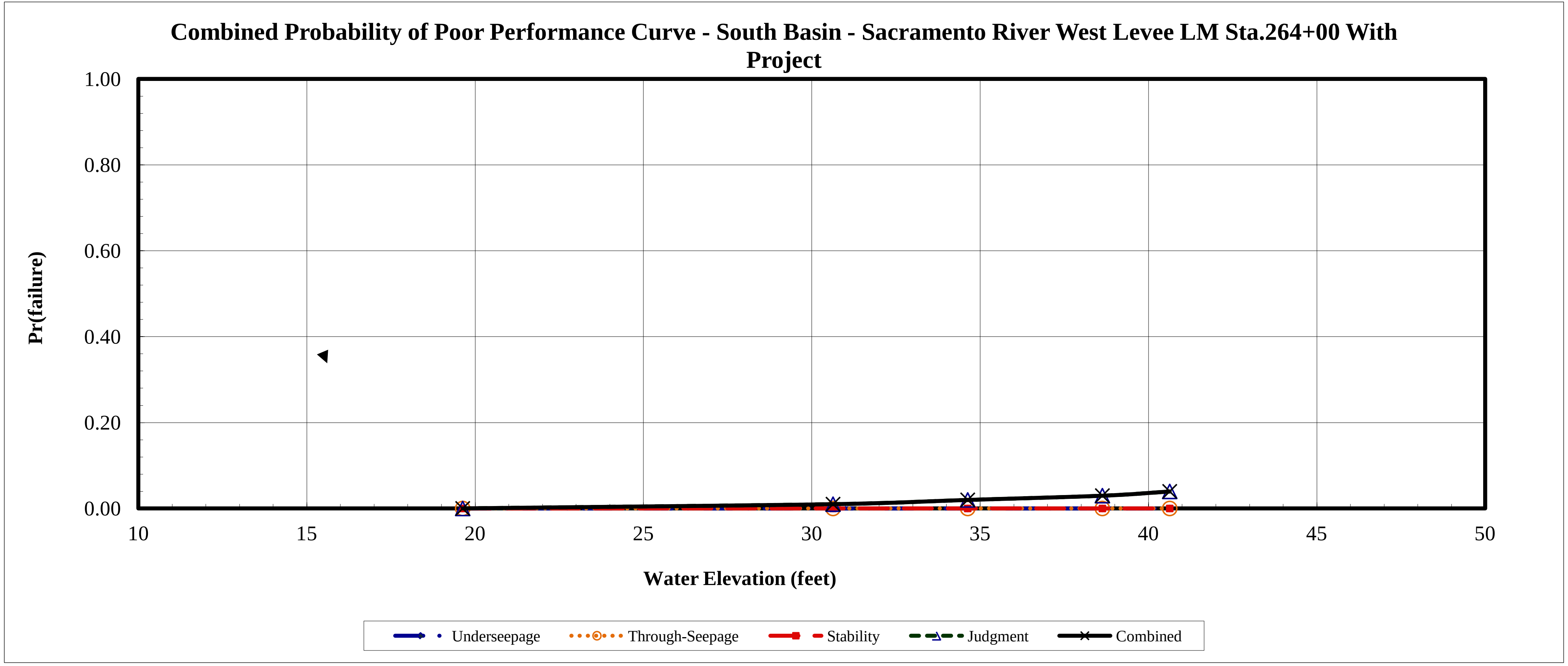
Project: West Sacramento GRR
Study Area: Sacramento River
River Section: South Basin - Sacramento River W

Levee Mile: Sta.264+00
River Mile: 56.74
Analysis Case: With Project

Crest Elev.: 40.63
L/S Toe Elev.: 19.63
W/S Toe Elev.: 19.63

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/25/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
19.63	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
30.63	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0100	0.9900	0.0100	0.9900
34.63	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0199	0.9801	0.0199	0.9801
38.63	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0298	0.9702	0.0298	0.9702
40.63	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0397	0.9603	0.0397	0.9603



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

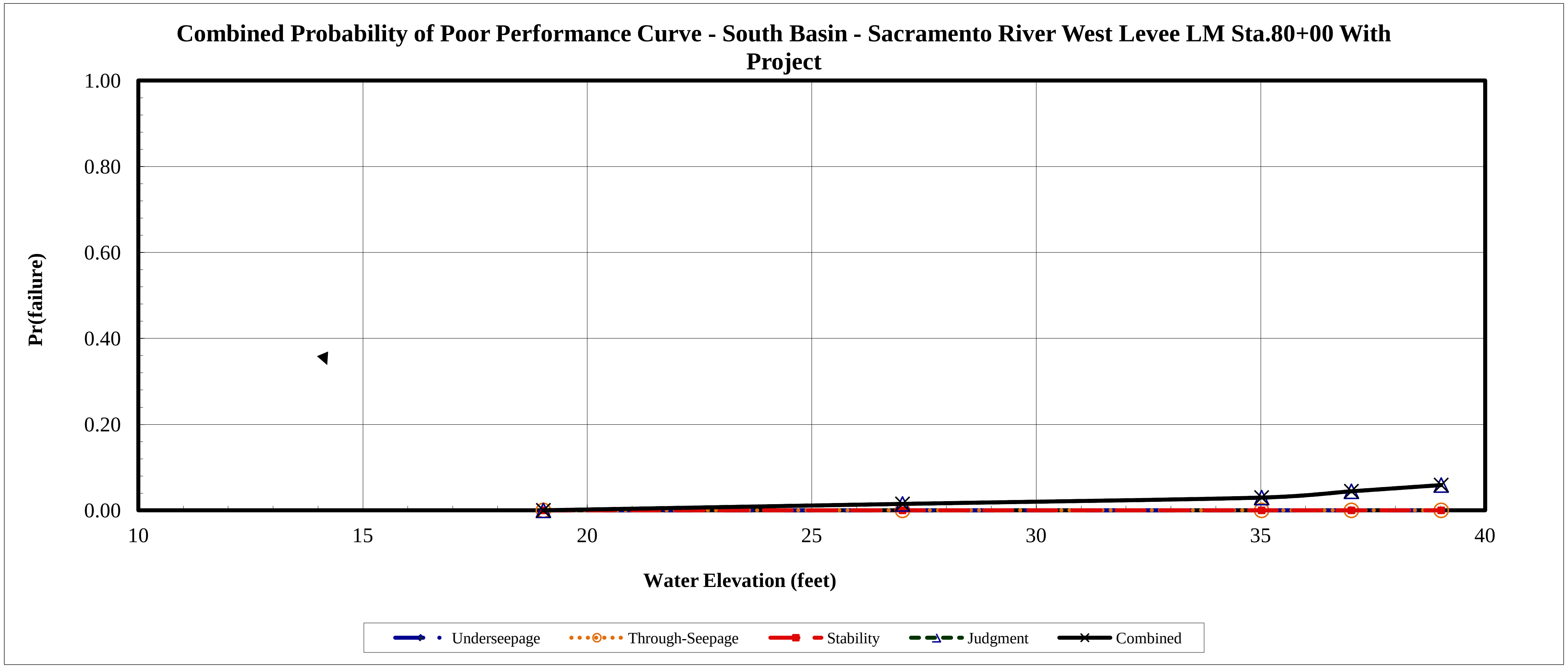
Project: West Sacramento GRR
Study Area: Sacramento River
River Section: South Basin - Sacramento River W

Levee Mile: Sta.80+00
River Mile: 53.08
Analysis Case: With Project

Crest Elev.: 39.02
L/S Toe Elev.: 19.02
W/S Toe Elev.: 19.02

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/25/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
19.02	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
27.02	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0149	0.9851	0.0149	0.9851
35.02	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0297	0.9703	0.0297	0.9703
37.02	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0444	0.9556	0.0444	0.9556
39.02	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0589	0.9411	0.0589	0.9411



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

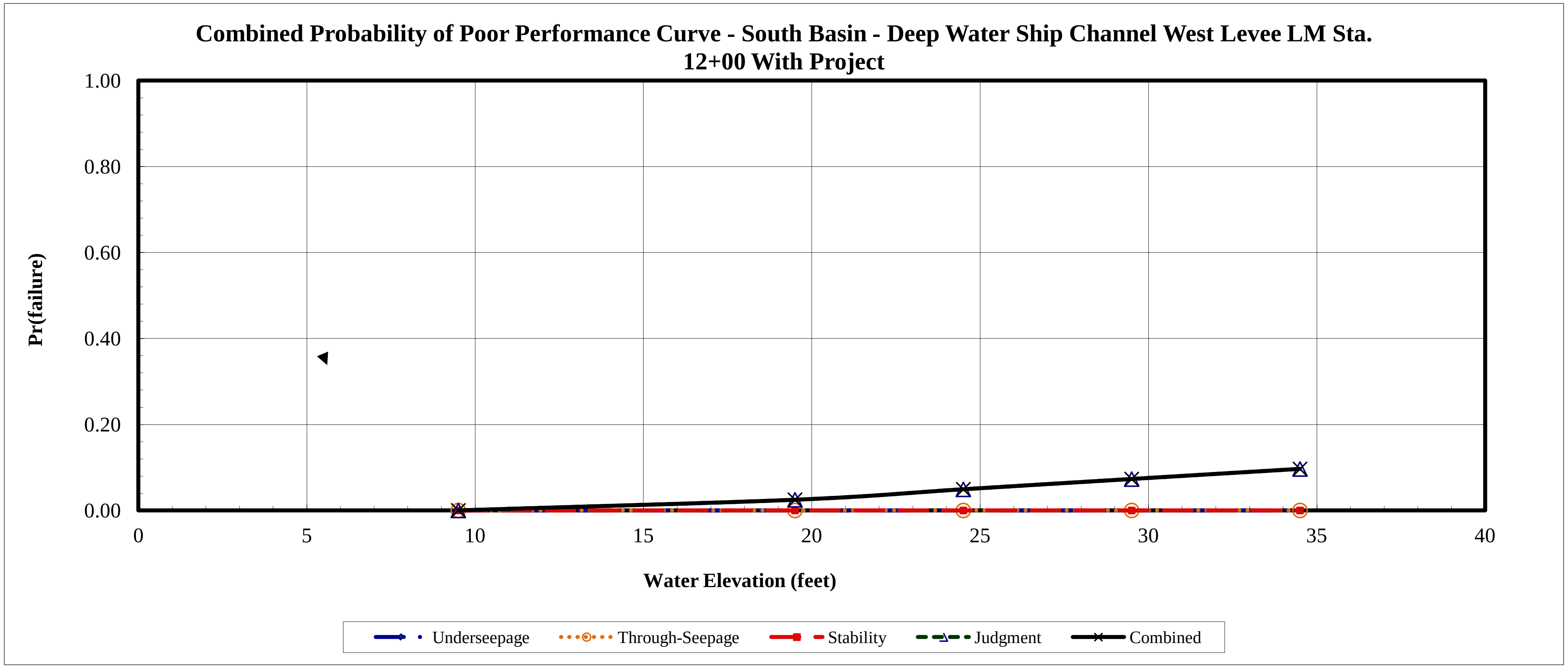
Project: West Sacramento GRR
Study Area: Deep Water Ship Channel
River Section: South Basin - Deep Water Ship Ch

Levee Mile: Sta. 12+00
River Mile: 41.21
Analysis Case: With Project

Crest Elev.: 34.50
L/S Toe Elev.: 9.50
W/S Toe Elev.: 9.50

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/26/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
9.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
19.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0248	0.9752	0.0248	0.9752
24.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0491	0.9509	0.0491	0.9509
29.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0730	0.9270	0.0730	0.9270
34.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0965	0.9035	0.0965	0.9035



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

Project: West Sacramento GRR
Study Area: Deep Water Ship Channel
River Section: South Basin - Port South Levee

Levee Mile: Sta.123+55
River Mile: 43.45
Analysis Case: With Project

Crest Elev.: 21.67
L/S Toe Elev.: 13.00
W/S Toe Elev.: 13.00

Analysis By: A. Deus
Checked By: M. Kynett
Date: 4/24/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
13.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
14.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0075	0.9925	0.0075	0.9925
18.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0150	0.9851	0.0150	0.9851
20.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0224	0.9776	0.0224	0.9776
21.67	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0298	0.9702	0.0298	0.9702