ITEM 10

Agenda of October 20, 2016

TO: **Sacramento Area Flood Control Agency**
Board of Directors

FROM: **Timothy Washburn, Director of Planning**
(916) 874-7606

SUBJECT: **RESOLUTION – APPROVING THE SACRAMENTO AREA FLOOD CONTROL AGENCY DEVELOPMENT IMPACT FEE PROGRAM 2016 UPDATE**

OVERVIEW:
By adopting Resolution No. 2016-110, the Board would approve the Sacramento Area Flood Control Agency Development Impact Fee Program 2016 Update (Update Report) which is attached as Exhibit A to the resolution, thereby authorizing the following modifications to the Development Impact Fee (DIF) Program (Fee Program):

- Modify the area covered by the Fee Program (Program Area) so that it corresponds to the area protected by the projects funded by SAFCA's Consolidated Capital Assessment District No. 2 (CCAD 2);
- Modify the development projections that informed creation of the Fee Program in 2008 to better reflect current projections;
- Modify the projects to be funded by the Fee Program to reflect flood risk reduction accomplishments since 2008 and current development projections; and
- Modify the allocation of costs between land uses to reflect updated depth/damage curves and current best management practices in calculating expected annual damages (EAD) as a measure of flood risk.
- Modify the rates to be charged to residential and non-residental new development.

These modifications would take effect on January 1, 2017. Adoption of Resolution No. 2016-110 would also confirm the DIF rates that have been applied to new development since December 2015.

MEASURES/EVALUATION:
As described in the Update Report, the proposed modifications to the Fee Program would ensure that new development in the Program Area during the period 2009 to 2025 (period of analysis) would not increase the area's exposure to increased flood damages and the governmental costs associated therewith.

FINANCIAL IMPLICATIONS:
Under the proposed modifications to the Fee Program, the DIF rates currently charged to new single family and multifamily structures would remain largely unchanged while the rates charged to new commercial and industrial structures would be reduced by about 50 percent.

ENVIRONMENTAL IMPACTS:
The environmental effects of the projects that would be funded by the updated Fee Program are evaluated in the Final Subsequent Program EIR on Updated Local Funding Mechanisms for Sacramento Area Flood Control Improvements, which was certified by the SAFCA Board in April 2016.

RECOMMENDATION:
Staff recommends that the Board adopt Resolution No. 2016-110, thereby approving the Sacramento Area Flood Control Agency Development Impact Fee Program 2016 Update and authorizing the modifications to the Fee Program described therein.

BACKGROUND

The SAFCA Act of 1990 (SAFCA Act) gives the SAFCA Board of Directors (Board) the authority to "prescribe, revise, and collect fees as a condition of development of land" by adopting a resolution: (1) describing the specific flood control projects that are needed in order for the areas proposed for development to meet the flood protection standards determined by the Board; (2) estimating cost of these projects and associated environmental mitigation and specifying a plan for financing that cost; (3) determining a tentative time schedule for implementation of these projects; and (4) determining the reasonable portion of the cost to be apportioned to new development. The Board's intent to consider exercising this authority as part of SAFCA's ongoing flood risk management program was initially set forth in the Environmental Impact Report on Local Funding Mechanisms for Comprehensive Flood Control Improvements for the Sacramento Area (Local Funding EIR), which the Board certified in February 2007.

The Local Funding EIR identified the following flood risk management objectives: (1) complete the projects necessary to provide 100-year flood protection for developed areas in Sacramento's major floodplains as quickly as possible, (2) provide at least 200-year flood protection to these areas over time, and (3) ensure that new development in these areas does not substantially increase the expected damage of an uncontrolled flood. In order to accomplish these objectives, the Local Funding EIR identified a series of structural and non-structural improvements and evaluated the environmental effects of these improvements at a programmatic level. The Local Funding EIR anticipated SAFCA's creation of two funding mechanisms to provide the local share of the cost of these improvements: the Consolidated Capital Assessment District (CCAD) and the Fee Program. The CCAD was created in 2007. The Fee Program was approved in 2008 and became effective on January 1, 2009.

Since that time, however, changes in federal and State standards affecting urban levee design, floodplain delineation, and levee operation and maintenance standards have altered the scope and timing of the improvement program supported by the CCAD and caused the Board to replace CCAD with CCAD 2. Moreover, growth rates in the areas protected by this improvement program have fallen far short of the projections made in 2008. These developments have necessitated an update of the Fee Program. The establishment of CCAD 2 and the update of the Fee Program were evaluated in the Final Subsequent Program EIR on Updated Local Funding Mechanisms for Sacramento Area Flood Control Improvements, which was certified by the SAFCA Board in April 2016.

DISCUSSION

As described in the Update Report, implementation of the Fee Program would ensure that new structures placed in the Program Area do not increase Sacramento's exposure to flood damages and the governmental costs associated therewith. This exposure is measured by EAD, a metric that integrates the probability of an uncontrolled flood and the resulting property damage. New development could significantly increase EAD by increasing the economic consequences of an uncontrolled flood. The Fee Program would mitigate this impact by funding a series of flood risk reduction measures that would build on the flood risk reduction accomplishments of CCAD and CCAD 2 and thereby ensure that new development occurring beyond the baseline of existing conditions at the outset of the CCAD will be EAD neutral.

As set forth in the Update Report, the steps needed to achieve this objective are: (1) establish a period of analysis beyond baseline conditions and develop growth projections for this period; (2) perform an analysis of the increase in EAD that would result from this growth; (3) identify a series of flood risk reduction measures that could mitigate this increase and reiterate the EAD analysis with these measures in place; and (4) apportion the cost of the fee-funded projects to the new development based on the damage potential of each category of new development (single family residential, multi-family residential, commercial and industrial). Each of these steps is described below.

Growth Projections

Economic Planning Systems Inc. (EPS) provided the growth projections for the Update Report. Based on consultation with SAFCA staff, it was decided to focus on a period of analysis extending from the inception of the Fee Program on January 1, 2009 through the end of Fiscal Year (FY) 2024-25. This allowed EPS to develop growth projections based on two sets of data: (1) fee collection data provided by SAFCA for the period January 1, 2009 to June 30, 2016, and (2) growth projections for the subsequent 9 years based on data provided by the Sacramento Area Council of Governments and the affected land use jurisdictions in the Program Area. EPS used these two sets of data to derive growth estimates for the Program Area during the period of analysis as measured by damageable square footage within the following land use categories:

- Single Family Residential;
- Multifamily Residential;
- Commercial; and
- Industrial.

These land use categories were selected to facilitate the EAD analysis which relies on flood depth damage relationships that have been established for each of these categories.

EAD Analysis

David Ford Consulting Engineers (Ford) provided the EAD analysis. As in 2008, EAD was calculated by:

- Defining the floodplain areas of concern;
- Identifying the relevant watershed hydrology and hydraulics from which appropriate water surface elevations (with associated probabilities) are calculated for a range of flood events in the channels surrounding the area;
- Evaluating the performance reliability of the flood control facilities likely to be constructed as part of the CCAD 2 funded flood risk reduction program at each of the key water surface elevations;
- Conducting an inventory of the damageable structures located in the area; and
- Developing appropriate damage curves for these structures at various depths of flooding, and correlating channel water surface elevations and interior flood depths assuming failure of one or more of the area's flood control facilities.

From these calculations, (1) the annual probability of uncontrolled flooding was linked to (2) various levels of resulting damage. These two variables were integrated and expressed as a measure of flood risk in the form of EAD. The analysis showed that the projected development in the Program Area during the period of analysis would cause a substantial increase in exposure to economic losses by comparison to baseline conditions as measured by EAD.

Funded Projects

Working iteratively with Ford, SAFCA staff developed a series of risk reduction measures to be funded by the Fee Program that would augment the risk reduction accomplishments of the CCAD 2 funded projects and thus offset the identified potential increase in EAD. As in 2008, these measures include elements of the CCAD 2 funded projects that are likely to experience federal or state funding gaps. Accordingly, Fee Program revenues collected during the period of analysis would be used to cover the following project improvement costs:

- A portion of the expected Federal share of the cost of raising levees around the Natomas Basin as this measure has been excluded from the Federally authorized Natomas Project ($9.0 million);
- A portion of the State share of the cost of completing the Folsom Dam Raise Project allocable to construction of the Temperature Shutter Modifications, as no State sponsor for this measure has been identified ($11.0 million);

- A portion of the cost of implementing a corridor management plan in the North Sacramento area as no Federal or State contributions to this measure have been identified ($5.0 million);
- The cost of raising and strengthening portions of the Beach Stone Lake Levee in South Sacramento beyond the accomplishments of the South Sacramento Streams Group Project as no Federal or State contributions to this measure have been identified ($5.0 million);
- A portion of the cost of containing flows into the Natomas Basin through the gap in the Pleasant Grove Creek Canal west levee at Sankey Road as no Federal or State contributions to this measure have been identified ($3.0 million);
- A portion of the cost of increasing the conveyance capacity of the Sacramento and Yolo Bypass systems as these improvements do not receive funding from CCAD 2 assessments ($7.64 million); and
- A portion of the cost of acquiring agricultural conservation easements on 1,600 acres of land on the west side of the Sacramento River in Yolo County ($3.5 million).

The EAD analysis determined that with these improvements in place, the identified increase in EAD that would otherwise result from growth during the period of analysis would be fully mitigated.

Methodology for Calculating the Updated Development Impact Fee (DIF)

The methodology used to apportion the fee-funded project costs to new development involved the following steps:

1. From the growth projections for the period of analysis, determine the total damageable square footage by land use category that will be newly introduced into the Program Area during this period.
2. From the EAD analysis, determine the relative benefit factors attributable to each of the selected land use categories based on their damage potential per damageable square foot, both individually and cumulatively.
3. From the project cost estimates, determine the total cost of the improvements to be funded by the Fee Program during the period of analysis.
4. Allocate the total costs of the improvements to each land use category by applying the relative benefit factors determined in Step 2 to the total projected damageable square footage per land use category. Distributing the total cost per land use category over the projected damageable square footage for that category provides the total estimated cost per square foot by land use.
5. Determine the fee per damageable square foot for each of the selected land use categories by adding the amounts calculated in Steps 3 and 4.

Fee Credits

Staff has been approached by landowners in the Sutter County portion of the Natomas Basin who are interested in accelerating construction of the improvements needed to contain flows through the gap in the Pleasant Grove Creek Canal west levee at Sankey Road. These landowners would be willing to advance the cost of these improvements if they were given assurance that their costs could be credited against their future DIF charges. Toward this end, the Update Report contains provisions that would accommodate this sort of advance funding of Fee Program projects.

Fee Program Administration

Since the inception of the Fee Program in January 2009, the DIF has been collected by the agencies with jurisdiction over development in the Program Area (City of Sacramento, County of Sacramento and County of Sutter). Each of these agencies has entered into fee collection agreements with SAFCA pursuant to which they administer the Fee Program and receive compensation for this effort in an amount equal to about two to three percent of the total Fee Program collections during the initial phase of the Program. These agreements incorporate, by reference of an administrative procedures manual, the most recent version of which was adopted by the Board in February 2012. Pursuant to these procedures, the DIF is collected as a condition of obtaining a building permit. Upon receipt of a building permit application, the responsible land use agency makes an initial determination of the applicability of the Fee Program, based on the location of the proposed development project and computes the fee, taking into account applicable credits.

The process allows for variations in the method of fee payment, including:

- Use of any lawfully created assessment district or community facilities district to finance development fee payment; and
- Voluntary accelerated payment of the DIF at the time of filing of any application for a tentative subdivision map, parcel map or an earlier land use application, at the then-applicable rate.

Periodic Adjustment

DIF rates are subject to periodic adjustment to reflect inflationary costs based on the Engineering News - Record Construction Cost Index (ENR, Twenty Cities) (or similar index selected by the Executive Director in the event the ENR, Twenty Cities is no longer available). Such periodic adjustments must be presented to the Board at its April meeting for approval, and provided to the responsible land use agencies on or before May 1 of each year. Staff will apply the next adjustment in April of 2018. It has come to staff’s attention that the most recent inflationary adjustment was not presented to the Board. This adjustment has been in effect since December 2015. To clear up this discrepancy, Resolution No. 2016-111 includes a provision that confirms the rates currently being charged.

FINANCIAL CONSIDERATIONS

As indicated in the Update Report, the Fee Program has raised a total of about $11.24 million from its inception on January 1, 2009 through June 30, 2016. This is a small percentage of the revenues projected in 2008. Based on EPS' growth projections, the updated Fee Program will generate an additional $33.0 million over the nine year period ending on June 30, 2025. The cumulative total of $44.24 million will be used to support the fee-funded projects identified above that are necessary to ensure that growth in the Program Area from the inception of the Fee Program to the end of the period of analysis is EAD neutral. The rates necessary to raise $33.0 million over the next nine years would be applied to each of the affected land use categories on a per damageable square foot basis as follows:

- Residential
  - Single-Family - $2.06
  - Multifamily - $1.18

- Non-Residential
  - Commercial - $1.57
  - Industrial - $1.14

The residential rates are comparable to what is currently being charged. The commercial and industrial rates represent about a 50 percent reduction compared to the current commercial and industrial rates. These reductions reflect the impact of changes in the depth damage curves used to calculate EAD since 2008. Staff will apply the next periodic adjustment in April of 2018.

POLICY CONSIDERATIONS

The updated Fee Program would serve several important policy objectives. First, it would preserve the fiscal integrity of CCAD 2 by providing coverage for the funds being advanced from other benefit zones in the Program Area to support the early implementation project in Natomas. Second, it would augment the CCAD 2 funds available for achieving SAFCA's flood risk reduction objectives in the Program Area. Third, it would address ongoing Federal and State floodplain management concerns by providing a strategy for managing the residual risk of damage in the Program Area as new development occurs over time, thus promoting consistency with current Federal and State floodplain management policies.

ENVIRONMENTAL IMPACTS

The environmental effects of the projects that would be funded by the updated Fee Program have been evaluated in the Final Subsequent Program EIR on Updated Local Funding Mechanisms for Sacramento Area Flood Control Improvements, which was certified by the SAFCA Board in April 2016.

RECOMMENDATION

Staff recommends that the Board adopt Resolution No. 2016-110 approving the Sacramento Area Flood Control Agency Development Impact Fee Program 2016 Update and confirming the rates currently being charged to new development in the Program Area.

TNWlr\Development Fee Staff Report.bd
Attachment(s)

EXHIBIT A

The Economics of Land Use

Sacramento Area Flood Control Agency Development Impact Fee Program

2016 Update

Prepared for:

Sacramento Area Flood Control Agency (SAFCA)

Prepared by:

Economic & Planning Systems, Inc. (EPS)

October 2016

EPS #142057

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List of Acronyms

ARCF GRR................................American River Common Features General Reevaluation Report

CCAD ....Consolidated Capital Assessment District

CCAD 2... Consolidated Capital Assessment District No. 2

DIF ....Development Impact Fee

District 1.. Operation and Maintenance Assessment District No. 1

EAD .... Expected Annual Damages

EDUs .... Equivalent Damage Units

EGM .... Economic Guidance Memorandum

EPS .... Economic & Planning Systems, Inc.

FEMA .... Federal Emergency Management Agency

FY .... Fiscal Year

Ford Engineers .... David Ford Consulting Engineers

HEC-FDA .... Flood Damage Reduction Analysis Software Developed by the USACE Hydrologic Engineering Center

HEC-RAS .... River Analysis System Software Developed by the USACE Hydrologic Engineering Center

MFR .... Multifamily Residence

NFIP .... National Flood Insurance Program

PGCC .... Pleasant Grove Creek Canal

R&U .... Risk and Uncertainty

SACOG .... Sacramento Area Council of Governments

SAFCA .... Sacramento Area Flood Control Agency

SFR .... Single Family Residence

SRFCP .... Sacramento River Flood Control Project

USACE .... US Army Corps of Engineers

1. INTRODUCTION

The Sacramento Area Flood Control Agency (SAFCA) was formed in 1989 to address the Sacramento region's potential for flooding and to provide the region with increased flood protection. The SAFCA Act, passed in 1990, gives the SAFCA Board of Directors (Board) the authority to "prescribe, revise, and collect fees as a condition of development of land." Further, the SAFCA Act states that fee revenue collected from a specific area "may be used only for the acquisition, engineering, design, construction, reconstruction, maintenance, or operation of flood control projects that protect that area, or used to pay the debt service on, or reduce the principal of, any bonded indebtedness of that area."

As required by the SAFCA Act, the resolution adopting the fee program must describe (1) the specific flood control projects needed so the areas proposed for development meet the flood protection standards determined by the Board, (2) the estimated cost of these projects, (3) a tentative time schedule for their implementation, and (4) the reasonable portion of the cost to be apportioned to new development. (Water Code App. § 130-150.)

Pursuant to this authority, in May 2008, the SAFCA Board established a development impact fee program (Fee Program) designed to preserve the flood risk reduction accomplishments of the ongoing program to improve the federal/state flood control system in the Sacramento area. The Fee Program became effective on January 1, 2009. When measured as reductions in expected annual damages (EAD)—a correlation of the probability and consequences of uncontrolled flooding—these accomplishments could be undermined by local decisions to place new damageable structures in the areas protected by the improved flood control system (Program Area). Accordingly, the Fee Program requires persons wishing to build new structures in the Program Area to pay the development impact fee (DIF). Then the DIF is used to fund additional improvements to the flood control system that further reduce the probability of uncontrolled flooding, thus offsetting the potential increase in flood damages associated with the new structures and mitigating any increase in EAD.

The Fee Program is described in the Sacramento Area Flood Control Agency Development Fee Program 2008 Final Report, dated May 5, 2008 (2008 Final Report), adopted by the SAFCA Board on May 15, 2008. The 2008 Final Report reflects growth projections and a funded improvement program that have proven significantly to be at variance with actual trends since 2008. Over the last 8 years, growth in the Program Area has occurred at a fraction of the rate projected in the 2008 Final Report. Moreover, the flood control system improvements to which the Fee Program is tied have undergone substantial adjustment during this period. These improvements initially were identified in the Final Engineer's Report for the SAFCA Consolidated Capital Assessment District (CCAD), which was adopted by the SAFCA Board on April 26, 2007. Since then, changes in federal and state standards affecting urban levee design, floodplain delineation, and levee operation and maintenance requirements have altered the scope and timing of the identified improvements. These changes are reflected in the Final Engineer's Report of the SAFCA CCAD No. 2 (CCAD 2), which the SAFCA Board adopted on June 16, 2016.[1]

In light of these developments, the SAFCA Board has determined that it is necessary to update the Fee Program to:

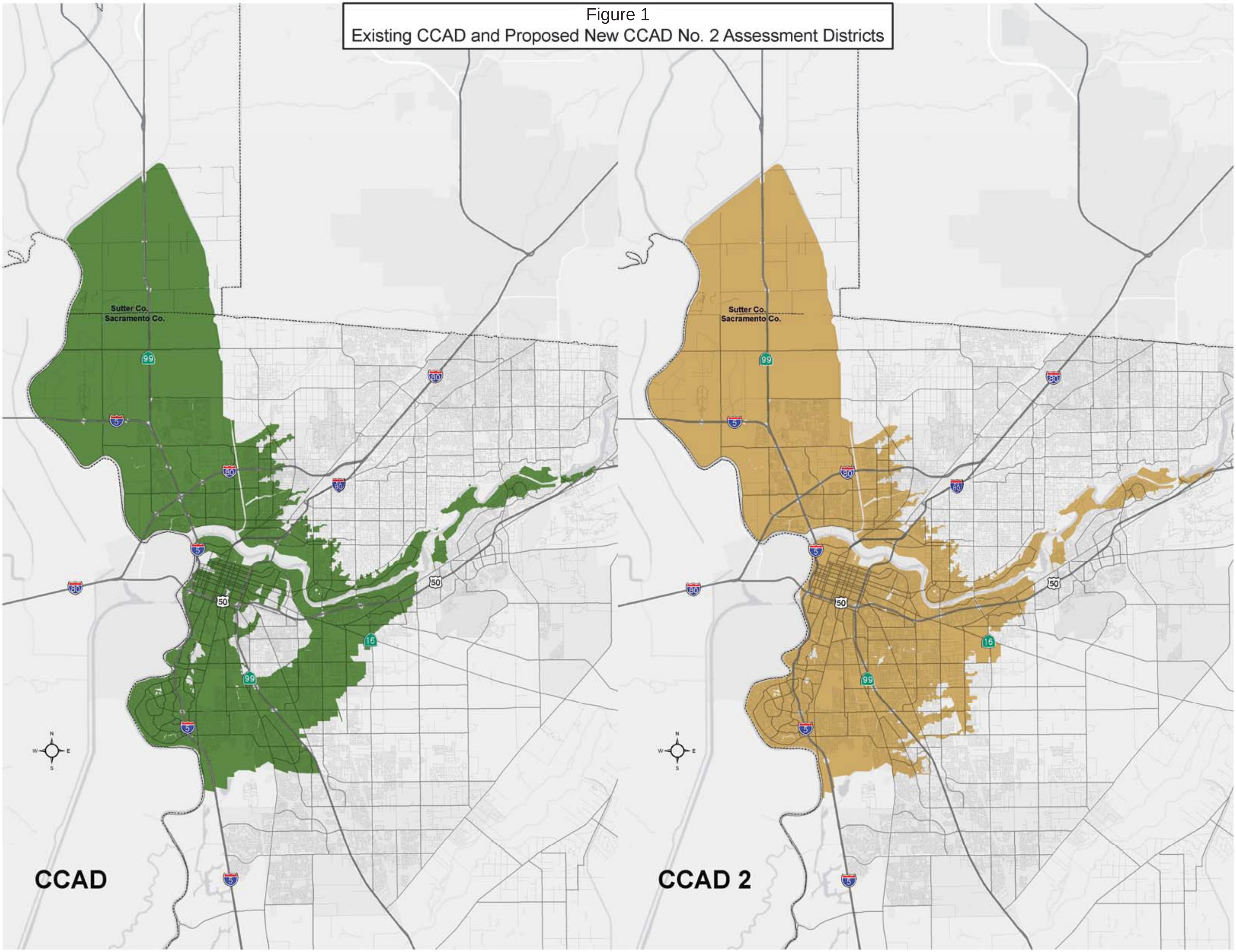
- Modify the protected area covered by the Fee Program so it corresponds to the area protected by CCAD 2-funded projects. This modification is shown in **Figure 1**, which compares the CCAD 2-protected area to the area protected by the CCAD. CCAD 2 covers an area that is slightly larger than the Sacramento area 200-year floodplain.
- Modify the development projections contained in the 2008 Final Report to better reflect current development projections.
- Identify improvements to be funded by the Fee Program that are tailored to meeting the objectives of the Fee Program in light of the modified development projections.
- Modify the allocation of costs between land uses to reflect updated depth/damage curves and current best practices in estimating EAD.

This report provides the information necessary to support the proposed update of the Fee Program as follows:

- **Chapter 2** restates the guiding policies and principles of the Fee Program, including the flood risk management context in which the Fee Program is being implemented, the use of EAD as a measure of flood risk, and the basis (baseline conditions) for measuring potential increases in EAD over time.
- **Chapter 3** provides growth estimates and projections for growth in the Program Area during the sixteen year period from the inception of the Fee Program on January 1, 2009 through June 30, 2025 (period of analysis) based on fee collection data provided by SAFCA and current data obtained from the Sacramento Area Council of Governments (SACOG).
- **Chapter 4** describes the flood risk reduction projects that would be funded by the Fee Program and the estimated amounts and timeline of this funding.
- **Chapter 5** provides an analysis of the accomplishments of the Fee Program by comparing EAD under three scenarios: baseline conditions on January 1, 2009 assuming no new development occurs in the Program Area during the period of analysis, and future conditions in 2025 assuming new development occurs in the Program Area between 2009 and 2025 as estimated and projected with and without the flood risk reduction improvements to be funded by the Fee Program. For purposes of the cost allocation, this chapter also identifies the 2016 EAD.

[1] The Final Engineer's Report of the SAFCA CCAD No. 2 can be accessed on the SAFCA Web site at http://www.safca.org/documents/Assessments/NewAssessment_CCAD2/Engineers_Report_06.13.2016_FINAL.pdf.

Figure 1
Existing CCAD and Proposed New CCAD No. 2 Assessment Districts



- **Chapter 6** outlines the structure of the Fee Program, including the methodology used to apportion the identified project costs to new development and the formula for calculating the fee.
- **Chapter 7** summarizes the Fee Program implementation and administration and refers to the Administrative Procedures Manual for the detailed procedures and requirements.

This report also includes two appendices:

- **Appendix A** contains the detailed growth projections for the Fee Program Area.
- **Appendix B** contains the Comparative Risk Assessment report, prepared by David Ford Consulting Engineers (October 2016).

2. Overview of the Fee Program

Flood Risk Management Context

In February 2006, the SAFCA Board adopted a white paper entitled, "Legislative Framework for Flood Control and Flood Risk Management in the Sacramento Valley," which has provided policy guidance for SAFCA's ongoing effort to reduce the risk of flooding in the Sacramento Metropolitan Area (Sacramento). In summary, the white paper calls for a State plan of flood protection for the Sacramento Valley that builds on the accomplishments of the Sacramento River Flood Control Project (SRFCP) and provides different standards of flood protection for urban areas, non-urban areas, and small communities based on their differing levels of development and expected damage in an uncontrolled flood.

- The flood protection standard for urban areas, including Sacramento, West Sacramento, Woodland, Yuba City, and Marysville (along with Reclamation District No. 784), should be 200-year flood protection.
- Non-urban areas should be protected to a level consistent with the minimum design standards of the SRFCP (i.e., non-urban levees should meet the SRFCP's minimum freeboard requirements and should have adequate structural stability to contain the SRFCP's design flows with a reasonable degree of reliability appropriate for lightly populated agricultural areas).
- Small communities should be protected by compact perimeter levees that at least meet the minimum design standards of the National Flood Insurance Program.

The goal of this dichotomous system of flood protection should be to reduce the risk of flood damages over time by increasing the protective capacity of the flood control system and confining the extent of urban development. This approach subsequently was endorsed by the Legislature in the Central Valley Flood Protection Act of 2008. (See Water Code §§ 9601(a)-(g), 9602(i).)

Consistent with this framework, SAFCA has adopted the following objectives to guide its flood protection efforts:

1. Provide at least a 100-year level of flood protection to the developed areas in Sacramento's major floodplains as quickly as possible.
2. Achieve the State of California's 200-year flood protection standard for these areas within the timeframe allowed by the Legislature.
3. Improve the resiliency, robustness, and structural integrity of the flood control system over time so the system safely can contain flood events larger than a 200-year flood.
4. Ensure new development in the areas protected by the improved flood control system does not substantially increase the expected damage of an uncontrolled flood.

In February 2007, the SAFCA Board certified a Final Environmental Impact Report on Local Funding Mechanisms for Comprehensive Flood Control Improvements for the Sacramento Area (Local Funding EIR), identifying the structural and non-structural improvements necessary to achieve these objectives and evaluating the environmental effects of these improvements at a programmatic level. The Local Funding EIR anticipated SAFCA's creation of two funding mechanisms to provide the local share of the cost of these improvements: the CCAD and the Fee Program. The CCAD was created in 2007. The Fee Program was established in 2008. However, changes in federal and state standards since 2007 affecting urban levee design, floodplain delineation, and levee operation and maintenance standards have altered the scope and timing of the improvement program supported by the CCAD and caused the SAFCA Board to replace CCAD with CCAD 2. Moreover, growth rates in the areas protected by this improvement program have fallen far short of the projections made in 2008. These developments have necessitated an update of the Fee Program as reflected in this Report. The establishment of CCAD 2 and the update of the Fee Program have been evaluated in the Final Subsequent Program EIR on Updated Local Funding Mechanisms for Sacramento Area Flood Control Improvements, which was certified by the SAFCA Board in April 2016. The following sections describe the principles that will be used to allocate local costs between CCAD 2 and the updated Fee Program.

Using EAD as a Measure of Flood Risk

The risk of flooding has two aspects: the probability of flooding, and the consequences that would follow. An area could have a high probability of flooding but minimal consequences because it is forested and contains no infrastructure or people, so the risk because of flooding would be considered low. Conversely, a highly urbanized community that has a moderate or low probability of flooding would be considered high risk because the consequences of a flood in that location (i.e., loss of life, livelihood, property, health, and human suffering) would be considered very high.[2]

EAD is a statistical measure that integrates the probability of an uncontrolled flood and the resulting property damage. This integrated approach commonly is used as a risk management tool. For example, the risk of damage to automobiles is managed principally by creating insurance pools based on premiums charged to automobile owners that reflect the probability of an accident and the amount of damage likely to result from the accident. On this basis, the owner of a higher priced vehicle likely will pay a higher premium than the owner of a lower priced vehicle because the damage to the higher priced vehicle likely will be greater even if the probability of an accident is the same. By the same token, a designated safe driver with a record indicating a low probability of an accident likely will pay a lower premium than a driver without such a designation for a comparably priced vehicle.

[2] This explanation of the risk of flooding is set forth in the Executive Summary of "A California Challenge—Flooding in the Central Valley," a report from an Independent Review Panel to the Department of Water Resources, State of California, October 15, 2007.

EAD typically is calculated by:

- Defining the floodplain area of concern.
- Identifying the relevant watershed hydrology and hydraulics from which appropriate water surface elevations (with associated probabilities) are calculated for a range of flood events in the channels surrounding the area.
- Evaluating the performance reliability of the area's flood control facilities at each of the key water surface elevations.
- Conducting an inventory of the damageable structures located in the area.
- Developing appropriate damage curves for these structures at various depths of flooding, and correlating channel water surface elevations and interior flood depths, assuming failure of one or more of the area's flood control facilities.

From these calculations, (1) the annual probability of uncontrolled flooding can be linked to (2) various levels of resulting damage. These two variables can be integrated and expressed as a measure of flood risk in the form of EAD.

Background of Federal and State Flood Risk Reduction Efforts

As a general rule, flood risk reduction projects are considered cost-effective if their anticipated benefits, measured as a reduction in EAD, exceed their one-time capital and annual operation and maintenance costs. For the past two decades, this benefit-to-cost relationship has been the single most important determinant in planning and prioritizing federal and state flood risk reduction efforts. A key problem for flood risk managers is how to account for changes in the flood risk equation over time because of development in protected floodplains. Such development may be subject to guidelines promulgated by the Federal Emergency Management Agency (FEMA) under the provisions of the National Flood Insurance Program (NFIP). In floodplain areas where the annual probability of flooding exceeds 1/100, these guidelines require elevation or flood proofing of all new structures. If the affected areas are subject to deep flooding, compliance with these guidelines may be economically infeasible, thus severely restricting new development. Flood control projects that relieve these restrictions by lowering the annual probability of flooding to less than 1/100 have the potential to facilitate development and thus increase the damageable property at risk from flooding. This potential creates tension between reducing flood damages and promoting economic development, the two goals that historically have guided federal and state flood risk management efforts.

This tension has produced conflicting federal/state policies, especially in floodplain areas such as the Yuba Basin (Reclamation District No. 784/Plumas Lake) in Yuba County and the Natomas Basin in Sacramento and Sutter Counties. These historically agricultural basins are in transition. They have relatively substantial urban populations in need of protection, but they also have the potential for absorbing significant amounts of new development over time.

On the one hand, Congress has made it clear that the benefit base should not include "any new or substantially improved structure (other than a structure necessary for conducting a water-dependent activity) built in the 100-year flood plain with a first floor elevation less than the

100-year elevation after July 1, 1991 or any structure that becomes located in the 100-year flood plain with a first floor elevation less than the 100-year flood elevation or in the 10-year flood plain, as the case may be, by virtue of constrictions placed in the flood plain after July 1, 1991."[3] More pointedly, Congress adopted legislation in 1992 admonishing the Secretary of the Army not to undertake improvements to the Natomas Basin that would have the effect of "encouraging development of deep floodplains."[4] (The legislation did not define "deep floodplains.") On the other hand, in the interest of national economic development, federal project feasibility studies have allocated "location benefits" to projects that would remove the regulatory barriers to such development.[5]

The tension between promoting economic development and reducing flood damages has grown in the aftermath of Hurricane Katrina as the economic consequences (including governmental costs) associated with flooding a major American city have become clear. Accordingly, federal flood risk management policy has tilted toward reducing governmental exposure to such costs. A similar shift is occurring in California, spurred by a series of judicial decisions that have established the potential breadth of state liability in the event of flooding in areas of the Central Valley, where the state has played an instrumental role in designing, funding, operating, and maintaining large integrated flood control systems. In addition to serving as an indicator of flood risk, EAD also is an indicator of potential governmental liability for flood response, relief, and recovery costs. Thus, the current emphasis of federal and state flood risk management policy is on reducing EAD in the most cost-effective manner possible.

Fee Program Consistency with Federal and State Risk-Reduction Efforts

The updated Fee Program would be consistent with this emphasis. As discussed below, the Fee Program recognizes that the flood control projects funded by CCAD 2, for which there is authorized state and federal support, will provide the Sacramento area with sufficient flood protection to meet the minimum standards of the NFIP and the state's urban level of flood protection. This will permit new development in the Program Area to proceed in accordance with adopted local land-use plans and the region's "blueprint" for growth over the next two decades. Under applicable federal policies and guidelines, this development cannot contribute to the benefit base or the reduction in EAD justifying federal support for the CCAD 2-funded projects. At the same time, planned development should not be allowed to compromise the benefits of these flood control projects by contributing to an increase in flood risk and associated

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[3] Section 308(a)(1)(A), Water Resources Development Act of 1990 (PL 101-640).

[4] Section 9159(b)(1) of the Defense Appropriations Act of 1993 (PL 102-396).

[5] As defined in Economic and Environmental Principles for Water and Related Land Resources Implementation Studies issued by the U. S. Water Resources Council March 10, 1983, location benefits are a measure of the net income or market value of floodplain land with and without the flood protection project in place. In 1991, the US Army Corps of Engineers issued a feasibility study as part of the American River Watershed Investigation that allocated location benefits to alternatives that provided sufficient protection to remove the Natomas Basin from the FEMA 100-year floodplain and thus would increase the market value of land in the basin.

governmental liability (as measured by EAD) over time. In short, planned, new development should be flood risk (or EAD) neutral.

In Sacramento, this flood-risk neutrality could be achieved in several ways. New structures could be raised or otherwise flood-proofed on a structure-by-structure or subdivision-by-subdivision basis to avoid an increase in flood risk (as measured by EAD). Alternatively, the new structures could generate funds through payment of fees to be used for improvements to the flood control system protecting the floodplains in which they are located, as proposed under the Fee Program. In this respect, maintaining EAD neutrality is similar to maintaining a roadway level of service. Where new development has the potential to decrease the baseline level of service by adding new traffic to the roadway, this impact could be mitigated, either by creating a new, separate roadway used only by the newcomers (if this were feasible) or by expanding or otherwise improving the existing roadway and creating the incidental benefit of improving roadway capacity for the use of all.

As in the case of mitigating traffic impacts, investments in improving the flood control system as a whole is the most cost-effective way to achieve flood risk (or EAD) neutrality for several reasons. Because of the depth of flooding likely to result from a failure of the levee system protecting Sacramento's major floodplains, the cost of raising or otherwise flood-proofing new structures on a structure-by-structure or subdivision-by-subdivision basis would be substantial, and the design of such structures/ subdivisions would create significant unevenness throughout the urban landscape. By comparison, because these floodplains are already extensively developed, investments in systemwide improvements, in the form of mitigation fees, would reduce flood risk, thereby generating reductions in EAD in a much more cost-effective manner than the structure-by-structure or subdivision-by subdivision alternatives.

Because under the systemwide approach, the investments of the existing and new development are intertwined, there must be an accounting of the flood control projects and risk reduction accomplishments attributable to these separate investments. The following section describes how this accounting will be carried out in connection with the proposed Fee Program.

Baseline Conditions

To account for the investments of the Fee Program and the accomplishments of this program with respect to avoiding an increase in EAD, it is necessary to identify a baseline condition reflecting the investments of existing development. These investments are described in the Final Engineer's Report for the CCAD 2 (June 13, 2016). SAFCA has determined that the baseline condition should include the projects funded by CCAD 2 for which there is authorized federal and state support and sufficient local funding:

- Folsom Dam Modifications—The baseline includes the flood risk reduction elements of the Folsom Dam Joint Federal Project authorized in Defense Appropriations Act of 2007 including construction of a new Folsom Auxiliary Spillway (expected to be completed in 2017) and the adoption of an Updated Water Control Manual for Folsom Dam as authorized in the Water Resources Development Act of 1999.

- Natomas Levee Improvements—The baseline includes all elements of the Natomas Levee Improvement Program that have been authorized as part of the Water Resources Reform and Development Act of 2014. These include all levee strengthening activities, all rights of way and relocations needed to support these activities, and the mitigation associated with these activities. Much of this work has been completed by SAFCA as part of state-local early implementation project. The remainder will be constructed as part of a follow on federal project.

- American River Levee Improvements—The baseline includes all elements of the Common Features Project along the American River including the levee strengthening and levee raising improvements authorized as part of the Water Resources Development Acts of 1996 and 1999. These activities were completed in 2016. The baseline also includes the levee armoring improvements along the American River that are recommended in the American River Common Features General Reevaluation Report (ARCF GRR) which was transmitted by the Corps to Congress in 2016 with the support of the state and SAFCA.

- Sacramento River Levee Improvements—The baseline includes all the levee strengthening improvements along the Sacramento River that are recommended in the ARCF GRR including the elements of the recommended project that will be completed by SAFCA as part of a state-local early implementation project.

- North Sacramento Streams Levee Improvements—The baseline includes all the levee strengthening improvements along the east levee of the Natomas East Drainage Canal, the south levee of Arcade Creek, and west levee of the Magpie Diversion Channel that are recommended in the ARCF GRR including the elements of the recommended project that will be completed by SAFCA as part of a state-local early implementation project.

- South Sacramento Streams Group Improvements—The baseline includes all the levee, floodwall and channel improvements along Morrison Creek and its tributaries in South Sacramento that have been authorized as part of the Water Resources Development Act of 1999, including the elements of the project that have been completed by as part of separate local and state-local early implementation projects.

Taken together, these projects funded by CCAD 2 with authorized state and federal support substantially will reduce the risk of flooding to existing development in the major floodplains of Sacramento. The estimated reduced EAD that would be attributable to 2008 existing development after completing these improvements represents the baseline EAD condition against which EAD increases attributable to projected new development will be evaluated. The EAD analysis in **Chapter 5** measures EAD increases over the baseline that would result from development during the period of analysis from the inception of the Fee Program in 2009 through 2025, both with and without Fee Program-funded improvements.

Program Phasing

The objective of the Fee Program is to avoid any substantial increase in the baseline EAD as new development occurs in Sacramento's floodplain. Because of uncertainties in the timing and volume of such development and in the direction and accomplishments of federal and state flood risk management efforts over time, the Fee Program is being implemented in phases.

As set forth in the 2008 Final Report, the current phase focuses on filling federal and state funding gaps in the projects needed to provide a 200-year level of flood protection to the Program Area. Under the requirements of the Central Valley Flood Protection Act of 2008, this is the level of flood protection that Sacramento (and other urban areas in the Central Valley) must attain by 2025 (the end of the period of analysis) in order to continue development in the Program Area. Thereafter, it is anticipated that the focus of the Fee Program will shift to providing greater than a 200-year level of flood protection by funding improvements to increase the conveyance capacity of the Yolo Bypass system and increasing the capacity of the flood control system in the American River watershed. This phasing strategy is reflected in the following chapters of this Report. Growth estimates and projections are presented for the sixteen year period of analysis based on SAFCA fee collections and current SACOG data. During this period, Fee Program revenues would be used primarily to fill federal and state funding gaps in CCAD 2 projects at Folsom Dam and in the Natomas, North Sacramento, and South Sacramento areas and secondarily to support projects focusing on expanding the Sacramento and Yolo Bypass systems.

3. DEVELOPMENT ESTIMATES AND PROJECTIONS

Economic & Planning Systems, Inc., (EPS) developed Fee Program growth estimates and projections for the period of analysis from inception of the Fee Program through the end of Fiscal Year (FY) 2024-2025 (June 30, 2025). EPS estimated the development that occurred from 2009, when the Fee Program was established, through the end of FY 2015-2016 based on fee collection data provided by SAFCA for this time period. In addition, EPS developed projections for the remainder of the period of analysis through FY 2024-2025. These estimates of current development and projections of future growth were needed to assess the change in EAD with and without flood control improvements that would result from growth from the time the Fee Program was established through FY 2024-2025.

The development projections are detailed in **Appendix B** and summarized in this chapter. They are based on data provided by SACOG and David Ford Consulting Engineers (Ford Engineers). EPS used the SACOG and Ford Engineers data to derive growth estimates for the Program Area as measured by damageable square footage. Damageable square feet provides an estimate of the portion of a structure that may be damaged in the event of a flood. Damageable square feet consists of the first two floors of all residential structures and the first floor of all other types of development. Estimates of projected future damageable square feet were developed for the following four land use categories.

- Single Family
- Multifamily
- Commercial
- Industrial

These land use categories were selected to facilitate development of the Fee Program and preparation of the EAD analysis, which rely on flood depth damage relationships that have been established for each of these categories.[6]

Because the SACOG projections cover a wider range of land use categories, EPS used SACOG's Blueprint Modeling Land Use Menu 1 (Blueprint Menu), dated August 1, 2003, to categorize the SACOG land uses into the four Fee Program land use categories. EPS applied square feet per dwelling unit and square feet per employee factors to the SACOG dwelling unit and employee projections to arrive at estimates of damageable square feet. These factors are shown in **Table B-1** of **Appendix B**.

[6] Note that the current Fee Program includes development projections and fees for six land use categories, as it distinguishes between single family and multifamily one-story and two-story (or more) land uses. The existing single family one-story and two-story fees differ by only 8 cents per square foot, while the multifamily one-story and two-story fees differ by only 6 cents per square foot. Because there is little difference between the two single family fees or between the two multifamily fees, for this update, the project team consolidated the two single family categories and the two multifamily categories into one single family and one multifamily category, respectively.

The SACOG growth projections tend to project a faster pace of development than actual historical development trends have shown to occur. Consequently, EPS adjusted the SACOG projections downward to develop more conservative projections in keeping with observed levels of development activity. For the different areas of the Fee Program (e.g., City of Sacramento, unincorporated Sacramento County, Sutter County), EPS researched planned development projects and historical development trends to determine appropriate adjustments.

Table 1 summarizes the estimated current and projected future damageable square feet by Fee Program land use. The methodology to develop these estimates and projections is described below and detailed in **Appendix B**:

- **Estimated growth in damageable square feet from 2009 through FY 2015-16**
  These damageable square feet estimates are based on fee collection data provided by SAFCA to represent the existing growth in damageable square feet that has occurred since the start of the Fee Program.

- **Projected growth in damageable square feet for the 9-year period from FY 2016-2017 through FY 2024-2025**
  These growth projections are based on annualized growth projections for the 25-year period from 2010 to 2035. EPS developed the annual growth projections from SACOG data and then applied them to the period from FY 2016-2017 through FY 2024-2025 as detailed in the following steps.

  1. SACOG provided a projected development database that included the land use and projected 2035 dwelling units or employees for all parcels in the Fee Program area.
  2. EPS excluded the existing development parcels (based on data from Ford Engineers) from the 2035 database, leaving only parcels for which future growth was projected for the 25-year period from 2010 through 2035.EPS applied adjustments to the SACOG dwelling unit and employee growth projections to develop projections representative of historical and anticipated future growth rates. Various adjustment factors were applied for the different areas of the Fee Program (e.g., City of Sacramento, unincorporated Sacramento County, and Sutter County).
  3. For each SACOG residential land use, EPS estimated the average damageable square feet per dwelling unit as detailed below and summarized in **Table B-1**:
     - An average total square feet per dwelling unit factor was established for each SACOG land use.
     - All single family development was assumed to be one or two stories. Because the first two stories of residential development is assumed to be damageable, for each single family category, the damageable square feet per dwelling unit was set equal to the estimated total square feet per dwelling unit.
     - For each multifamily category, EPS estimated the average number of stories, which ranged between 3.5 and 6 stories. The average square feet per story was then estimated as the total square feet divided by the number of stories. This average square feet factor was multiplied by 2 to estimate the damageable square feet on the first two stories.

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Table 1
SAFCA Development Impact Fee Update
Projected Damageable Square Feet Summary

	Damageable Square Feet		
Land Use	**Projected:** 01/01/09-06/30/16 [1]	**Projected:** 07/01/16-06/30/25	**Total**
Source		*Table A-2*	
Single-Family	3,246,000	8,029,238	**11,275,238**
Multifamily	270,000	6,925,154	**7,195,154**
Commercial	649,000	3,229,782	**3,878,782**
Industrial	1,229,000	2,803,730	**4,032,730**
Total	**5,394,000**	**20,987,904**	**26,381,904**

sq ft

[1] Estimated from actual SAFCA DIF collections.

4. For each SACOG commercial and industrial land use, EPS estimated the average damageable square feet per employee as detailed below and summarized in **Table B-1**:
   - An average total square feet per employee factor was established for each SACOG land use.
   - The average number of stories was estimated for each SACOG land use.
   - Because only the first story of commercial and industrial development is considered to be damageable, the average damageable square feet per employee was estimated as the square feet per employee divided by the number of stories.
5. For each single family, multifamily, commercial, and industrial parcel, the projected growth in damageable square feet was estimated as the average damageable square feet per dwelling unit or employee multiplied by the number of dwelling units or employees.
6. The damageable square feet were summed across all parcels by SACOG and Fee Program land use resulting in damageable square feet growth projections by Fee Program land use for the 25-year period from 2010 through 2035.
7. Average annual damageable square feet projections by land use were developed from the 25-year projections described in the previous step. These annual projections were multiplied by nine to arrive at damageable square feet growth projections for the nine year period from FY 2016-2017 through FY 2024-2025.

4. IMPROVEMENTS FUNDED BY THE FEE PROGRAM

Improvements

To offset the potential increase in EAD that otherwise could result from the projected growth described in the previous chapter, revenues generated by the Fee Program would be used to fund the projects that are shown in **Figure 2** and described in detail below. These projects are in addition to the baseline improvements described in **Chapter 2** and were identified by SAFCA as improvements needed to mitigate the EAD generated by development from 2009 through 2025.

Folsom Dam Modifications

The Folsom Dam Modifications Project includes dam raise and temperature shutter modifications authorized as part of the Water and Energy Appropriations Act of 2003. These elements are not likely to be fully cost shared as no state sponsor has been identified for the temperature shutter modifications included in the authorized project. This funding gap—estimated to be approximately $11 million of the estimated $285 million total cost of the authorized project—would be filled by the Fee Program.

Natomas Levee Improvements

The federal authorization of the Natomas Levee Improvement Program does not include the following project elements covered by CCAD 2: (1) levee raising activities along 5.3 miles of the Natomas Cross Canal and approximately 13 miles of the Sacramento River east levee and (2) construction of drainage facilities in the vicinity of the Sankey Road gap in the Pleasant Grove Creek Canal (PGCC) west levee. The levee raising work is needed to meet federal and state urban levee freeboard requirements. This work has been completed by the state and SAFCA as part of the early implementation project for an estimated cost of approximately $30 million. Because it is outside the scope of the federally authorized project, this expenditure is not eligible for federal cost sharing or credits. The resulting gap in federal funding has increased SAFCA's share of the cost of the project by $9 million. This gap would be filled by the Fee Program.

The interior drainage work is needed to manage flows through the gap in the PGCC west levee when high water surface elevations in the Sacramento River combine with significant runoff in the watersheds west of the PGCC to overload the existing containment facilities and spill water into the northern portion of the Natomas Basin. Alternative measures to manage these spills have been identified in the Sutter Pointe Specific Plan approved by the Sutter County Board of Supervisors in 2009. The Fee Program would cover a significant share of the cost of these measures from fees collected from the new development anticipated in the plan when this development moves forward. It is likely that Fee Program contributions will take the form of credits for costs incurred by landowners in advance of the development of their land. During the period of analysis, these credits are expected to total approximately $3 million.

Figure 2 DIF-Funded Projects

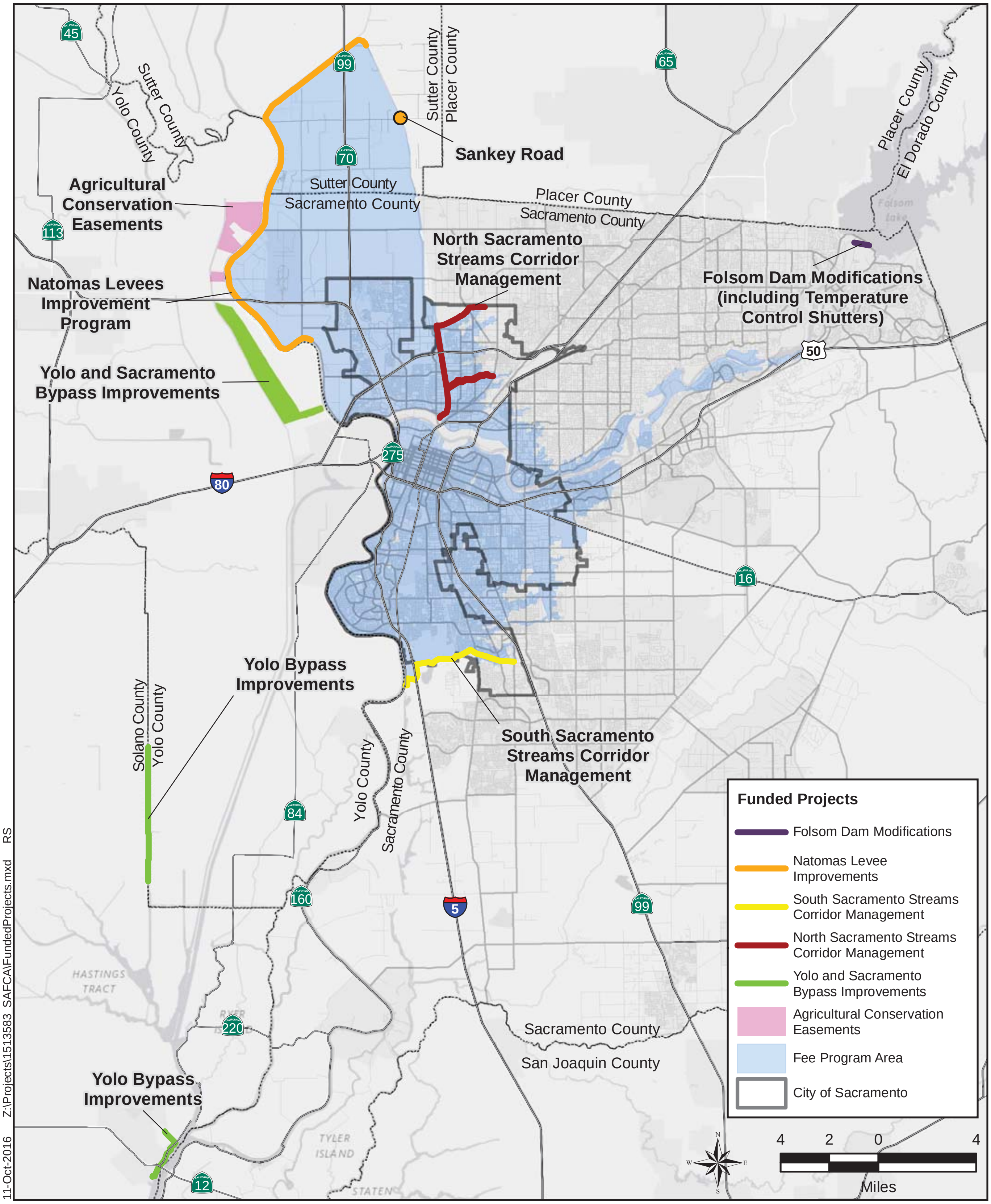

Figure Source: WSP Parsons Brinckerhoff, 2016; GEI Consultants, Inc., 2016.

North Sacramento Streams Corridor Management

SAFCA's early implementation project in the North Sacramento Streams area includes stream corridor improvement activities designed to promote free flowing stream conditions in the Natomas East Main Drainage Canal by eliminating existing flowage obstructions (primarily beaver dams and the non-native vegetation that thrives in the backwater conditions created by the dams). These activities which will lower flood stages in the channel are not included in the recommendations of the ARCF GRR and will thus not be fully funded as part of the federal project. This will create a funding gap of about $5 million that will need to be filled by the Fee Program.

South Sacramento Streams Corridor Management

The federally authorized South Sacramento Streams Group Project includes provisions for raising two miles of the Beach Lake levee between the Sacramento River and the downstream end of Morrison Creek. This work which has been completed is designed to contain high water surface elevations in the floodplain corridor south of the levee that are generated by high flows in the Cosumnes and Mokelumne Rivers and high stages in the northern portion of the Sacramento-San Joaquin Delta (North Delta). SAFCA has determined that the completed work may not sufficiently account for a failure of the Sacramento River east levee downstream of the Beach Lake levee particularly under high wind conditions. Accordingly, additional improvements are needed to address these conditions. These improvements could include redesign of the tree mitigation included in the Sacramento River Levee Improvement Project to create an effective wind barrier along the waterside toe of the Beach Lake levee; adding slightly more height to the Beach Lake levee; and contributing to improvements in the North Delta that would lower water surface elevations in the vicinity of the Beach Lake levee. The Fee Program would cover the cost of these improvements which is estimated to be $5 million.

Sacramento/Yolo Bypass Improvements

The ARCF GRR recommends widening the Sacramento Weir by about 1,500 feet and setting back the north levee of the Sacramento Bypass by an equivalent distance to increase the diversion of flows from the Sacramento River channel through the Sacramento Bypass to the Yolo Bypass. This work is not covered by CCAD 2 because the state has indicated its intention to fully fund an early implementation project that would involve setting back the Sacramento Bypass north levee as recommended in the ARCF GRR and joining this action with setting back the east levee of the Yolo Bypass between the westerly end of the new north levee and I-5. Credits generated by this early implementation project and the early implementation project along the Sacramento River east levee in the Pocket area would cover the balance of any non-federal contribution to the cost of extending the Sacramento Weir and relocating the Sierra Northern rail line immediately west of the Weir. As indicated in the ARCF GRR, during large flood events in the Sacramento-Feather River watershed, these improvements would lower water surface elevations in the Sacramento River channel by more than a foot between the I-Street Bridge and Freeport.

To facilitate the state's early implementation project, SAFCA has indicated its willingness to cover the annual cost of maintaining the new Sacramento Bypass and Yolo Bypass levees and to assist the state in ensuring timely completion of right of way, relocation, and mitigation issues associated with this and other related projects in the Yolo Bypass. During the period of analysis, the cost of these commitments is estimated to be up to $7.64 million.

Agricultural Conservation Easements

This project consists of acquiring agricultural conservation easements in the northern portion of the Elkhorn area in Yolo County—a sparsely populated agricultural area protected in part by a portion of the Sacramento River west levee directly across from the Natomas Basin. These easements which were acquired by the state in 2009 are designed to preserve an open space area that could absorb flood waters without severe damage in the event of a very large flood along the Lower Sacramento River, thereby relieving pressure on the Sacramento River east levee protecting the Natomas Basin. To facilitate the project, SAFCA agreed to contribute a portion of the cost of the easements ($3 million) and to cover ongoing annual costs associated with managing the encumbered property (approximately $30,000 annually). To date, these costs have been advanced by SAFCA's Operation and Maintenance District No. 1 (Assessment District No. 1) with the understanding that these advances would be covered by the Fee Program.

Project Costs and Timeline

Table 2 identifies the projects described above and details the estimated project costs allocable to the Fee Program and the timeline for these expenditures. Note that the costs include both Fee Program costs that already have been incurred and projected future costs through FY 2024-2025. These estimates are based on the assumption that, for the most part, Fee Program expenditures will occur as reimbursements either to the CCAD 2 or to SAFCA's Assessment District No. 1, which will serve (or have served) as the initial funding sources for the identified projects. This structure will accommodate expected differences between the timing of new development and the timing of project implementation. Thus, while the timing of fee collection and project implementation as shown in **Table 2** generally correspond with respect to Natomas, Folsom Dam, and the Sacramento/Yolo Bypass, fee collection likely will lag significantly behind project implementation in North Sacramento and South Sacramento. These projects will be funded as appropriate by either CCAD or CCAD 2, and the expenditures will be reimbursed by the Fee Program in the timeframes shown in **Table 2**.

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Table 2
SAFCA Development Impact Fee Update
Summary of DIF-Funded Costs and Projected Timeline (in Millions)

		Estimated Cost by Fiscal Year (in Millions)									
Improvements	**Total**	01/01/09-06/30/16	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022	2022-2023	2023-2024	2024-2025
Folsom Dam	$ 11.00	-	$ 0.90	$ 0.80	$ 1.20	$ 1.50	$ 2.20	$ 2.30	$ 2.10	-	-
Natomas Levee	$ 12.00	$ 9.00	-	-	-	-	-	-	-	$ 1.20	$ 1.80
North Sacramento Streams Corridor	$ 5.00	-	-	-	-	-	-	$ 0.50	$ 1.10	$ 2.00	$ 1.40
South Sacramento Streams Corridor	$ 5.00	-	$ 0.30	$ 0.70	$ 1.30	$ 1.30	$ 1.00	$ 0.40	-	-	-
Sacramento/Yolo Bypass	$ 7.64	$ 1.00	$ 0.90	$ 1.63	$ 1.13	$ 0.83	$ 0.43	$ 0.43	$ 0.43	$ 0.43	$ 0.43
Agricultural Conservation Easements	$ 3.50	$ 1.20	$ 1.56	$ 0.53	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03	$ 0.03
Total	**$ 44.14**	**$ 11.20**	**$ 3.66**	**$ 3.66**	**$ 3.66**	**$ 3.66**	**$ 3.66**	**$ 3.66**	**$ 3.66**	**$ 3.66**	**$ 3.66**

cost

Source: SAFCA

5. Comparative EAD Analysis

Introduction

This chapter summarizes the results of a comparative EAD analysis performed by Ford Engineers (**Appendix B**). This analysis focuses on the benefits of the projects that would be funded by the Fee Program in terms of the value of the flood damages that would be prevented by these projects. These benefits are measured by comparing the estimated incremental increase in total structure and content damage that would result from the estimated growth projections from **Chapter 3** with and without the Fee Program projects discussed in **Chapter 4**. Because the random nature of flooding makes it impossible to predict the damages prevented in any particular year, EAD (the statistical average damage value) is used as the measure of the comparative benefits of the Fee Program.

Overview of EAD Analysis

For purposes of the EAD analysis, the baseline condition estimates the EAD resulting from the aggregate of all damageable building square footage in the Program Area as of 2009, which is the year during which the Fee Program became effective. The future condition estimates the EAD resulting from the aggregate of all damageable building square footage that has been added and is expected to be added to the Program Area during the period of analysis (January 1, 2009 to June 30, 2025).

2009 is used for the baseline EAD condition and 2025 for the future condition to demonstrate the effect of all planned Fee Program improvements on the EAD resulting from the corresponding development during the time period for which the improvements are planned and the costs are incurred. These improvements include improvements for which fee revenue has already been collected and future planned improvements still to be funded.

EAD was calculated for the baseline condition and future conditions with and without the projects funded by the Fee Program using the statistical sampling procedure developed by the US Army Corps of Engineers (USACE) (1996). This is commonly known as the risk and uncertainty analysis procedure, or R&U. This procedure is included in HEC-FDA, the flood damage reduction analysis software developed by the USACE Hydrologic Engineering Center. To compute EAD with HEC-FDA, the following information is required:

- Index points and impact areas—These analysis locations are used for aggregating and representing the system performance. Index points are selected locations used to represent hydrologic, hydraulic, and geotechnical characteristics for a reach of a stream. Impact areas are delineations of the areas of the floodplain with similar flooding depths.

- Stage (elevation)-frequency relationship for each index point—This describes the annual probability or frequency of channel water surface in the river (exterior channel) reaching or exceeding a specified elevation.

- Exterior elevation-interior elevation function for each impact area—This function relates the water surface elevation in the channel (exterior) at the index point to the elevation of flooding in the floodplain adjacent to the channel (interior).
- A levee performance relationship for each index point. These functions represent the conditional probability of a levee failure for each channel water surface elevation.
- Elevation-damage function for each impact area—This function relates economic damage in the floodplain to water surface elevation in the interior floodplain (the area protected by the levee).

Each of these data sets is described below.

Impact Areas and Index Points

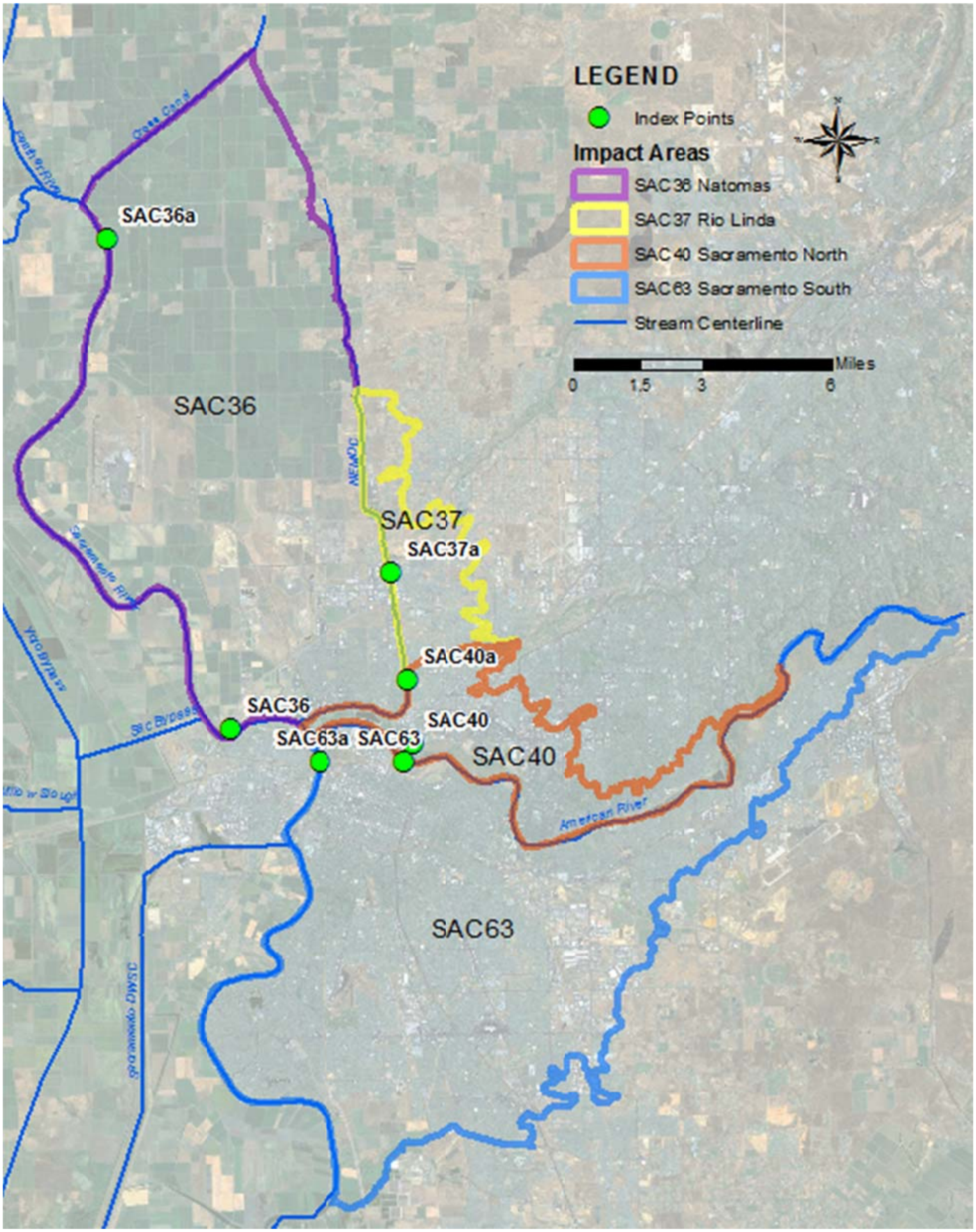
For the EAD analysis, Ford Engineers disaggregated the study area into impact areas, representing different flooding conditions in various portions of the study area, illustrated in **Figure 3**. Each impact area is associated with one or more representative index points, representing the hydrologic, hydraulic, and geotechnical conditions for a given reach of stream.

For damage computations, a relationship of the interior (floodplain) water surface elevation to exterior water surface elevation is developed with a hydraulic model at each index point. This relationship describes how water will flow from the channel onto the floodplain in impact areas without levees and it describes how water will flow over protecting levees or through a breach in the levee for areas thus protected.

The four Central Valley Flood Protection Plan (CVFPP) impact areas and seven index points used to compute flood damage in this assessment are summarized below:

Description	2017 CVFPP Impact Area	Index Point	Stream and Station
Natomas basin	SAC36	SAC36	Sacramento River, 62.4965
		SAC36a	Sacramento River, 78.2548
Rio Linda	SAC37	SAC37a	NEMDC, 5.905
Sacramento North	SAC40	SAC40	American River, 2.6667
		SAC40a	NEMDC, 3.368
Sacramento South	SAC63	SAC63	American River, 2.6667
		SAC63a	Sacramento River, 59.85

Figure 3
Index Points and Impact Areas



Stage-Frequency Function

The stage-frequency function defines the probability that water surface elevation at a given index point will equal or exceed a specified magnitude. In a simple river system, this function may be developed by fitting a probability model (a probability density function) to a sample of water surface elevations by fitting a probability model to a sample of discharges and transforming that with a water surface elevation-discharge (rating) function, or by using the so-called design-storm assumption, in which runoff from precipitation events of specified probability is computed with a rainfall-runoff model and assigned a probability consistent with that of the precipitation.

For the Sacramento River and American River basins, development of the stage-frequency function is complicated by the hydraulic interconnectivity of the system and the nature of overflow and storage of water in the upper reaches of the system. The stage at a downstream index point for any flood depends on what happens to levees upstream. If levees in the system perform as designed, water stays in the channels up to a design limit and moves downstream. The water surface elevation in downstream reaches is as great as the volume entering those reaches. However, if an upstream levee fails, water is diverted from the channel and stored in the floodplain. Less water will move downstream, and the resulting stage downstream will be less than that associated with the non-failure condition.

For the EAD analysis, stage-frequency functions were developed using the USACE Sacramento River Basin HEC_RAS model (Sac Basin Model) in unsteady mode. The HEC_RAS model is River Analysis System software developed by the USACE Hydrologic Engineering Center. The stage-frequency functions were provided by MBK Engineers (June 27, 2016).

Exterior-Interior and Levee Performance Relationships

When water overflows the channel in a small watershed, the water surface elevation in an impact area adjacent to the stream may rise to the water surface elevation in the channel if the flood causing the overflow has sufficient volume to fill the impact area. However, in systems such as the Sacramento and American Rivers, with thousands of acres of floodplain, this is not typically the case. The volume is not sufficient to fill most impact areas. Near the channel, the water surface elevation in the floodplain may equal that in the channel. However, farther away, the elevation may be more or less, depending on the terrain and the conditions of the overflow into the impact area. The exterior-interior relationship represents this, defining the interior flood elevation for damage computation as a function of the elevation of water in the channel.

Levees that protect the floodplains in the Program Area further complicate this. If a levee protecting an impact area fails, water will flow through the breach and into the impact area. The elevation in the floodplain may rise to that in the channel, or it may be less, depending on the volume of water in the channel, the characteristics of the opening, and the floodplain terrain. The exterior-interior relationship describes this.

For the EAD analysis, exterior-interior relationships were developed using hydraulic models of the channels and floodplains. This study used the most recently available CVFFP 2-dimensional hydraulic modeling, obtained from the California Department of Water resources. The greatest source of uncertainty in the exterior-interior relationship is how the system levees will perform. A levee will prevent flow of water from the exterior channel into the interior area until the design capacity of the levee is exceeded or until the levee fails. Without overtopping or failure, the interior stage is zero, regardless of the exterior stage. But the analysis must account for the probability that the levee will fail before overtopping. Of course, the likelihood that a levee designed for the p=0.01 (100-year) event will fail during a p=0.10 (10-year) event is small, but the analysis procedure should account for this.

HEC-FDA includes a model of levee performance uncertainty, which was used for the analysis. This relationship, referred to as the levee fragility curve, defines the probability of failure of the levee, given exterior stage. The levee performance curves for all except Natomas used in this DIF risk assessment were developed for the 2017 CVFFP by AECOM. For the index point SAC36a in Natomas, the fragility curve used includes 200-year fixes accounting for seepage issues but not freeboard for the baseline condition.

Interior Elevation-Damage Functions

The elevation-damage function relates inundation damage to water surface elevation in an impact area. This damage relationship is developed from information about location and value of property in the floodplain. For this analysis, damage relationships for both current and future conditions were needed. The damages for the study area were divided by structure type into damage categories. The damage categories used in the EAD analysis are summarized below.

Damage Categories Used in the EAD Analysis

Category	Description
Single Family residence (SFR)	Single family residential structures; mobile homes
Multifamily residence (MFR)	Multifamily residential structures
Commercial	Offices, retail facilities, hotels and motels, shopping centers
Industrial	Manufacturing plants, oil refineries, meat packing plants, canneries, and similar facilities, farm buildings

This risk assessment maintains the same structure and content depth-damage functions that were used in the CCAD 2 Engineers Report. For residential structures, structure and content depth-damage functions are from the USACE Economic Guidance Memorandum (EGM) 04-01 (USACE 2003).

For nonresidential structures, the depth-damage functions used were those that were published in the American River Watershed Project, Folsom Modification, and Folsom Dam Raise Final Economic Reevaluation Report (USACE 2008).

EAD Computations

The HEC-FDA program (USACE 2014) was used to compute damage to structure contents. As noted above, this program requires specification of stage-frequency, stage-damage, and exterior-interior stage functions, along with models of the uncertainty in each.

For some of the impact areas, flood damages could be attributed to more than one index point. However, for any one impact area there is only one EAD. If there was more than one index point contributing to damages for a particular impact area, the EAD is determined using the correlation between flooding sources to determine how the EAD from each index point will be used in EAD computations. The index points that contribute to damages for each impact area are summarized below.

Index Points Contributing to Impact Area Damages

Impact Area	Flooding from Index Point
SAC 36	SAC 36, SAC 36a
SAC 37	SAC37a
SAC 40	SAC40a
SAC 63	SAC63, SAC63a

Results of EAD Analysis

Table 3 presents the results of the EAD analysis for the period of analysis (2009 through 2025). These results indicate that if the projected development occurs in the Program Area during this period without the projects that would be funded by the Fee Program, there will be a substantial increase in exposure to economic losses by comparison to 2009 baseline conditions as measured by EAD. However, if this development occurs with the funded projects, this increased risk will be avoided. In addition to the baseline conditions and the 2025 conditions, **Table 3** also includes the 2016 EAD with no updated DIF-funded projects. This 2016 amount is necessary for the purposes of the cost allocation and fee calculation described in the next chapter.

Table 3
Expected Annual Damage for Assessment Condition

Damage Category	Expected Annual Damage for Assessment Condition ($1,000)			
	2009 Baseline Condition	2016 - No Updated DIF-Funded Projects	2025 - No Updated DIF-Funded Projects	2025 with Updated DIF-Funded Projects
Single-Family	$ 29,210	$ 30,002	$ 35,216	$ 26,326
Multifamily	$ 1,240	$ 1,255	$ 3,818	$ 2,899
Commercial	$ 3,555	$ 3,605	$ 5,199	$ 4,000
Industrial	$ 2,656	$ 2,912	$ 3,915	$ 2,975
Total	**$ 36,661**	**$ 37,774**	**$ 48,148**	**$ 36,200**

6. IMPROVEMENT COST ALLOCATION AND FEE CALCULATION

Introduction

Chapter 4 detailed the total cost of improvements expected to be funded by the Fee Program from its inception in 2009 through FY 2024-2025. This chapter describes the methodology used to allocate these costs to the projected development in the Fee Program during the same time period (presented in **Chapter 3**). The cost allocation and DIF calculation methodology uses the EAD by land use calculations (discussed in **Chapter 5**) to assess each land use's relative benefit received from flood improvements.

Cost Allocation Time Period

The comparative EAD analysis described in the previous chapter was performed for the period from January 1, 2009 through June 30, 2025 to include the effect of all Fee Program funded improvements on the EAD of estimated and projected development for the same time period. The cost allocation methodology described in this chapter allocates anticipated future improvement costs to projected future development, recognizing that the fees already collected offset the costs of improvements identified for funding from the inception of the fee program through June 30, 2016. Collectively, the improvements for which fee revenue has already been collected and the improvements planned to be funded from future fee revenue reduced the aggregate EAD for the time period from January 1, 2009 through June 30, 2025.

Cost Allocation Methodology and Fee Derivation

The cost allocation methodology involves the following steps:

1. Estimate the future growth in damageable square feet by Fee Program land use for the period from FY 2016-2017 through FY 2024-2025 The damageable square feet projections were presented in **Chapter 3**.

2. Determine the total cost of the improvements to be funded by the Fee Program to serve future development for the time period from FY 2016-2017 through FY 2024-2025. The estimated improvement costs were detailed in **Chapter 4**.

3. Determine the relative benefit factor for each land use based on each land use's damage potential per damageable square foot, relative to the other land uses. The damage potential is calculated as the increase in EAD from new development from FY 2016-2017 through FY 2024-2025 if the flood control improvements are not constructed. **Table 4** details the calculation of the relative benefit factors for each land use category.

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Table 4
SAFCA Development Impact Fee Update
Cost Allocation Factors

Land Use	Expected Annual Damage Increase if Growth with No Project [1] 2016 EAD (without projects)	2025 EAD (without projects)	Increase in Damage	Percentage of Total Increase	Damageable Square Feet (2016-2025) [2]	Benefit per Damageable Sq. Ft.	Relative Benefit Factor
Single-Family	$ 30,002,000	$ 35,216,000	$ 5,214,000	50%	8,029,238	$ 0.65	1.00
Multifamily	$ 1,255,000	$ 3,818,000	$ 2,563,000	25%	6,925,154	$ 0.37	0.57
Commercial	$ 3,605,000	$ 5,199,000	$ 1,594,000	15%	3,229,782	$ 0.49	0.76
Industrial	$ 2,912,000	$ 3,915,000	$ 1,003,000	10%	2,803,730	$ 0.36	0.55
Total	**$ 37,774,000**	**$ 48,148,000**	**$ 10,374,000**	**100%**	**20,987,904**		

factors

[1] Provided by David Ford Consulting Engineers.
[2] See Table 1.

4. Allocate the total costs of the improvements to the Fee Program land uses as described below and detailed in **Table 5**:

   - For each land use, estimate equivalent damage units (EDUs) as the projected Fee Program damageable square feet for FY 2016-2017 through FY 2024-2025 multiplied by the land use's relative benefit factor.

   - Determine the percentage of total EDUs attributable to each land use, and use the percentage distribution to allocate the future improvements cost for FY 2016-2017 through FY 2024-2025 of $32.94 million to the land uses.

   - For each land use, determine the estimated cost per square foot as the total allocated cost divided by the projected new damageable square feet for FY 2016-2017 through FY 2024-2025. For each land use, the proposed DIF rate is equal to the allocated cost per square foot.

Administration Costs

The DIF Program administration costs have been included in the local costs of the improvement program shown in **Table 2**. These administration costs will cover the following tasks:

- All collection and accounting costs associated with the Fee Program.
- Annual review of the Fee Program costs, fees, and policies.
- Annual reporting requirements associated with the Fee Program.
- Any other ongoing and recurring administrative procedures associated with the Fee Program.

With respect to the collection of the fee by the local agencies, SAFCA will compensate the City and Counties per the terms of fee collection agreements that were negotiated with SAFCA.

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Table 5
SAFCA Development Impact Fee Update
Cost Allocation by Land Use

Land Use	Damageable Square Feet (2016 - 2025)	Relative Benefit Factor	Equivalent Damage Units	Percentage of Total	Allocated Cost (2016-2025) [1]	Cost per Damageable Square Foot
Source	*Table 1*	*Table 4*			*Table 2*	
Formula	*a*	*b*	*c=a*b*	*d=c/total c*	*e=d*total e*	*e/a*
Single-Family	8,029,238	1.00	8,029,238	50%	$16,555,732	**$ 2.06**
Multifamily	6,925,154	0.57	3,946,862	25%	$ 8,138,155	**$ 1.18**
Commercial	3,229,782	0.76	2,454,661	15%	$ 5,061,342	**$ 1.57**
Industrial	2,803,730	0.55	1,544,558	10%	$ 3,184,772	**$ 1.14**
Total	**20,987,904**		**15,975,319**	**100%**	**$ 32,940,000**	

alloc

[1] See Table 2 for total cost from 2016 - 2025.

7. FEE PROGRAM IMPLEMENTATION AND ADMINISTRATION

In 2008, pursuant to the authority granted to SAFCA under the SAFCA Act, the Board adopted an implementing resolution that established the Fee Program and authorized collection of the fees. This update to the Fee Program, and all other updates, will occur by resolution of the Board.

The fee calculations presented in this report are in constant 2016 dollars and are based on the best improvement cost estimates, administrative cost estimates and land use information available at this time. If costs change significantly, if the type or amount of new projected development changes, or if other assumptions significantly change, the Fee Program will be updated accordingly. In addition, each year, SAFCA may adjust the costs and fees for inflation, subject to SAFCA Board of Directors' approval.

SAFCA has entered into fee collection agreements with each of the three land use jurisdictions (City of Sacramento, Sacramento County, and Sutter County) within the boundary of the Fee Program. These agencies are referred to collectively as the Responsible Agencies. Each of the three jurisdictions has designated an agency to be responsible for the Fee Program administration. EPS developed an Administrative Procedures Manual that details the procedures to be used by the Responsible Agencies in computing and collecting the DIF as development occurs. The Administrative Procedures Manual has been updated periodically to clarify and update procedures. It serves as a companion document to this report and contains detailed information on the following Fee Program implementation and administrative items:

- Annual Inflation Adjustments
- Other Periodic Adjustments
- General Applicability of the DIF
- Designated Responsible Agencies
- DIF Boundary
- DIF Coverage Period
- Development Subject to the DIF
- DIF Exemptions, Credits, and Special Circumstances
- DIF Deferrals
- Calculation of the DIF (including examples)
- Fee Collection Procedures
- Refunds and Appeals Process
- DIF Accounting

The Administrative Procedures Manual was last updated in 2012 and will again be updated following adoption of this report to reflect program changes (e.g., Fee Program land use changes) and DIF adjustments.

Credit Agreements

When updating the Administrative Procedures Manual, EPS will add details concerning credit agreements for developer-constructed flood improvement projects. These credit agreements would establish requirements and procedures for developers to receive credits against the DIF. SAFCA has developed the following guidelines for credit agreements:

A. Upon application by the property owner or authorized agent, SAFCA's Executive Director or his designee may, at its sole discretion, enter into a credit agreement authorizing the construction of any flood control facility, or portions thereof, at the time and as designated in the Fee Program in lieu of all, or a portion of, the development impact fee required by the Fee Program. If so authorized, the credit to be provided to the property owner shall be equal to the estimated cost of the facility as set forth in the Fee Program in effect at the time when the facility is accepted by SAFCA, including, but not limited to, unit prices, quantities and project descriptions. Any agreement in excess of $100,000 shall be approved by the SAFCA Board of Directors.

B. Where the amount of the credit is less than the amount of the otherwise applicable development impact fee, the property owner shall pay the difference. Reimbursement may be allowed in special circumstances at the sole discretion of the Executive Director.

C. If the flood control facilities provider and a property owner agree, the property owner may receive a credit against its development impact fee in an amount not to exceed the value of property conveyed to SAFCA or the State of California, in an amount as determined by SAFCA.

D. By entering into a credit agreement, a property owner is not relieved of the obligation to pay the development impact fee in the manner and amount specified herein.

APPENDICES:

Appendix A: Development Projections

Appendix B: Comparative Risk Assessment

APPENDIX A:

Development Projections

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Table A-1
SAFCA Development Impact Fee Update
Development Assumptions

SACOG Land Use	Building Square Feet per Unit/Employee	Note on Building Square Feet	Stories	Damageable Square Feet per Unit/Emp
Single-Family	*per unit*			*per unit*
Rural Residential	2,500.0		1 or 2	2,500
Farm Home	2,500.0		1 or 2	2,500
Very Low Density Residential	2,500.0		1 or 2	2,500
Low Density Residential	2,000.0		1 or 2	2,000
Medium Density Residential	1,200.0		1 or 2	1,200
Low Density Mixed Residential	2,000.0		1 or 2	2,000
Medium Density Mixed Residential	1,100.0		1 or 2	1,100
Multifamily	*per unit*			*per unit*
Medium-High Density Residential	900.0		3.5	514
High Density Residential	900.0		5.0	360
Urban Residential	750.0		5.0	300
CSUS Housing	500.0		4.0	250
Intense Urban Residential	750.0		6.0	250
Mixed Use Residential Focus	800.0		4.0	400
Mixed Use Res- Higher Density	800.0		4.0	400
Jackson Hwy Med Density Mix	1,000.0		3.5	571
Commercial	*per employee*			*per employee*
High-Intensity Office	250.0	office	10.0	25
Sac CBD High Intensity Mixed Use Office	250.0	office	10.0	25
Moderate-Intensity Office	250.0	office	6.0	42
CBD Office	250.0	office	10.0	25
Community/Neighborhood Retail	400.0	retail	2.0	200
Regional Retail	400.0	retail	1.0	400
Community/Neighborhood Commercial/Office	362.5	75% retail/25% office	2.0	181
Community/Neighborhood Commercial/Office - Modified	362.5	75% retail/25% office	2.0	181
New CNCO	362.5	75% retail/25% office	2.0	181
Regional Commercial/Office	362.5	75% retail/25% office	3.0	121
Mixed Use Employment Focus	362.5	75% retail/25% office	4.0	91
Employment Focus Mixed Use Center/Corridor	362.5	75% retail/25% office	5.0	73
Low Density Mixed Use Center or Corridor	362.5	75% retail/25% office	3.5	104
Low Density Mixed-Use Center/Corridor	362.5	75% retail/25% office	3.5	104
Medium Density Mixed Use Center or Corridor	362.5	75% retail/25% office	3.5	104
Medium Density Mixed Use Center/Corridor	362.5	75% retail/25% office	3.5	104
MHDR & HDR w/CNCO Blend for Corridors	362.5	75% retail/25% office	3.0	121
MHDR CNCO Blend for Corridors	362.5	75% retail/25% office	3.5	104
High Density Mixed Use Center or Corridor	362.5	75% retail/25% office	4.0	91
R Street High Density Mixed-Use Center	362.5	75% retail/25% office	6.0	60
High-Density Mixed Use Center/Corridor	362.5	75% retail/25% office	4.0	91
Medical Facility	250.0	office	4.0	63
Medical Office Modified	250.0	office	2.0	125
Industrial	*per employee*			*per employee*
Light Industrial - Office	400.0	25% industrial/75% office	1.0	400
Light Industrial - Office with More Retail	625.0	50% industrial/50% retail	1.0	625
Light Industrial	700.0	75% industrial/25% office	1.0	700
Light Industrial with More Retail	625.0	50% industrial/50% retail	1.0	625
Heavy Industrial	850.0	industrial	1.0	850

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Table A-2
SAFCA Development Impact Fee Update
Summary of Damageable Square Feet in DIF Area

	Growth: 2010 - 2035		Damageable	Damageable Square Feet		
SACOG Land Use	Dwelling Units [1]	Employees [1]	**Sq. Ft. per Unit/Employee**	25-Year	Per Year	9-Year
Source			*Table A-1*			
Formula	*a*	*b*	*c*	*d=a*c or b*c*	*e=d/25*	*e*9*
Single-Family						
Rural Residential	93		2,500	231,816	9,273	83,454
Farm Home	20		2,500	49,412	1,976	17,788
Very Low Density Residential	204		2,500	509,419	20,377	183,391
Low Density Residential	5,351		2,000	10,701,133	428,045	3,852,408
Medium Density Residential	8,558		1,200	10,269,301	410,772	3,696,948
Low Density Mixed Residential	250		2,000	500,192	20,008	180,069
Medium Density Mixed Residential	38		1,100	42,165	1,687	15,179
Subtotal	**14,513**			**22,303,438**	**892,138**	**8,029,238**
Multifamily						
Medium-High Density Residential	21,052		514	10,826,995	433,080	3,897,718
High Density Residential	11,067		360	3,984,042	159,362	1,434,255
Urban Residential	334		300	100,248	4,010	36,089
CSUS Housing	2,538		250	634,437	25,377	228,397
Intense Urban Residential	2,928		250	731,964	29,279	263,507
Mixed Use Residential Focus	4,944		400	1,977,686	79,107	711,967
Mixed Use Res- Higher Density	574		400	229,620	9,185	82,663
Jackson Hwy Med Density Mix	1,315		571	751,545	30,062	270,556
Subtotal	**44,753**			**19,236,538**	**769,462**	**6,925,154**
Commercial						
High-Intensity Office		5,376	25	134,406	5,376	48,386
Sac CBD High Intensity Mixed Use Office		1,859	25	46,468	1,859	16,728
Moderate-Intensity Office		28,785	42	1,199,383	47,975	431,778
CBD Office		2,071	25	51,787	2,071	18,643
Community/Neighborhood Retail		4,256	200	851,289	34,052	306,464
Regional Retail		6,124	400	2,449,716	97,989	881,898
Community/Neighborhood Commercial/Office		6,019	181	1,090,992	43,640	392,757
Community/Neighborhood Commercial/Office - Modified		1,087	181	197,030	7,881	70,931
New CNCO		1,086	181	196,881	7,875	70,877
Regional Commercial/Office		1,762	121	212,848	8,514	76,625
Mixed Use Employment Focus		99	91	8,945	358	3,220
Employment Focus Mixed Use Center/Corridor		2,754	73	199,648	7,986	71,873
Low Density Mixed Use Center or Corridor		68	104	7,088	284	2,552
Low Density Mixed-Use Center/Corridor		337	104	34,924	1,397	12,573
Medium Density Mixed Use Center or Corridor		5	104	480	19	173
Medium Density Mixed Use Center/Corridor		227	104	23,488	940	8,456
MHDR & HDR w/CNCO Blend for Corridors		44	121	5,289	212	1,904
MHDR CNCO Blend for Corridors		19	104	1,957	78	705
High Density Mixed Use Center or Corridor		4,790	91	434,054	17,362	156,259
R Street High Density Mixed-Use Center		1,175	60	70,976	2,839	25,551
High-Density Mixed Use Center/Corridor		492	91	44,620	1,785	16,063
Medical Facility		1,483	63	92,697	3,708	33,371
Medical Office Modified		12,933	125	1,616,649	64,666	581,994
Subtotal		**82,852**		**8,971,616**	**358,865**	**3,229,782**
Industrial						
Light Industrial - Office		1,404	400	561,467	22,459	202,128
Light Industrial - Office with More Retail		213	625	133,359	5,334	48,009
Light Industrial		7,520	700	5,264,100	210,564	1,895,076
Light Industrial with More Retail		123	625	76,905	3,076	27,686
Heavy Industrial		2,062	850	1,752,310	70,092	630,832
Subtotal		**11,322**		**7,788,140**	**311,526**	**2,803,730**
TOTAL	**59,266**	**94,173**		**58,299,733**	**2,331,989**	**20,987,904**

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[1] Sum of projections by area. See Table A-3 through Table A-7 for projections by area.

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Table A-3
SAFCA Development Impact Fee Update
Damageable Square Feet in DIF Area - City of Sacramento

SACOG Land Use	Growth: 2010 - 2035 Dwelling Units [1]	Employees [1]	Damageable Sq. Ft. per Unit/Employee	Damageable Square Feet 25-Year	Per Year	9-Year
Source			*Table A-1*			
Formula	*a*	*b*	*c*	*d=a*c or b*c*	*e=d/25*	*e*9*
Single-Family						
Rural Residential	19		2,500	48,705	1,948	17,534
Farm Home	0		2,500	0	0	0
Very Low Density Residential	94		2,500	236,239	9,450	85,046
Low Density Residential	3,855		2,000	7,709,196	308,368	2,775,311
Medium Density Residential	6,781		1,200	8,137,550	325,502	2,929,518
Low Density Mixed Residential	233		2,000	466,563	18,663	167,963
Medium Density Mixed Residential	15		1,100	16,841	674	6,063
Subtotal	**10,998**			**16,615,094**	**664,604**	**5,981,434**
Multifamily						
Medium-High Density Residential	17,843		514	9,176,222	367,049	3,303,440
High Density Residential	10,024		360	3,608,721	144,349	1,299,139
Urban Residential	334		300	100,248	4,010	36,089
CSUS Housing	2,538		250	634,437	25,377	228,397
Intense Urban Residential	2,928		250	731,964	29,279	263,507
Mixed Use Residential Focus	4,393		400	1,757,299	70,292	632,628
Mixed Use Res- Higher Density	574		400	229,620	9,185	82,663
Jackson Hwy Med Density Mix	0		571	0	0	0
Subtotal	**38,634**			**16,238,511**	**649,540**	**5,845,864**
Commercial						
High-Intensity Office		5,376	25	134,406	5,376	48,386
Sac CBD High Intensity Mixed Use Office		1,859	25	46,468	1,859	16,728
Moderate-Intensity Office		19,423	42	809,300	32,372	291,348
CBD Office		2,071	25	51,787	2,071	18,643
Community/Neighborhood Retail		2,842	200	568,480	22,739	204,653
Regional Retail		5,828	400	2,331,303	93,252	839,269
Community/Neighborhood Commercial/Office		4,464	181	809,101	32,364	291,276
Community/Neighborhood Commercial/Office - Modified		746	181	135,198	5,408	48,671
New CNCO		1,086	181	196,881	7,875	70,877
Regional Commercial/Office		1,709	121	206,525	8,261	74,349
Mixed Use Employment Focus		54	91	4,911	196	1,768
Employment Focus Mixed Use Center/Corridor		2,754	73	199,648	7,986	71,873
Low Density Mixed Use Center or Corridor		68	104	7,088	284	2,552
Low Density Mixed-Use Center/Corridor		337	104	34,924	1,397	12,573
Medium Density Mixed Use Center or Corridor		5	104	480	19	173
Medium Density Mixed Use Center/Corridor		227	104	23,469	939	8,449
MHDR & HDR w/CNCO Blend for Corridors		0	121	0	0	0
MHDR CNCO Blend for Corridors		19	104	1,957	78	705
High Density Mixed Use Center or Corridor		4,320	91	391,494	15,660	140,938
R Street High Density Mixed-Use Center		1,175	60	70,976	2,839	25,551
High-Density Mixed Use Center/Corridor		274	91	24,793	992	8,926
Medical Facility		1,207	63	75,410	3,016	27,148
Medical Office Modified		12,933	125	1,616,649	64,666	581,994
Subtotal		**68,777**		**7,741,249**	**309,650**	**2,786,850**
Industrial						
Light Industrial - Office		881	400	352,410	14,096	126,867
Light Industrial - Office with More Retail		213	625	133,359	5,334	48,009
Light Industrial		1,490	700	1,043,226	41,729	375,561
Light Industrial with More Retail		0	625	0	0	0
Heavy Industrial		931	850	791,567	31,663	284,964
Subtotal		**3,516**		**2,320,561**	**92,822**	**835,402**
TOTAL	**49,632**	**72,293**		**42,915,416**	**1,716,617**	**15,449,550**

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[1] SACOG projections from 2010 through 2035 adjusted by EPS to account for slower historical development trends and reflect development projections from the City General Plan.

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Table A-4
SAFCA Development Impact Fee Update
Damageable Square Feet in DIF Area - Sacramento SOI

SACOG Land Use	Growth: 2010 - 2035 Dwelling Units [1]	Growth: 2010 - 2035 Employees [1]	Damageable Sq. Ft. per Unit/Employee	Damageable Square Feet 25-Year	Damageable Square Feet Per Year	Damageable Square Feet 9-Year
Source			*Table A-1*			
Formula	*a*	*b*	*c*	*d=a*c or b*c*	*e=d/25*	*e*9*
Single-Family						
Rural Residential	4		2,500	8,976	359	3,232
Farm Home	0		2,500	0	0	0
Very Low Density Residential	10		2,500	25,047	1,002	9,017
Low Density Residential	114		2,000	228,856	9,154	82,388
Medium Density Residential	557		1,200	668,483	26,739	240,654
Low Density Mixed Residential	0		2,000	0	0	0
Medium Density Mixed Residential	0		1,100	0	0	0
Subtotal	**685**			**931,362**	**37,254**	**335,290**
Multifamily						
Medium-High Density Residential	1,433		514	737,159	29,486	265,377
High Density Residential	275		360	99,063	3,963	35,663
Urban Residential	0		300	0	0	0
CSUS Housing	0		250	0	0	0
Intense Urban Residential	0		250	0	0	0
Mixed Use Residential Focus	18		400	7,270	291	2,617
Mixed Use Res- Higher Density	0		400	0	0	0
Jackson Hwy Med Density Mix	0		571	0	0	0
Subtotal	**1,727**			**843,491**	**33,740**	**303,657**
Commercial						
High-Intensity Office		0	25	0	0	0
Sac CBD High Intensity Mixed Use Office		0	25	0	0	0
Moderate-Intensity Office		1,111	42	46,304	1,852	16,669
CBD Office		0	25	0	0	0
Community/Neighborhood Retail		604	200	120,851	4,834	43,506
Regional Retail		296	400	118,413	4,737	42,629
Community/Neighborhood Commercial/Office		362	181	65,652	2,626	23,635
Community/Neighborhood Commercial/Office - Modified		32	181	5,866	235	2,112
New CNCO		0	181	0	0	0
Regional Commercial/Office		52	121	6,323	253	2,276
Mixed Use Employment Focus		0	91	10	0	4
Employment Focus Mixed Use Center/Corridor		0	73	0	0	0
Low Density Mixed Use Center or Corridor		0	104	0	0	0
Low Density Mixed-Use Center/Corridor		0	104	0	0	0
Medium Density Mixed Use Center or Corridor		0	104	0	0	0
Medium Density Mixed Use Center/Corridor		0	104	0	0	0
MHDR & HDR w/CNCO Blend for Corridors		44	121	5,289	212	1,904
MHDR CNCO Blend for Corridors		0	104	0	0	0
High Density Mixed Use Center or Corridor		470	91	42,560	1,702	15,322
R Street High Density Mixed-Use Center		0	60	0	0	0
High-Density Mixed Use Center/Corridor		0	91	0	0	0
Medical Facility		0	63	0	0	0
Medical Office Modified		0	125	0	0	0
Subtotal		**2,972**		**411,268**	**16,451**	**148,056**
Industrial						
Light Industrial - Office		83	400	33,180	1,327	11,945
Light Industrial - Office with More Retail		0	625	0	0	0
Light Industrial		930	700	651,201	26,048	234,432
Light Industrial with More Retail		0	625	0	0	0
Heavy Industrial		564	850	479,800	19,192	172,728
Subtotal		**1,578**		**1,164,180**	**46,567**	**419,105**
TOTAL	**2,412**	**4,550**		**3,350,301**	**134,012**	**1,206,108**

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[1] SACOG projections from 2010 through 2035 adjusted by EPS to account for slower historical development trends.

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Table A-5
SAFCA Development Impact Fee Update
Damageable Square Feet in DIF Area - Sacramento County [1]

	Growth: 2010 - 2035		Damageable	Damageable Square Feet		
SACOG Land Use	Dwelling Units [1]	Employees [1]	Sq. Ft. per Unit/Employee	25-Year	Per Year	9-Year
Source			*Table A-1*			
Formula	*a*	*b*	*c*	*d=a*c or b*c*	*e=d/25*	*e*9*
Single-Family						
Rural Residential	60		2,500	149,686	5,987	53,887
Farm Home	13		2,500	31,972	1,279	11,510
Very Low Density Residential	22		2,500	54,102	2,164	19,477
Low Density Residential	37		2,000	73,677	2,947	26,524
Medium Density Residential	290		1,200	348,032	13,921	125,292
Low Density Mixed Residential	17		2,000	33,629	1,345	12,106
Medium Density Mixed Residential	23		1,100	25,324	1,013	9,117
Subtotal	**461**			**716,423**	**28,657**	**257,912**
Multifamily						
Medium-High Density Residential	809		514	416,079	16,643	149,789
High Density Residential	260		360	93,688	3,748	33,728
Urban Residential	0		300	0	0	0
CSUS Housing	0		250	0	0	0
Intense Urban Residential	0		250	0	0	0
Mixed Use Residential Focus	533		400	213,117	8,525	76,722
Mixed Use Res- Higher Density	0		400	0	0	0
Jackson Hwy Med Density Mix	1,315		571	751,545	30,062	270,556
Subtotal	**2,917**			**1,474,430**	**58,977**	**530,795**
Commercial						
High-Intensity Office		0	25	0	0	0
Sac CBD High Intensity Mixed Use Office		0	25	0	0	0
Moderate-Intensity Office		6,500	42	270,847	10,834	97,505
CBD Office		0	25	0	0	0
Community/Neighborhood Retail		549	200	109,767	4,391	39,516
Regional Retail		0	400	0	0	0
Community/Neighborhood Commercial/Office		611	181	110,756	4,430	39,872
Community/Neighborhood Commercial/Office - Modified		0	181	0	0	0
New CNCO		0	181	0	0	0
Regional Commercial/Office		0	121	0	0	0
Mixed Use Employment Focus		44	91	4,024	161	1,449
Employment Focus Mixed Use Center/Corridor		0	73	0	0	0
Low Density Mixed Use Center or Corridor		0	104	0	0	0
Low Density Mixed-Use Center/Corridor		0	104	0	0	0
Medium Density Mixed Use Center or Corridor		0	104	0	0	0
Medium Density Mixed Use Center/Corridor		0	104	19	1	7
MHDR & HDR w/CNCO Blend for Corridors		0	121	0	0	0
MHDR CNCO Blend for Corridors		0	104	0	0	0
High Density Mixed Use Center or Corridor		0	91	0	0	0
R Street High Density Mixed-Use Center		0	60	0	0	0
High-Density Mixed Use Center/Corridor		219	91	19,827	793	7,138
Medical Facility		277	63	17,287	691	6,223
Medical Office Modified		0	125	0	0	0
Subtotal		**8,200**		**532,527**	**21,301**	**191,710**
Industrial						
Light Industrial - Office		0	400	0	0	0
Light Industrial - Office with More Retail		0	625	0	0	0
Light Industrial		3,064	700	2,144,977	85,799	772,192
Light Industrial with More Retail		123	625	76,905	3,076	27,686
Heavy Industrial		322	850	273,331	10,933	98,399
Subtotal		**3,509**		**2,495,212**	**99,808**	**898,276**
TOTAL	**3,378**	**11,709**		**5,218,592**	**208,744**	**1,878,693**

county

[1] Only a portion of Sacramento County is in the DIF area. The development projections are for this area only.
[2] SACOG projections from 2010 through 2035 adjusted by EPS to account for slower historical development trends.

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Table A-6
SAFCA Development Impact Fee Update
Damageable Square Feet in DIF Area - Rancho Cordova [1]

SACOG Land Use	Growth: 2010 - 2035 Dwelling Units [1]	Growth: 2010 - 2035 Employees [1]	Damageable Sq. Ft. per Unit/Employee	Damageable Square Feet 25-Year	Damageable Square Feet Per Year	Damageable Square Feet 9-Year
Source			*Table A-1*			
Formula	*a*	*b*	*c*	*d=a*c or b*c*	*e=d/25*	*e*9*
Single-Family						
Rural Residential	2		2,500	3,782	151	1,361
Farm Home	0		2,500	0	0	0
Very Low Density Residential	5		2,500	12,879	515	4,636
Low Density Residential	2		2,000	4,644	186	1,672
Medium Density Residential	863		1,200	1,036,170	41,447	373,021
Low Density Mixed Residential	0		2,000	0	0	0
Medium Density Mixed Residential	0		1,100	0	0	0
Subtotal	**872**			**1,057,474**	**42,299**	**380,691**
Multifamily						
Medium-High Density Residential	967		514	497,534	19,901	179,112
High Density Residential	507		360	182,571	7,303	65,726
Urban Residential	0		300	0	0	0
CSUS Housing	0		250	0	0	0
Intense Urban Residential	0		250	0	0	0
Mixed Use Residential Focus	0		400	0	0	0
Mixed Use Res- Higher Density	0		400	0	0	0
Jackson Hwy Med Density Mix	0		571	0	0	0
Subtotal	**1,475**			**680,105**	**27,204**	**244,838**
Commercial						
High-Intensity Office		0	25	0	0	0
Sac CBD High Intensity Mixed Use Office		0	25	0	0	0
Moderate-Intensity Office		1,750	42	72,933	2,917	26,256
CBD Office		0	25	0	0	0
Community/Neighborhood Retail		261	200	52,191	2,088	18,789
Regional Retail		0	400	0	0	0
Community/Neighborhood Commercial/Office		463	181	83,986	3,359	30,235
Community/Neighborhood Commercial/Office - Modified		0	181	0	0	0
New CNCO		0	181	0	0	0
Regional Commercial/Office		0	121	0	0	0
Mixed Use Employment Focus		0	91	0	0	0
Employment Focus Mixed Use Center/Corridor		0	73	0	0	0
Low Density Mixed Use Center or Corridor		0	104	0	0	0
Low Density Mixed-Use Center/Corridor		0	104	0	0	0
Medium Density Mixed Use Center or Corridor		0	104	0	0	0
Medium Density Mixed Use Center/Corridor		0	104	0	0	0
MHDR & HDR w/CNCO Blend for Corridors		0	121	0	0	0
MHDR CNCO Blend for Corridors		0	104	0	0	0
High Density Mixed Use Center or Corridor		0	91	0	0	0
R Street High Density Mixed-Use Center		0	60	0	0	0
High-Density Mixed Use Center/Corridor		0	91	0	0	0
Medical Facility		0	63	0	0	0
Medical Office Modified		0	125	0	0	0
Subtotal		**2,475**		**209,110**	**8,364**	**75,280**
Industrial						
Light Industrial - Office		99	400	39,462	1,578	14,206
Light Industrial - Office with More Retail		0	625	0	0	0
Light Industrial		807	700	565,063	22,603	203,423
Light Industrial with More Retail		0	625	0	0	0
Heavy Industrial		13	850	11,405	456	4,106
Subtotal		**919**		**615,930**	**24,637**	**221,735**
TOTAL	**2,347**	**3,394**		**2,562,619**	**102,505**	**922,543**

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[1] Only a portion of Rancho Cordova is in the DIF area. The development projections are for this area only.
[2] SACOG projections from 2010 through 2035 adjusted by EPS to account for slower historical development trends.

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Table A-7
SAFCA Development Impact Fee Update
Damageable Square Feet in DIF Area - Sutter County [1]

SACOG Land Use	Growth: 2010 - 2035 Dwelling Units [1]	Employees [1]	Damageable Sq. Ft. per Unit/Employee	Damageable Square Feet 25-Year	Per Year	9-Year
Source			*Table A-1*			
Formula	*a*	*b*	*c*	*d=a*c or b*c*	*e=d/25*	*e*9*
Single-Family						
Rural Residential	8		2,500	20,667	827	7,440
Farm Home	7		2,500	17,440	698	6,278
Very Low Density Residential	72		2,500	181,152	7,246	65,215
Low Density Residential	1,342		2,000	2,684,761	107,390	966,514
Medium Density Residential	66		1,200	79,065	3,163	28,463
Low Density Mixed Residential	0		2,000	0	0	0
Medium Density Mixed Residential	0		1,100	0	0	0
Subtotal	**1,496**			**2,983,085**	**119,323**	**1,073,910**
Multifamily						
Medium-High Density Residential	0		514	0	0	0
High Density Residential	0		360	0	0	0
Urban Residential	0		300	0	0	0
CSUS Housing	0		250	0	0	0
Intense Urban Residential	0		250	0	0	0
Mixed Use Residential Focus	0		400	0	0	0
Mixed Use Res- Higher Density	0		400	0	0	0
Jackson Hwy Med Density Mix	0		571	0	0	0
Subtotal	**0**			**0**	**0**	**0**
Commercial						
High-Intensity Office		0	25	0	0	0
Sac CBD High Intensity Mixed Use Office		0	25	0	0	0
Moderate-Intensity Office		0	42	0	0	0
CBD Office		0	25	0	0	0
Community/Neighborhood Retail		0	200	0	0	0
Regional Retail		0	400	0	0	0
Community/Neighborhood Commercial/Office		119	181	21,496	860	7,739
Community/Neighborhood Commercial/Office - Modified		309	181	55,966	2,239	20,148
New CNCO		0	181	0	0	0
Regional Commercial/Office		0	121	0	0	0
Mixed Use Employment Focus		0	91	0	0	0
Employment Focus Mixed Use Center/Corridor		0	73	0	0	0
Low Density Mixed Use Center or Corridor		0	104	0	0	0
Low Density Mixed-Use Center/Corridor		0	104	0	0	0
Medium Density Mixed Use Center or Corridor		0	104	0	0	0
Medium Density Mixed Use Center/Corridor		0	104	0	0	0
MHDR & HDR w/CNCO Blend for Corridors		0	121	0	0	0
MHDR CNCO Blend for Corridors		0	104	0	0	0
High Density Mixed Use Center or Corridor		0	91	0	0	0
R Street High Density Mixed-Use Center		0	60	0	0	0
High-Density Mixed Use Center/Corridor		0	91	0	0	0
Medical Facility		0	63	0	0	0
Medical Office Modified		0	125	0	0	0
Subtotal		**427**		**77,463**	**3,099**	**27,887**
Industrial						
Light Industrial - Office		341	400	136,416	5,457	49,110
Light Industrial - Office with More Retail		0	625	0	0	0
Light Industrial		1,228	700	859,634	34,385	309,468
Light Industrial with More Retail		0	625	0	0	0
Heavy Industrial		231	850	196,207	7,848	70,635
Subtotal		**1,800**		**1,192,257**	**47,690**	**429,212**
TOTAL	**1,496**	**2,227**		**4,252,804**	**170,112**	**1,531,009**

sutter

[1] Only a portion of Sutter County is in the DIF area. The development projections are for this area only.
[2] SACOG projections from 2010 through 2035 adjusted by EPS to account for slower historical development trends.

APPENDIX B:

Comparative Risk Assessment

Appendix B
Comparative Risk Assessment

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Sacramento Area Flood Control Agency

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Executive summary

Situation

The City of Sacramento and surrounding areas face a severe risk of flooding. Flood risk has 2 aspects: the probability of flooding and the consequences of that flooding. Flood risk reduction measures such as levee improvements reduce the probability of uncontrolled flooding. Conversely, development in the protected area increases the amount of damageable property in the protected floodplain, thereby increasing the consequences of flooding.

The Sacramento Area Flood Control Agency (SAFCA) has implemented 2 funding mechanisms to address both aspects of flood risk: the Consolidated Capital Assessment District (CCAD) (SAFCA 2007), and the development impact fee (DIF) program (SAFCA 2008). Under the first mechanism, flood control projects funded by CCAD and its successor program CCAD 2 (SAFCA 2016) are aimed at providing the Sacramento area with sufficient flood protection to meet the minimum standards of the National Flood Insurance Program and the state's required urban level of flood protection (DWR 2013). Under the second mechanism, persons wishing to build new structures in the protected floodplain may pay a DIF. The DIF is then used to fund additional improvements to the flood control system that further mitigate the increase in flood risk associated with the new structures.

In the intervening years since the CCAD and DIF programs were initiated, several factors have changed the flood risk context for these programs, including updated growth projections and changes in federal and state standards affecting urban levee design, floodplain delineation, and levee operation and maintenance requirements. In light of these changes, SAFCA is updating the CCAD (SAFCA 2016) and the DIF program.

To update its DIF program, SAFCA is:

- Modifying the protected area covered by the DIF program so that it aligns with the updated CADD 2 protected area.
- Updating the development projections used in the determination of the DIF.
- Updating its identification of improvements to be funded by the DIF.
- Allocating local costs between CCAD 2 and the updated DIF program.

The allocation of local costs between CCAD 2 and the updated DIF program (hereinafter, "updated DIF") requires a corresponding allocation of the benefit attributable to flood control measures funded by CCAD 2 and the updated DIF. This benefit is measured by the reduction in expected annual damage (EAD). The results of the risk assessment described in this report form the basis of the allocation of updated DIF benefits among land use categories.

Study area

The extent of the protected area covered by the updated DIF (and CCAD 2), which in this report we call the *study area*, is shown in Figure 1. The study area comprises the following impact areas analyzed in the 2012 Central Valley Flood Protection Plan (CVFPP): SAC36, SAC37, SAC40, and SAC63 (DWR 2012b).

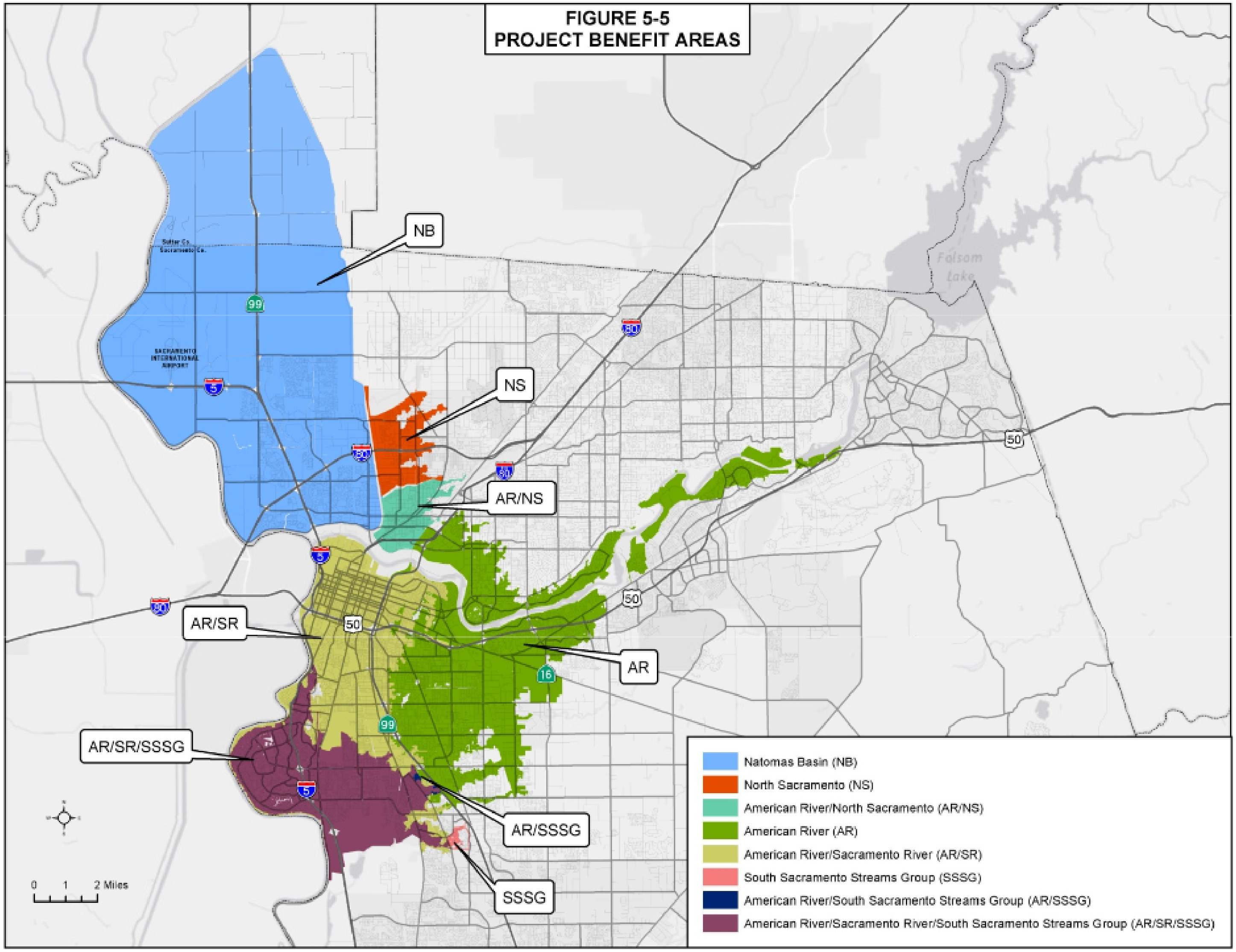


Figure 1. Study area for updated DIF risk assessment (SAFCA 2016)

Task

We computed the change in flood risk, measured in EAD, attributable to projects that would be funded by the updated DIF. Specifically, we computed and compared the flood risk under the baseline condition in 2009 to the flood risk in 2016 and 2025 with projected growth for 2 conditions: (1) without the updated DIF in place and (2) with the updated DIF in place. The baseline condition is the without-updated-DIF condition for the current number and type of damageable property in the analysis area. The baseline and analysis conditions are described in Chapter 5 of the main report. Development of the growth projections used in this analysis are described in Chapter 3 of the main report.

Analysis method

For this updated DIF risk assessment, we followed US Army Corps of Engineers (Corps) risk assessment procedures. These procedures require that hydrologic, hydraulic, geotechnical, and economic information be used to compute EAD, accounting explicitly for uncertainty in the information.

The computation procedures we used are automated with the Corps' computer program HEC-FDA; we used version 1.4 (USACE 2014) of this program. Required input includes stage-frequency functions, stage-percent damage functions, and levee performance functions.

Results

In this analysis, we evaluated EAD without and with the updated DIF to determine the change in risk attributable to the flood risk reduction projects that would be funded by the updated DIF. Table 1 shows the results of the EAD computations for each condition by damage category without the updated DIF and with the updated DIF.

Table 1. Comparison of expected annual damage for the baseline condition, future without-updated-DIF condition, and future with-updated-DIF condition

	EAD[1] ($1,000)					
Damage category (1)	**2009 baseline (2)**	**2009 with-updated DIF (3)**	**2016 without updated DIF (4)**	**2016 with updated DIF (5)**	**2025 without updated DIF (6)**	**2025 with updated DIF (7)**
SFR	29,210	21,948	30,002	22,564	35,216	26,326
MFR	1,240	1,002	1,255	1,014	3,818	2,899
Commercial	3,555	2,786	3,605	2,830	5,199	4,000
Industrial	2,656	2,092	2,912	2,269	3,915	2,975
Total	36,661	27,829	37,774	28,678	48,148	36,200

1. Values reported in 2014 dollars.

EAD increases over time without the updated DIF, as seen by comparing column 4 and column 6 of Table 1. This increase in EAD is due to increased development and a constant annual probability of flooding. The probability of flooding remains constant because, without the updated DIF, the baseline condition is not enhanced in the future with any flood risk reduction improvements funded by the updated DIF.

At the end of the analysis period, with updated-DIF-funded projects in place, column 7 shows that the updated DIF mitigates the rise in EAD from future development.

How we do risk assessment

Definition of flood risk

Flood risk is a description of the likelihood of adverse consequences from flooding for a given impact area with a specified climate condition, land use condition, and flood risk management system (existing or planned) in place. The components of flood risk assessment include: (1) hazard, which is the probability and magnitude of flood flows, (2) performance of flood risk reduction measures, (3) exposure of people and property in the floodplain, and (4) vulnerability to harm of people and property exposed to the hazard. Consequence is the harm that results from a single occurrence of the hazard.

The flood risk components are defined in greater detail below:

- **Hazard (also known as loading)** – The hazard is what causes the harm—in this case, the hazard is a flood. The flood hazard is described in terms of probability of water surface elevation (stage), velocity, extent, depth, and other flood properties.
- **Performance** – Performance is the system's reaction to the hazard. Performance can be described for engineered systems (such as levees or reservoirs) that affect the hazard directly.
- **Exposure** – Exposure is a measure of who and what may be harmed by the flood hazard. It incorporates a description of where the flooding occurs at a given probability (frequency) and what exists in that area. Tools such as flood inundation maps provide information on the extent and depth of flooding; and structure inventories provide information on the people and property that may be affected by the flood hazard.
- **Vulnerability** – Vulnerability is the susceptibility to harm of people and property exposed to the hazard. Depth-percent damage functions describe vulnerability.
- **Consequence** – As noted above, consequence is the harm that results from a single occurrence of the hazard. The consequence of flood inundation may be measured in terms of economic damage, loss of life, environmental impact, or other specified measure of flood risk.

The relationships among flood risk components are illustrated conceptually in Figure 2.

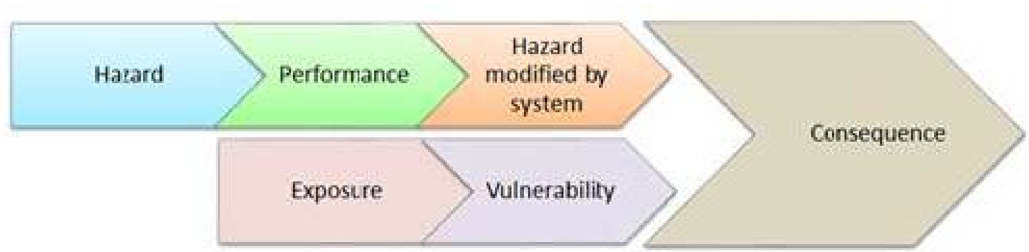


Figure 2. Relationship among flood risk assessment components

Flood risk reduction (e.g., benefit) is achieved by altering the hazard, performance, exposure, and/or vulnerability, thereby reducing adverse consequences.

Flood risk is not the damage incurred by a single catastrophic event. Rather, it is the probability of each of many outcomes that is expressed as a consequence-probability function. The consequence-probability function can be integrated to compute an expected or most likely value of the consequence. If the probabilities are annual values, this most likely value is called the expected annual value. The reduction in expected annual damage is often used as a standard for measuring the effectiveness of proposed flood risk management measures.

Flood risk is assessed and reported for an impact area, which is a separable geographic area within a floodplain. Flood hazard for the impact area is represented at an index point, which, in turn, represents an interface between the impact area and the channel. The impact areas and index points used in this analysis are described later in this report and shown in Figure 5.

Use of EAD to describe flood risk

In this assessment, we describe flood risk with expected annual damage (EAD). EAD describes the residual risk of flooding that remains with flood risk reduction projects in place. Essentially, EAD is the annual probability of flooding multiplied by the damage associated with that flooding.

As development continues within the Sacramento area, the flood risk increases, even if the annual probability of flooding stays the same. This is illustrated in Figure 3(A). To mitigate this increased flood risk due to development, the annual probability of flooding must be reduced. The latter is illustrated in Figure 3(B). The goal of the DIF program is to collect fees and implement measures to lower the probability of flooding and thus offset any increase in flood risk.

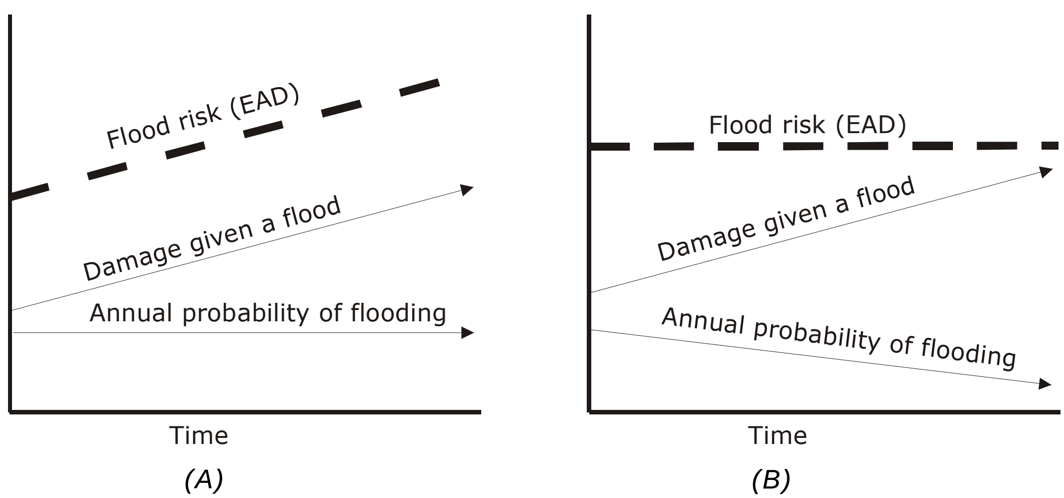
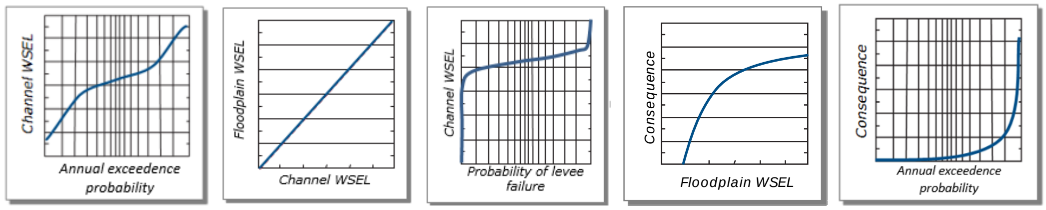


Figure 3. Flood risk with time with development: unmitigated (A) and mitigated (B)

Calculation of EAD

EAD is calculated as the integral of the damage-probability function, which weights the damage for each event by the probability of that event happening in any given year, and then sums across all possible events. The damage-probability function is commonly derived by the transformation of available hydrologic, hydraulic, and economic information, as illustrated on Figure 4.



(a) (b) (c) (d) (e)

Figure 4. Illustration of components of flood risk assessment: function (a) is a channel water surface elevation-probability [stage-frequency] function; function (b) is an interior-exterior function; function (c) is a levee performance function; function (d) is a (floodplain) water surface elevation-consequence function; and function (e) is a consequence-probability function.

Measurement of benefit

Benefit is measured by the consequence prevented. In this assessment we compared the expected economic damage *without* DIF-funded projects and *with* updated-DIF-funded projects:

Economic benefit = [EAD w/o updated DIF] – [EAD w/ updated DIF]

Additional theoretical background and methods of EAD computation are provided in Attachment 1.

Information required for this risk assessment and where we obtained it

Study configuration

Study area, impact areas, and index points

The study area is shown in Figure 1, above. For this risk assessment, we disaggregated the study area into impact areas. These impact areas represent the different flooding conditions, such as depth of flooding, in the various portions of the study area. Each impact area is represented in the hydraulic model as a separate hydraulic storage area. These areas were selected with input from the project team, considering previous analyses in the study area.

We associated each impact area with one or more index points. These index points represent the hydrologic, hydraulic, and geotechnical conditions for a given reach of stream. A water surface elevation-probability function considered representative of the exterior (river) water surface elevation is developed at each index point.

For damage computations, a relationship of the interior (floodplain) water surface elevation to exterior water surface elevation is developed with a hydraulic model at each index point. This relationship describes how water will flow from the channel onto the floodplain in impact areas without levees and it describes how water will flow over protecting levees or through a breach in the levee for areas thus protected.

The 4 impact areas and 7 index points used to compute flood damage in this assessment are summarized in Table 2.

Table 2. The index points used in the updated-DIF risk assessment

Description (1)	2017 CVFPP impact area (2)	Index point (3)	Stream and station (4)
Natomas basin	SAC36	SAC36	Sacramento River, 62.4965
		SAC36a	Sacramento River, 78.2548
Rio Linda	SAC37	SAC37a	NEMDC, 5.905
Sacramento North	SAC40	SAC40	American River, 2.6667
		SAC40a	NEMDC, 3.368
Sacramento South	SAC63	SAC63	American River, 2.6667
		SAC63a	Sacramento River, 59.85

The impact areas and index points used to represent the study area are shown in Figure 5. All of the index points and impact areas used in this study are consistent with the California Department of Water Resources (DWR) Central Valley Flood Protection Plan (CVFPP) currently under revision and due for publication in 2017.

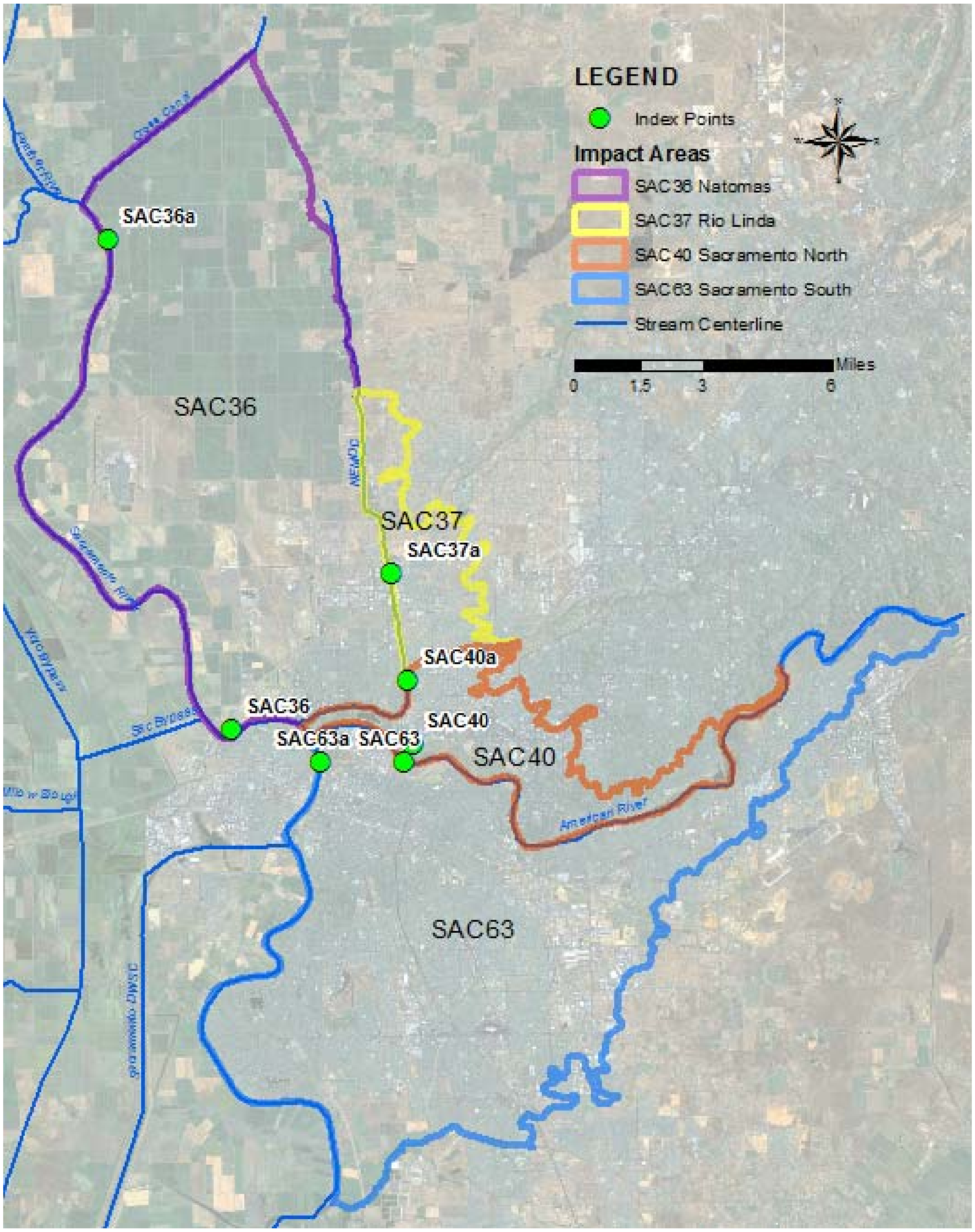


Figure 5. Index points and impact areas used in this updated DIF risk assessment

With- and without-updated-DIF conditions

For this analysis, we were interested in the benefit of planned flood risk reduction measures to which the updated DIF would contribute. These planned measures and evaluation conditions are described below and summarized in Table 3.

Table 3. Summary of baseline and with-updated-DIF conditions

Condition (1)	Description (2)
Baseline condition	• Folsom Dam with joint federal project (JFP) in place (auxiliary spillway and adoption of new water control manual). • All elements of Natomas Levee Improvement Program authorized as part of Water Resources Development Act (WRDA) 2014. • All elements of the American River Common Features Project along American River authorized by WRDA 1996 and 1999. • All levee armoring improvements along American River recommended in the American River Common Features general reevaluation report (ARCF GRR) (USACE 2015). • All levee improvements along Sacramento River recommended by ARCF GRR. • All levee strengthening improvements along the Natomas East Main Drainage Canal (NEMDC) east levee, Arcade Creek south levee, and Magpie Diversion Channel west levee recommended in the ARCF GRR. • All levee, floodwall, and channel improvements along Morrison Creek and its tributaries in South Sacramento authorized by WRDA 1999.
With updated DIF	• Folsom Dam Modifications Project, including dam raise and temperature shutter modifications. • Levee raising along Sacramento River east levee between Power Line Road and the mouth of the Natomas Cross Canal (NCC) to address identified levee height deficiencies. • Sacramento Weir and Bypass widening by 1,500 ft. • Yolo Bypass Lower Elkhorn levee setback. • North Sacramento streams corridor management plan (CMP). • South Sacramento streams corridor management activities.

We compared EAD for the conditions described above at 3 points in time—the year 2009 (when SAFCA began collecting the DIF), 2016, and the year 2025. EAD is reported as of 2009 for both the without-updated-DIF and with-updated-DIF conditions using a structure inventory representing structures on the ground in 2010. Little development occurred between 2009 and 2010, therefore EAD computed using a 2010 structure inventory is representative of 2009 conditions. Table 4 shows the residential square footage from the 2010 structure inventory.

To account for growth from 2009 to 2016, we scaled up the 2009 EAD (rather than adjusting the number of structures in the structure inventory). We arrived at a scaling factor as follows: SAFCA provided 2009 to 2016 damageable square footage development information by impact area as shown in Table 5. The growth scale factor was computed by summing the 2009-2016 and 2010 square footage, then dividing by the 2010 square footage. The ratios are shown in Table 6.

Table 4. 2010 square footage (representative of 2009 conditions)

Impact area (1)	Single-family square footage (2)	Multi-family square footage (3)	Commercial square footage (4)	Industrial square footage (5)
SAC36	45,712,527	802,674	3,018,837	3,434,484
SAC37	8,594,802	604,354	407,921	2,412,206
SAC40	3,155,812	19,532,721	7,028,297	6,390,247
SAC63	152,485,738	17,750,369	27,932,952	30,075,092
Total	164,236,352	37,887,444	38,388,008	42,312,030

Table 5. Damageable square footage development from 2009 to 2016 by impact area[1]

Impact area (1)	Single-family square footage (2)	Multi-family square footage (3)	Commercial square footage (4)	Industrial square footage (5)	Total (6)
SAC36	1,337,661	22,331	0	895,731	2,255,723
SAC37	635,972	82,771	216,173	111,000	1,045,915
SAC40	635,972	82,771	216,173	111,000	1,045,915
SAC63	635,972	82,771	216,173	111,000	1,045,915
Total	3,245,576	270,643	648,518	1,228,732	5,393,469

1. Development outside SAC36 distributed evenly between remaining impact areas.

Table 6. 2009 to 2016 growth ratios

Impact area (1)	Single-family square footage (2)	Multi-family square footage (3)	Commercial square footage (4)	Industrial square footage (5)
SAC36	1.0293	1.0278	-	1.2608
SAC37	1.0740	1.1370	1.5299	1.0460
SAC40	1.2015	1.0042	1.0308	1.0174
SAC63	1.0042	1.0047	1.0077	1.0037

The without-DIF and with-DIF conditions were assessed for 2025 using a structure inventory that represents 9 years of growth from 2016 to 2025. Information about the structure inventories used in this assessment is provided elsewhere in this appendix as well as in Attachment 4. Information about the growth projections used in this assessment is provided in Chapter 3 of the main report.

Table 7 summarizes the risk assessment conditions and development status for which we computed EAD.

Table 7. Condition and development status assessed for EAD computations

Assessment year (1)	Assessment condition (2)	Flood risk reduction projects in place (3)	Development status (4)
2009	Without updated DIF	Baseline	Structures on the ground in 2010 (representative of 2009 conditions)
2009	With updated DIF	Baseline	Structures on the ground in 2010 (representative of 2009 conditions)
2016	Without updated DIF	Same as baseline: current and authorized projects	2009 plus approximated growth from 2009-2016
2016	With updated DIF	Baseline plus updated-DIF-funded projects	2009 plus approximated growth from 2009-2016
2025	Without updated DIF	Same as baseline: current and authorized projects	Projected growth for 2025
2025	With updated DIF	Baseline plus updated-DIF-funded projects	Projected growth for 2025

Overview of information required to compute EAD

We computed EAD using the statistical sampling procedure (flood risk assessment) that is performed by the Corps' software application HEC-FDA. (We used HEC-FDA version 1.4 [2014]). To compute EAD with HEC-FDA, the following are required:

- Index points and impact areas to represent the study area. These analysis locations are used for aggregating and representing the system performance. Index points are selected locations used to represent hydrologic, hydraulic, and geotechnical characteristics for a reach of a stream. Impact areas are delineations of the floodplain with similar flooding depths. The hazard and performance information are described by index point, and exposure information is described by impact area.
- An in-channel water surface elevation-probability (stage-frequency) relationship for each index point. These relationships describe the hazard in terms of annual probability of channel water surface elevation in the river reaching or exceeding a specified elevation.
- An exterior water surface elevation-interior water surface elevation relationship for each impact area. These functions describe hazard by relating the water surface elevation in the channel (exterior) at the index point to the elevation of flooding in the floodplain adjacent to the channel (interior).

- A levee performance relationship for each index point. These functions represent the conditional probability of a levee failure for each channel water surface elevation.
- Structure inventories for each impact area at each assessment year. These inventories describe exposure—what is in the area protected by the levee.
- An elevation-percent damage relationship for each impact area. These functions describe vulnerability by relating economic damage in the floodplain to water surface elevation in that floodplain (the area protected by the levee).

Ultimately, a water surface elevation-damage relationship for each damage category (e.g., residential, commercial, and industrial) is evaluated. The water surface elevation-damage relationship may either be input directly into HEC-FDA, or HEC-FDA may compute the relationship between interior water surface elevation and damage using the information described above. The latter approach was used for this DIF program risk assessment.

Models of uncertainty about the information

The functions required for the risk assessment are not known with certainty. For example:

- Uncertainty about future precipitation events and watershed conditions leads to uncertainty about discharge probability. For example, we do not know with certainty the magnitude of the p=0.01 discharge at any point in the system. This leads, in turn, to uncertainty about the water surface elevation-probability relationship.
- Uncertainty arises from the use of models to describe complex hydraulic phenomena, from lack of ability to predict upstream levee failures, from the lack of detailed geometric data, from material variability, and from errors in estimating slope and roughness factors. All this leads to uncertainty about the water surface elevation-probability relationship. For example, we do not know with certainty the water surface elevation that will be reached near Natomas if the discharge rate in the Sacramento River is 125,000 cfs.
- Economic and social uncertainties, including lack of information about the relationship between depth and inundation damage, lack of accuracy in estimating structure values and locations, and lack of ability to predict how the public will respond to a flood, lead to uncertainty about the water surface elevation-damage relationship. Thus, we cannot be sure what damage will be incurred if the water depth in an impact area is 0.9 ft, or if it is 9.0 ft.
- If the impact area is protected by a levee, the exterior-interior water-surface elevation relationship is not known with certainty, because we are not certain about how a levee subjected to rare stresses and loads caused by floods will perform. For example, if the levee is able to provide protection to its top, the interior flooding water surface elevation will be zero for all exterior water surface elevations less than the top of levee elevation. However, if the levee breaches at a lower elevation, water will flow into the impact area, and the interior water surface elevation will be greater than zero.

Consistent with guidelines in *Engineer Manual (EM) 1110-2-1619, Risk-based analysis for flood damage reduction studies* (USACE 1996), HEC-FDA includes models of these uncertainties. We used those models for this DIF program assessment, providing model parameters for uncertainty about the water surface elevation-probability relationship, uncertainty about the exterior-interior uncertainty relationship (in the form of a levee performance function), and uncertainty about the water surface elevation-damage relationship.

Summary of data and information sources

The sources for the data and information used in this assessment are summarized in Table 8. Each of the types of data and information used in this assessment are described in greater detail following the table.

Hazard information

The flood hazard is described by in-channel water surface elevation-probability relationships and relationships of channel water surface elevation to floodplain water surface elevation given a levee failure (exterior-interior functions).

Channel water surface elevation-probability relationships

Channel water surface elevation-probability relationships at the index points define the probability that water surface elevation at a given index point will equal or exceed a specified magnitude.

In a simple river system, this function may be developed by fitting a probability model (a probability density function) to a sample of water surface elevations, by fitting a probability model to a sample of discharges and transforming that with a water surface elevation-discharge (rating) function, or by using the so-called design-storm assumption, in which runoff from precipitation events of specified probability is computed with a rainfall-runoff model and assigned a probability consistent with that of the precipitation.

Table 8. HEC-FDA inputs for updated DIF risk assessment

Component (1)	Description (2)	Source (3)
Hazard		
In-channel water surface elevation-probability function	This function represents the most-likely relationship between channel water surface elevation and exceedence probability at an index point that represents conditions for an impact area.	MBK Engineers supplied the in-channel water surface elevation-probability functions. It was based on Comprehensive Study (USACE 2002) hydrology. Hydrology on the east side of the Natomas basin was updated by USACE for the Natomas post-authorization change report (PACR) (2010). MBK Engineers updated American River flows (in 2016) for Folsom JFP/dam raise conditions.
Exterior-interior function	This relationship describes the water surface elevation of the interior (protected) floodplain if the levee fails at a specified channel (exterior) water surface elevation.	The exterior-interior functions were obtained from DWR CVFPP. (They are available by request from DWR.)
System performance		
Levee performance	This function is the conditional probability of a levee failure for each of a set of channel water surface elevations.	AECOM originally developed these levee performance curves for the 2012 CVFPP using levee geometry and data collected from the DWR urban levee evaluation and non-urban levee evaluation (ULE/NULE) projects. AECOM modified these functions as part of the 2017 CVFPP efforts. For Natomas (index point SAC36a), baseline conditions are represented by a levee performance curve that includes 200-year strengthening. The with-updated-DIF condition includes a levee raise.
Flood warning system	A flood warning system comprises the hardware, software, plans and procedures, and personnel that work in an integrated manner to increase the mitigation (action) time for floodplain communities prior to the onset of flooding, allowing more time to mitigate flood damage.	This information is from the USACE *Enhanced flood response and emergency preparedness* (EFREP) project (2006), as used in DWR CVFPP Basin-Wide Feasibility Studies (BWFS).
Exposure	Exposure information describes who or what is subject to the hazard.	The projected structure inventory was built from information developed for the 2012 CVFPP and subsequently updated for the DWR BWFS, and growth projections from the Sacramento Area Council of Governments (SACOG) for the year 2035, interpolated by EPS to the year 2025.

Component (1)	Description (2)	Source (3)
Vulnerability		
Residential structures depth-damage functions (DDFs)	These DDFs describe the relationship between economic damage and flood depth for residential structures.	These functions are from USACE *Economic guidance memorandum (EGM) 04-01* (2003).
Residential content depth-damage functions	These DDFs describe the relationship between economic damage and flood depth for residential content.	These functions are from USACE *EGM 04-01* (2003).
Non-residential structures depth-damage functions	These DDFs describe the relationship between economic damage and flood depth for non-residential structures.	These functions are from USACE Sacramento District's Folsom Dam modifications ERR (2008) and Natomas PACR (2010).
Non-residential content depth-damage functions	These DDFs describe the relationship between economic damage and flood depth for non-residential content (these functions are Sacramento-specific).	These functions are from USACE Sacramento District's Folsom Dam modifications ERR (2008).

For the Sacramento River and American River basins, development of the water surface elevation-probability function is complicated by the hydraulic interconnectivity of the system and the nature of overflow and storage of water in the upper reaches of the system. Water surface elevation at a downstream index point for any flood depends on what happens to levees upstream. If levees in the system perform as designed, water stays in the channels up to a design limit and moves downstream. The water surface elevation in downstream reaches is great as the volume entering those reaches is great. However, if an upstream levee fails, water is diverted from the channel and stored in the floodplain. Less water will move downstream, and the resulting water surface elevation downstream will be less than that associated with the non-failure condition.

Development of channel water surface elevation-probability relationships used in this study

The water surface elevation-probability relationships used in this assessment were provided by MBK Engineers (by email on April 25, 2016). A description provided by MBK Engineers summarizing the development of the water surface elevation-probability and discharge-probability relationships for this risk assessment is included in this report as Attachment 2.

Description of uncertainty

Algorithms in HEC-FDA describe the uncertainty of a stage-frequency function with a statistical model, parameters of which are related to the length of the record from which the stage-frequency function is derived. If the frequency function is not derived by fitting a probability density function with a sample of historical stage, HEC-FDA employs an equivalent record length specified by the program user instead. *EM 1110-2-1619* (USACE 1996) provides guidance for selection of this equivalent record length.

From past studies, the Corps and DWR estimated, for index locations throughout the Sacramento River system, an equivalent record length and published these values along with the documentation on the current standard hydrology used for analysis of the Sacramento system. This estimate is based on the data used for model calibration and other considerations.

We used, as a starting point, equivalent record lengths from previous studies for modeling uncertainty about the stage-frequency functions in the analysis. To describe additional uncertainty about the hydraulic conditions, we lowered the previously used equivalent record length to 20 years for each index point.

Exterior-interior relationships

For the EAD computations, a relationship between channel (exterior) water surface elevations and floodplain (interior) elevations, given a levee failure or overtopping, is needed. This exterior-interior relationship does not involve probabilities. Rather, it is a physical relationship based on simulation of levee failures and floodplain evaluation. The shape of the relationship is a function of the levee breach model parameters, the water in the channel that spills to the floodplain, and the floodplain topography.

Development for this study

For this study, we used exterior-interior relationships developed using the most recently available CVFPP 2-dimensional hydraulic modeling. These interior-exterior functions are available from DWR by request.

Description of uncertainty

As with all other functions used for the risk assessment, we are uncertain about the exterior-interior relationship.

The greatest source of uncertainty is how the system levees will perform. A levee will prevent flow of water from the exterior channel into the interior area until the design capacity of the levee is exceeded or until the levee fails. Without overtopping or failure, the interior stage is zero, regardless of the exterior stage. But we must account for the probability that the levee will fail prior to overtopping. Of course, the likelihood that a levee designed for the p=0.01 (100-year) event will fail during a p=0.10 (10-year) event is small, but the analysis procedure should account for this.

HEC-FDA includes a model of levee performance uncertainty, which we used for the analysis. This relationship, referred to as the levee fragility curve, defines the probability of failure of the levee, given exterior stage. Information about the levee performance curves used in this risk assessment is provided below.

System performance information

Levee performance relationships

Performance of a flood control system levee is described with a site-specific levee performance relationship. This function estimates the probability that the levee will fail to prevent inundation of the interior floodplain area if water rises to a specified elevation on the river side of the levee. In this application, "failure" is defined as a levee breach in which water from the water side of the levee flows in an uncontrolled manner to the landside of the levee, potentially resulting in damage (e.g., structural or content damage) in the floodplain.

The levee performance curves for all except Natomas used in this updated DIF risk assessment were developed for the 2017 CVFPP by AECOM. The curves provide relationships between river water surface elevation and the probability that the levee segment will fail when exposed to that water surface elevation. Development of a performance curve by a geotechnical engineer considers the physical properties of the levee and underlying foundation, manner of and history of maintenance and repairs of the levee, and history of observed performance. For the 2017 CVFPP, new levee performance curves were developed at each index point. Data for performance function derivation came from DWR's urban levee evaluations (DWR 2012d) and non-urban levee evaluation projects (DWR 2011). Performance functions were developed for both the baseline condition and improved levee conditions and described further in *2014 Performance curve development* (DWR 2014). Attachment 3 of this appendix summarizes these values for each analysis condition.

For the index point SAC36a baseline condition, we used a fragility curve that includes 200-year fixes; these fixes account for the seepage issues, but not freeboard. For the with-updated-DIF condition, we coordinated with MBK Engineers to determine the as-built top-of-levee elevation (that includes the levee raise) at index point SAC36a. These without-DIF and with-updated-DIF levee performance functions are included in Attachment 3 of this appendix.

Performance of flood warning system

A flood warning system includes hardware, software, plans and procedures, and personnel that work in an integrated manner to increase the mitigation (action) time for floodplain communities prior to the onset of flooding, allowing more time to mitigate flood damage. An increase in mitigation time is a consequence of a reduction in the time required to collect data and information, to evaluate and identify the flood threat, to notify emergency personnel and the public, and to make decisions about the appropriate response. However, the effectiveness (i.e., performance) of a flood warning system must also consider how many people receive a warning from that system and are able to take action (Carsell et al. 2004).

An enhanced flood response and emergency preparedness (EFREP) initial project (USACE 2006) was proposed as a component of the *Sacramento and San Joaquin river basins comprehensive study* (widely known as the Comp Study). Under EFREP, an expert elicitation panel estimated mitigation times for the without- and with-project conditions for 110 impact areas (which are similar to those used for the BWFS). The panel members included DWR and National Weather Service (NWS) forecasters and emergency response personnel. These mitigation times were used to inform the 2012 CVFPP life risk analysis (DWR 2012c).

Since then, flood warning systems in some communities have improved (while others have been hindered by budget cuts). As part of the BWFS, an expert elicitation panel, again composed of DWR and NWS staff, convened to update the EFREP mitigation times as a result of changes to flood warning systems included in the baseline condition. While mitigation times improved for most impact areas, in a few areas the mitigation times decreased (e.g., where staff cuts have hindered the flood warning system). These updated baseline mitigation times (combined with information regarding how many residents receive the warning and take action) are used to compute estimates of residential content damage. (The content-damage functions are described later in this appendix.)

Exposure information

Development of the structure inventory was an integral step in this flood risk assessment. We developed both a baseline structure inventory and a projected structure inventory for the year 2025.

Baseline structure inventory

For the baseline structure inventory, this risk assessment used the structure inventory developed for the 2012 CVFPP with updates for the BWFS (DWR 2015). Information about the development of the CVFPP/BWFS structure inventory is provided in Attachment 4 to this appendix.

The damage categories used in this updated-DIF assessment are summarized in Table 9.

Table 9. Damage categories used in this updated-DIF assessment

Category (1)	Description (2)
Single family residence (SFR)	Single family residential structures; mobile homes
Multi-family residence (MFR)	Multi-family residential structures
Commercial	Offices, retail facilities, hotels and motels, shopping centers
Industrial	Manufacturing plants, oil refineries, meat packing plants, canneries, and similar facilities; farm buildings

The baseline structure inventory (number of structures and structure value) by damage category is shown in Table 10.

Table 10. Baseline structure inventory—number of structures and structure value—by damage category

Damage category (1)	Baseline total structure count (2)	Baseline development—structure value ($1,000) (3)
SFR	144,990	14,760,818
MFR	11,763	1,082,073
Commercial	5,384	2,343,170
Industrial	2,144	937,183
Total	164,281	19,123,244

2025 structure inventory

Information about development of the 2025 structure inventory is in Attachment 4 of this appendix.

The projected inventory of additional structures (number of structures and structure value) in the year 2025 is shown in Table 11.

Table 11. Additional structure inventory—number of structures and structure value—by damage category

Structure category (1)	Projected additional total structure count (2)	Projected additional development—structure value ($1,000) (3)
SFR	5,595	1,517,022
MFR	1,594	1,029,132
Commercial	1,202	646,257
Industrial	905	197,076
Total	9,296	3,389,487

Vulnerability information

Vulnerability is the susceptibility to harm of people, property, and the environment exposed to the flood hazard. In risk assessment vulnerability is described by depth-percent damage or similar functions (hereafter called a depth-damage function [DDF]). However, to compute EAD, HEC-FDA ultimately requires a stage-damage function for each damage category (e.g., residential, commercial, and industrial) evaluated. The elevation-damage function relates inundation damage to water surface elevation within an impact area. We used relationships for both baseline (2009) and future (2025) conditions.

Damage is expressed as a percentage of total value, and depth is measured relative to the first floor elevation at each structure. In application, HEC-FDA transforms the DDFs to water surface elevation-damage functions by multiplying the percent damage values by the total value and by adding the first floor elevation to depths.

We used depth-percent damage functions consistent with the CADD 2 engineers report.

Residential depth-damage relationships

We used the same structure and content depth-damage functions that were used in the CCAD 2 engineer's report (SAFCA 2016). For residential structures, structure and content DDFs are from the USACE *Economic guidance memorandum (EGM) 04-01* (USACE 2003). They are shown in Table 12 and Table 13, respectively.

Table 12. Depth-damage functions for residential structures without basements (EGM 04-01)

First-floor depth (ft) (1)	1 story, without basement		2 or more stories, without basement	
	Structure damage[1] (2)	Standard deviation (3)	Structure damage[1] (4)	Standard deviation (5)
-2.0	0	0.0	0.0	0.0
-1.0	2.5	2.7	3.0	4.1
0.0	13.4	2.0	9.3	3.4
1.0	23.3	1.6	15.2	3.0
2.0	32.1	1.6	20.9	2.8
3.0	40.1	1.8	26.3	2.9
4.0	47.1	1.9	31.4	3.2
5.0	53.2	2.0	36.2	3.4
6.0	58.6	2.1	40.7	3.7
7.0	63.2	2.2	44.9	3.9
8.0	67.2	2.3	48.8	4.0
9.0	70.5	2.4	52.4	4.1
10.0	73.2	2.7	55.7	4.2
11.0	75.4	3.0	58.7	4.2
12.0	77.2	3.3	61.4	4.2
13.0	78.5	3.7	63.8	4.2
14.0	79.5	4.1	65.9	4.3
15.0	80.2	4.5	67.7	4.6

1. Values shown are damage as percentage of structure value.

Table 13. Depth-damage functions for residential content (structures without basements) (EGM 04-01)

First-floor depth (ft) (1)	1 story		2 or more stories	
	Content damage[1] (2)	Standard deviation (3)	Content damage[1] (4)	Standard deviation (5)
-2.0	0.0	0.0	0.0	0.0
-1.0	2.4	2.1	1.0	3.5
0.0	8.1	1.5	5.0	2.9
1.0	13.3	1.2	8.7	2.6
2.0	17.9	1.2	12.2	2.5
3.0	22.0	1.4	15.5	2.5
4.0	25.7	1.5	18.5	2.7
5.0	28.8	1.6	21.3	3.0
6.0	31.5	1.6	23.9	3.2
7.0	33.8	1.7	26.3	3.3
8.0	35.7	1.8	28.4	3.4
9.0	37.2	1.9	30.3	3.5
10.0	38.4	2.1	32.0	3.5
11.0	39.2	2.3	33.4	3.5
12.0	39.7	2.6	34.7	3.5
13.0	40.0	2.9	35.6	3.5
14.0	40.0	3.2	36.4	3.6
15.0	40.0	3.5	36.9	3.8

1. Values shown are damage as percentage of structure value.

Residential content DDFs were modified to reflect baseline flood warning mitigation times, as shown in Table 14. With sufficient warning, residents are able to move personal property such as televisions, clothing, and food either to a higher floor or out of the potential flood area. Thus, with increasing mitigation times, the percent damage is reduced for specified depths. Each impact area was assigned a residential content DDF from Table 14 depending on how close its estimated mitigation time matched one of the times shown in that table. SAC36 is the only impact area that uses a 1-hour mitigation time (column 3 of Table 14). All other impact areas have 0-hour mitigation times, and therefore use the percent damage values listed in column 2 of Table 14.

Commercial and industrial depth-damage relationships

For nonresidential structures, structure and content DDFs are from the *American River watershed project, Folsom Dam modifications and Folsom Dam raise project final economic reevaluation report* (Folsom mod ERR) (USACE 2008). The non-residential structure DDFs are shown in Table 15.

Table 14. Depth-damage functions for single-family-residential content modified for mitigation times

Depth above first floor (1)	Mitigation time 0 hours[1] (2)	1 hour[2] (3)
-2.0	0%	0%
-1.0	2.4%	2.4%
0.0	8.1%	6.3%
1.0	13.3%	11.8%
2.0	17.9%	16.2%
3.0	22.0%	19.9%
4.0	25.7%	23.5%
5.0	28.8%	27.0%
6.0	31.5%	29.6%
8.0	35.7%	32.9%
10.0	38.4%	35.4%
15.0	40.0%	36.8%

1. Source: EGM 04-01 (USACE 2003) single-family residential contents DDF. These damage percentages are applied to structure value and not content value. They are equivalent to 0-hour mitigation time.
2. Modified from USACE 2003 single-family residential contents DDF, taking into account various mitigation times. Changes in percent damage for mitigation times only occur for stages greater than 0 because these changes are based on information developed by the USACE EFREP, which only evaluated changes in percent damage for depths greater than 0. Therefore, percent damage does not change for the -1 and -2 depths for all mitigation times.

Table 15. Depth-percent damage functions for 1-story and 2-story non-residential structures

First-floor depth (ft) (1)	Commercial/Industrial 1-story[1] (2)	Commercial/Industrial 2-story[1] (3)
-2.0	0.0	0.0
-1.0	0.0	0.0
0.0	7.0	5.0
1.0	22.0	15.0
3.0	31.0	22.0
5.0	32.0	23.0
10.0	54.0	46.0
15.0	86.0	80.0

1. Values shown are damage as a percentage of structure value.

What we found

We used HEC-FDA to compute damage to:

- Structures
- Structure contents

Expected annual damage

We computed EAD for all of the impact areas in the study area for each of the evaluation conditions. Table 16 shows the results of the EAD computations, by damage category, with and without the updated DIF. Column 2 shows the EAD for the baseline condition in 2009. Column 3 shows the EAD for the with-updated-DIF features in place for 2009. Columns 4 and 5 show the EAD computed for 2016 without and with the updated DIF, with the SFR and MFR categories scaled by the 2009 to 2016 growth factor. Column 6 shows the EAD computed for the 2025 without the updated DIF. Column 7 shows the EAD values computed for 2025 with the updated DIF. As shown, absent the additional flood protection measures that would be funded by the updated DIF, EAD increases with additional development.

Table 16. Expected annual damage for 2009 baseline, 2016 baseline, 2016 with-updated-DIF, 2025 without-updated-DIF, and 2025 with-updated-DIF scenarios

	EAD[1] ($1,000)					
Damage category (1)	**2009 baseline (2)**	**2009 with-updated DIF (3)**	**2016 without updated DIF (4)**	**2016 with updated DIF (5)**	**2025 without updated DIF (6)**	**2025 with updated DIF (7)**
SFR	29,210	21,948	30,002	22,564	35,216	26,326
MFR	1,240	1,002	1,255	1,014	3,818	2,899
Commercial	3,555	2,786	3,605	2,830	5,199	4,000
Industrial	2,656	2,092	2,912	2,269	3,915	2,975
Total	36,661	27,829	37,774	28,678	48,148	36,200

1. Values reported in 2014 dollars.

Flooding from multiple index points

For some of the impact areas, flood damages could be attributed to more than one index point. However, there is only a single EAD value for an impact area. If an impact area is flooded from multiple index points, the EAD for the impact area is not simply the sum of the EAD values computed with information for the individual index points; to compute it in this way would overestimate the damage potential.

For the DIF risk assessment a multiple index point approach for impact areas with multiple sources of flooding was used, consistent with methods presented in *Multiple flood source expected annual damage computations* (Pingel and Watkins 2010). Here the correlation between flooding sources is used to determine how the EAD from each index point will be used in EAD computations. Hydrologic and hydraulic correlation is generally put into 3 categories:

1. **Independent (uncorrelated) flooding sources** – The flows and stages in 1 stream are completely independent of the other.

2. **Moderately correlated flooding sources** – The flows and stages at 2 index points are not independent, nor are they highly correlated.

3. **Highly correlated flooding sources** – When the flows and stages are high at 1 index point, similar conditions exist at the other index points. This indicates essentially a single source of flooding, but with multiple levee reaches (Pingel and Watkins 2010).

Flood sources for the DIF risk assessment were all considered highly correlated. For example, if flood stages in the Sacramento River are high, flow through the Sacramento Weir will begin to fill the Yolo Bypass. Therefore, high stages in the Sacramento River equal high stages in the Yolo Bypass. For highly correlated streams, Pingel and Watkins (2010) suggest computing risk at multiple index points and using the highest EAD. For the DIF risk assessment EAD was computed at each index point and the highest (maximum) EAD value of all index points within an impact area is used in the EAD computations.

Table 17 summarizes the index points that contribute to damages for each impact area. The impact areas are shown in Figure 5.

Table 17. Index points contributing to impact area damages

Impact area (1)	Flooding from index point(s) (2)
SAC 36	SAC36, SAC36a
SAC 37	SAC37a
SAC 40	SAC40a
SAC 63	SAC63, SAC63a

Synthesis of results

EAD computed in 2025 without the updated DIF is greater than EAD computed in 2025 with the updated DIF. This increase in EAD is due to a combination of increased development and a constant annual probability of flooding during the 9-year period from 2016 to 2025. The probability of flooding remains constant because, without the updated DIF, no levee improvements or other flood protection measures are funded by the updated DIF.

Conversely, implementation of the measures funded by the updated DIF reduces the 2025 EAD from $48,148,000 without the updated DIF to $36,200,000 with the updated DIF. In other words, results of the risk assessment show that the updated DIF mitigates the rise in EAD due to future development by approximately $11,948,000.

Attachment 1. Expected annual damage computation procedure

Theoretical background

In mathematical terms, if X represents the value of annual flood damage, then the expected value of annual damage, $E[X]$, is computed as

$$E[X] = \int_{-\infty}^{\infty} x f_X(x)\, dx \qquad (1)$$

in which x represents the random value of annual damage that occurs with probability $f_X(x)dx$. With this, all the information about the probability of occurrence of various magnitudes of damage is condensed into a single number by summing the products of all possible damage values and the likelihood of their occurrence.

In the equation, $f_X(x)$ is what statisticians refer to as the *probability density function* (PDF). In hydrologic engineering, an alternative representation of the same information, the so-called *cumulative distribution function* (CDF), is more commonly used. This is defined as

$$F_X[x] = \int_{-\infty}^{x} f_X(u)du \qquad (2)$$

This probability distribution function, also known as a *frequency function*, defines the probability that annual maximum damage will not exceed a specified value X. Alternately, by exchanging the limits of integration, the CDF could define the probability that the damage will exceed a specified value. In either case, the CDF and PDF are related as

$$\frac{dF_X[x]}{dx} = f_X(x) \qquad (3)$$

so the expected value of annual damage can be computed as

$$E[X] = \int_{-\infty}^{\infty} x \frac{dF_X(x)}{dx} dx \qquad (4)$$

Method of computation

Mechanically, then, finding the expected value of annual damage is equivalent to integrating the annual damage cumulative frequency function. The function could be integrated analytically if it were written as an equation. This approach is of little practical value because analytical forms commonly are not available. In fact, the damage-frequency function required for expected-annual-damage computation commonly is not available in any form. Theoretically, the function could be derived by collecting annual damage data over time and fitting a statistical model. In most cases, such damage data are not available or are very sparse for existing conditions, and they *never* are available for modified conditions.

Instead, the damage-frequency function is derived commonly via transformation of available hydrologic, hydraulic, and economic information, as illustrated in Figure 6. A stage-frequency function (Figure 6*a*) is developed using principles of hydrology and hydraulics. An elevation-damage function (Figure 6*b*) is developed from information about location and value of damageable property in the floodplain. With this, the stage-frequency function can be transformed to yield the required damage-frequency function (Figure 6*c*). Finally, to compute the expected damage, the resulting damage-frequency function can be integrated.

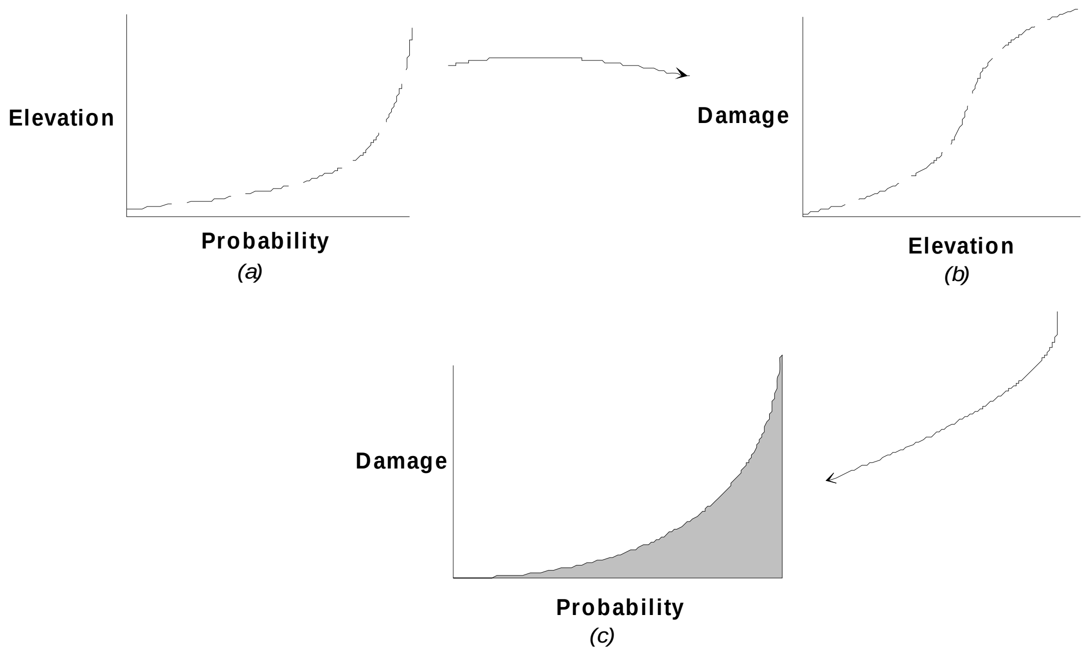


Figure 6. EAD computed by transformation and integration

This integration task was completed for the study reported herein using the Corps of Engineers' computer program HEC-FDA (USACE 2014). The program is based on the concept that the average of damages that are incurred over a very long period will approach the true EAD. It uses a statistical model to generate a long sequence of flood elevations, uses the elevation-damage transformation to create an equally long record of annual damages, and averages those.

Attachment 2. Water surface elevation-probability relationships

Water surface elevation-probability functions

MBK Engineers provided the water surface elevation-probability functions we used for this analysis (via e-mail, April 25, 2016). These functions include events ranging from p=0.500 (2-year) to p=0.002 (500-year). The water surface elevation-probability functions for the without- and with-updated-DIF conditions included different modeling. Table 18 summarizes the water surface elevation-probability function assumptions for each evaluation condition.

Table 18. Water surface elevation (WSEL)-probability function model assumptions

Evaluation scenario (1)	WSEL-probability function parameters (2)
2016 and 2025 without updated DIF	• Base hydrology • Folsom JFP • 2014 NEMDC conditions
2016 and 2025 with updated DIF	• Base hydrology • Folsom JFP + dam raise • Maintained NEMDC according to CMP • Widened Sacramento Weir and Bypass • Yolo Bypass Lower Elkhorn levee setback

As noted in the main body of this appendix, to describe the hydrologic and hydraulic uncertainty in the water surface elevation-probability function, we used an equivalent record length of 20 years. With the equivalent record length, the uncertainty about the water surface elevation-probability function changes with the probability of a given elevation being exceeded: the rarer the event, the greater the uncertainty.

Table 19 through Table 25 show these water surface elevation-probability functions for each index point (IP). All water surface elevations are shown in NAVD88.

Table 19. Water surface elevation-probability functions for IP SAC36

Without updated DIF		**With updated DIF**	
AEP (1)	**WSEL (ft) (2)**	**AEP (3)**	**WSEL (ft) (4)**
0.500	29.61	0.500	29.53
0.100	30.68	0.100	30.64
0.040	31.68	0.040	30.67
0.020	33.60	0.020	32.12
0.010	34.31	0.010	32.97
0.005	35.77	0.005	33.90
0.002	38.50	0.002	36.67

Table 20. Water surface elevation-probability functions for IP SAC36a

Without updated DIF		**With updated DIF**	
AEP (1)	**WSEL (ft) (2)**	**AEP (3)**	**WSEL (ft) (4)**
0.500	35.41	0.500	35.40
0.100	38.01	0.100	37.87
0.040	40.52	0.040	40.35
0.020	41.66	0.020	41.43
0.010	42.77	0.010	42.57
0.005	43.99	0.005	43.87
0.002	44.87	0.002	44.82

Table 21. Water surface elevation-probability functions for IP SAC37a

Without updated DIF		**With updated DIF**	
AEP (1)	**WSEL (ft) (2)**	**AEP (5)**	**WSEL (ft) (6)**
0.500	30.43	0.500	30.11
0.100	33.91	0.100	33.21
0.040	36.32	0.040	35.41
0.020	38.16	0.020	37.21
0.010	40.15	0.010	39.11
0.005	41.46	0.005	40.43
0.002	44.71	0.002	44.53

Table 22. Water surface elevation-probability functions for IP SAC40

Without updated DIF		With updated DIF	
AEP (1)	WSEL (ft) (2)	AEP (3)	WSEL (ft) (4)
0.500	29.36	0.500	29.29
0.100	31.27	0.100	31.31
0.040	33.37	0.040	32.55
0.020	36.18	0.020	35.22
0.010	36.66	0.010	35.74
0.005	39.30	0.005	36.38
0.002	43.42	0.002	42.92

Table 23. Water surface elevation-probability functions for IP SAC40a

Without updated DIF		With updated DIF	
AEP (1)	WSEL (ft) (2)	AEP (3)	WSEL (ft) (4)
0.500	29.33	0.500	29.28
0.100	31.43	0.100	31.09
0.040	34.05	0.040	33.46
0.020	36.03	0.020	35.30
0.010	37.62	0.010	36.90
0.005	38.60	0.005	37.98
0.002	44.47	0.002	44.42

Table 24. Water surface elevation-probability functions for IP SAC63

Without updated DIF		With updated DIF	
AEP (1)	WSEL (ft) (2)	AEP (3)	WSEL (ft) (4)
0.500	29.36	0.500	29.29
0.100	31.27	0.100	31.31
0.040	33.37	0.040	32.55
0.020	36.18	0.020	35.22
0.010	36.66	0.010	35.74
0.005	39.3	0.005	36.38
0.002	43.42	0.002	42.92

Table 25. Water surface elevation-probability functions for IP SAC63a

Without updated DIF		With updated DIF	
AEP (1)	WSEL (ft) (2)	AEP (3)	WSEL (ft) (4)
0.500	28.78	0.500	28.70
0.100	30.11	0.100	30.10
0.040	31.40	0.040	30.26
0.020	33.39	0.020	31.92
0.010	34.09	0.010	32.76
0.005	35.62	0.005	33.68
0.002	38.70	0.002	37.25

Background information on the development of the water surface elevation-probability functions

The descriptions on the following pages of how MBK Engineers developed the water surface elevation-probability (stage-frequency) relationships were provided to Ford Engineers on 6/27/2016.

Development of Stage-Frequency and Flow-Frequency Relationships for SAFCA Developer Impact Fee Analysis

Received from MBK Engineers 6/27/16

Hydraulic Model

The MBK Engineers (MBK) version 2015-03 of Release 4 of the U.S. Army Corps of Engineers (USACE) Sacramento River Basin HEC-RAS model (Sac Basin Model) was used for this analysis. The hydraulic simulations were made with version 4.1 of HEC-RAS in unsteady mode. The domain of the hydraulic model includes the Sacramento River from Colusa to Collinsville, the Feather River below Oroville Dam, the American River below Folsom Dam, the Sutter Bypass, the Yolo Bypass, and other major tributaries (Figure 1).

California Urban Levee Design Criteria (ULDC) conditions were assumed for levees. Urban levees crest elevations were no lower than the 200-year water surface elevation plus 3 feet, and non-urban State-Federal Project levees satisfied the Sacramento River Flood Control Project minimum crest elevation (1957 Profile). Levees were assumed to act as weirs if overtopped, and not fail.

Hydrology

Hydrology developed in 2002 by USACE for the Sacramento and San Joaquin River Basins Comprehensive Study (Comprehensive Study) (USACE, 2002) was used for the Sacramento and Feather River watersheds. The Comprehensive Study hydrology consists of a number of hydrologic inflow data sets representing different storm "centerings." The storm centerings relied on historical storm patterns in the upstream basin to define the shape and magnitude of the flow contributions from each of the sub-basins, and were designed to stress specific locations within the system. The following three storm centerings which were designed to stress the system in the SAFCA study area were used for this analysis:

- Sacramento River at the latitude of Sacramento (Sacramento Centering)
- Feather River at Shanghai Bend (Shanghai Bend Centering)
- American River below Folsom Dam (American River Centering)

The final water surface elevation was the highest computed by the three storm centerings.

The following annual exceedance probability (AEP) flood events were simulated: 1-in-2, 1-in-10, 1-in-25, 1-in-50, 1-in-100, 1-in-200, and 1-in-500.

The hydrology for the watersheds on the east side of the Natomas basin, including Dry Creek, Robla Creek, and Arcade Creek was updated by USACE in 2010 (USACE, 2010) for the American River Watershed Common Features General Reevaluation Report (Common Features GRR) (USACE, 2015). American River flows were updated by MBK in March 2016 (MBK Engineers, 2016) for two conditions:

1. Folsom Joint Federal Project (JFP)
2. Folsom JFP plus Folsom Dam raise

The peak American River flows for the conditions and storm events evaluated are summarized in Table 1.

Table 1. American River Peak Flows, cubic feet per second (cfs)

AEP	American River Centering		Sacramento Centering		Shanghai Bend Centering	
	JFP	JFP + raise	JFP	JFP + raise	JFP	JFP + raise
1-in-2	25,000	25,000	25,000	25,000	25,000	25,000
1-in-10	50,000	50,000	50,000	50,000	50,000	50,000
1-in-25	80,000	80,000	80,000	80,000	80,000	80,000
1-in-50	115,000	115,000	115,000	115,000	80,000	80,000
1-in-100	115,000	115,000	115,000	115,000	115,000	115,000
1-in-200	160,000	115,000	115,000	115,000	115,000	115,000
1-in-500	361,700	360,600	341,000	334,000	281,700	257,200

Scenarios

Four scenarios were evaluated:

1. 2014 condition NEMDC; Folsom JFP
2. NEMDC with corridor maintenance plan (CMP); Folsom JFP
3. NEMDC with CMP; Folsom JFP plus Folsom Dam raise
4. NEMDC with CMP; Sacramento Weir and Bypass widened 1,500 feet; Yolo Bypass Lower Elkhorn levee setback

References

MBK Engineers. (2016). *Development Impact Fee - Joint Federal Project Improvements at Folsom Hydrology and Hydraulic Model Inputs. March 31, 2016.*

USACE. (2002). *Sacramento and San Joaquin River Basins Comprehensive Study, Technical Studies Documentation. December 2002.*

USACE. (2010). *American River Common Features Project General Reevaluation Report, Appendix B, Dry and Arcade Creek Flow Frequency Curves and Synthetic 8-Flood Series Hydrographs Upstream of Steelhead Creek. January 2010.*

USACE. (2015). *American River Watershed Common Features General Reevaluation Report, Final Report. December 2015.*

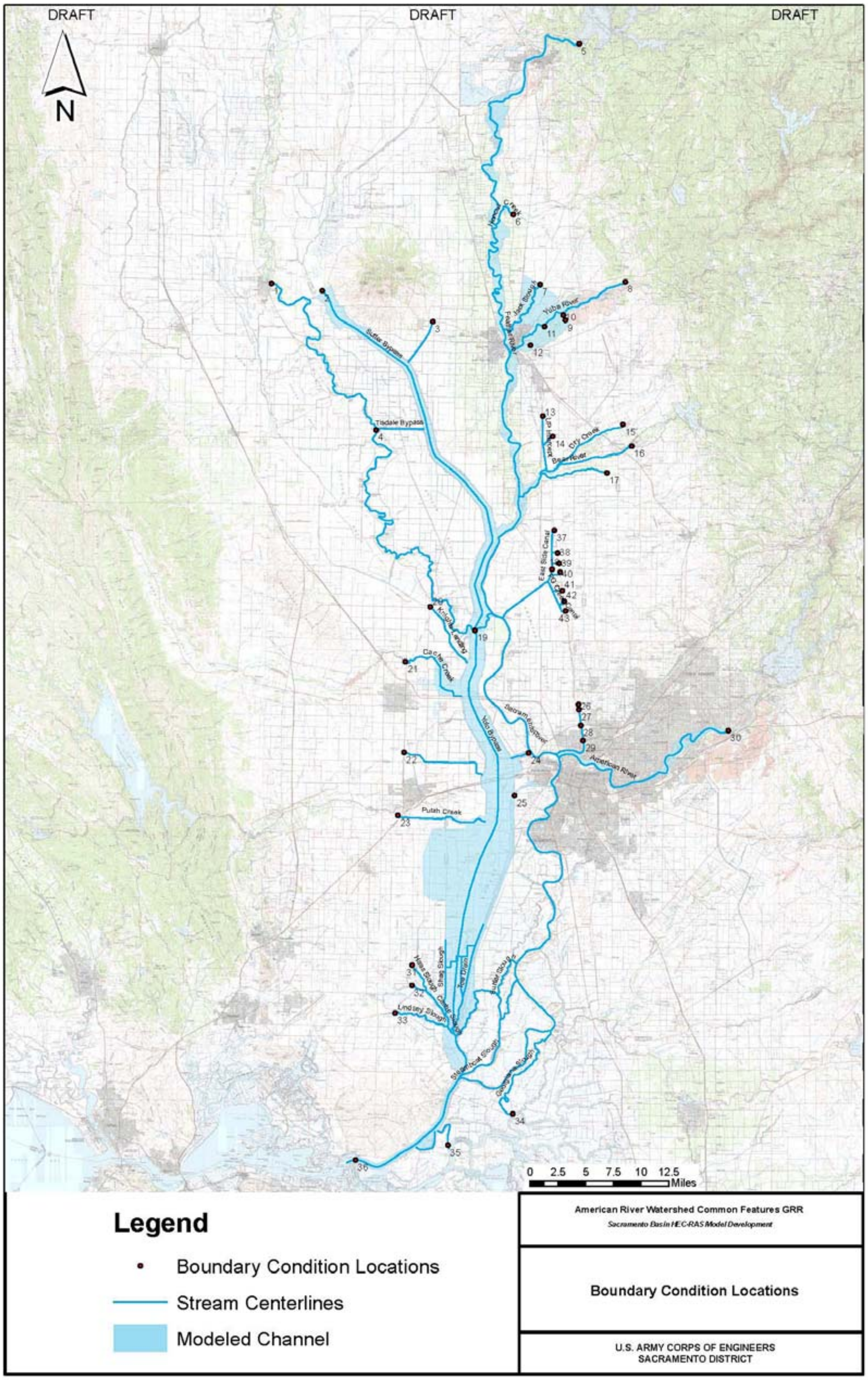


Figure 1: Sacramento River Basin HEC-RAS Model Domain

HYDROLOGY AND HYDRAULIC MODEL INPUTS

For the hydraulic model, *Sacramento and San Joaquin River Basins Comprehensive Study* (Comp Study) hydrology was adopted with updates to the American River hydrology to reflect improvements at Folsom Reservoir. The reservoir model was operated on an hourly timestep with regulated Folsom inflow derived from the latest American River Watershed hydrology provided by USACE (FMOS2014-06-24E3Hydrology.DSS). This was routed through the upstream reservoirs in the J602 HEC-ResSim model (received Jun 5, 2015) to produce regulated hourly Folsom inflow.

JOINT FEDERAL PROJECT MODEL

MBK utilized a custom Folsom operations model configured to represent two operational scenarios: the Joint Federal Project improvements (JFP) and the JFP with an additional three and a half-foot "mini-raise." The JFP configuration for Folsom reservoir includes the newly constructed Auxiliary Spillway and a modified Flood Control Diagram (FCD) with updated Emergency Spillway Release Diagram (ESRD) per the USACE proposed changes to the Water Control Manual (received Mar 21, 2016). The FCD reflects forecast-informed operations and an updated Spring Refill Curve. Top of Conservation is now calculated based on forecasts of inflow volume for 24-, 48-, 72- and 120-hour durations. The same durations are used for the forecast-informed release schedule, which notably allows stepped releases in advance of the primary flood wave when forecasted inflow volumes exceed key thresholds. This provides greater flexibility for drawing down the reservoir preceding a flood wave, thus improving reservoir performance in managing large-scale flood events.

The JFP with dam raise scenario includes an increase to the Top of Flood Pool by 3.5 feet. In addition to providing more flood control space, this affects implementation of the ESRD; all elevation ordinates for the ESRD curves were also shifted up by 3.5 feet.

STORM CENTERINGS AND RECURRENCE INTERVALS

Routings for JFP and JFP with raise conditions were provided for three storms centerings: American River (AR), Sacramento River Mainstem at Latitude of Sacramento (SR) and Feather River above Shanghai Bend, with a Specific Centering on Yuba River (SHY). For each reservoir configuration, and each storm centering, routings were provided for the 2-, 10-, 25-, 50-, 100-, 200- and 500-year events. For all but the American River centering 200-year scaling, the 1986 historical pattern was adopted. For the 200-year AR centering scenarios, a balanced hydrograph was adopted (received Feb 12, 2016). Balanced hydrographs provide additional volume compared to the straight-scaled historical patterns and thus prevent operational benefits from being overstated for the 1-in-200 year AR scenarios.

The Comp Study includes tables mapping an event's percent chance exceedence to specific recurrence intervals at mainstem index points for each storm centering. Table 26 summarizes the equivalent recurrence intervals at the American River at Folsom index point for each event magnitude and each storm centering. For the SR and SHY centerings, the calculated equivalent recurrence intervals were then matched to the nearest scaling available in the American River Watershed hydrology ensemble, noted in the “adopted” columns. This was then routed through the reservoir to produce input for the hydraulic model.

Table 26: Equivalent Recurrence Intervals (years) for American River at Folsom by Storm Centering

Hydraulic Model	Mainstem Index Point: American River at Folsom				
	American River Centering	Sacramento River Mainstem at Latitude of Sacramento		Feather River above Shanghai Bend, with a Specific Centering on Yuba River	
		SR Equivalent†	SR Adopted	SHY Equivalent ‡	SHY Adopted
2	**2**	2	**2**	1	**2**
10	**10**	8	**10**	7	**10**
25	**25**	21	**25**	16	**10**
50	**50**	40	**50**	33	**25**
100	**100**	79	**100**	65	**50**
200	**200**	156	**150**	132	**150**
500	**500**	400	**400**	323	**350**

† Calculated from *Sacramento and San Joaquin River Basins Comprehensive Study, California - Appendix B: Synthetic Hydrology Technical Documentation:* Table B.4-1b. USACE Dec 2002.
‡ Calculated from *Yuba River Basin Project AFB (F4A) Conference Report: Synthetic Hydrology & Reservoir Operations Technical Documentation:* Table 2. USACE 2004.

STORM CENTERINGS AND RECURRENCE INTERVALS

The routed hydrographs were matched translated to the simulation time window of the Comp Study hydrology routings for the American River. The rising limb of the hydrograph, specifically the approach to releases of 115,000 cfs was used to match the event patterns. The synched hydrographs were then incorporated into the system hydraulic model.

Attachment 3. Levee performance relationships

Per the Corps' standards, the uncertainty in levee performance is described with a levee performance (fragility) function that specifies the probability of levee failure, given a channel water surface elevation (WSEL). Tables in this attachment show the levee performance functions provided by AECOM for each index point. AECOM developed these levee performance curves as part of DWR's CVFPP. Development of the levee performance curves is discussed further in the technical memorandum *2014 Performance curve development* (DWR 2014). With the exception of index point SAC36a, the DIF risk assessment used a single levee performance function at each index point—a curve reflecting an improved levee condition. Levee improvements completed by agencies other than SAFCA are considered in place for the without- and with-updated-DIF conditions. All elevations provided by AECOM are in NAVD88.

At index point SAC36a for the baseline condition, we used the 2008 DIF fragility curve that reflects 200-year fixes. To convert the fragility curve from NGVD29 to NAVD88, we used a 2.35 ft conversion factor as recommended by MBK Engineers. Because SAC36a is approximately 2 miles upstream from the 2008 DIF analysis index point, we added 1.0 ft, the approximated stage difference between index point locations, also recommended by MBK. For the with-updated-DIF condition, we used SAFCA's *Natomas levee improvement project: Economic and risk analysis* Alternative B fragility curve that also includes 200-year fixes. To reflect the levee raise, we coordinated with MBK to determine the as-built top-of-levee elevation at index point SAC36a. We set the last point in the with-updated-DIF fragility curve to 48.4 ft with a P(f)=1.0, as show in Figure 7. Fragility curves for all index points are shown in Table 27 through Table 33.

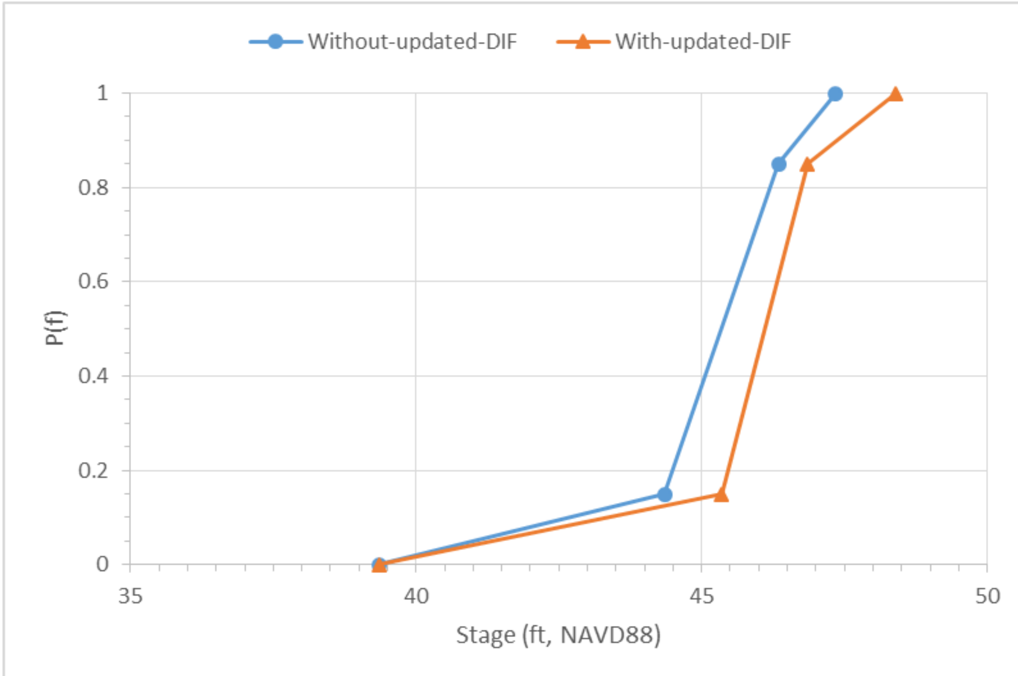


Figure 7. SAC36a without- and with-updated DIF fragility curves

Table 27. Levee performance function for index point SAC36 without and with updated DIF, Sacramento River at river mile 62.50

Without updated DIF		**With updated DIF**	
P(f) (1)	**Channel WSEL (ft) (2)**	**P(f) (3)**	**Channel WSEL (ft) (4)**
0.0000	23.27	0.0000	23.27
0.0000	24.13	0.0000	24.13
0.0001	24.99	0.0001	24.99
0.0001	25.85	0.0001	25.85
0.0002	26.71	0.0002	26.71
0.0002	27.57	0.0002	27.57
0.0004	28.43	0.0004	28.43
0.0006	29.29	0.0006	29.29
0.0009	30.15	0.0009	30.15
0.0014	31.01	0.0014	31.01
0.0021	31.87	0.0021	31.87
0.0032	32.73	0.0032	32.73
0.0049	33.59	0.0049	33.59
0.0075	34.45	0.0075	34.45
0.0116	35.31	0.0116	35.31
0.0178	36.17	0.0178	36.17
0.0282	37.03	0.0282	37.03
0.0394	37.89	0.0394	37.89
0.0616	38.75	0.0616	38.75
0.0840	39.61	0.0840	39.61
0.1064	40.47	0.1064	40.47

Note: Top of levee = 40.47 ft

Table 28. Levee performance function for index point SAC36a without and with updated DIF, Sacramento River at river mile 78.25

Without updated DIF		**With updated DIF**	
P(f)[1] (1)	**Channel WSEL (ft) (2)**	**P(f) (3)**	**Channel WSEL (ft) (4)**
0.00	39.35	0.00	39.35
0.15	44.35	0.15	45.35
0.85	46.85	0.85	46.85
1.00	47.35	1.00	48.40

1. P(f) was adjusted from 0.10 to 0.15 so that the without-updated-DIF and with-updated-DIF curves did not cross.

Table 29. Levee performance function for index point SAC37 without and with updated DIF, NEMDC at river mile 5.91

Without updated DIF		**With updated DIF**	
P(f) (1)	**Channel WSEL (ft) (2)**	**P(f) (3)**	**Channel WSEL (ft) (4)**
0.0000	26.08	0.0000	26.08
0.0000	26.99	0.0000	26.99
0.0001	27.90	0.0001	27.90
0.0001	28.81	0.0001	28.81
0.0001	29.72	0.0001	29.72
0.0002	30.64	0.0002	30.64
0.0003	31.55	0.0003	31.55
0.0004	32.46	0.0004	32.46
0.0006	33.37	0.0006	33.37
0.0008	34.28	0.0008	34.28
0.0012	35.19	0.0012	35.19
0.0018	36.10	0.0018	36.10
0.0025	37.01	0.0025	37.01
0.0036	37.92	0.0036	37.92
0.0057	38.83	0.0057	38.83
0.0085	39.75	0.0085	39.75
0.0113	40.66	0.0113	40.66
0.0164	41.57	0.0164	41.57
0.0296	42.48	0.0296	42.48
0.0428	43.39	0.0428	43.39
0.0561	44.30	0.0561	44.30

Note: Top of levee = 44.30 ft

Table 30. Levee performance function for index point SAC40 without and with updated DIF, NEMDC at river mile 3.37

Without updated DIF		With updated DIF	
P(f) (1)	Channel WSEL (ft) (2)	P(f) (3)	Channel WSEL (ft) (4)
0.0000	27.62	0.0000	27.62
0.0001	28.45	0.0001	28.45
0.0001	29.28	0.0001	29.28
0.0001	30.11	0.0001	30.11
0.0002	30.94	0.0002	30.94
0.0003	31.77	0.0003	31.77
0.0004	32.59	0.0004	32.59
0.0007	33.42	0.0007	33.42
0.0010	34.25	0.0010	34.25
0.0015	35.08	0.0015	35.08
0.0023	35.91	0.0023	35.91
0.0035	36.74	0.0035	36.74
0.0053	37.57	0.0053	37.57
0.0080	38.40	0.0080	38.40
0.0127	39.34	0.0127	39.34
0.0156	40.15	0.0156	40.15
0.0194	40.96	0.0194	40.96
0.0237	41.77	0.0237	41.77
0.0285	42.58	0.0285	42.58
0.0341	43.39	0.0341	43.39
0.0409	44.20	0.0409	44.20

Note: Top of levee = 44.40 ft

Table 31. Levee performance function for index point SAC40a without and with updated DIF, NEMDC at river mile 3.37

Without updated DIF		**With updated DIF**	
P(f) (1)	**Channel WSEL (ft) (2)**	**P(f) (3)**	**Channel WSEL (ft) (4)**
0.0000	18.28	0.0000	18.28
0.0000	19.53	0.0000	19.53
0.0000	20.77	0.0000	20.77
0.0000	22.02	0.0000	22.02
0.0000	23.27	0.0000	23.27
0.0000	24.52	0.0000	24.52
0.0000	25.76	0.0000	25.76
0.0001	27.01	0.0001	27.01
0.0001	28.26	0.0001	28.26
0.0002	29.50	0.0002	29.50
0.0004	30.75	0.0004	30.75
0.0008	32.00	0.0008	32.00
0.0017	33.24	0.0017	33.24
0.0033	34.49	0.0033	34.49
0.0065	35.74	0.0065	35.74
0.0129	36.99	0.0129	36.99
0.0256	38.23	0.0256	38.23
0.0414	39.48	0.0414	39.48
0.0703	40.73	0.0703	40.73
0.0877	41.97	0.0877	41.97
0.1051	43.22	0.1051	43.22

Note: Top of levee = 43.22 ft

Table 32. Levee performance function for index point SAC63 without and with updated DIF, American River at river mile 2.67

Without updated DIF		With updated DIF	
P(f) (1)	Channel WSEL (ft) (2)	P(f) (3)	Channel WSEL (ft) (4)
0.0000	29.69	0.0000	29.69
0.0013	30.44	0.0013	30.44
0.0022	31.20	0.0022	31.20
0.0032	31.95	0.0032	31.95
0.0041	32.70	0.0041	32.70
0.0052	33.46	0.0052	33.46
0.0063	34.21	0.0063	34.21
0.0074	34.96	0.0074	34.96
0.0087	35.72	0.0087	35.72
0.0101	36.47	0.0101	36.47
0.0117	37.23	0.0117	37.23
0.0135	37.98	0.0135	37.98
0.0164	38.73	0.0164	38.73
0.0347	39.49	0.0347	39.49
0.0565	40.24	0.0565	40.24
0.0830	40.99	0.0830	40.99
0.1155	41.75	0.1155	41.75
0.1558	42.50	0.1558	42.50
0.2062	43.25	0.2062	43.25
0.2698	44.01	0.2698	44.01
0.3505	44.76	0.3505	44.76

Note: Top of levee = 44.76 ft

Table 33. Levee performance function for index point SAC63a without and with updated DIF, Sacramento River at river mile 59.85

Without updated DIF		**With updated DIF**	
P(f) (1)	**Channel WSEL (ft) (2)**	**P(f) (3)**	**Channel WSEL (ft) (4)**
0.0000	30.94	0.0000	30.94
0.0006	31.35	0.0006	31.35
0.0008	31.77	0.0008	31.77
0.0009	32.18	0.0009	32.18
0.0011	32.59	0.0011	32.59
0.0013	33.00	0.0013	33.00
0.0016	33.42	0.0016	33.42
0.0019	33.83	0.0019	33.83
0.0023	34.24	0.0023	34.24
0.0027	34.65	0.0027	34.65
0.0034	35.07	0.0034	35.07
0.0043	35.48	0.0043	35.48
0.0055	35.89	0.0055	35.89
0.0072	36.31	0.0072	36.31
0.0096	36.72	0.0096	36.72
0.0130	37.13	0.0130	37.13
0.0178	37.54	0.0178	37.54
0.0254	37.96	0.0254	37.96
0.0356	38.37	0.0356	38.37
0.0459	38.78	0.0459	38.78
0.0561	39.19	0.0561	39.19

Note: Top of levee = 39.19 ft

Attachment 4. Structure inventory and valuation

For this risk assessment we developed baseline and projected (2025) structure inventories.

Development of baseline structure inventory and damageable property valuation

For the baseline structure inventory this risk assessment used the structure inventory developed for the 2012 CVFPP with updates for the BWFS (DWR 2015).

Development of CVFPP/BWFS structure inventory

The following basic steps were taken to develop and value the 2012 CVFPP structure inventory:

1. Develop a structure inventory by conducting a reconnaissance-level field survey for areas inside the CVFPP impact areas. The June 2010 county parcel data compiled by ParcelQuest were used as the basis for developing the structure inventory. The field surveys were conducted to obtain the following information to support development of structure values: structure categories, occupancy type, number of buildings, number of units per residential parcel, construction class for a building, construction quality for a building, depreciation percentage, and foundation height.
2. Populate missing data based on existing parcel data and survey results.
3. Identify building costs per square foot, and calculate the structure cost for each structure inside the CVFPP impact areas. The cost per square foot of a new building was identified based on a combination of its occupancy type, construction class, and structure quality, and the October 2010 price level of the cost per square foot. This price level was developed from the third quarter (October 2010) edition of Marshall & Swift and was adjusted based on the current cost multiplier and local multiplier.

The 2012 CVFPP structure values were updated for the BWFS using:

- Improved procedures to fill parcel data gaps related to building area (especially for commercial, industrial, and public structures).
- Additional field surveys to identify high value properties.
- Updated cost per square foot values to June 2014 dollars using Marshall & Swift cost and local multipliers.

Baseline structure count

Table 34 shows the baseline number of structures by impact area and damage category.

Table 34. Baseline structure count by impact area and damage category

Impact area (1)	SFR (2)	MFR (3)	Commercial (4)	Industrial (5)	Total (6)
SAC36	24,148	464	405	194	25,211
SAC37	6,395	358	60	108	6,921
SAC40	11,013	1,691	966	300	13,970
SAC63	103,434	9,250	3,953	1,542	118,179
All impact areas	144,990	11,763	5,384	2,144	164,281

Baseline structure value

Consistent with the Corps' standards, we used the structure's depreciated replacement value for the economic analysis. The depreciated replacement value is considered the cost of replacing the structure less any depreciation, which accounts for a reduction in a structure's value due to deterioration prior to flooding. Structure values were taken directly from the structure inventories developed as part of the BWFS.

Table 35 shows the baseline structure value by impact area and damage category.

Table 35. Baseline structure value by impact area and damage category

Impact area (1)	SFR ($1,000) (2)	MFR ($1,000) (3)	Commercial ($1,000) (4)	Industrial ($1,000) (5)	Total ($1,000) (6)
SAC36	2,982,694	33,331	215,028	105,740	3,336,793
SAC37	560,406	28,780	29,920	61,201	680,307
SAC40	1,274,452	149,488	427,319	108,727	1,959,986
SAC63	9,943,266	870,474	1,670,903	758,958	13,243,601
All impact areas	14,760,818	1,082,073	2,343,170	937,183	19,123,244

Residential and non-residential content values

Residential and non-residential contents value was estimated in HEC-FDA as a function of the structure value by multiplying the depreciated replacement value by the contents-to-structure ratio, as shown in Table 36.

These ratios are from the *USACE American River watershed project, Folsom Dam modifications and Folsom Dam raise project final economic reevaluation report* (USACE 2008) and were used for the 2012 CVFPP as well as the BWFS. Because of the nature of the building usage, this contents-to-structure ratio varies with occupancy type.

Table 36. Content-to-structure ratios (USACE 2008)

ID	Occupancy Type	Description	Ratio	Occupancy Type	Description	Ratio
1	C-RET1	Retail — one-story	51%	I-LT1	Light industrial — one-story	188%
2	C-RET2	Retail — two-story	47%	I-LT2	Light industrial — two-story	126%
3	C-DEAL1	Full service auto dealership — one-story	69%	I-HV1	Heavy manufacturer — one-story	31%
4	C-DEAL2	Full service auto dealership — two-story	69%	I-HV2	Heavy manufacturer — two-story	20%
5	C-FURN1	Furniture store — one-story	55%	I-WH1	Warehouse — one-story	89%
6	C-FURN2	Furniture store — two-story	36%	I-WH2	Warehouse — two-story	85%
7	C-HOS1	Hospital — one-story	92%	P-CH1	Church — one-story	20%
8	C-HOS2	Hospital — two-story	87%	P-CH2	Church — two-story	17%
9	C-AUTO1	Auto sales — one-story	62%	P-GOV1	Government building — one-story	35%
10	C-AUTO2	Auto sales — two-story	62%	P-GOV2	Government building — two-story	26%
11	C-HOTEL1	Hotel — one-story	69%	P-REC1	Recreation/assembly — one-story	132%
12	C-HOTEL2	Hotel — two-story	69%	P-REC2	Recreation/assembly — two-story	58%
13	C-FOOD1	Food-retail — one story	42%	P-SCH1	School — one-story	38%
14	C-FOOD2	Food-retail — two story	43%	P-SCH2	School — two-story	32%
15	C-RESTFF1	Fast food restaurant — one-story	42%	SFRB1	Single-family — one-story with basement	50%
16	C-RESTFF2	Fast food restaurant — two-story	42%	SFRB2	Single-family — two-story with basement	50%
17	C-GROC1	Grocery store — one-story	106%	SFRBS	Single -family split with basement	50%
18	C-GROC2	Grocery store — two-story	106%	SFR1	Single-family — one-story	50%
19	C-MED1	Medical — one-story	148%	SFR2	Single-family — two-story	50%
20	C-MED2	Medical — two-story	121%	SFRS	Single -family split	50%

ID	Occupancy Type	Description	Ratio	Occupancy Type	Description	Ratio
21	C-OFF1	Office — one-story	34%	MFR1	Multi-family — one-story	50%
22	C-OFF2	Office — two-story	28%	MFR2	Multi-family — two-story	50%
23	C-SHOP1	Shopping center — one-story	67%	MH	Mobile home	50%
24	C-SHOP2	Shopping center — two-story	54%			
25	C-REST1	Restaurant — one-story	134%			
26	C-REST2	Restaurant — two-story	118%			
27	C-SERV1	Auto service — one-story	193%			
28	C-SERV2	Auto service — two-story	193%			
31	FIRE1	Government building — one-story	35%			
32	FIRE2	Government building — two-story	26%			

Summary of baseline structure and content value

After all the structures and contents were valued, we calculated a total damageable property value by summing the structure and content values for each category as shown in Table 37.

Table 37. Total damageable property value by structure category

Structure category (1)	Baseline structure value ($1,000) (2)	Baseline content value[1] ($1,000) (3)	Baseline total damageable property[2,3] ($1,000) (4)
Single family residential	14,760,818	7,377,730	22,138,548
Multi-family residential	1,082,073	541,037	1,623,110
Commercial	2,343,171	1,321,384	3,664,555
Industrial	1,034,626	1,269,539	2,304,165
Total	19,220,688	10,509,690	29,730,378

1. Residential content is assumed 50% of residential structure value for this table. For EAD computations, the content damage is computed as a function of the structure value.
2. Total damageable property value includes all 4 impact areas.
3. Values reported are 2014 dollars.

Development of 2025 additional structure inventory and damageable property valuation

For development of the future growth elevation-damage relationship, EPS provided projections of development likely to occur over the next 9 years, 2016-2025, for each of the impact areas. The basis of the development projections is information provided by SACOG for the years from 2010 to 2035. (A complete description of how future growth was estimated is in Chapter 3 of the main report.)

To avoid double-counting structures, we:

1. "Subtracted" 2010 baseline inventory from projected total 2035 inventory.
2. Assigned new structures to damage categories.
3. Identified building square footage.
4. Assigned the cost per square foot of a new building based on a combination of its occupancy type, construction class, and structure quality, as well as the June 2014 price level of the cost per square foot. This price level was developed from the third quarter (October 2010) edition of Marshall & Swift (M&S 2010), and was adjusted based on the current cost and local multipliers.

Projected additional structure count

Table 38 shows the projected number of additional structures by impact area and damage category in 2025.

Table 38. Additional structure count by impact area and damage category

Impact area (1)	SFR (2)	MFR (3)	Commercial (4)	Industrial (5)	Total (6)
SAC36	2,054	376	311	166	2,907
SAC37	599	21	25	68	713
SAC40	226	141	160	44	571
SAC63	2,716	1,056	706	627	5,105
All impact areas	5,595	1,594	1,202	905	9,296

Projected additional structure value

Table 39 shows the projected value of additional structures by impact area and damage category in 2025.

Table 39. Additional structure value by impact area and damage category

Impact area (1)	SFR ($1,000) (2)	MFR ($1,000) (3)	Commercial ($1,000) (4)	Industrial ($1,000) (5)	Total ($1,000) (6)
SAC36	685,816	317,213	167,115	72,890	1,243,034
SAC37	78,766	10,850	747	26,156	116,519
SAC40	44,415	56,045	79,096	3,554	183,110
SAC63	708,023	645,023	399,299	94,476	1,846,821
All impact areas	1,517,020	1,029,131	646,257	197,076	3,389,484

Projected additional residential and non-residential content value

As with baseline residential and non-residential content values, projected content values were estimated as a function of the structure value by multiplying the depreciated replacement value by the contents-to-structure ratio.

Summary of projected additional structure and content value

After all the projected additional structures and contents were valued, we calculated a total projected additional damageable property value by summing the structure and content values for each category as shown in Table 40.

Table 40. Total projected additional damageable property value by structure category

Structure category (1)	**Additional structure value ($1,000) (2)**	**Additional content value[1] ($1,000) (3)**	**Additional total damageable property[2,3] ($1,000) (4)**
Single-family residential	1,517,020	758,510	2,275,530
Multi-family residential	1,029,131	514,566	1,543,697
Commercial	646,257	315,770	962,027
Industrial	197,076	285,276	482,352
Total	3,389,484	1,874,122	5,263,606

1. Residential content is assumed 50% of residential structure value for this table. For EAD computations, the content damage is computed as a function of the structure value.
2. Total damageable property value includes all 4 impact areas.
3. Values reported are 2014 dollars.

Attachment 5. References

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NOTE: This report contains several references to the Central Valley Flood Protection Plan Basin-Wide Feasibility Studies (CVFPP BWFS). These studies are ongoing as of the date of this report. Models, information, and documentation related to the BWFS are available to DWR by request.