APPENDIX C

ENGINEERING –

FLOOD RISK MANAGEMENT

HYDRAULIC ENGINEERING

TECHNICAL MEMORANDUM

FOR

EXISTING CONDITION ANALYSIS FOR RISK INFORMED DECISION MAKING FOR PROJECT ALTERNATIVE SELECTION

DELTA ISLANDS AND LEVEES FEASIBILITY STUDY, CALIFORNIA

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12 August 2013

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1.0 INTRODUCTION AND BACKGROUND

1.1 Purpose

On February 2012, Major General Walsh, Deputy Commanding General for Civil Works and Emergency Operations issued a memorandum of feasibility study program execution and delivery. This memorandum issued guidance for the current portfolio of feasibility studies to produce a more efficient, effective, and quality decision document and introduced the 3x3x3 rule for USACE planning studies. In deference to the memorandum, this technical memorandum presents the feasibility-level hydraulic evaluation of the existing conditions, conclusions, and recommendations for the Delta Islands and Levees Feasibility Study (DILFS). This memorandum has been developed in accordance with our new Planning Paradigm using the "SMART" Planning Criteria.

According to the USACE Planning Community Toolbox ,"SMART" is a mnemonic giving criteria to guide in the setting of project management objectives that shifts the emphasis from discipline specific tasks to multi-criterion decision making. The letters conform to the words **Specific**, **Measureable**, **Attainable**, **Risk-Informed**, and **Timely.** The development and use of these criteria in the context of the USACE SMART Planning are described below:

1. The "**Specific**" criterion stresses the need for a specific goal rather than a more general one. For DILFS our specific criteria is to identify projects and features within the study area that can be evaluated within USACE business lines, for a recommendation of USACE investment. For this study, alternatives that focus on Ecosystem Restoration and Flood Risk Management are the USACE business lines are under evaluation.
2. The "**Measurable**" criterion stresses the need to develop concrete criteria for measuring progress toward plan selection of the Tentatively Selected Plan. For DILFS our measurement requirement, or decision criteria, is defined by a system evaluation criterion in the form of National Economic Benefit (NED), Environmental Quality (EQ), Regional Economic Development (RED), Other Social Effects (OSE), Cost, and Real Estate evaluation.
3. The "**Attainable**" criterion stresses the importance of project alternatives that are realistic and attainable, or actionable, and are in the national interest. Following the evaluation of alternatives using the measurable criteria listed above, a comparison of measures using the system of accounts, multi-criteria Decision and Trade-off analyses are completed to inform the recommendation of a Plan.
4. The fourth criterion, "**Risk-Informed**," stresses the importance of using risk analysis to improve decision making under uncertainty. For the DILFs Study the USACE is working in coordination with the State of California's Bay Delta Conservation Plan (BDCP) and the Delta Risk Management Strategy (DRMS) to leverage the USACE's national objective to develop water resources projects based on sound science that maximize net national economic, environmental, and social benefits. Another key performance guideline gives priority to projects that address a significant risk to human safety.
5. The final criterion is "**Timely**" and stresses the importance for grounding project goals within a timeframe along with a commitment to a deadline in order to focus team efforts for study completion. The SMART feasibility study process uses a series of study milestones to

ensure all of the discipline specific study efforts meet the 3-year SMART Planning objective.

This feasibility-level SMART planned study hydraulic evaluation and recommendations are based upon a summary of existing, best available knowledge of hydrology and hydraulics in the Sacramento San Joaquin Delta. The information presented is intended to guide the Project Delivery Team's focus away from legacy, task driven, efforts to the new risk-informed decision making orientation in the selection of alternatives and measures. The conclusions and recommendations presented in this report are generalized for local conditions and uncertainties about the values given in this report have been identified within the Study Risk Register.

1.2 <u>Background</u>

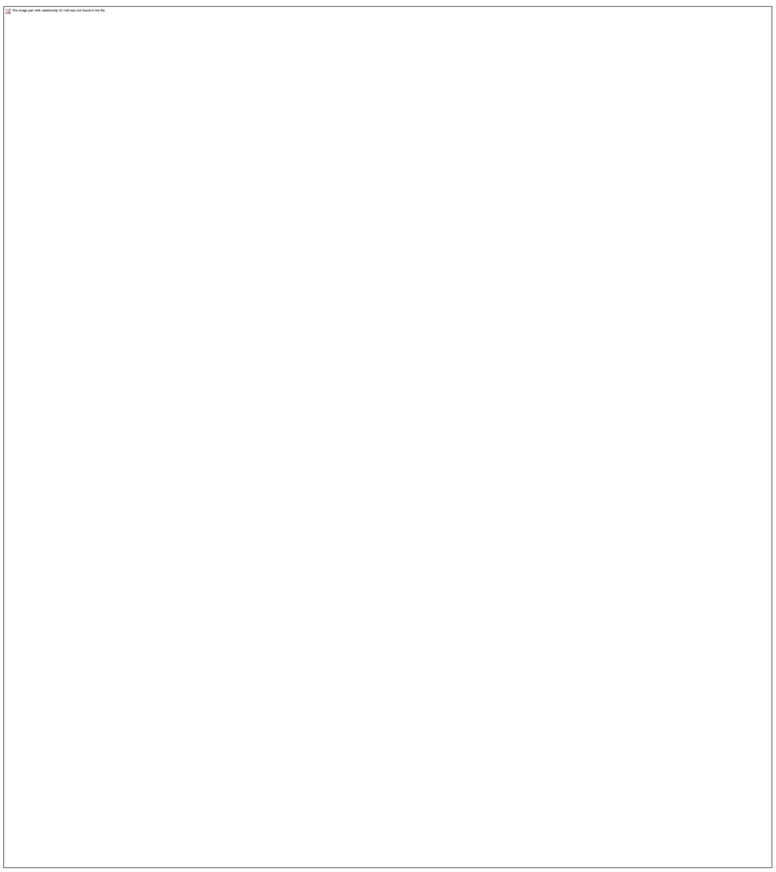


Figure 1- 1 Sacramento – San Joaquin River Basins

The Central Valley of California, here illustrated in Figure 1-1, is defined by a watershed drainage area of 59,380 square miles, and includes the Sacramento River (27,580 square mile watershed) which flows south from the Sacramento Valley and the San Joaquin River (31,800 square mile watershed) which flows north from the San Joaquin Valley. The Calaveras and Mokelumne Rivers flow from the east into the Sacramento San Joaquin Delta.

The Sacramento - San Joaquin Delta (Delta) as defined for this study, extending east of the Carquinez Straight through Suisun Bay to the northeast along the Sacramento River to Freeport, southeast along the San Joaquin River to Vernalis, and through the network of islands and levees east to Stockton. The Delta is a controlled system of over 700 miles of interconnected waterways and islands protected by approximately 1,100 miles of levees that include approximately 400 miles of federal levees. The levees are aging and under threat from subsidence, animal burrowing, earthquakes, wind and wave action, floods, high tides, and sea level rise.

Figure 1- 2 ADH & Extended EFDC Model Domains

Prior to the DILFS study SMART Planning reformulation, the primary task hydraulics' focused on was the development of a comprehensive framework of hydrodynamic models. The models included in the framework are the USACE "AD"aptive Hydraulic Model (ADH), and the Environmental Protection Agencies' (EPA) Environmental Fluid Dynamics code (EFDC) model. The ADH model was selected to allow the modeling of intricate and transient model domains such as levee failures, sediment transport, navigation, and detailed hydraulic structures in large systems. EFDC fits well within the framework as it is a 3-dimensional hydrodynamic, sediment transport, water quality, and linked ecosystem model. This framework of models will enable USACE to simulate existing conditions and system-wide impacts of natural and purposeful changes to the Delta in order to proactively manage this vital water resource. The physical process model, created in EFDC, is a comprehensive framework of numerical models necessary to advance the understanding of the system-wide effects of natural changes and improvement projects including changes in water levels, flows, salinity, water quality, and consequently the ecosystem. The EFDC model is an open-source, general purpose modeling package supported by the US EPA for simulating multi-dimensional flow and transport in surface waters and has been used for hundreds of estuarine applications worldwide. Our effort to date and has been Agency Technically Reviewed (ATR'ed) through the efforts of ERDC's Environmental Lab. Please see figure 1-3 for the major submodels in EFDC.

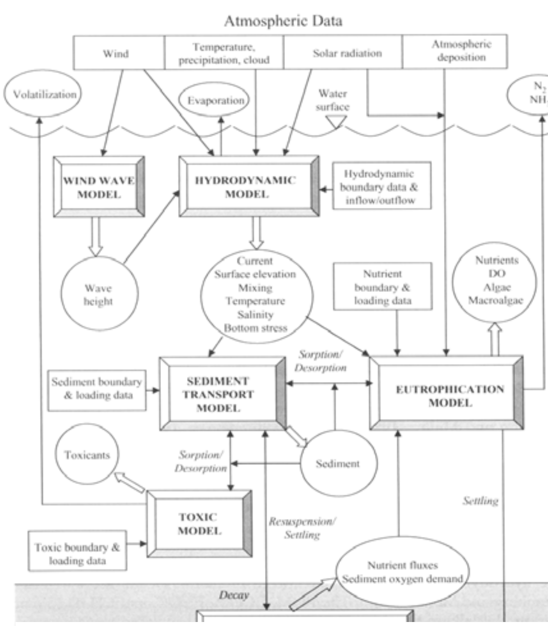


Figure 1- 3 EFDC Submodels

Figure 1-1-2 Major Components of EFDC

The 3-dimensional sediment transport submodel within EFDC simulates both cohesive and non-cohesive sediment and bedload transport. The water quality submodel within EFDC simulates the transport of nutrients, dissolved oxygen, up to 3 algae classes, eutrophication and sediment diagenesis. The hydrodynamic and water quality models serve as drivers for the Comprehensive Aquatic System (CASM) ecosystem model and the ELAM fish movement behavior model. The EFDC development efforts to date and the resulting model analyses have been used to identify areas of high shear stress and tidal impacts of the delta and have been used to analyze risk in the Delta. Both the ADH and the EFDC models have been developed, calibrated, and validated to simulate existing conditions in the Delta. Additional refinements and analysis using our comprehensive modeling framework have been placed on hold until federal interest has been identified and future work authorized.

1.3 Data Sources for the Delta Levee System Risk and Vulnerability Analysis

1.3.1 Previous work for this project includes studies done by the State of California Department of Water (DWR). The Corps of Engineers supported the joint state-federal Delta Risk Management Strategy (DRMS) effort that has produced detailed reports on risks and risk management for the Sacramento-San Joaquin Delta. These documents provided much of the risk informed data included in this memorandum. Important sections for DRMS can be found at:
http://www.water.ca.gov/floodsafe/fessro/levees/drms/ .

1.3.2 The hydrology used for the subsequent downscaling of the hydraulic analysis effort to support SMART Planning of the Sacramento San Joaquin Delta FRM analysis was the 1992 Sacramento District Office Report labeled "Sacramento-San Joaquin Delta Special Study. This report will serve as the baseline data source for the simplified Inundation modeling framework used in the simplified hydraulic analysis whose output will be used as input for the project economic decision model. This report presents stage-frequency curves for 24 tide gage locations, wave runup data for 12 locations and 1:50-, 1:100-, and 1:300 ACE maximum water surface elevation plots around the islands of the Sacramento San Joaquin Delta. The stage-frequency curves in this report are updates to the stage-frequency presented in a similarly named document dated December 1976. Data in this 1992 report include stage data recorded through water year 1988. Stage values given in the 1992 report have been converted to NAVD'88 values via the NGS website VertCon conversion at the URL listed below.
http://www.ngs.noaa.gov/cgi-bin/VERTCON/vert_con.prl.

1.3.3 The topographic and bathymetric datasets used for this spatial analysis were supplied by the Bay Delta Office of the California Department of Water Resources (DWR) from two different sources. The first source is the San Francisco Bay and Sacramento-San Joaquin Delta Digital Elevation Model (DEM) developed by Rueen-Fang Wang and Eli Ateljevich of DWR. This product is a set of mutually consistent 10m and 2m integrated elevation maps (DEM) in standard ASCII format. This product was developed based on synthesizing LiDAR, single- and multibeam sonar soundings and existing integrated maps collated from multiple sources. Figure 1-2 below shows the data sources used for different areas. The western part of the Bay-Delta work blends the original Foxgrover dataset with the 1/3 arc second DEM produced by NOAA. For more information regarding this dataset please refer to the URL listed below.
http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/modelingdata/DEM.cfm

The second DWR Bay-Delta dataset used for this analysis is the CVFED Delta LiDAR collected in March and April of 2008. This dataset has a vertical accuracy of 0.6 ft Consolidated (1.96 x $RMSE_z$), and 0.6 ft Fundamental (95^{th}) percentile; Horizontal accuracy of 3.5 ft (1.75 x $RMSE_{x,y}$). Native Projection and datum is UTM 10N, NAD83, US Foot; Vertical Datum NAVD'88. This dataset is void of bathymetric or hydrographic data and was used as a consistency check for in-island terrain analysis.

1.4 Delta Levee System Risk and Vulnerability Analysis Summary

The National Research Council [NRC1994] defines risk analysis as having three core elements. They are risk assessment, risk management, and, risk communication.

The first element of risk analysis is risk assessment and it is the process through which the probability of loss within a system is estimated and the magnitude, or consequence, is also measured or estimated. Risk management is the process through which the potential frequency of magnitude and contributing factors to risk are estimated, evaluated, minimized, and controlled. Risk communication is the process through which information about the nature of risk and consequences are communicated to support Risk-Informed decision making.

This analysis uses the best available existing information to assemble composite risk management information useful to USACE for Risk-Informed decision making. It summarizes the Delta Risk Management Study (DRMS); expresses the DRMS and other findings in terms of the USACE's Composite Risk Management matrix; and examines the results for management decision support.

Army and Corps of Engineers guidance documents define risk as the "probability and severity of loss linked to hazards" and prescribe a composite risk assessment method to be used in USACE projects. The Delta Risk Management Strategy Phase 1 and 2 reports are sound and rigorous analyses of the relative probability of hazards and severity of risks in the Delta and provide the information needed for risk analysis compliance within Corps of Engineers' requirements.

The tables listed in the body of this document below provide rank-ordered lists of the highest risk zones – those with the greatest probability of failure combined with the most severe consequences. Those tables and the Appendices are used in this DILFS risk management framework to identify needed risk management efforts.

While uncertainties in the absolute magnitude of the results make them most useful for comparisons, the actual values of the probabilities and consequences are alarming. For example, Sargent Barnhart Tract, northwest of Stockton, has a mean annual failure rate of 0.07, or an expected levee failure every 14 years, with a probable 96 fatalities for a nighttime seismic-induced failure. Adjacent tracts with only slightly lower failure probabilities put another 500 lives at risk. Zone SM-124 has a projected failure rate of 0.5, or once every 2 years, with maximum possible damages exceeding $250 million. The Sacramento Pocket Area, with a mean annual failure rate of 0.006, has over $9 billion at risk.

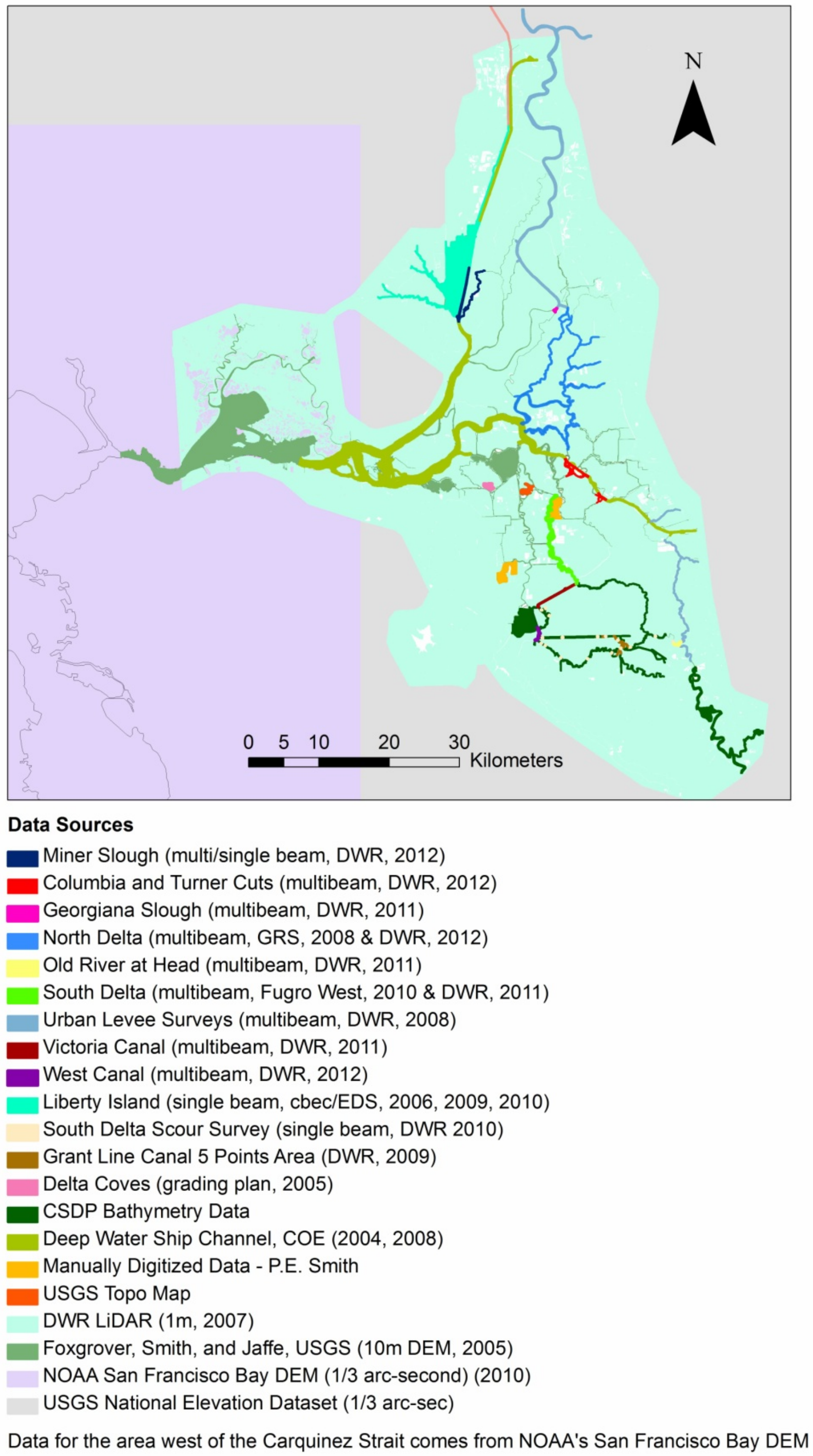


Figure 1- 2. Data Sources for Sacramento San Joaquin Delta DEM

While refinements to these risk estimates are possible, this report and the Delta Risk Management Strategy analyses provide more than sufficient evidence that flooding in the Sacramento –San Joaquin Delta presents significant risks to California and the nation. Hundreds of lives and billions of dollar damages are at high probability of occurrence. Urgent action is necessary to manage those risks.

2.0 DELTA RISK MANAGEMENT STRATEGY (DRMS)

The California Department of Water Resources commissioned the Delta Risk Management Study (DRMS) on behalf of the CALFED agencies – more than 20 state and Federal organizations with resource management responsibilities in the Sacramento-San Joaquin Delta. The purposes of the DRMS were to:

> *… assess expected performance of Delta and Suisun Marsh levees (under various stressors and hazards) and the potential economic, environmental, and public health and safety consequences of levee failures to the Delta region and to California as a whole (Phase 1). After the completion of Phase 1, the purpose of DRMS is to address the consequences of levee failures by developing and evaluating risk reduction strategies (Phase 2). (URS/JBA 2008)*

The DRMS Phase 1 report was published (still labeled as a draft) in October 2008, following a final revision in response to reviews by a panel of independent peer reviewers. Those documents (URS/JBA 2008 and CALFED Science Program Independent Review Panel 2008) are used here for the DRMS Phase 1 findings. Phase 2 findings were reported in URS/JBA (2011)

2.1 <u>Hazards and Assessment Measures</u>

DRMS evaluated three hazard categories as potential threats to Delta and Suisun levees:

- Seismic Events
- Hydrologic Events (floods)
- Normal Events

Seismic events were expressed as the probability of a given ground motion in each area of the Delta for an earthquake of a given type and magnitude on a given fault. Flood events were expressed in terms of a combined probability of water level occurrence, given (a) inflows from all streams using a Log-Pearson Type III distribution of historical flows plus the predicted change in flow probabilities arising from climate change; and (b) tidal elevation probabilities from historical gauged water level stations adjusted for projected sea level rise. Normal events included non-seismic, non-flood events, such as those precipitated by high tides, rodent damage, etc. Sea level change and climate change were considered to be part of the Delta environment (i.e., not hazards), with an associated probability for each in a given year (2005 (base year), 2050, and 2100). Detailed zone-by-zone analysis was performed for 2005 conditions. For future conditions, analyses predicted the overall changes of risk for the Delta. Section 3.3 of this report (below) summarizes the future risks.

For each category the threat was quantified in terms of a "Hazard Analysis" or probability of occurrence and a "Levee Vulnerability Analysis" that is the conditional probability of failure for a levee. A "System Model" was used to evaluate the combination of events and levee damage for a number of threat scenarios.

The System Model considered the combination of a hazard and levee vulnerability to have three possible levee outcomes – No Damage, Damage without Breaching, and Breaching. The latter two were assumed to constitute events with consequences – Emergency Response costs for Damage without Breaching and all assumed consequences (next section) for Breaching. The result was a tree-structure sequence of events and consequences (Section 3.3 below). For more information regarding the system model please refer to the DRMS URL listed above.

2.2 Consequences and Assessment Methods

Consequences of levee failures and subsequent flooding were considered in three main categories:

- Life Safety
- Water Quality
- Economic

Consequences were evaluated quantitatively where possible and qualitatively otherwise. They were also evaluated on a per-island and Delta/state-wide basis. Per-island economic consequences were evaluated for 182 individual zones – islands and a few non-island areas adjacent to the levees – for life loss and damage costs specific to those zones, which are mapped in **Figure 4-1**. Delta-wide and state-wide consequences were presented for scenarios of 1 to 50 islands experiencing levee failure.

Life safety impacts were evaluated for life-loss probability using a simplified form of the LIFESim model (Aboelata et al. 2003) which considered six scenarios of flood, seismic, and sunny day failures during daytime and nighttime through evaluations of:

- Flood routing
- Population exposure
- Warning and evacuation

The System Model assessed the potential for events that would damage the levees and included uncertainty for natural variability (aleatory uncertainty) and for limited knowledge (epistemic uncertainty). The DRMS Phase 1 report described it as:

> *The system model defines the relationship between hazards and their possible combination to assess the state of the Delta immediately after an event (e.g., an earthquake of magnitude [M] 6 on the Hayward Fault). The term "state-of-the- Delta" refers to the condition of all levees and islands immediately after the event. Given an earthquake and the probabilistic nature of levee performance (see levee vulnerability*

above), numerous combinations exist in which various levees will breach and different islands flood. The system model describes the potential combination of events and the framework for calculating their frequency of occurrence. Each combination of flooded islands is referred to as a levee failure sequence.

The system model also models islands that have not flooded, but whose levees may be damaged and could deteriorate (as a result of wave action) and result in further island flooding. Other factors or random events such as the time of year an event occurs, the type of hydrologic water year, etc. are also included in the system model because of their importance in assessing the hydrodynamic response to and consequences of levee failures. (URS/JBA 2008)

The analysis showed that 10 zones had at least a 10 percent probability of 100 deaths or more if a breach occurred in their protecting levees:

- 57_124
- Lincoln_Village_Tract
- Sacramento_Pocket_Area
- Sargent_Barnhart_Tract 2
- Sargent_Barnhart_Tract 2
- Shima_Tract
- Smith_Tract
- West Sacramento North
- Zone 158
- Zone 185

Twenty-six zones had at least a 10 percent probability of 10 deaths or more if a breach occurred:

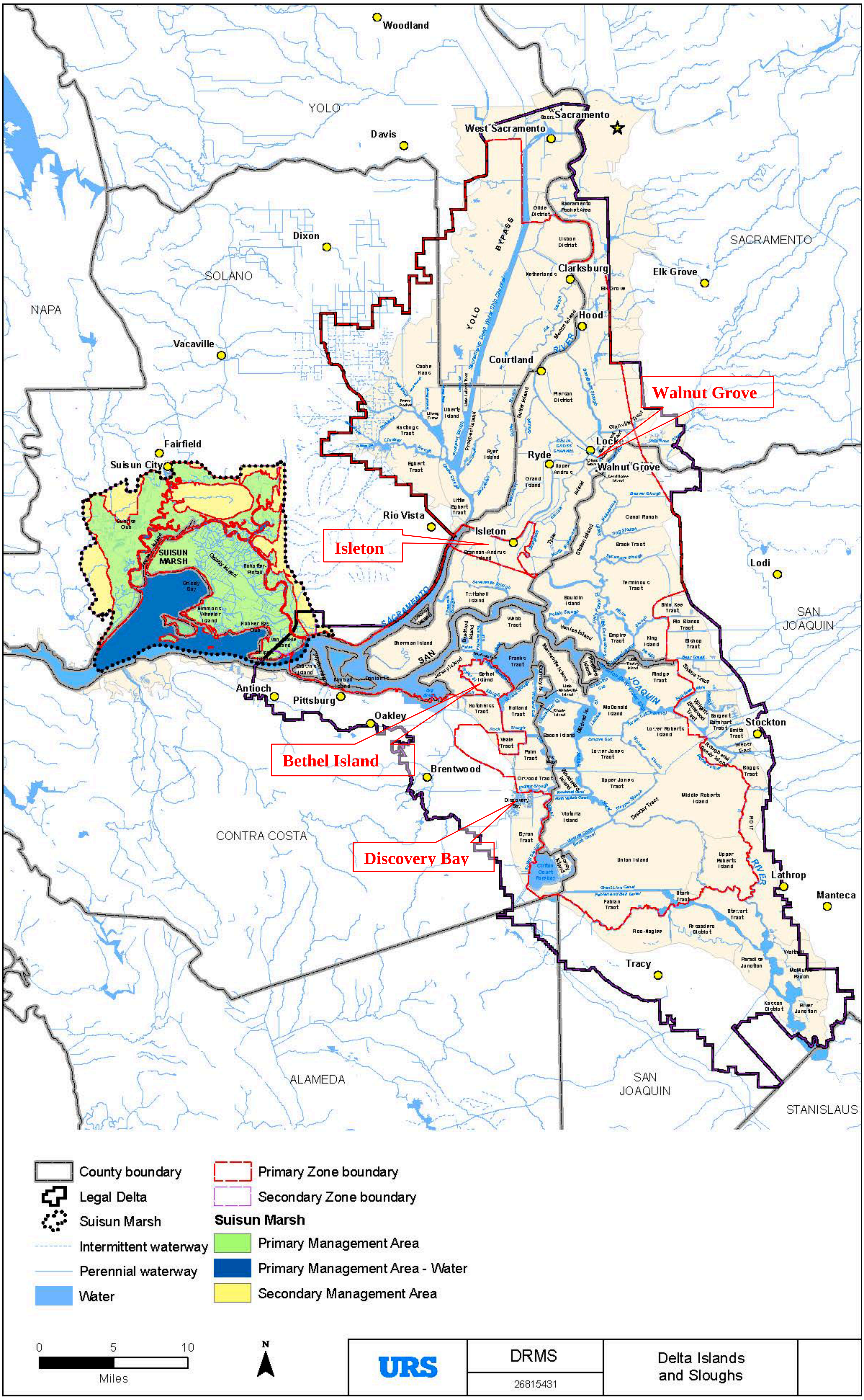
- *57_124*
- Bethel_Island
- Bishop_Tract
- Boggs_Tract
- Elk_Grove 1
- Hotchkiss_Tract 1
- Kasson_District
- Libby_McNeil_Tract 1
- Lincoln_Village_Tract
- Paradise Junction
- RD 17 (Mossdale)
- Rio_Blanco_Tract
- Sacramento_Pocket_Area
- Sargent_Barnhart_Tract 2
- Sargent_Barnhart_Tract 3
- Sherman_Island
- Shima_Tract
- Smith_Tract
- Veale_Tract 1
- Walnut_Grove
- West Sacramento North
- Wright-Elmwood_Tract
- *Zone 158*
- *Zone 185*

The zones listed in italics are not shown in Figure 3-1. Sensitivity tests indicated that the above probabilities could be 2 to 5 times higher or lower, depending on the validity of assumptions in the analysis. Despite this wide range, the results are very useful in ranking the relative probability of adverse consequences among islands.

Economic consequences were calculated as:

- **Impacts**
  - Value of lost output
  - Lost jobs
  - Lost labor income
  - Lost value added

- **Costs**
  - In-Delta
  - Statewide
  - Total



2-1. Delta Islands and Sloughs

Table 10-1 Significant Islands for Repair Prioritization

(Based on Population, Infrastructure, and Volume/Salinity)

Bacon Island	Rough & Ready Island
Bethel Island	Ryer Island
Bishop Tract	Sacramento Pocket Area (196)
Bouldin Island	Sargent-Barnhart Tract 2 (188)
Brack Tract	Sherman Island
Bradford Island	Shima Tract
Brannon-Andrus Island	Shin Kee Tract
Byron Tract 1 (127)	SM-124 (Suisun Marsh, Southwest of Suisun City)
Byron Tract 2 (128)	Staten Island
Canal Ranch	Sutter Island
Coney Island	Terminous Tract 2 (87)
Discovery Bay	Twitchell Island
Empire Tract	Tyler Island 1 (Walnut Grove; 62)
Fabian Tract	Tyler Island 2 (63)
Grand Island	Union Island 1 (117)
Hastings Tract 2	Veale Tract 2 (129)
Holland Tract	Venice Island
Hotchkiss Tract 1 (108)	Victoria Island
Jersey Island	Webb Tract
Jones Tract (Upper and Lower)	West Sacramento North
King Island	West Sacramento South 1
Mandeville Island	Woodward Island
McDonald Tract	Wright Elmwood Tract (190)
Medford Island	Wright-Elmwood/Sargent-Barnhart Tract (191)
Netherlands 3 (142)	Zone 126 (Pico Naglee, north Tracy)
New Hope Tract	Zone 148 (E of Sac River near Hood)
Orwood Tract (20)	Zone 157 (Smith Tract, West Stockton)
Palm Tract (16)	Zone 158 (Weber Tract, West Stockton)
Pierson District 1 (149)	Zone 159 (Boggs Tract, West Stockton)
Quimby Island	Zone 185 (Northwest Stockton)
RD 17 Mossdale (Lathrop Area)	Zone 197 (E of Sac River N of Hood)
Ringe Tract	Zone 37 (North Shore Suisun Bay near Benicia Bridge)
Rio Blanco Tract	Zone 68 (Little Egbert Tract)
Roberts Island (Middle, 154/Lower, 106)	Zone 70 (Egbert Tract)
	Zone 76 (Freeport-Franklin)

Note: It is assumed all flooded or damaged islands will be repaired after an event.

Figure 3 2. "Significant Islands" as Listed in the DRMS Report.

2.3 Future Risks

Future risks were considered in terms of the 2005 hazards as they might change with time and also as the Delta environment – climate, sea level, landscape, levee condition, population, infrastructure, and economics – may change over the next 200 years.

The fundamental conclusion of the DRMS future risks analysis (Section 14 in URS/JBA 2008) was that all significant risk factors will increase with time, some modestly (e.g., tidal amplitude) and others dramatically (e.g., population). **Table 3-1** shows the expected increases in flood risk factors for 2050 and 2100 under low, medium, and high change scenarios.

Predicted Percentage Increases in Flood Risk Factors (Adapted* from URS/JBA 2008)

Risk Factor	Year 2050			Year 2100		
	Low	Medium	High	Low	Medium	High
Flood Hazard	30	200	500	100	500	1000
Life Loss	700	700	800	NA	NA	NA
Damage Costs	700	700	800	NA	NA	NA

* Percentages rounded to one significant digit.

2.4 Risk Management (DRMS Phase 2)

DRMS Phase 2 (URS/JBA 2011) developed and evaluated strategies to manage risk of Delta levee failures. Strategies were formulated in terms of "building blocks" of individual improvements which could be combined in specific plans or "scenarios" for evaluation.

Building blocks presented in the Phase 2 report were:

- *Conveyance Improvements / Flood Risk Reduction and Life Safety*
  - *Improved Delta Levee Maintenance*
  - *Upgraded Delta Levees*
  - *Enhanced Emergency Preparedness/Response*
  - *Pre-Flooding of Selected Islands*
  - *Land Use Changes to Reduce Island Subsidence*
  - *Armored Pathway through Delta Conveyance (TDC)*
  - *Isolated Conveyance Facility Alternatives (ICF)*
  - *San Joaquin Bypass & San Joaquin River Widening*
- *Infrastructure Risk Reduction*
  - *Raising State Highways and Placing them on Piers,*
  - *Bypass Construction of an Armored Infrastructure Corridor across Central Delta*
- *Environmental Risk Mitigation*
  - *Suisun Marsh Tidal Wetland Restoration*
  - *Tidal Marsh Cache Slough Restoration*
  - *Install Fish Screens*
  - *Setback Levees to Restore Shaded Riverine Habitat*
  - *Reduce Water Exports from the Delta*

These building blocks were combined into four scenarios for detailed evaluation:

- *Improved Levees*
- *Armored Pathway (Through-Delta Conveyance)*
- *Isolated Conveyance Facility*
- *Dual Conveyance*

Results of the four scenarios are shown in **Table 3-2** below.

Summary of Costs and Benefits of Trial Scenarios (in billions of 2005 dollars)

Cost/Benefit Component	Scenario 1: Improved Levees	Scenario 2: Through Delta Conveyance	Scenario 3: Isolated Conveyance Facility	Scenario 4: Dual Conveyance
Capital cost	10.4	15.6	14.8	17.1
Reduction in expected economic losses from base case* during 2005 to 2050	69.0	70.9	83.3	79.9
Reduction in expected economic losses from base case* during 2005 to 2100	123.1	126.2	143.7	139.7
Reduction in expected value of lost output from base case* during 2005 to 2050	8.7	9.1	12.4	11.3
Reduction in expected value of lost output from base case* during 2005 to 2100	17.9	18.4	23.0	21.8

*Base case (Business-As-Usual) – includes current (2005) management practices and regulatory requirements.

2.5 Evaluation of Results

The DRMS Phase 1 Draft 4 report (URS/JBA 2008) was reviewed by the CALFED Science Program Independent Review Panel (2008). Their report stated:

> *… the revised DRMS Phase 1 Report is acceptable for use as a tool for informing policymakers and others regarding potential resource allocations and strategies to address risk in the Delta region, provided that some important caveats (detailed below) are well understood. The first caveat is common to any broad analysis that relies on a series of linked models. In such analyses, caution is imperative when interpreting scenarios that deviate substantially from baseline conditions. In the case of the DRMS analysis, baseline conditions are the 2005 base - year results. Predictions of conditions 20 to 30 years into the future are inherently highly uncertain, and reliable predictions of conditions 50 to 100 years into the future are virtually impossible. We therefore caution that future estimates of consequences must be viewed as projections that can indicate potential directions of effects, not predictions to be interpreted literally. In a related issue, the IRP cautions readers and users of the DRMS report to avoid the common mistake of equating precision with accuracy. Precision is the exactness of the reported results. Accuracy is how close the predictions are to truth. The DRMS analysis involves many computer-based calculations that can be reported with very high precision, from which it is often tempting to infer great accuracy. In turn,*

this could lead to misinterpretation of the DRMS results, and thus to incorrect decisions.
The second caveat is specific to the DRMS analysis and is due to the minimal ecosystem consequences that are actually assessed in the revised DRMS Phase I Report. Estimates of the effect of island flooding on vegetation and wildlife were much reduced from what was described in the methods section of the first draft of the DRMS Phase I Report and in the Impact to Ecosystems Technical Memoranda (TM). Furthermore, there was no assessment of consequences for aquatic resources (i.e., fish). With ecosystem consequences minimally represented in the current DRMS models, and with fish absent from the predictions, the IRP believes this could easily lead to erroneous interpretations of DRMS model results. Thus, anyone using the results of the DRMS scenarios must be very aware that ecosystem effects are not fully captured in the analysis, and that, in particular, the lack of ecosystem consequences reported does not imply small ecosystem impacts. Rather, the IRP notes that some scenarios could result in extremely large ecosystem disturbances, but these impacts will not be quantified because ecosystem consequences are inadequately accounted for in the current DRMS modeling framework.

The IRP believes that these caveats require users of the DRMS model framework to exercise due diligence to ensure scientifically credible interpretations of the results.

To these caveats can be added that the DRMS analysis, as comprehensive as it was, did not include consideration of human-induced threats, such as terrorism and vandalism, nor did it include the compounding effect of an upstream dam break on flood levels.

Previous work for this project includes studies done by the local sponsors, the State of California Department of Water (DWR). DWR conducted a study of the Delta under the Delta Risk Management Study (DRMS). This work was reviewed and utilized as part of the basis of our evaluation of the existing conditions. The probability of failure curves for the existing condition was directly converted to a format that is compatible with the USACE Flood Damage Assessment (FDA) model. These reports indicate that most of the Delta islands and tracks are vulnerable to failure from underseepage and from deformation as a result of seismic activity. The extent to which each reach fails to meet design criteria varies, but without exception, each island or tract has locations that have a high probability of failure, often along multiple reaches.

3.0 SACRAMENTO-SAN JOAQUIN DELTA LEVEE RISK ASSESSMENT

To achieve the first objective of presenting available Sacramento-San Joaquin Delta levee risk information in a matrix form consistent with USACE and Army policies and suitable for identifying areas of USACE concern, pertinent data were extracted from the DRMS Phase 1 report (URS/JBA 2008):

- Predicted levee breach probability from Table 13-8, expressed as "Annual Mean Number of Failures.
- Predicted Damage cost estimates from Tables 12-7 and 12-8, for flooding by a 100-year river flood, expressed as the sum of:
  - "Repair Costs"
  - "Differential Repair Costs for Point Assets" (Scour)
  - "Differential Repair Costs for Linear Assets" (Scour)
- Predicted maximum potential facilities caused by levee breaching from Table 12C, expressed as "Breach Mean (Life Loss)".

All the estimates extracted from the DRMS report were for calendar year 2005. The extracted data are listed in **Appendix B** and are discussed further below.

3.1 Translation Approach

Histograms of the DRMS data were constructed to determine logical intervals for the Hazard and Consequences matrices described in Army Field Manual 5-19 and Engineer Circular EC 1110-2-6062 (USACE 2011c). Economic damages and human fatalities were examined separately, but both analyses employed the same levee breach probability intervals. Finally, each island or other analysis zone (both referred to as "zones" hereafter) was assigned a category from 1 (low) to 5 (high) for both the hazard probability (levee breach) and the consequences (damages and fatalities), producing a matrix of 25 possible combinations. The intervals for each are shown in Table 4-2, Life Loss, and Table 4-3, Economic Damages.

Two Risk Indices – Breach Mean Life Loss and Predicted Damage – were computed for each zone using Equation 2-1, the product of the Annual Mean Number of Failures and the consequences divided by a Normalizing Value. The Normalizing Variable in Equation 2-1 was chosen to be the maximum value of the numerator, so that the Risk Indices range from 0 to 1.

Choice of intervals for grouping the failure rates and consequences is somewhat arbitrary and can be changed if needed, using the calculated Risk Indices to refine the analysis, creating more or fewer categories, according to the application.

Tables showing the calculation details are presented in Appendix B. Extracts are presented and discussed below.

3.2 Translated Hazards and Consequences Matrices

The Risk Matrix, with 5 Levee Failure Rate categories and 5 Life Loss categories, results in 25 possible pairs, which are aggregated into 5 Risk Levels labeled and color coded as shown in Table 4-1. Table 4-2 shows the Life Loss matrix with the number of zones that fall within each Matrix pair. One zone (discussed later) qualifies for the maximum Life Risk label, with greater than 0.1 failures per year and over 100 lives at risk. Using the five Levels of Table 4-1, 7 zones fall within the Highest Risk level and 14 Fall within the Higher Risk level. Fifty are in the High, 4 are in the Lower, and 2 are in the Lowest Risk level, totaling 77 unique zones categorized for Life Loss Risk.

Table 3-1. Matrix Risk Levels and shading for Tables 4-2 through 4-6

Risk Level Key
5. Highest
4. Higher
3. High
2. Lower
1. Lowest

Table 3-2. Life Loss Risk Matrix with Number of Zones within Each Risk Category

Maximum "Mean Life Loss" (Category)	Annual Mean Number of Failures (Category)				
	0-0.01 (1)	0.01-0.025 (2)	0.025-0.05 (3)	0.05-0.1 (4)	>0.1 (5)
>100 (5)	**0**	**0**	**2**	**2**	**1**
50-100 (4)	**0**	**0**	**2**	**0**	**2**
10-50 (3)	**1**	**0**	**4**	**3**	**2**
1-10 (2)	**0**	**0**	**8**	**14**	**7**
0-1 (1)	**2**	**0**	**4**	**14**	**9**

Table 4-3 shows the Damage Cost Risk Matrix, with 5 Levee Failure Rate categories and 5 Damage Cost categories, resulting in 25 possible pairs which are aggregated into 5 Risk Levels labeled and color coded as shown in Table 4-3. Also shown in the table are the number of zones that fall within the Damage Cost Risk Matrix. Fourteen zones fall within the Highest Risk level and 36 fall within the Higher Risk level. Eighty-one are in the High, 10 are in the Lower, and 2 are in the Lowest Risk level, totaling 143 unique zones categorized for Damage Cost Risk. Risk levels for specific zones are discussed below.

Table 3-3. Cost Damage Risk Matrix with Number of Zones Falling Within Each Risk Category

Maximum Damage Costs $M (Category)	Annual Mean Number of Failures (Category)				
	0-0.01 (1)	0.01-0.025 (2)	0.025-0.05 (3)	0.05-0.1 (4)	>0.1 (5)
>500 (5)	0	2	2	3	1
100-500 (4)	4	2	1	3	6
50-100 (3)	0	0	2	5	3

10-50 (2)	1	1	13	21	18
0-10 (1)	2	1	7	23	22

Table 4-4 lists the zones with the greatest Life Loss Risk Index, sorted by Risk Index and color-coded by Table 4-1 category. Tracts Sargent Barnhart 2, Smith, Shima, and Lincoln Village all have Risk Indices greater than 0.5, with maximum mean life loss values of 100 or greater and more than 0.02 mean failures per year. Boggs Tract, Sherman Island and Bethel Island come next, all in the Highest Risk category. Interspersed Higher and High categories in Table 4-3 illustrate the imprecise nature of the matrix at the boundaries between two categories.

Table 4-5 lists the zones with the greatest Damage Costs Risk Index, sorted by Risk Index and color-coded by category. SM-124, not appearing in Table 4-4, has the greatest Risk Index of 1, followed by Sargent Barnhart Tract with 0.6. Sacramento Pocket Area, Discovery Bay, Lincoln Village, and Smith Tract follow, all with Damage Costs Risk Indices greater than 0.2.

Table 4-6 compares the Risk Indices for the zones with the greatest combined risk categories. It also demonstrates that Life Loss and Damage Cost predictions were not available for all zones, including some of those with substantial threats. Appendix B identifies those with missing predictions.

Table 3-4. Twenty-Five Zones with Greatest Life Loss Risk Index

From DRMS Draft Report 4			Calculations			
Zone	Maximum Mean Life Loss	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Risk Index*	Notes
Sargent_Barnhart_Tract 2	96.200	7.43E-02	5	5	1	Use Sargent Barnhart Tract Failure Rates
Smith_Tract	148.000	3.91E-02	5	4	0.8	
Shima_Tract	195.175	2.36E-02	5	3	0.6	
Lincoln_Village_Tract	109.150	4.11E-02	5	4	0.6	Use Smith Tract - Lincoln Village Tract Failure Rate
Boggs_Tract	90.650	1.82E-02	5	3	0.2	
Sherman_Island	14.800	9.46E-02	4	5	0.2	
Bethel_Island	11.100	6.96E-02	4	5	0.1	
Bishop_Tract	19.425	1.98E-02	4	3	0.05	
Walnut_Grove	2.775	1.09E-02	3	3	0.00	
New_Hope_Tract	2.775	9.73E-02	3	5	0.04	
Rio_Blanco_Tract	13.875	1.54E-02	4	3	0.03	
Sargent_Barnhart_Tract 3	2.775	7.43E-02	3	5	0.03	Use Sargent Barnhart Tract Failure Rates
Byron_Tract 1	1.850	4.51E-02	3	4	0.01	Use Byron_Tract 1 Life Loss

Wright-Elmwood_Tract	2.775	2.88E-02	3	4	0.011	
Venice_Island	0.925	7.31E-02	2	5	0.009	
Hotchkiss_Tract 1	1.850	3.48E-02	3	4	0.009	Use Hotchkiss_Tract 1 Life Loss
Jersey_Island	0.925	6.96E-02	2	5	0.009	
Staten_Island	0.925	6.78E-02	2	5	0.009	
Libby_McNeil_Tract 1	3.700	1.52E-02	3	3	0.008	
Libby McNeil Tract 2	3.700	1.52E-02	3	3	0.008	Use Libby McNeil Tract 1 Life Loss
Brack_Tract	0.925	6.01E-02	2	5	0.008	
Brannan-Andrus Island	0.925	5.82E-02	2	5	0.008	
Twitchell_Island	0.925	5.60E-02	2	5	0.007	
Empire_Tract**	0.925	5.02E-02	2	5	0.006	

* Numbers rounded from the raw calculations in Appendix B.
** Plus 8 others tied for 23rd place.

Table 3-5. Twenty-five Zones with Greatest Damage Costs Risk Index

From DRMS Draft 4 Report.			Calculations			
Zone	Total Asset Damages * $M	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Notes
SM-124	252.9	0.485	4	5	1	
Sargent_Barnhart Tract 2	965.4	0.0743	5	5	0.6	Use Sargent Barnhart Tract Failure Probability
Sacramento_Pocket_Area	9,414.6	0.0059	5	2	0.5	
Discovery_Bay	760.744	0.0451	5	4	0.3	Use Byron Tract Failure Probability
Lincoln_Village_Tract	742.7	0.0411	5	4	0.2	Use Smith Tract _ Lincoln Village Tract Failure Probability
Smith_Tract	733.2	0.0391	5	4	0.2	
RD 17 (Mossdale)	375.8	0.0579	4	5	0.2	
Shima_Tract	567.2	0.0236	5	3	0.1	
Boggs_Tract	732.9	0.0182	5	3	0.1	
Bethel_Island	169.7	0.0696	4	5	0.1	
West Sacramento North	1807.75	0.0059	5	2	0.09	Use West Sacramento 1 Failure Probability
Zone 158 (Smith Tract_2)	264.9	0.0391	4	4	0.08	Use Smith Tract Failure Probability
SM-123	18.2	0.485	2	5	0.07	
Brannan-Andrus Island	145.8	0.0582	4	5	0.07	
SM-39	15.9	0.474	2	5	0.06	
SM-85-Grizzly_Island	15.5	0.461	2	5	0.06	

Tyler_Island 2	81.5	0.0839	3	5	0.06	
SM-57	13.8	0.489	2	5	0.06	
Jones_Tract-Upper_and_Lower	105.5	0.0588	4	5	0.05	
Middle_Roberts Island	110.2	0.0552	4	5	0.05	Use Roberts Island Failure Probability
Grand Island	163.0	0.0359	4	4	0.05	
Elk Grove South West	429.3	0.0125	4	3	0.04	Use Damage from Elk_Grove 1
SM-54	75.1	0.068	3	5	0.04	
SM-84	10.8	0.461	2	5	0.04	
Netherlands 2	120.5	0.0407	4	4	0.04	Use Netherlands Failure Probability
Sherman_Island	51.4	0.0946	3	5	0.04	

* Numbers rounded from the raw calculations in Appendix B.

Table 3-6. Sixteen Highest Combined Risk Zones, Listed Alphabetically

Zone	Life Loss Risk Index*	Damage Cost Risk Index
Bethel_Island	0.1	0.1
Boggs_Tract	0.2	0.1
Brannan-Andrus Island	0.008	0.07
Jones_Tract-Upper_and_Lower	0	0.05
Lincoln_Village_Tract	0.6	0.2
Middle_Roberts Island	0	0.05
RD 17 (Mossdale)	NA	0.2
Sacramento_Pocket_Area	NA	0.4
Sargent_Barnhart_Tract 2	1	0.6
Sherman_Island	0.2	0.04
Shima_Tract	0.6	0.1
SM 124	NA	1
Smith Tract	0.6	0.08
Smith_Tract	0.8	0.2
Tyler_Island 2	0	0.06
West Sacramento North	NA	0.09

* Note: NA indicates zones for which Life Loss predictions were not found in the DRMS report.

Figures 4-1 and **4-2** show a Delta Map with the analysis zones color coded according to the Risk categorization in Table 4-1. Areas with insufficient data to calculate a risk index are shown with gray shading.

Complete results can be found in Appendix B.

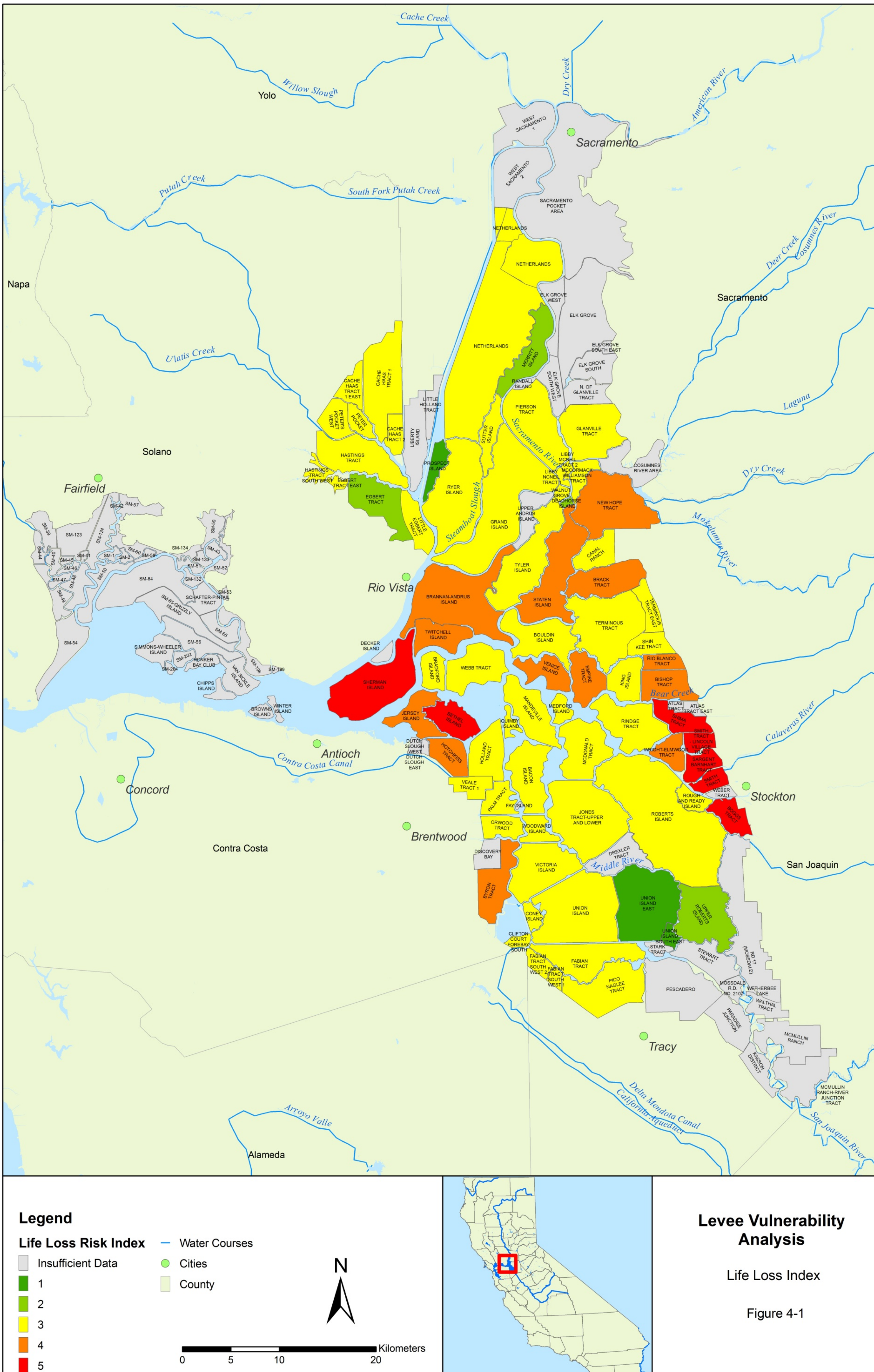
3.3 Sea Level Rise

The incorporation of future sea-level rise was accounted per USACE Engineering Circular 1165-2-212. The modified National Research Council's (NRC) equations accounts for historic global mean sea level and local meal sea level change were used to calculate the potential sea level rise. Curve I is based on the historical rate of sea level rise. Curve II reflects an intermediate estimate of the future rate of sea level rise. Curve III reflects a high estimate of the future rate of sea level rise. A table was provided to Economics with 10 year intervals beginning from year 2015 to 2075:

Year	Curve 1	Curve 2	Curve 3
2025	0.11	0.18	0.26
2035	0.23	0.41	0.60
2045	0.37	0.69	1.01
2055	0.53	1.01	1.50
2065	0.71	1.38	2.06
2075	0.90	1.80	2.69

3.4 Evaluation of Results

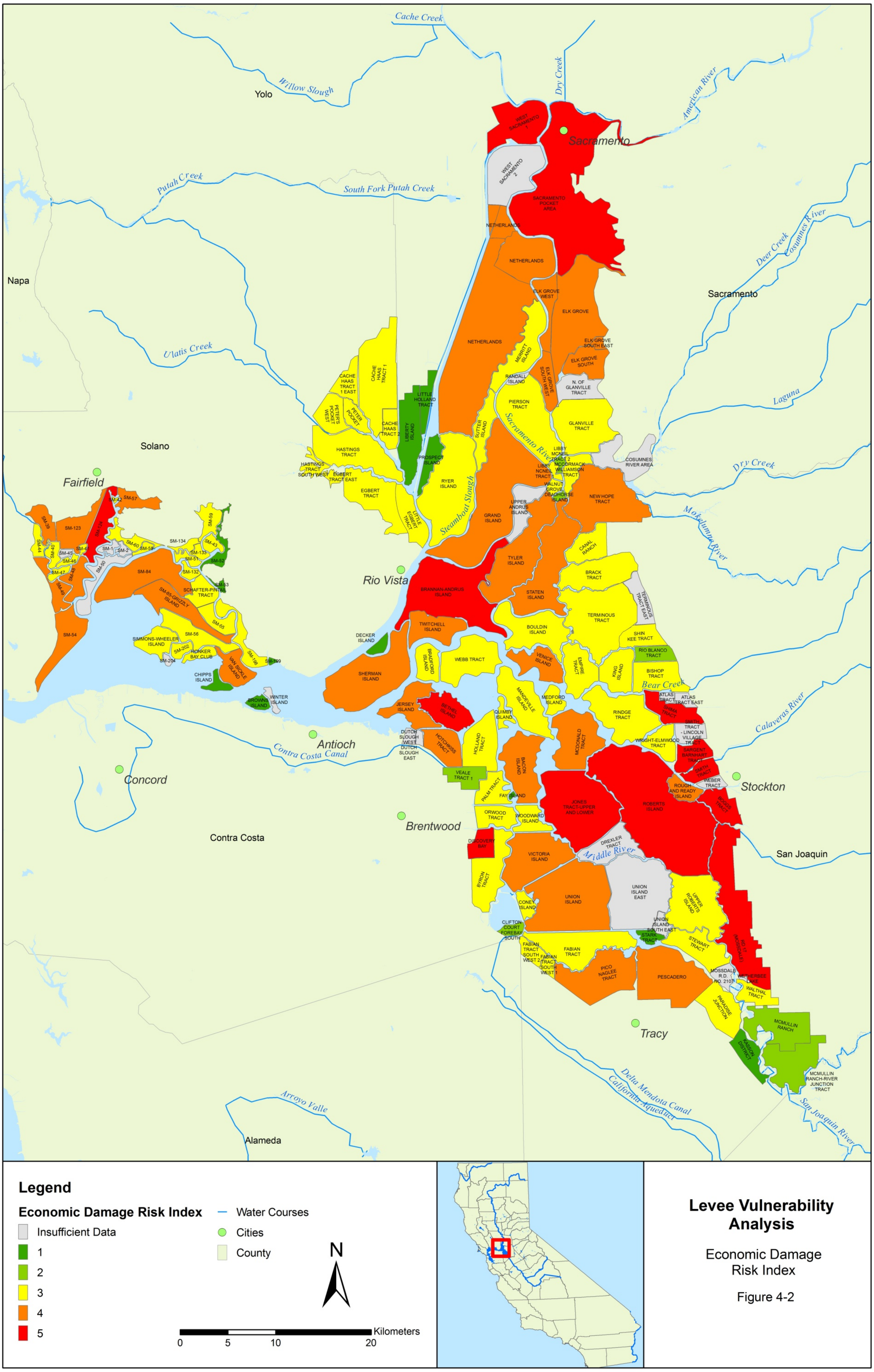
As was pointed out in the DRMS report, significant uncertainties are inherent in these analyses, and the Department of the Army approach does not reduce those uncertainties. However, the results can be extremely useful when used in a comparative sense and with careful application of sound judgment. For example, decisions about the priority of levee improvements between



Levee Vulnerability Analysis

Life Loss Index

Figure 4-1



Levee Vulnerability Analysis

Economic Damage Risk Index

Figure 4-2

Bethel Island and Boggs Tract using Table 4-6 alone are inadvisable: the differences between their Life Loss and Damage Cost indices are small and statistically insignificant, respectively. However, Sargent Barnhart Tract 2 is shown by Table 4-6 to be clearly at greater Risk (indices of 1 and 0.6) than either Bethel or Boggs. In the absence of other information, Sargent Barnhart Tract would clearly be a levee repair and rehabilitation priority over most other zones shown.

Table 4-7 below lists the zones that appear in the DRMS report “Significant Island” list and Tables 4-4 and 4-5 of this report. Zones that appear in all three lists are highlighted in dark tan and those on two of the lists are highlighted in a lighter tan. Using the results in a comparative sense would again suggest that those on two or three lists be considered for early improvements, but in light of all factors relative to USACE projects.

Table 3-7. Listing of Zones Identified as Having Significant Risk

Zone	USACE Report		URS/JBA 2008
	Life Loss Index Top 25	Damage Cost Index Top 25	Significant Island
Bacon Island			X
Bethel Island	X	X	X
Bishop_Tract	X		X
Boggs_Tract	X	X	X
Bouldin Island			X
Brack Tract	X		X
Bradford Island	X		X
Brannan-Andrus Island	X	X	X
Byron Tract 1 (127)	X		X
Byron Tract 2 (128)			X
Canal Ranch			X
Coney Island			X
Discovery Bay		X	X
Elk Grove South West		X	
Empire Tract	X		X
Fabian Tract			X
Grand Island		X	X
Hastings Tract 2			X
Holland Tract	X		X
Hotchkiss_Tract 1	X		
Jersey Island	X		X
Jones Tract (Upper and Lower)		X	X

King Island			X
Libby McNeil Tract 2	X		
Libby_McNeil_Tract 1	X		
Lincoln_Village_Tract	X	X	
Mandeville Island			X
McDonald Tract			X
Medford Island			X
Netherlands 2		X	
Netherlands 3			X
New Hope Tract	X		X
Orwood Tract (20)	X		X
Palm Tract (16)			X
Pierson District 1 (149)			X
Quimby Island			X
RD 17 (Mossdale)		X	X
Ringe Tract			X
Rio Blanco Tract	X		X
Roberts Island		X	X
Rough & Ready Island			X
Ryer Island			X
Sacramento Pocket Area (196)		X	X
Sargent_Barnhart Tract 2	X		X
Sargent_Barnhart_Tract 3	X		
Sherman Island	X	X	X
Shima Tract	X	X	X
Shin Kee Tract	X		X
SM-123		X	
SM-124 (Suisun Marsh, Southwest of Suisun City)		X	X
SM-39		X	
SM-54		X	
SM-57		X	
SM-84		X	
SM-85-Grizzly_Island		X	
Smith_Tract	X	X	X
Staten Island	X		X
Sutter Island			X
Terminous Tract 2 (87)	X		X
Twitchell Island	X		X
Tyler Island 1 (Walnut Grove; 62)			X

Tyler Island 2 (63)		X	X
Union Island 1 (117)			X
Veale Tract 2 (129)			X
Venice Island	X		X
Victoria Island			X
Walnut Grove		X	X
Webb Tract	X		X
West Sacramento North		X	X
West Sacramento South 1			X
Woodward Island			X
Wright-Elmwood	X		X
Zone 126 (Pico Naglee, north Tracy)			X
Zone 148 (E of Sac River near Hood)			X
Zone 158 (Weber Tract, West Stockton)			X
Zone 185 (Northwest Stockton)			
Zone 197 (E of Sac River N of Hood)			X
Zone 37 (North Shore Suisun Bay near Benicia Bridge)			X
Zone 68 (Little Egbert Tract)			X
Zone 70 (Egbert Tract)			X

These results show that translating the risks of Delta flooding into a form compatible with Department of the Army and Corps of Engineers requirements does not change the overall conclusions to be drawn from the DRMS effort and report. However, this translation makes the results compliant with Army and Corps of Engineers Regulations and produces a different prioritized list for management action.

Events of recent years – Hurricane Katrina, Deepwater Horizon explosion, and Tohoku earthquake-tsunami – illustrate the horrific effects of low-probability, high consequence events for which society was ill prepared. The analysis presented here is deliberately biased towards high consequence events – large potential life loss and damage costs – in order to keep them in focus for the DILFS/CALFED effort.

While uncertainties in the absolute magnitude of the results make them most useful for comparisons, the actual values of the probabilities and consequences are alarming. For example, Sargent Barnhart Tract, northwest of Stockton, has a mean annual failure rate of 0.07, or an expected levee failure every 14 years, with a probable 96 fatalities for a nighttime seismic-induced failure. Adjacent tracts with only slightly lower failure probabilities put another 500 lives at risk. Zone SM-124 has a projected failure rate of 0.5, or once every 2 years, with maximum potential damages exceeding $250 million[1]. The Sacramento Pocket Area, with a mean annual failure rate of 0.006, has over $9 billion at risk.

3.5 Final Site Selection for FRM Analysis

Using a systems approach, the analysis described above uses the best available information to assemble risk management information useful to USACE for Risk-Informed decision making. It summarizes the Delta Risk Management Study (DRMS); expresses the DRMS and other findings in terms of the USACE's Composite Risk Management matrix (See Appendix A); and examines the results for management decision support.

Using CRM described above we have used Risk-Informed decision making to reduce the study effort from more than 70 Islands in the Sacramento San Joaquin Delta to the "Top 25" in terms of Life loss and infrastructure damage consequences. Using additional management controls we can further refine the list through the elimination of those "Top 25" islands located within the footprint of other ongoing USACE Planning efforts. These efforts include the American River Common Features Study and the West Sacramento Studies to the north, and the Lower San Joaquin Study to the south. By eliminating the islands within the footprint of other planning studies currently underway we can further refine the list and focus on those remaining "Top 25". In order to evaluate the sensitivity of our decision criterion we started by analyzing the 3 of the next remaining islands of the "Top 25" and adding a fourth, Discovery Bay, from input by our sponsor . By selecting to carry out an FRM analysis of the four islands on the list that have the next highest life loss and infrastructure damage consequences we can evaluate the need to analyze the remaining islands on the list. Listed below are the islands the PDT has selected to analyze in terms of Flood Risk Management:

- Bethel Island
- Walnut Grove
- Brannen Andrus Island (Isleton), and
- Discovery Bay

4.0 FLOOD RISK ANALYSIS

All 1,100+ miles of Delta levees surrounding each island are made up of sediment dredged from adjacent channels, excavated from island interiors, or imported from other areas by truck or barge. The height of a levee surrounding any island is a function of the depth of subsidence and the magnitude of water elevation change, due either to tides or floods. Since subsidence has

[1] Note that "sunny day" failures for SM-124 would not produce this level of loss, which corresponds to the value of all property at risk that might occur under flood conditions.

occurred slowly over the last 100 years, Delta levees have grown more expansive with the addition of material on the top and sides, rather than being constructed all at one time. For this reason, few levees in the Delta meet modern engineering standards. In addition, most Delta levees rest on weak, seismically unstable foundations that have little resiliency to conditions that increase the likelihood of levee failures. As described in DRMS phase 1, floods, earthquakes, and high tides can cause local or widespread levee failures along these poorly constructed levees on weak foundations as evidenced by 166 levee failures in the past 100 years with the last levee failure occurring in 2004 at Jones tract.

It is worth noting that Delta levees are not levees, per se. While levees within the Sacramento and San Joaquin watersheds hold back water only during flood events, Delta levees have high water always against them. These “levees” are more accurately described as polders and are similar to those protecting the Dutch from the sea. Webster’s Dictionary defines Polders “…as a tract of low land reclaimed from the sea…and protected by dikes”. A dike is defined as “…an embankment built to prevent flooding from the sea”. However, since dikes in the Delta are widely referred to as “levees”, we continue with that convention.

The levees in the Delta are prone to overtopping and erosion during storms, principally when high winds create large waves at high tides. Levees also fail due to seepage. The elevation difference between the water surface in the channel and the floor of the subsided island causes water to flow both through and under the levee. Seepage is common for most levees and does not normally lead to failure. However, when water pressure gradients are great, seepage can erode material within and under the levee, causing sand boils on the levee interior, eventually leading to collapse. Rodents, particularly beavers, can exacerbate this problem. Poor foundations or levee construction materials can lead to slumping, cracking or sagging of levees that allows water to flow through and over the levee, leading to its failure. And finally, levees can fail during earthquakes as shaking causes either the foundation or embankments to lose cohesion, deform, or collapse. The levee failure mechanisms described above have one thing in common: the forces that cause these failures are all increasing or will worsen in the future. This stems from both the natural degradation of levees with time and the progressive changes in physical forces acting on them. For this reason, it is prudent to assume that, without intervention, levee failures will increase in the future.

Although Delta levees can fail in many ways, this evaluation will not focus on the mechanism of levee failure but rather the consequences of flooding if the levees of an island were to fail. This scaled down hydraulic evaluation was conducted to support the SMART planning of the Delta Islands and Levees Feasibility study. The purpose being to develop Depth-Frequency information for each parcel within the island used to support the economic decision making technique of “Cost-Benefit.” This method evaluates risk in terms of reducing the frequency of occurrence of an undesirable hydrologic event and the associated consequences are appraised using damages to the impacted asset using some form of monetary lost value analysis. This methodology is the traditional USACE approach to flood risk management (FRM) decision making and expresses the ratio of cost versus benefit to evaluate alternatives in terms of economic “Benefits” to the Nation.

For each hydrologic event the information needed includes the frequency of the event, an estimate of the uncertainty associated with that frequency, and the water-surface elevation (stage) in the Delta associated with that event. The data used for stage, frequency, and uncertainty event analysis originated from the February 1992 Hydrology Office Report of the Sacramento-San Joaquin Delta Special Study by the U.S. Army Corps of Engineers Sacramento district and is the best available data that encompasses the more than 1,000 square miles of the Primary Delta. To model the consequences of a flood event we used a simplified inundation model for analysis in the form of a constant water surface elevation, or stage, across the entire island. The stage used for this simplified inundation model is the Stage in Feet for each Annual Chance Exceedance (ACE) event developed for the 1992 office report as described in the table 5-1 below. For the economic analysis, the estimate of uncertainty associated with the data will be evaluated using the supplied period of record for input to FDA is listed the table below.

Chart Number	Chart Description	Datum Conversion to NAVD'88	Stage in Feet (NAVD'88) Annual Chance Exceedance								Period of Record YEARS
			1:2	1:5	1:10	1:20	1:50	1:100	1:200	1:500	
Chart 12:	Stage Frequency Curve San Joaquin River at San Andreas Landing	2.36	7.3	8.1	8.5	8.9	9.2	9.4	9.6	9.7	30
Chart 4:	Stage Frequency Curve Sacramento River at Rio Vista	2.47	7.5	8.3	9.0	9.7	10.5	10.9	11.2	11.5	30**
Chart 5:	Stage Frequency Curve Sacramento River at Walnut Grove	2.39	11.4	13.8	14.9	15.9	16.7	17.3	17.8	18.4	43
** For details please see discussion on page 8 of the February 1992 Hydrology Office Report of the Sacramento-San Joaquin Delta Special Study											

Table 5- 1. Stage Frequency Values

4.1 <u>Bethel Island</u>

Bethel Island is located in Contra Costa County and is one of the most urbanized of the Delta islands with, according to the 2010 Census, a population of 2,137. This 5.1 square mile island is located approximately 9 miles east of the City of Antioch, CA. Bethel Island is bordered on the East by the flooded Franks Tract, the north by Taylor and Piper Sloughs, to the west by Taylor Slough, and the south by Sand Mound and Dutch Sloughs. The only access to Bethel Island by road is from a bridge over Dutch Slough along Bethel Island Road. The topographic data supplied by the Bay Delta Office of DWR indicates the estimated Top-Of- Levee (TOL) for Bethel Island to be

approximately 12 feet NAVD'88. Contra Costa County FEMA FIRM Map number 06013C0170F defines Bethel Island to be in an "AE" zone for the 1% BFE of 9 ft NAVD'88.

The simplified hydraulic analysis for Bethel Island was accomplished using ESRI's ArcGIS version 10.0 Spatial Analyst Extension. In general, the spatial analysis used the terrain datasets (DEM) provided by the Bay Delta office of DWR as the baseline to determine the ground elevations for each parcel and stage frequency data from Chart 12 of the 1992 Office Report as input for the simplified inundation modeling framework. The first step in the workflow was to simplify the inundation analysis for each parcel originally described as a polygon shape from each parcels plat. For the inundation analysis of Bethel Island these parcel polygons were converted into parcel-centroids, or parcel-points, where each point now represents a single unique parcel whose record includes all the database fields supplied in the original cadastral dataset. The second step in this workflow was to use the available extraction tools in Spatial Analyst to assign ground elevations to each parcel-point from the supplied DEM in order to populate an "Elevation" field in the parcel-point data layer. Plate 5-1illustrates a plan view of Bethel Island while Plate 5-5 illustrates the Bethel Island interior profile line "AA" created to describe the deep Bethel Island Floodplains. The final step in the analysis was to apply the simplified stage inundation framework for each frequency by invoking the field calculator function within ArcGIS to compute the depth of flooding for each parcel. This depth-frequency dataset was then supplied to the Economics Section for their depth/damage/frequency calculations used to support the economic analysis for decision making.

Figures 5-1 below and Figures 5-2 through 5-9 located in Plate 5-9 describe in tabular form a statistical summary and the frequency distribution of the tabular data created for this analysis. Analyzing tabular data often involves finding how many of something belongs to a given category or finding patterns in the data by looking at the frequency distribution of values from within the dataset. Statistical analysis is useful to identify and confirm spatial patterns, such as the center of a group of features, directional trends or skews, or whether features form clusters. While patterns may be apparent on a map, trying to draw conclusions from a map can be difficult as how the data is classified and can obscure or overemphasize patterns. Statistical functions analyze the underlying data and give a measure that can be used to confirm the existence and strength of the patterns within the data. By analyzing the Parcel Elevation Statistics (Figure 5-1) we can quickly infer the range of elevations for structures located at Bethel Island. We can also validate the Top of Levee estimate of approximately 12 ft since we know structures have been constructed on the levee. Additionally, we can quickly estimate, given the published FEMA 1% BFE of 9 ft and a mean structure elevation of 1.41 ft, the average depth of water over the Island in the event of a catastrophic levee failure of greater than 7 feet. By evaluating the frequency distribution in the dataset we find an unusual pattern in the data that was worth investigation .

Parcel Elevation Statistics	Value
Count:	1872
Minimum Value:	-23.29
Maximum Value:	12.9
Mean:	1.41
Standard Deviation:	6.18

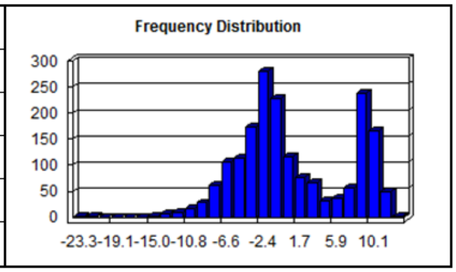


Figure 5- 1 Bethel Island Parcel Point Elevation Statistics & Frequency Distribution

Upon evaluation this bimodal distribution seen in the data was created from the approximate 500 of 1,872 parcels that were elevated above +10 ft NAVD'88 as part of the now defunct Delta Coves development project. This project, pictured to the right, went bankrupt after the financial collapse of their financial partner, Lehman Brothers. This anomaly is also seen in the subsequent depth frequency statistics as a "0" for minimum value for statistics run for each "n"- year ACE analysis and illustrated in Plate 5-2. As these parcels have no structures we can further define the dataset by removing these parcels from the parcel selection set used for the economic decision analysis.

4.2 Discovery Bay

Discovery Bay was originally established in the 1970's as a weekend and summer resort community. Today with a full-service marina, shopping and business centers, sheltered boat access to some 700 miles of Delta channels, and access to the San Francisco Bay, Discovery Bay has developed into a popular full time community. Also located in Contra Costa County, Discovery Bay is the most urbanized of the Delta islands with, according to the 2010 Census, a resident population of 13,352. Discovery Bay was built on land of the Byron Tract and this 7 square mile community has 6.2 square miles of land an 0.8 square miles of water. Discovery Bay is located approximately 18 miles by automobile southeast of the City of Antioch, CA.

Even though FEMA FIRM maps of Contra Costa County in the area state:

"This area is shown as being protected from the 1-percent annual chance or greater event from a levee system that has been provisionally accredited…"

It took a spatial analysis of the Discovery Bay terrain to determine the relative location. As this levee's location is not defined in either State of California Levee Database or the USACE National Levee Database. The result of the spatial analysis using the Bay Delta DEM is illustrated within the Terrain Data Frame of Plate 5-3. Plate 5-3 also shows FEMA FIRM data that describes the parcels as elevated above the BFE. These elevated parcels act, in effect, like a levee to protect the interior structures located particularly around Willow Lake and the golf course within the confines of Discovery Bay. Plate 5-4 describes those parcels that are being protected by the high ground of the Discovery Bay and are the only structures could potentially be damaged due to a flood. Plate 5-5 profile line BB shows a typical high ground section of the community. Figure 5-10 below describes statistical summary and frequency distribution of the Discovery Bay dataset in its entirety. The bimodal shape of the frequency distribution can be easily accounted by viewing the terrain spatial analysis and evaluation described above.

Parcel Elevation Statistics	Value
Count:	6642
Minimum Value:	-10.5
Maximum Value:	24.8
Mean:	11.6
Standard Deviation:	4.3

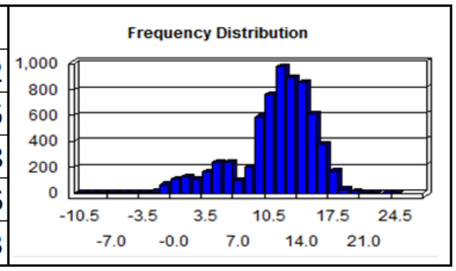


Figure 5- 10 Discovery Bay Island Parcel Point Elevation Statistics & Frequency Distribution

For Discovery Bay, a similar hydraulic analysis was accomplished using the same workflow as used for Bethel Island. Using ArcGIS, the Bay Delta DEM, and Chart 12 of the 1992 Office Report the simplified inundation analysis was conducted; results evaluated and turned over to Economics for further evaluation. Statistics for Discovery Bay are illustrated on Plate 5-6. Of the 6,649 parcels evaluated only 1,156 parcels, or 17% , would have the potential to flood in the event of an on foreseen geotechnical failure. The topographic data supplied by the Bay Delta Office of DWR indicates the estimated Top-Of-Levee (TOL) for Discovery Bay to be approximately 14 feet NAVD'88.

4.3 Isleton (Brannen Andrus Island)

According to the 2010 Census, the population of the 0.5 square mile City of Isleton is 804 persons. Isleton is located in the southwest section of Sacramento County behind the levees of the Sacramento River. FEMA FIRM MAP NUMBER 06067C0561H shows the City of Isleton in an "AE" Zone defined as:

> *"SPECIAL FLOOD HAZARD AREA SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD, 1% BFE = INTERIOR FLOODING TO 9 ft NAVD'88"*

For the City of Isleton, Plate 5-7, a similar hydraulic analysis was accomplished using the same inundation modeling workflow as was used for the other projects sites of the study. Using ArcGIS, the Bay Delta DEM, and Chart 4 of the 1992 Office Report the simplified inundation analysis was conducted and the were results evaluated and turned over to Economics for further evaluation .Statistics describing the depth inundation analysis for Isleton is shown on Plate 5-8. For Isleton, of the 486 parcels evaluated only 3.5% show elevations above the FEMA BFE and only 9.5% show mean values above the 7.5 ft estimate for the 1:2 ACE. Flooding at Isleton represents very deep inundation and is further illustrated as Section DD on Plate 5-11.

4.4 <u>Walnut Grove</u>

Walnut Grove is located in Sacramento County approximately 30 miles downstream of the City of Sacramento along the Sacramento River and is the site of the Delta Cross Channel (in Red). The Delta Cross channel is a feature of the U.S. Department of Reclamation's (Reclamation) Central Valley Project Delta Division. It is operated to divert water from the Sacramento River into a branch of the Mokelumne River to maintain a water quality balance with the transfer of controlled releases from the reservoirs at Lake Shasta and Folsom to the headwork's of the Delta-Mendota and Contra Costa Canals. These gates are closed during high water to prevent Sacramento River flood stages from entering the San Joaquin section of the Delta.

FEMA FIRM MAP NUMBER 060067C0560H states:

> *"THIS AREA IS SHOWN AS BEING PROTECTED FROM THE 1% ANNUAL CHANCE OR GREATER FLOOD HAZARD BY A LEVEE SYSTEM THAT HAS BEEN PROVISIONALLY ACCREDITED. OVERTOPPING OR FAILURE OF ANY LEVEE SYSTEM IS POSSIBLE."*

A similar hydraulic analysis was accomplished using the same inundation modeling workflow as was used for the other projects sites of the study. Using ArcGIS, the Bay Delta DEM, and Chart 5 of the 1992 Office Report the simplified inundation analysis was conducted and results were evaluated and turned over to Economics for further evaluation .Plate 5-9 Describes the Terrain Plan view of Walnut Grove and the statistics describing the depth inundation analysis are shown on Plate 5-10. Plate 5-11 Section CC is a representative section through Walnut Grove.

4.5 Summary of Hydraulic Handoffs

The hydraulic analysis was conducted with the same method for Bethel Island, Walnut Grove, Isleton and Discovery Bay. The Hydraulics section provided depth-frequency information for each parcel within the specific island for the 0.5, 0.2, 0.1, 0.05, 0.02, 0.01, 0.005, 0.002, 0.001 annual chance of exceedence, as well as the uncertainty associated, represented as the Period of Record (Years). The depth-frequency information was provided in an ARC-GIS shape file format to the Economics section.

5.0 CONCLUSIONS

While additional analyses are possible – quantification of ecosystem risks and evaluation of human threats among them – the evidence for system-wide catastrophic life loss and economic damages is more than sufficient to justify risk management through targeted system improvements.

The resulting Flood Risk Management analysis and the simplified economic inputs presented herein should be used as a guide for risk-informed decisions for future USACE actions in reducing flooding risks in the Sacramento-San Joaquin Delta and Suisun Marshes.

While refinements to these risk estimates are possible, this appendix and the Delta Risk Management Strategy analyses provide more than sufficient evidence that flooding in the Sacramento –San Joaquin Delta presents significant risks to California and the nation. Hundreds of lives and billions of dollar damages are at high probability of occurrence. Urgent action is necessary to manage those risks.

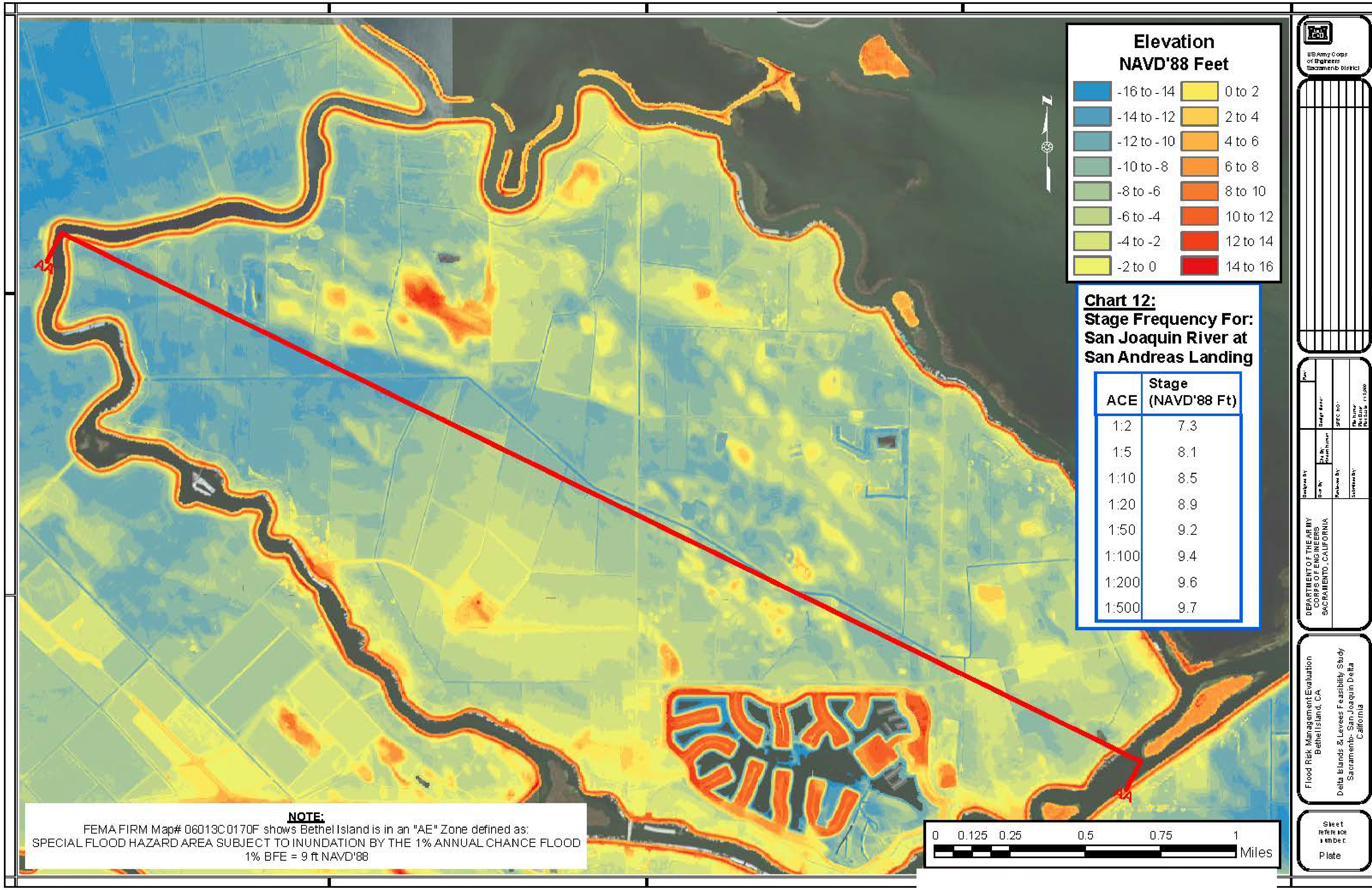


Plate 5-1: Bethel Island Terrain Plan View

1:2 ACE Depth Statistics	Value
Count:	1872
Minimum Value:	0
Maximum Value:	30.54
Mean:	6.57
Standard Deviation:	5.17

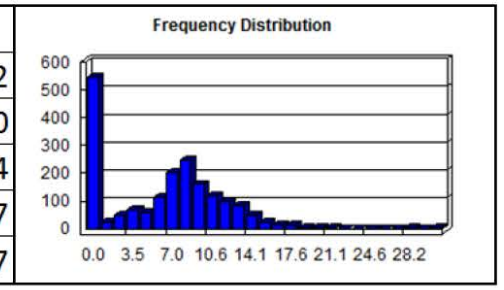


Figure 5- 2 Bethel Island 1:2 ACE Statistics & Frequency Distribution

1:5 ACE Depth Statistics	Value
Count:	1872
Minimum Value:	0
Maximum Value:	31.4
Mean:	7.2
Standard Deviation:	5.47

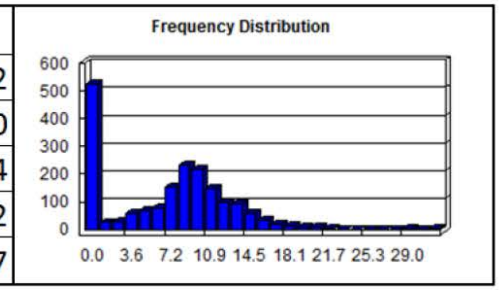


Figure 5- 3 Bethel Island 1:5 ACE Statistics & Frequency Distribution

1:10 ACE Depth Statistics	Value
Count:	1872
Minimum Value:	0
Maximum Value:	31.8
Mean:	7.5
Standard Deviation:	5.62

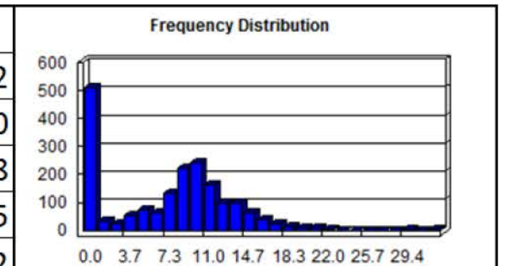


Figure 5- 4 Bethel Island 1:10 ACE Statistics & Frequency Distribution

1:20 ACE Depth Statistics	Value
Count:	1872
Minimum Value:	0
Maximum Value:	32.2
Mean:	7.8
Standard Deviation:	7.72

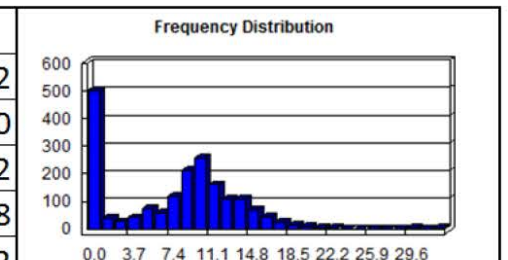


Figure 5- 5 Bethel Island 1:20 ACE Statistics & Frequency Distribution

1:50 ACE Depth Statistics	Value
Count:	1872
Minimum Value:	0
Maximum Value:	32.5
Mean:	8.0
Standard Deviation:	5.82

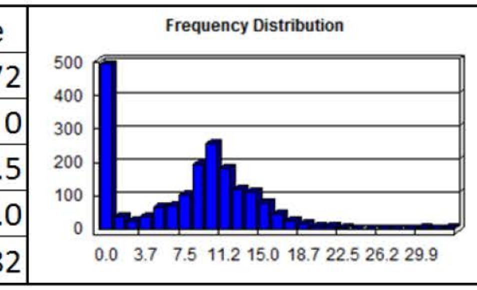


Figure 5- 6 Bethel Island 1:50 ACE Statistics & Frequency Distribution

1:100 ACE Depth Statistics	Value
Count:	1872
Minimum Value:	0
Maximum Value:	32.7
Mean:	8.2
Standard Deviation:	5.88

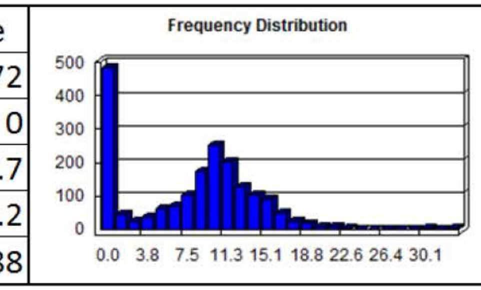


Figure 5- 7 Bethel Island 1:100 ACE Statistics & Frequency Distribution

1:200 ACE Depth Statistics	Value
Count:	1872
Minimum Value:	0
Maximum Value:	32.8
Mean:	8.3
Standard Deviation:	5.92

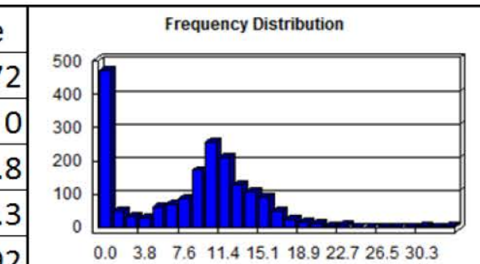


Figure 5- 8 Bethel Island 1:200 ACE Statistics & Frequency Distribution

1:500 ACE Depth Statistics	Value
Count:	1872
Minimum Value:	0
Maximum Value:	33
Mean:	8.5
Standard Deviation:	5.96

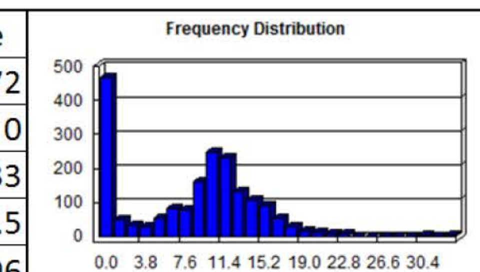


Figure 5- 9 Bethel Island 1:500 ACE Statistics & Frequency Distribution

Plate 5-2: Bethel Island Tabular Statistics & Frequency Distribution

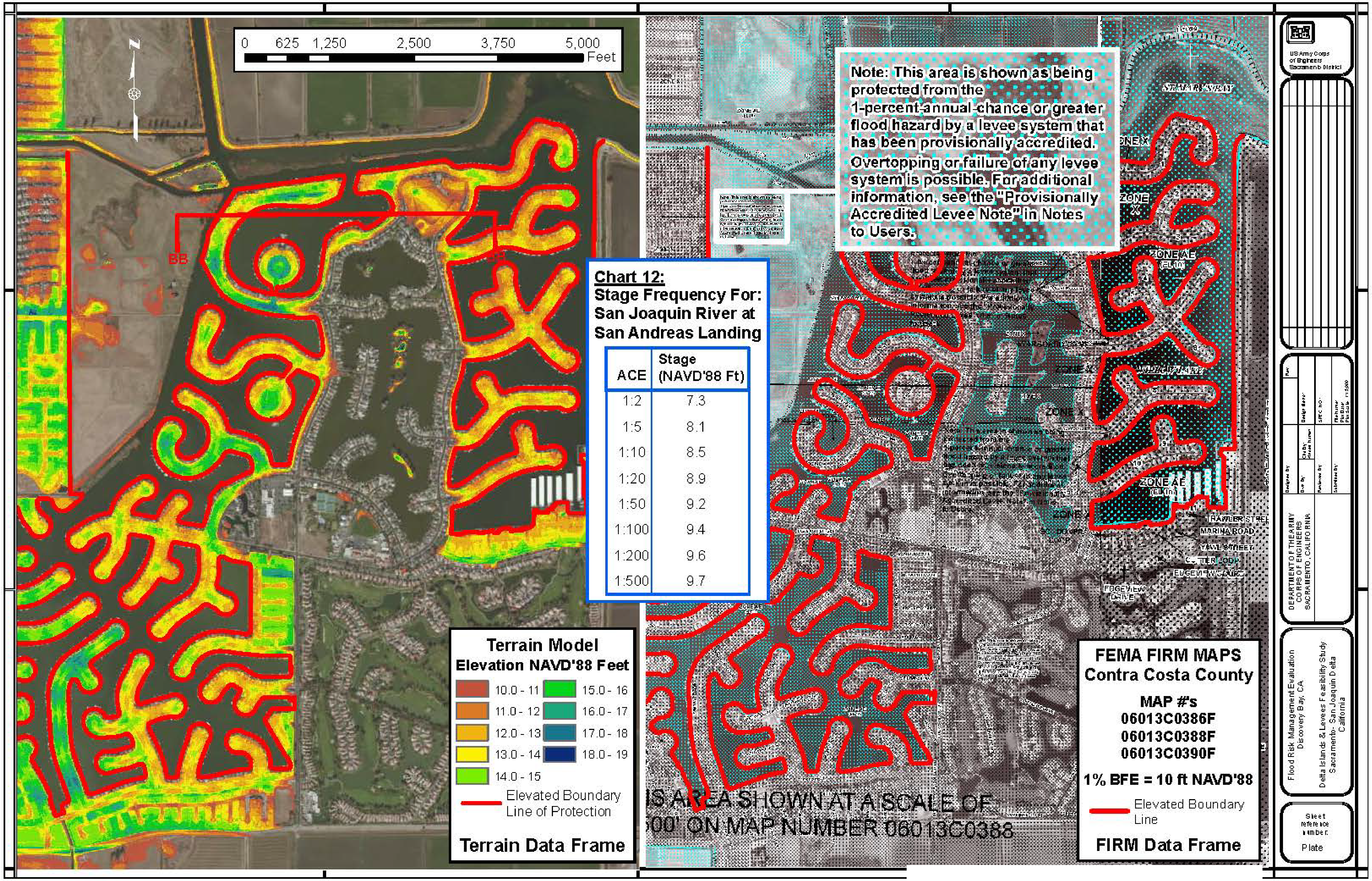


Chart 12:
Stage Frequency For: San Joaquin River at San Andreas Landing

ACE	Stage (NAVD'88 Ft)
1:2	7.3
1:5	8.1
1:10	8.5
1:20	8.9
1:50	9.2
1:100	9.4
1:200	9.6
1:500	9.7

Plate 5-3: Discovery Bay Terrain Plan View

Plate 5-4: Discovery Bay Levee Protected Parcels

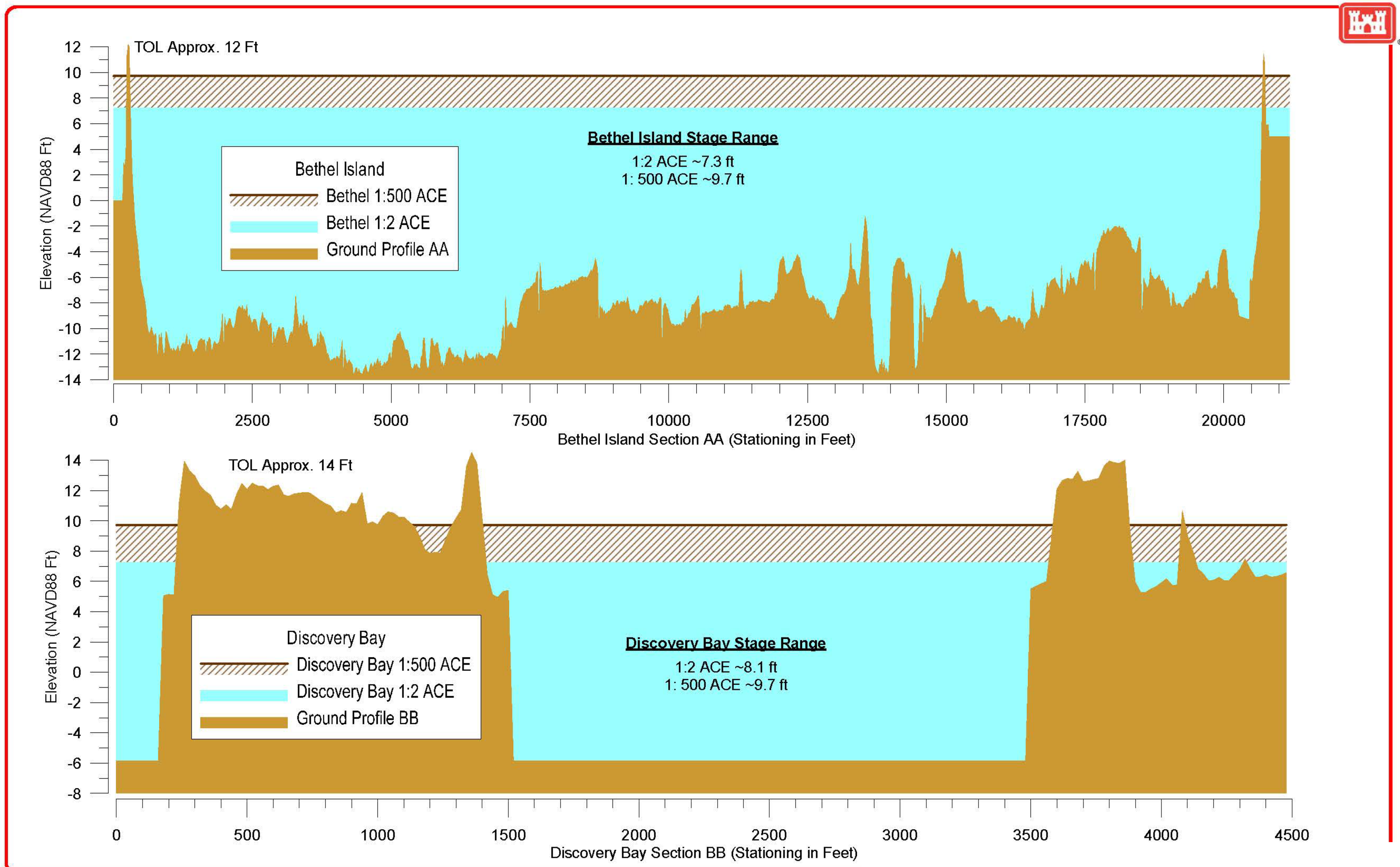


Plate 5-5: Bethel Island and the Discovery Bay In-island Profile View

1:2 ACE Depth Statistics	Value
Count:	1156
Minimum Value:	0
Maximum Value:	14.4
Mean:	3.2
Standard Deviation:	2.51

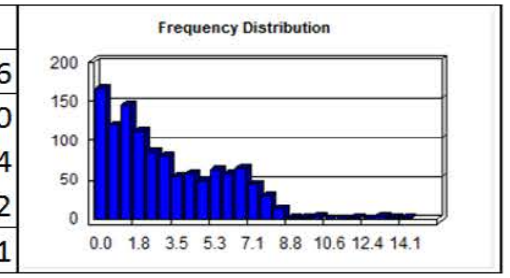


Figure 5- 11 Discovery Bay Interior Parcel 1:2 ACE Statistics & Frequency Distribution

1:5 ACE Depth Statistics	Value
Count:	1156
Minimum Value:	0
Maximum Value:	15.2
Mean:	3.9
Standard Deviation:	2.6

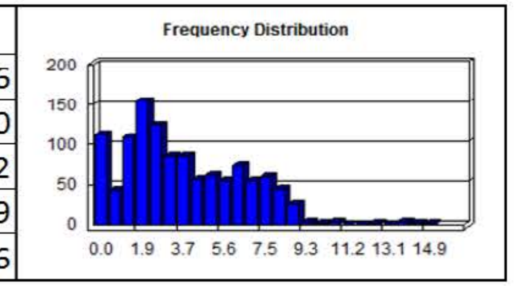


Figure 5- 12 Discovery Bay Interior Parcel 1:5 ACE Statistics & Frequency Distribution

1:10 ACE Depth Statistics	Value
Count:	1156
Minimum Value:	0
Maximum Value:	15.6
Mean:	4.3
Standard Deviation:	2.6

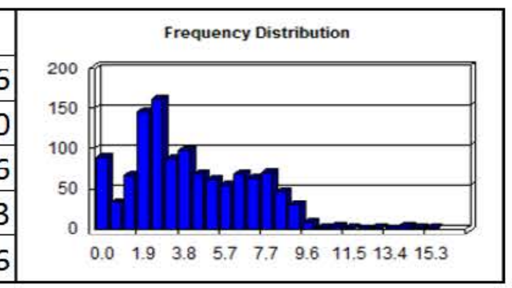


Figure 5- 13 Discovery Bay Interior Parcel 1:10 ACE Statistics & Frequency Distribution

1:20 ACE Depth Statistics	Value
Count:	1156
Minimum Value:	0
Maximum Value:	16
Mean:	4.7
Standard Deviation:	2.7

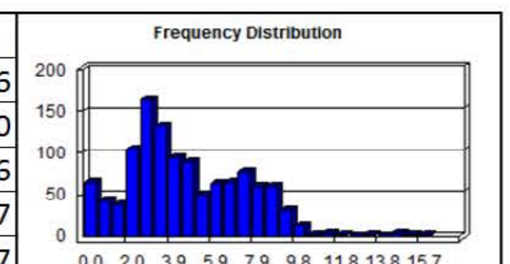


Figure 5- 14 Discovery Bay Interior Parcel 1:20 ACE Statistics & Frequency Distribution

1:50 ACE Depth Statistics	Value
Count:	1156
Minimum Value:	0
Maximum Value:	16.3
Mean:	5.0
Standard Deviation:	2.7

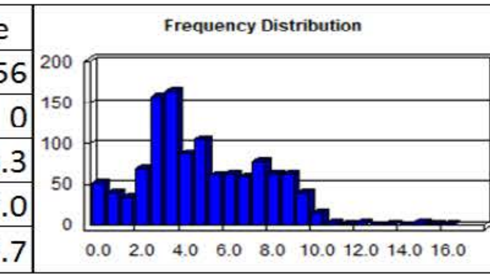


Figure 5- 15 Discovery Bay Interior Parcel 1:50 ACE Statistics & Frequency Distribution

1:100 ACE Depth Statistics	Value
Count:	1156
Minimum Value:	0
Maximum Value:	16.5
Mean:	5.2
Standard Deviation:	2.7

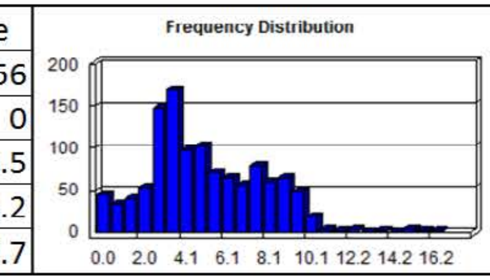


Figure 5- 16 Discovery Bay Interior Parcel 1:100 ACE Statistics & Frequency Distribution

1:200 ACE Depth Statistics	Value
Count:	1156
Minimum Value:	0
Maximum Value:	16.7
Mean:	5.3
Standard Deviation:	2.7

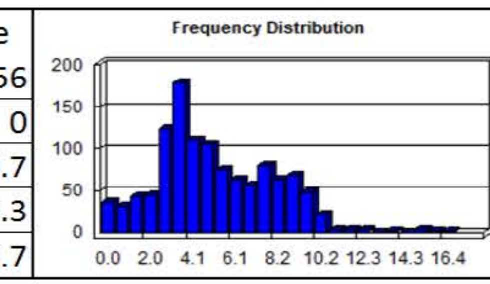


Figure 5- 17 Discovery Bay Interior Parcel 1:200 ACE Statistics & Frequency Distribution

1:500 ACE Depth Statistics	Value
Count:	1156
Minimum Value:	0
Maximum Value:	16.8
Mean:	5.5
Standard Deviation:	2.7

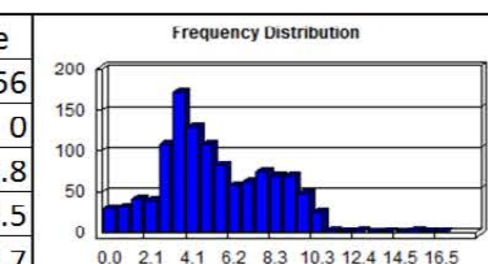


Figure 5- 18 Discovery Bay Interior Parcel 1:500 ACE Statistics & Frequency Distribution

Plate 5-6: Discovery Bay Interior Parcel Tabular Statistics & Frequency Distributions

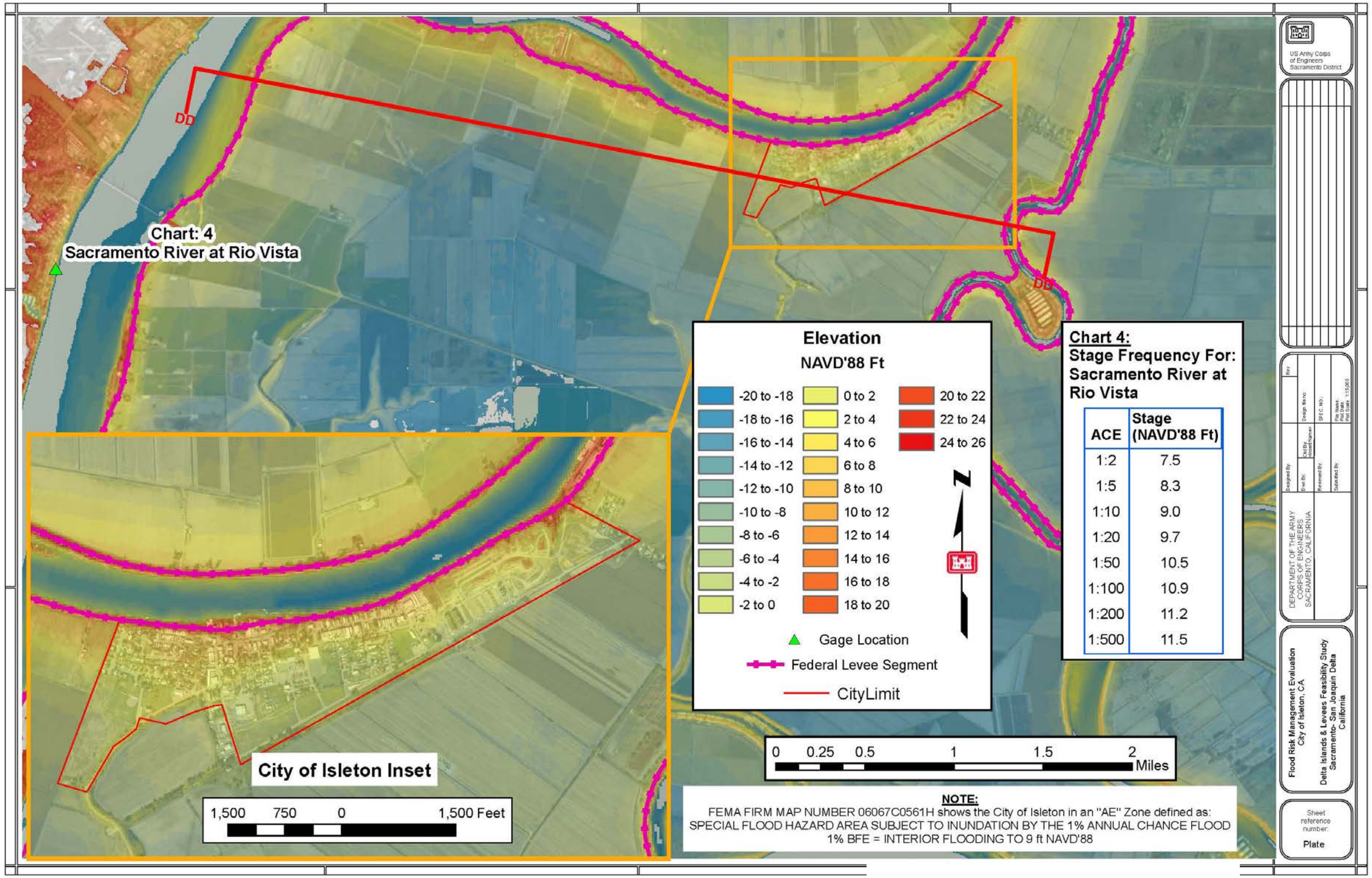


Plate 5-7: City of Isleton Terrain Plan View

1:2 ACE Depth Statistics	Value
Count:	486
Minimum Value:	0
Maximum Value:	14.5
Mean:	5
Standard Deviation:	4

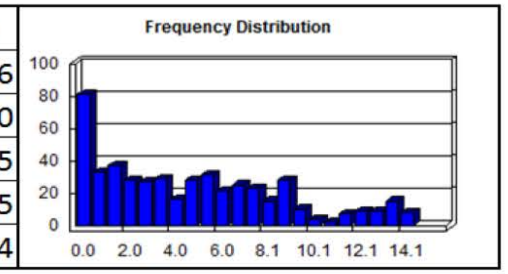


Figure 5- 19 Isleton Interior Parcel 1:2 ACE Statistics & Frequency Distribution

1:5 ACE Depth Statistics	Value
Count:	486
Minimum Value:	0
Maximum Value:	15.3
Mean:	5.8
Standard Deviation:	4

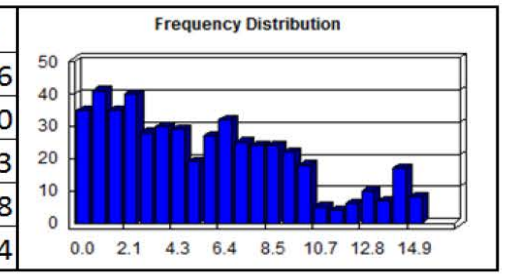


Figure 5- 20 Isleton Interior Parcel 1:5 ACE Statistics & Frequency Distribution

1:10 ACE Depth Statistics	Value
Count:	486
Minimum Value:	0
Maximum Value:	16
Mean:	6.4
Standard Deviation:	4.1

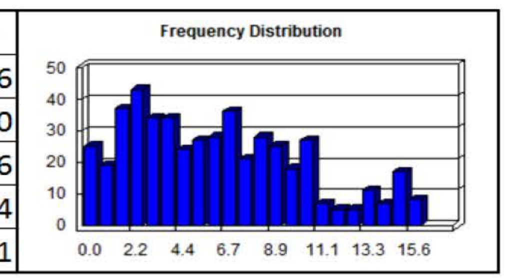


Figure 5- 21 Isleton Interior Parcel 1:10 ACE Statistics & Frequency Distribution

1:20 ACE Depth Statistics	Value
Count:	486
Minimum Value:	0
Maximum Value:	16.7
Mean:	7
Standard Deviation:	4.2

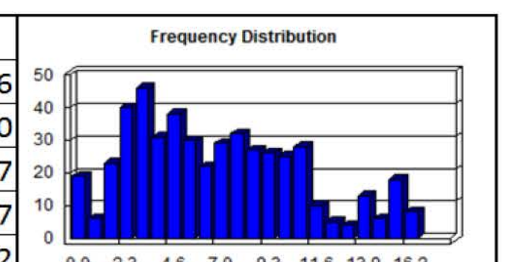


Figure 5- 22 Isleton Interior Parcel 1:20 ACE Statistics & Frequency Distribution

1:50 ACE Depth Statistics	Value
Count:	486
Minimum Value:	0
Maximum Value:	17.4
Mean:	7.8
Standard Deviation:	4.2

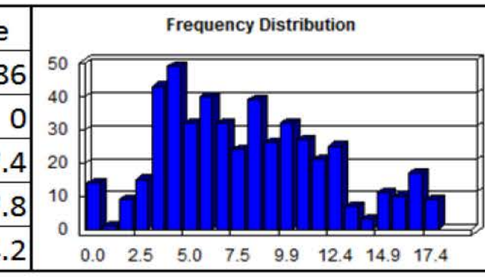


Figure 5- 23 Isleton Interior Parcel 1:50 ACE Statistics & Frequency Distribution

1:100 ACE Depth Statistics	Value
Count:	486
Minimum Value:	0
Maximum Value:	17.9
Mean:	8.2
Standard Deviation:	4.2

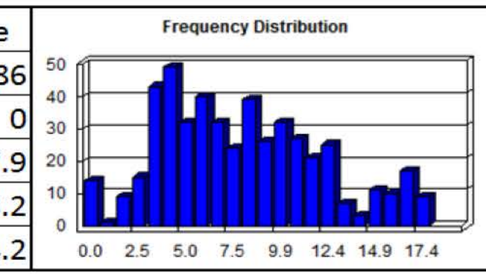


Figure 5- 24 Isleton Interior Parcel 1:100 ACE Statistics & Frequency Distribution

1:200 ACE Depth Statistics	Value
Count:	486
Minimum Value:	0
Maximum Value:	18
Mean:	8.5
Standard Deviation:	4.2

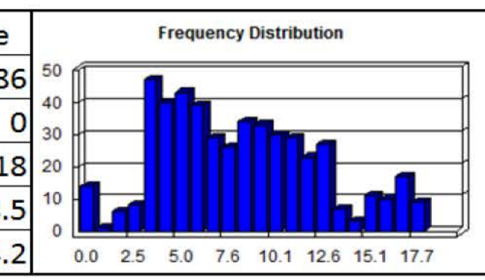


Figure 5- 25 Isleton Interior Parcel 1:200 ACE Statistics & Frequency Distribution

1:500 ACE Depth Statistics	Value
Count:	485
Minimum Value:	0
Maximum Value:	18.5
Mean:	8.8
Standard Deviation:	4.2

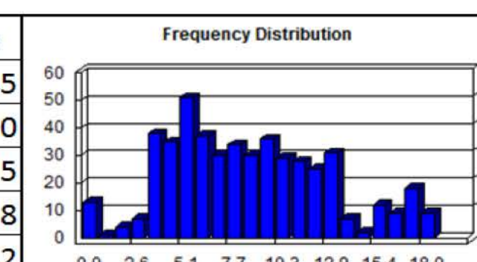
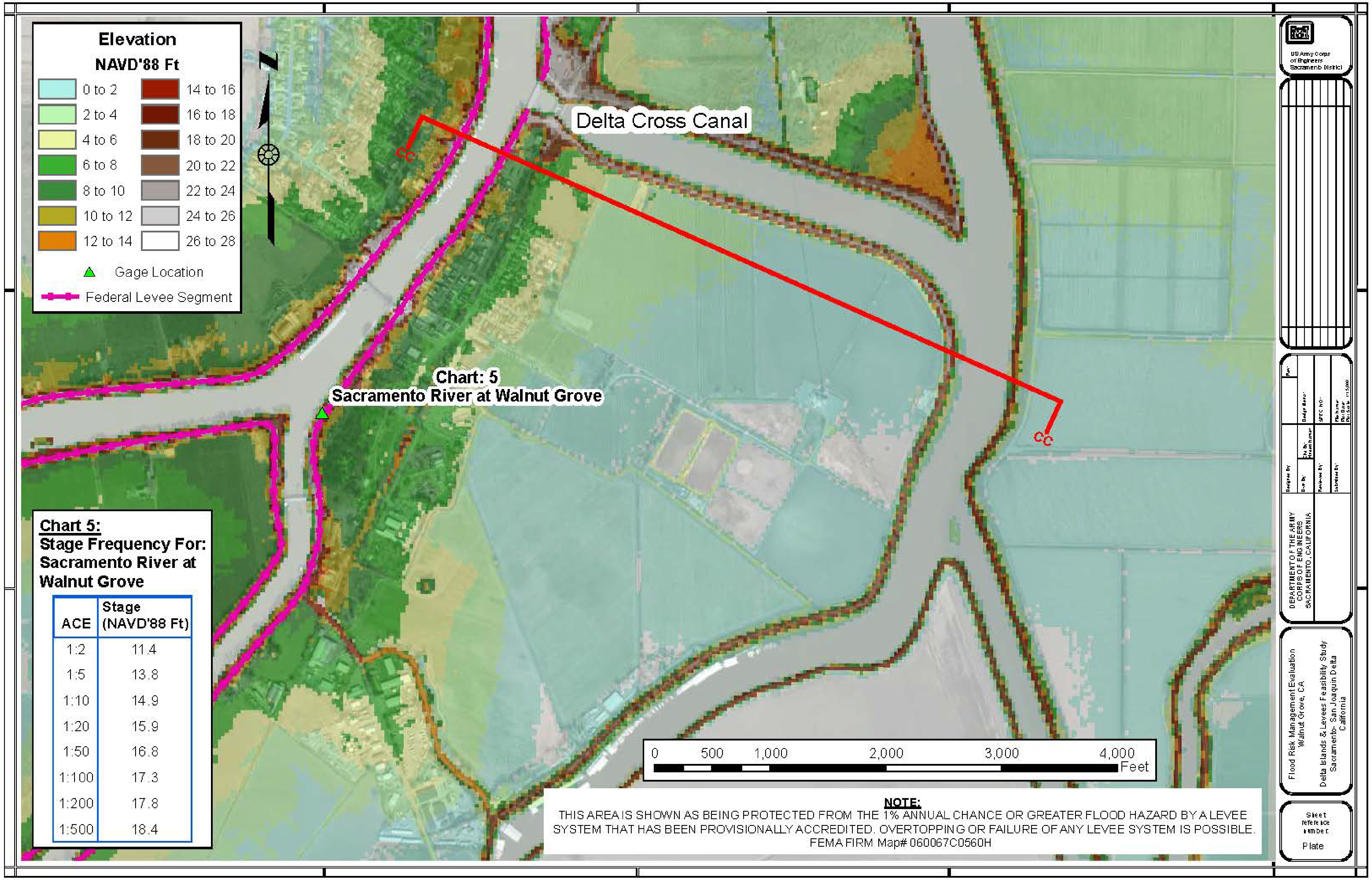


Figure 5- 26 Isleton Interior Parcel 1:500 ACE Statistics & Frequency Distribution

Plate 5-8: City of Isleton Parcel Tabular Statistics & Frequency Distributions



ACE	Stage (NAVD'88 Ft)
1:2	11.4
1:5	13.8
1:10	14.9
1:20	15.9
1:50	16.8
1:100	17.3
1:200	17.8
1:500	18.4

Plate 5-9: Walnut Grove Terrain Plan View

1:2 ACE Depth Statistics	Value
Count:	267
Minimum Value:	0
Maximum Value:	11.2
Mean:	3.3
Standard Deviation:	2.5

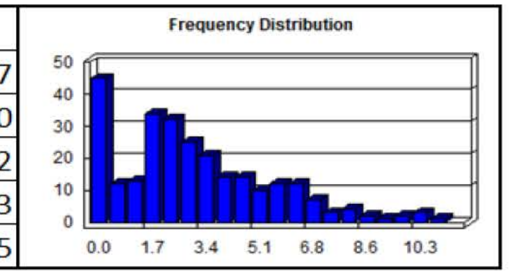


Figure 5- 27 Walnut Grove Interior Parcel 1:2 ACE Statistics & Frequency Distribution

1:5 ACE Depth Statistics	Value
Count:	267
Minimum Value:	0
Maximum Value:	13.6
Mean:	5.4
Standard Deviation:	2.9

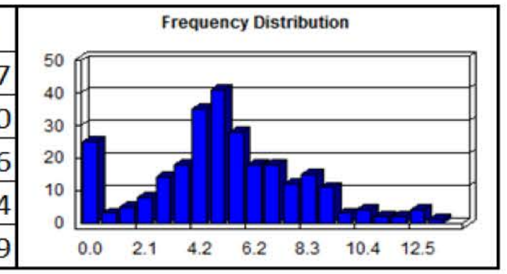


Figure 5- 28 Walnut Grove Interior Parcel 1:5 ACE Statistics & Frequency Distribution

1:10 ACE Depth Statistics	Value
Count:	267
Minimum Value:	0
Maximum Value:	14.7
Mean:	6.5
Standard Deviation:	3.1

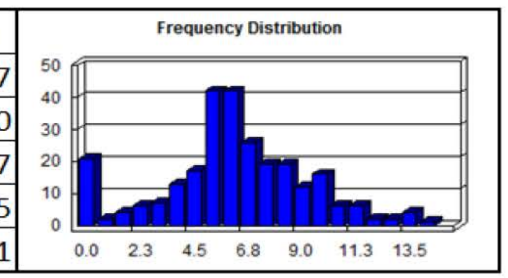


Figure 5- 29 Walnut Grove Interior Parcel 1:10 ACE Statistics & Frequency Distribution

1:20 ACE Depth Statistics	Value
Count:	267
Minimum Value:	0
Maximum Value:	15.6
Mean:	7.3
Standard Deviation:	3.2

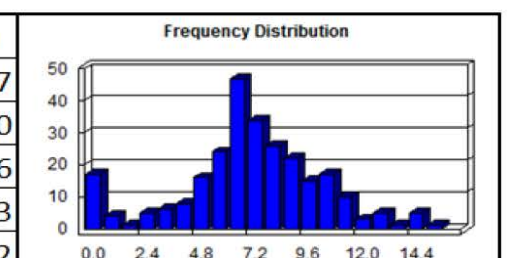


Figure 5- 30 Walnut Grove Interior Parcel 1:20 ACE Statistics & Frequency Distribution

1:50 ACE Depth Statistics	Value
Count:	267
Minimum Value:	0
Maximum Value:	16.5
Mean:	8.2
Standard Deviation:	3.3

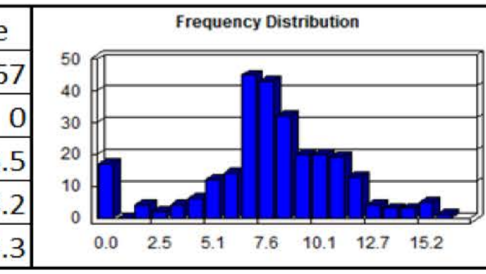


Figure 5- 31 Walnut Grove Interior Parcel 1:50 ACE Statistics & Frequency Distribution

1:100 ACE Depth Statistics	Value
Count:	267
Minimum Value:	0
Maximum Value:	17.1
Mean:	8.8
Standard Deviation:	3.4

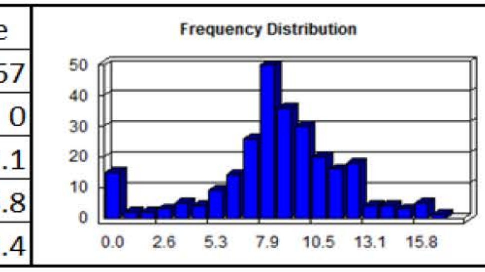


Figure 5- 32 Walnut Grove Interior Parcel 1:100 ACE Statistics & Frequency Distribution

1:200 ACE Depth Statistics	Value
Count:	267
Minimum Value:	0
Maximum Value:	17.6
Mean:	9.2
Standard Deviation:	3.4

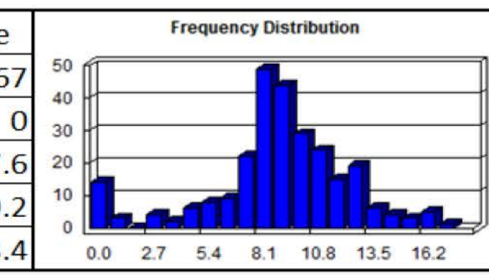


Figure 5- 33 Walnut Grove Interior Parcel 1:200 ACE Statistics & Frequency Distribution

1:500 ACE Depth Statistics	Value
Count:	267
Minimum Value:	0
Maximum Value:	18.1
Mean:	9.7
Standard Deviation:	3.5

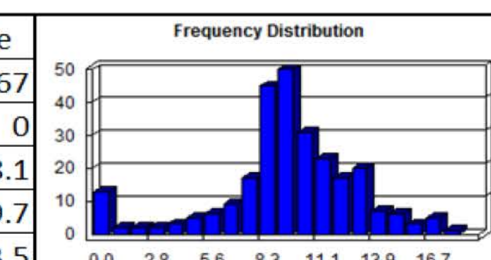


Figure 5- 34 Walnut Grove Interior Parcel 1:500 ACE Statistics & Frequency Distribution

Plate 5-10: Walnut Grove Parcel Tabular Statistics & Frequency Distributions

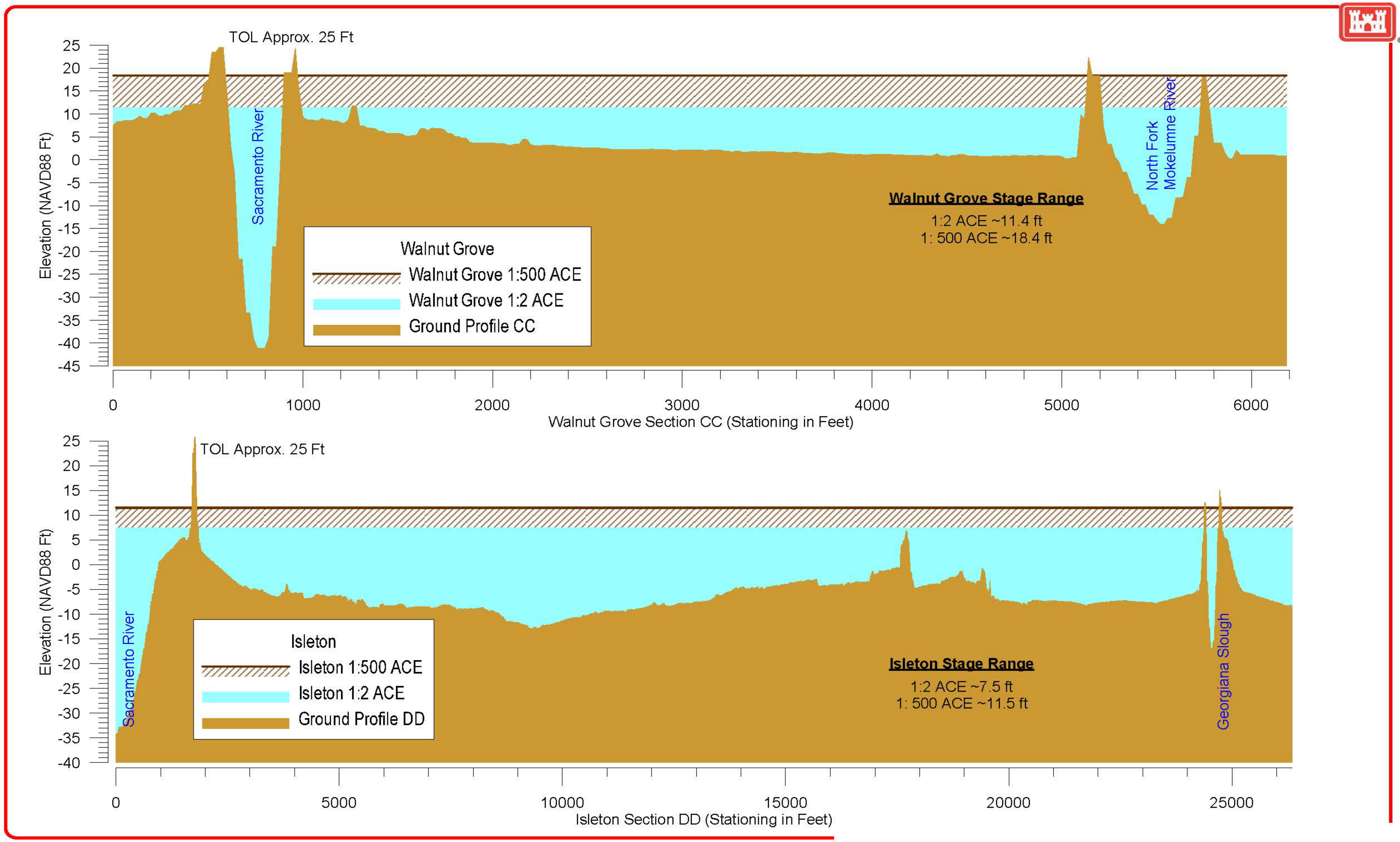


Plate 5-11: Walnut Grove and the City of Isleton In-island Profile View

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APPENDIX A

Appendix A: USACE & Army Risk Assessment and Management

A. Definitions

1. Risk

Army Field Manual FM 5-19, Composite Risk Management (Army 2006) defines risk as:

Risk: probability and severity of loss linked to hazards.

This definition is consistent with present professional practice in risk management (e.g., NRC 2007, ISO 2009) that recognizes two distinct components in risk – the probability of an event and the magnitude of consequences from that event.

Table A.1 illustrates the variability among definitions of risk from several USACE technical and guidance documents. It shows that newer definitions, while varying in word choice, are consistent with the Army Field Manual. Older documents may vary in substance, depending on date and context of the document. For example, Engineer Manual 1110-2-1619, Risk-Based Analysis for Flood Damage Reduction Studies (USACE 1996) gives the definition:

> *Long-term risk - The probability of capacity exceedance during a specified period. For example, 30-year risk refers to the probability of one or more exceedances of the capacity of a measure during a 30-year period.*

It does not include in the definition "severity" of consequences that forms part of the later publications. Despite this narrower definition of the term, EM 1110-2-1619 clearly requires consideration of consequences, saying:

> *… indices described herein represent some aspects of the non-economic performance of alternative plans; this performance is referred to herein as engineering performance. The indices include expected annual exceedance probability, long-term risk, consequences of capacity exceedance, and conditional probability.*

Engineer Circular 1110-2-6067, (USACE 2010) takes note of this variety of definitions and states:

> *Consistent with USACE agency-wide changes, the definition in the glossary "Risk – Measure of the probability and severity of undesirable consequences" is used for this document. In USACE dam safety policies and other USACE technical*

engineering guidance, 'risk' is used consistent with this definition, sometimes expressed as a probability-consequence diagram. Please note, however, that various USACE official guidance documents and policy letters have 'risk' in their titles, and that these documents often address only probability of occurrence or uncertainty. These documents will be corrected as they are updated and revised.

Table A-1. Some USACE definitions of "Risk"

DOCUMENT	DEFINITION	REFERENCE
USACE Risk Analysis Gateway (web)	*chance of an undesirable outcome in any given situation. It is a measure of the probability and consequence of uncertain future events and it includes: ● Potential for gain (opportunities) ● Exposure to losses (hazards)*	USACE 2011a
EC 1110-2-6067	*measure of the probability and severity of undesirable consequences."*	USACE 2010
IPET Report	*expected losses in terms of lives or dollars generally calculated by combining the probability of system failure with the consequences associated with that failure.*	IPET 2009
ETL-1110-2-561	*probability of a loss occurring in a given time period (annually), where loss consists of all economic damages (measured in dollars) and the environmental loss of habitat (habitat units loss) as well as the potential for loss of life.*	USACE 2006a
ER 1105-2-101	*probability that an area will be flooded, resulting in undesirable consequences*	USACE 2006
IWR RSK-04	*a characteristic of a situation, action, or event in which:* *● A number of outcomes are possible ● The particular one that will occur is uncertain ● At least one of the possibilities is undesirable.*	Males 2002
IWR 96-R-14	*potential for an incident to cause: (1) human injury, disease, or death resulting from exposure; (2) temporary or permanent damage to property and/or the ecological infrastructure; (3) loss of productivity*	Russell and O'Grady 1996

	and quality of life, due to incident-caused delays and evacuations; and (4) loss of revenues and increases in operating cost as reflected in diminished public perception and new regulatory controls.	
EM 1110-2-1619	*probability of capacity exceedance during a specified period*	USACE 1996
IWR 92-R-1	*potential for realization of unwanted, adverse consequences; estimation of risk is usually based on the expected result of the conditional probability of the occurrence of event multiplied by the consequence of the event, given that it has occurred.*	Greeley-Polhemus Group, 1992
IWR 88-R-4	*measure of the probability of occurrence of a potentially hazardous event and of the event's consequences to society*	Haimes et al. 1988
Principles and Guidelines	*Situations … in which the potential outcomes can be described in reasonably well known probability distributions.*	WRC 1983

The role of the two factors – probability of an event and the consequences of that event – in defining risk can be illustrated as in Figure A-1. The vertical axis represents the probability of an event, ranging from very low, such a 500-year return period storm, to a rather high probability, such as an annual spring runoff event. The horizontal axis represents the consequences of the event – low consequences might include small economic damages, whereas high consequences may include loss of human life. A low probability event with large consequences (such as Hurricane Katrina) is shown by point "A". On the other hand, a 500-year snowfall event along the coast might have only minor economic effects and be shown by point "B". Events that have a high probability, e.g., happening once per year like a spring freshet with small consequences, may be shown by point "C". The diagram can be categorized into low, medium and high risk zones, as shown in Figure A-1, with the actual delineations among them depending on a careful analysis of the specific system.

APPENDIX A

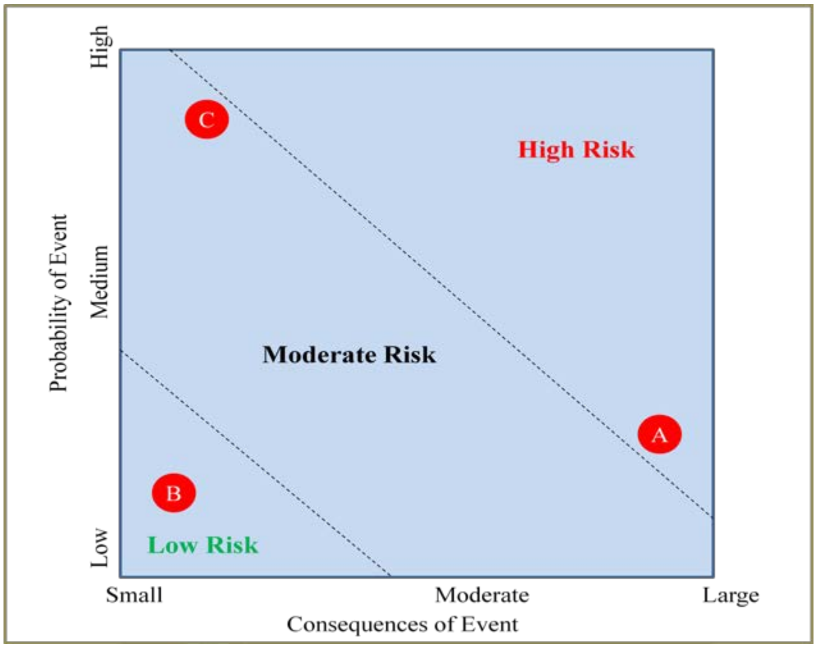

Figure A- 1 Illustration of the combined effects of event probability and event consequences in assigning risk levels

APPENDIX A

2. Risk Assessment

Field Manual FM 5-19 (Army 2006) defines risk assessment as:

Risk Assessment: The identification and assessment of hazards (the first two steps of the composite risk management process).

The USACE Risk Management Gateway provides a more detailed, descriptive definition:

> *Risk assessment is a systematic, evidence-based approach for describing the likelihood and consequences of any action, including no action. Risk assessment methodology is a technical and a scientific process by which the risks of a given situation for a system are modeled and quantified. A risk assessment asks the questions: What can go wrong? How can it happen? What is the likelihood it will go wrong? What is the consequence if it goes wrong? Risk assessment is a small part of the bigger process called risk management. Risk assessment provides a piece of the required data for the decision makers in the risk management process. Risk management includes the assessment, decision making, and communication aspects of risk. The domain of risk assessment is beyond engineering reliability, while reliability assessment is a significant activity in a risk assessment.* (USACE 2011b)

3. Risk Management

Field Manual FM 5-19 (Army 2006) defines Risk Management as:

Risk Management: The process of identifying, assessing, and controlling risks arising from operational factors and making decisions that balance risk cost with mission benefits.

The USACE Risk Management Gateway again provides a more detailed, descriptive definition:

> *Risk management is the keystone activity in the risk analysis process. It starts with identifying problems and decisions to be made. The next step is to begin efforts to identify and assess risks, which includes evaluating risk management options and selecting the best one from among them. It is also a risk management responsibility to implement and monitor the selected risk management activity and to modify those decisions when necessary.*
> …
> *Risk management has been defined in many different ways to meet the needs of many different organizations and applications. Common to many of these definitions are the following informal questions:*
> – *What is the problem?*
> – *What question(s) do we want risk assessment to answer?*
> – *What can be done to reduce the impact of the risk described?*
> – *What can be done to reduce the likelihood of the risk described?*
> – *What are the trade-offs of the available options?*
> – *What is the best way to address the described risk?*
> – *Is it working?*
>
> (USACE 2011b)

4. Composite Risk Management

Field Manual 5-19 does not explicitly define Composite Risk Management (CRM). It simply describes CRM as: "… the Army's primary decision making process for identifying hazards and controlling risks across the full spectrum of Army missions, functions, operations, and activities." (Army 2006)

The Manual explains the addition of the word "composite" by saying in the Preface: "This holistic approach focuses on the composite risks from all sources rather than the traditional practice of separating accident from tactical hazards and associated risks."

While the Manual's language is clearly tailored to the context of active duty military risk management, CRM can be defined in terms pertinent to this report as:

Composite Risk Management: The process of identifying, assessing, and controlling risks arising from all causes by making decisions that balance risk with benefits.

B. Consequences in Risk Management

USACE typically evaluates economic, human health and life, and environmental consequences separately. Attempts to address health and life losses quantitatively are often controversial and encounter the challenge that human life is priceless. Recently environmental consequences have proved susceptible to quantification through ecosystem services analyses, but the field is still developing.

Among other Federal agencies, the EPA has attempted to use the “Value of a Statistical Life” to define the cost-benefit ratio for regulations (EPA 2011) arriving at a value of $7.4M in 2006 dollars. The agency plans to change over to a “Value of Mortality Risk” in the future in order to reduce controversy. Other agencies have used the “Cost to Save a Statistical Life” as an alternative.

Recent efforts by USACE to formulate new dam and levee risk assessment strategies and the ongoing process to revise the Federal “Principles and Practices” may produce quantitative expressions for human health and safety and environmental quality. However, existing USACE guidance does not provide a mechanism for doing so. Separate risk assessments are the norm for economics, human health and life, and environmental quality, including ecosystem components.

C. Composite Risk Management Process

Field Manual 5-19 provides guidance on applying CRM through a five-step process depicted in **Figure C-2**. While the Manual explains the five steps in terms of military personnel and missions, e.g., “The factors of mission, enemy, terrain and weather, troops and support available, time available, and civil considerations (METT-TC) serve as a standard format for identification of hazards, on-duty or off-duty,” those terms have equivalent civil works factor connotations:

- Mission – Project purpose, operation and maintenance
- Enemy – Vandals, terrorists, earthquakes, floods
- Terrain and weather – Natural factors such as soil, water, weather, and animals
- Troops and support – USACE, local sponsors, stakeholders
- Time available – Time and budget constraints
- Civil considerations – Non-project activities such as recreation, farming, etc.

Once hazards have been identified, step 2 in the CRM is to assess each hazard by three sub-steps:

- Assess the probability of the event or occurrence.
- Estimate the expected result or severity of an event or occurrence.
- Determine the specified level of risk for a given probability and severity using the standard risk assessment matrix.

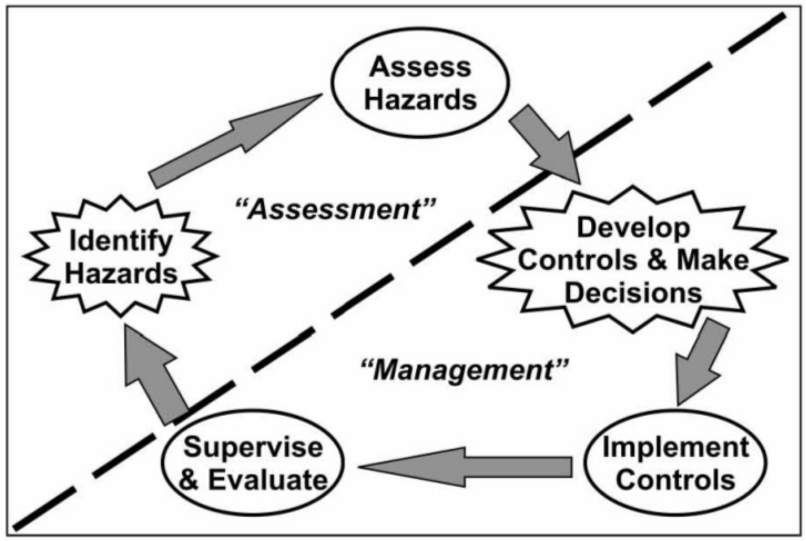

Figure C- 2 CRM Steps (Source: Army 2006)

Figure C-2 shows that the risk management steps following hazard assessment are:

- Develop controls and make decisions
- Implement controls
- Supervise and evaluate

Figure C-2 also indicates that the steps repeat, with the focus on "residual risk" in the next hazard identification step. The latter two bullets can be recognized as steps in an adaptive management approach, which the National Research Council (NRC 2009) describes as:

Adaptive Risk Management: Flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood.

Figure C-3 shows the Field Manual's Risk Assessment Matrix. It reflects the two components of risk as shown in Figure C-1 – probability of occurrence and severity of consequences. Probability of occurrence is expressed as one of five categories ranging from "Frequent" to "Unlikely" and severity of consequences is expressed as one of four categories ranging from "Negligible" to "Catastrophic". The Manual explains these categories in primarily military terms; nevertheless, the concepts are still applicable to civil works activities with suitable translation. For example, **Figure C-4** is an example risk matrix for major equipment rehabilitation decisions in civil works activities. In this case a Condition Index is used to define the probability of an adverse event and loss of revenue from a shutdown has been used to estimate the consequences ranging from “Low” to “High”. Numbers in the matrix cells of Figure C-4 represent a calculated non-dimensional index representing degree of risk.

RISK ASSESSMENT MATRIX						
		Probability				
Severity		Frequent A	Likely B	Occasional C	Seldom D	Unlikely E
Catastrophic	I	E	E	H	H	M
Critical	II	E	H	H	M	L
Marginal	III	H	M	M	L	L
Negligible	IV	M	L	L	L	L
E – Extremely High		H – High		M – Moderate		L – Low

Figure C-1. CRM Hazard Assessment Matrix. (Source: Army 2006)

Condition Index												Risk Level Results (Map #)
Poor	0 to 0.9	11	12	13	14	15	16	17	18	19	20	
Poor	1 to 1.9	10	11	12	13	14	15	16	17	18	19	High 17 - 20
Poor	2 to 2.9	9	10	11	12	13	14	15	16	17	18	
Fair	3 to 3.9	7	8	9	10	11	12	13	14	15	16	Medium-High 13 - 16
Fair	4 to 4.9	6	7	8	9	10	11	12	13	14	15	
Fair	5 to 5.9	5	6	7	8	9	10	11	12	13	14	Medium 9 - 12
Fair	6 to 6.9	4	5	6	7	8	9	10	11	12	13	
Good	7 to 7.9	3	4	5	6	7	8	9	10	11	12	Medium-Low 5 - 8
Good	8 to 8.9	2	3	4	5	6	7	8	9	10	11	
Good	9 to 10	1	2	3	4	5	6	7	8	9	10	Low 1 - 4
	Consequence	Low		Medium-Low		Medium		Medium-High		High		

Figure C-2. Risk Matrix for Major Equipment Rehabilitation (Source: USACE 2011c)

The CRM matrix in Figure C-3 expresses composite risk in four levels:

> *Extremely High Risk – Loss of ability to accomplish the mission if hazards occur during mission. A frequent or likely probability of catastrophic loss (IA or IB) or frequent probability of critical loss (IIA) exists. This implies that the risk associated with this mission, activity, or event may have severe consequences beyond those associated with this specific operation or event. The decision to continue must be weighed carefully against the potential gain to be achieved by continuing this Course of Action (COA).*

High Risk – Significant degradation of mission capabilities in terms of the required mission standard, inability to accomplish all parts of the mission, or inability to complete the mission to standard if hazards occur during the mission.

Occasional to seldom probability of catastrophic loss (IC or ID) exists. A likely to occasional probability exists of a critical loss (IIB or IIC) occurring. Frequent probability of marginal losses (IIIA) exists. This implies that if a hazardous event occurs, serious consequences will occur. The decision to continue must be weighed carefully against the potential gain to be achieved by continuing this COA.

Moderate Risk – Expected degraded mission capabilities in terms of the required mission standard and will result in reduced mission capability if hazards occur during mission. An unlikely probability of catastrophic loss (IE) exists. The probability of a critical loss is seldom (IID). Marginal losses occur with a likely or occasional probability (IIIB or IIIC). A frequent probability of negligible (IVA) losses exists.

Low Risk – Expected losses have little or no impact on accomplishing the mission. The probability of critical loss is unlikely (IIE), while that of marginal loss is seldom (IIID) or unlikely (IIIE). The probability of a negligible loss is likely or less (IVB through (IVE). Expected losses have little or no impact on accomplishing the mission. Injury, damage, or illness are not expected, or may be minor and have no long term impact or effect.

Of particular note is that the Manual-delineated process does not explicitly combine the hazards in a single composite risk evaluation. Each hazard is assessed and managed individually, as if it were uncorrelated with any other hazard. It is the responsibility of the command to understand how the hazards may interact to create a higher risk.

D. <u>Risk Assessment Matrix</u>

Using the risk assessment matrix is the key guidance provided by Field Manual 5-19, but its implementation for civil works activities diverges from the military-centric procedures and examples given in the Manual. Other USACE guidance describes the process for performing composite risk management in civil works.

Factors to be considered in identifying levee hazards are given by EC 1110-2-6067 (USACE 2010) to include:

- Construction records and quality control testing
- Existing Operation and Maintenance Plan
- Levee field inspection
- Levee height assurance determination

- Flood hazard characterization
- Capacity exceedance/failure criteria
- Closure structures and devices
- Interior drainage
- Embankment protection from current or wave action
- Embankment and foundation stability
- Seepage/underseepage analysis
- Settlement
- Seismic analysis
- Performance records
- Encroachments
- Ice issues
- Other applicable unique design criteria.

The EC also provides guidance and examples on how the assessments should be performed, but does not describe how to populate a risk matrix with those assessments.

Risk values used to populate a risk matrix can be simple designations of High, Medium, Low, etc., as shown in Figure D-3, or non-dimensional numeric values calculated by a risk assessment procedure as in Figure D-4. They can be expressed mathematically as a simple product:

$$Risk\ Index = \frac{\mathrm{P}\left[Event\right] * \left(Consequences\ of\ Event\right)}{Normalizing\ Value} \qquad \text{D-1}$$

Where the *Normalizing Value* is selected to remove units from the index and fit it to a certain range, such as 0 to 1, or 1 to 100 and P[ ] = probability function of the random variable within the brackets.

In toxic materials and security risk analyses the P[Event] is often defined as:

$$P[Event] = \mathrm{P}\left[Threat\right] * \left[Vulnerability\ to\ Threat\right] \qquad \text{D-2}$$

USACE (2011c) develops Figure 2-4 rather simply, using the sum:

$$Risk\ Index = \beta_{CI} + \beta_{RL} \qquad \text{D-3}$$

Where β_{CI} = index value ranging from 10 (high likelihood of failure) to 0 (Low likelihood of failure) from a lookup table corresponding to machinery Condition Indices ranging from 0 (poor) to 10 (Good) and β_{RL} = index value ranging from 1 (minor revenue loss) to 10 (high revenue loss). The result are the index values ranging from 1 (low risk) to 20 (high risk) and the diagonal division into four risk categories.

Engineer Circular 1110-2-6062 (USACE 2011c) applies a more complex analysis to an example dam breach problem, defining the risk as:

$$R = H\ P[F]\ P[E]\ X\ L \qquad 2\text{-}5$$

Where *R* = Risk in expected losses per year; *H* = number of expected events per year; *P[F]* = probability of failure of a project feature for each event; *P[E]* = probability of a breach, given event and feature failure; *X* = conditional exposure of people or property caused by the event; and *L* = loss rate for the exposed people and property.

While these mathematical forms are useful in understanding the interactions and separating high risk from low risk, risk values are not typically treated as precise magnitudes. They are more often scaled to a linear relationship appropriate for assigning classes of risk as displayed in Figures D-3 and D-4, and shown in Equation D-1.

These examples serve to illustrate the variety of ways risk can be estimated and expressed. Other than the overall approach, the conceptual form of the risk matrix, and requirement for sound analyses, USACE risk assessment has considerable latitude. In the words of Field Manual 5-19: "Technical competency, operational experience, and lessons-learned weigh higher than any set of alpha-numeric codes. Mathematics and matrixes are not a substitute for sound judgment." (Army 2006)

E. Uncertainty and Risk Assessment

Engineer Circular EC 1110-2-6067 (USACE 2010) defines uncertainty in National Flood Insurance Program levee evaluations as:

Uncertainty: A measure of the imprecision of knowledge of variables and functions used in the risk analysis.

The EC also states:

> *USACE policy is to apply a probability and uncertainty analysis framework to NFIP levee system evaluations for all engineering elements. As of the publication date of this EC, probability and uncertainty-based methodologies for the hydrology and hydraulics in Riverine situations is more advanced; elements*

> *of the uncertainty for NFIP levee system evaluation exist and will be applied as outlined below. Probability of exceedance and uncertainty assessment methods for coastal, estuarine, and lake settings are less mature, but being developed currently, and should be used as noted in paragraph 9.f., but with caution and appropriately applied until they become more codified into engineering guidance. Probability of exceedance and uncertainty-based methodologies are under development and emerging for structural and geotechnical engineering elements but are not yet sufficiently mature for direct application in NFIP levee system evaluations.* (USACE 2010)

Paragraph 9f cited in the quotation above provides guidance for hydrology and hydraulics uncertainty analyses in river and coastal environments, citing EM 1110-2-1619, Risk-Based Analysis for Flood Damage Reduction Studies (USACE 1996); Part II (Chapters 2 and 3) of EM 1110-2-1100, Coastal Engineering Manual (USACE 2008); and the Performance Evaluation of the New Orleans and Southeast Louisiana Hurricane Protection System (IPET 2009).

APPENDIX B: RISK CALCULATIONS

Data used in the risk calculations were taken from the Delta Risk Management Strategy report (URS/JBA 2008).

Table B1 – B2

Table B1 lists the Life Loss analysis zones alphabetically, with parallel columns for DRMS report data and calculations for those data. Table A2 contains the same list, sorted by Risk Index. Column details are:

"Zone" and *"Maximum Mean Life Loss":* Names of zones for which DRMS Appendix 12C provides estimated fatalities and the maximum value (usually a night-time event) of Mean Life Loss. Blanks indicate that the zone in *"URS Name"* column could not be identified in DRMS Appendix 12C. Shaded values in the *"Maximum Mean Life Loss"* column indicate that a value was assumed based on similarity of *"URS Name"* or apparent co-location on maps. The *"Notes"* column indicates where the assumed value was drawn from.

"URS_ID", *"URS Name"*, and *"Annual Mean No. of Failures"*: Numbers, names, and annual mean failures from DRMS Table 13-8. Blanks indicate that the zone in the *"Zone"* column could not be identified in DRMS Table 13-8. Shaded values in *"Annual Mean Number of Failures"* indicate that a value was assumed based on similarity of *"Zone"* name or apparent co-location on maps. The *"Notes"* column indicates where the assumed value was drawn from.

"Life Loss Category": Life Loss category for the *"Zone"*, using *"Maximum Mean Life Loss"* and the categories in Table 4-2.

"Failure Rate Category": Failure Rate category for the zone named in *"URS Name"*, using *"Annual Mean No. of Failures"* and the categories in Table 4-3.

"Life Loss Risk Index": Life Loss Risk Index calculated by Equation 2-1.

"Risk Category (Table 4-1)": Risk Level Category as defined by *"Life Loss Category"* and *"Failure Rate Category"* and Table 4-1 in the text.

"Notes": Notes indicate which values were assumed and where they were drawn from.

Table B3 – B4

Table A3 lists the Damage Costs analysis zones alphabetically; with parallel columns for DRMS report data and calculations for those data. Table A4 contains the same list, sorted by Risk Index. Column details are:

"Island Name", *"Old Island Name"*, and *"Total Asset Damages"*: Names of zones for which DRMS tables 12.7 and 12.8 provides estimated Damage Costs. Blanks indicate that the zone in

APPENDIX B

"URS Name" could not be identified in DRMS Part 12. Shaded values in *"Total Asset Damages"* indicate that a value was assumed based on similarity of *"URS Name"* name or apparent co-location on maps. *"Notes"* indicates where the assumed value was drawn from.

"URS Name" and *"Annual Mean No. of Failures"*: Names and annual mean failures from DRMS Table 13-8. Blanks indicate that the zone in *"Island Name"* could not be identified in DRMS Table 13-8. Shaded values in *"Annual Mean No. of Failures"* indicate that a value was assumed based on similarity of *"Island Name"* name or apparent co-location on maps. *"Notes"* indicates where the assumed value was drawn from.

"Damages Category": Damage Costs category for the zone named in *"Island Name"*, using *"Total Asset Damages"* and the categories in Table 4-2.

"Failure Rate Category": Failure Rate category for the zone named in *"Island Name"* or *"URS Name"*, using *"Annual Mean No. of Failures"* and the categories in Table 4-3.

"Risk Index": Damage Costs Risk Index calculated by Equation 2-1.

"Damages Risk Category": Risk Level category as defined by *"Damages Category"* and *"Failure Rate Category"* and Table 4-1 in the text.

"Notes": Notes indicate which values were assumed and where they were drawn from.

APPENDIX B

Table B-2. Life Loss Analysis Calculations, Sorted Alphabetically

From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
		1012	Atlas Tract	6.16E-03					
		185	Atlas Tract East	5.53E-04					
Bacon_Island	0.000	15	Bacon Island	5.12E-02	1	5	0.000	3	
Bethel_Island	11.100	10	Bethel Island	6.96E-02	4	5	0.108	5	
Bishop_Tract	19.425	1013	Bishop Tract	1.98E-02	4	3	0.054	4	
Boggs_Tract	90.650	159	Boggs Tract	1.82E-02	5	3	0.231	5	
Bouldin_Island	0.925	177	Bouldin Island	4.65E-02	2	4	0.006	3	
Brack_Tract	0.925	176	Brack Tract	6.01E-02	2	5	0.008	4	
Bradford_Island	0.925	6	Bradford Island	4.45E-02	2	4	0.006	3	

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
Brannan-Andrus Island	0.925	1007	Brannan-Andrus Island	5.82E-02	2	5	0.008	4	
Byron_Tract 1	1.850	127	Byron Tract	4.51E-02	3	4	0.012	4	Use Byron_Tract 1 Life Loss
Cache_Haas_Tract 1	0.000	88	Cache Haas Tract 1	3.99E-02	1	4	0.000	3	
	0.000	80	Cache Haas Tract 1 East	2.64E-02	1	4	0.000	3	Use Cache_Haas_Tract 1 Life Loss
Cache_Haas_Tract 2	0.000	89	Cache Haas Tract 2	4.28E-02	1	4	0.000	3	Use Cache_Haas_Tract 1 Life Loss
Canal Ranch	0.925	175	Canal Ranch	3.41E-02	2	4	0.004	3	
Clifton Court Forebay	0.925	1010	Clifton Court Forebay South	2.15E-02	2	3	0.003	3	Use Clifton Court Forebay Life Loss
Clifton Court Forebay Water	0.925			2.15E-02	2	3	0.003	3	Use Clifton Court Forebay South Failure Rate

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
Coney_Island	0.925	32	Coney Island	2.36E-02	2	3	0.003	3	
		171	Cosumnes River Area	1.00E-02		3			
Deadhorse Island	0.000	173	Deadhorse Island	1.20E-02	1	3	0.000	2	
		1002	Drexler Tract	5.52E-02		5			
		109	Dutch Slough East	2.52E-02		4			
		14	Dutch Slough West	2.34E-02		3			
Egbert_Tract	0.000	70	Egbert Tract	2.37E-02	1	3	0.000	2	
		69	Egbert Tract East	2.63E-02	1	4	0.000	3	Use Egbert_Tract Life Loss
		1005	Elk Grove	1.76E-03		1			

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
		78	Elk Grove South	1.76E-03		1			
		77	Elk Grove South East	6.46E-03		2			
		148	Elk Grove South West	1.25E-02		3			
		197	Elk Grove West	1.76E-03		1			
Empire_Tract	0.925	5	Empire Tract	5.02E-02	2	5	0.006	4	
Fabian_Tract	0.925	163	Fabian Tract	2.35E-02	2	3	0.003	3	
		216	Fabian Tract South West 1	1.13E-02	2	3	0.001	3	Use Fabian_Tract Life Loss
		162	Fabian Tract South West 2	1.81E-02	2	3	0.002	3	Use Fabian_Tract Life Loss
Glanville_Tract	0.925	170	Glanville Tract	2.11E-02	2	3	0.003	3	

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
Grand Island	0.925	147	Grand Island	3.59E-02	2	4	0.005	3	
Hastings_Tract 2	0.000	1001	Hastings Tract	2.89E-02	1	4	0.000	3	Use Hastings_Tract 2 Life Loss
		82	Hastings Tract South West	2.63E-02	1	4	0.000	3	Use Hastings_Tract 2 Life Loss
Holland_Tract	0.925	13	Holland Tract	4.28E-02	2	4	0.006	3	
		201	Honker Bay Club	1.04E-01		5			
Hotchkiss_Tract 1	1.850	108	Hotchkiss Tract	3.48E-02	3	4	0.009	4	Use Hotchkiss_Tract 1 Life Loss
Hotchkiss_Tract 2	0.925			3.48E-02	2	4	0.005	3	Use Hotchkiss Tract Failure Rates
Jersey_Island	0.925	9	Jersey Island	6.96E-02	2	5	0.009	4	
Jones_Tract-Upper_and_Lower	0.000	17	Jones Tract-Upper and Lower	5.88E-02	1	5	0.000	3	

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
		121	Kasson District	1.73E-03		1			
King_Island	0.925	7	King Island	2.94E-02	2	4	0.004	3	
Libby_McNeil_Tract 1	3.700	168	Libby McNeil Tract 1	1.52E-02	3	3	0.008	3	
	3.700	167	Libby McNeil Tract 2	1.52E-02	3	3	0.008	3	Use Libby_McNeil_Tract 1 Life Loss
Lincoln_Village_Tract	109.150			4.11E-02	5	4	0.628	5	Use Smith Tract - Lincoln Village Tract Failure Rate
Little_Egbert_Tract	0.000	68	Little Egbert Tract	4.76E-02	1	4	0.000	3	
Lower_Roberts_Island	0.000			5.52E-02	1	5	0.000	3	Use Roberts Island Failure Rate
Mandeville_Island	0.000	144	Mandeville Island	5.69E-02	1	5	0.000	3	
McCormack_Williamson_Tract	0.000	169	McCormack Williamson Tract	3.70E-02	1	4	0.000	3	

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
McDonald_Tract	0.000	12	McDonald Tract	6.20E-02	1	5	0.000	3	
		120	McMullin Ranch	8.90E-03		2			
		1014	McMullin Ranch-River Junction Tract	2.90E-03		1			
Medford_Island	0.000	152	Medford Island	5.37E-02	1	5	0.000	3	
Merritt Island	0.000	141	Merritt Island	2.17E-02	1	3	0.000	2	
Middle_Roberts_Island	0.000			5.52E-02	1	5	0.000	3	Use Roberts Island Failure Rate
		1009	Mossdale R.D. No. 2107	1.52E-02		3			
		75	N. of Glanville Tract	2.31E-03		1			
Netherlands 2	0.925	1000	Netherlands	4.07E-02	2	4	0.005	3	

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
New_Hope_Tract	2.775	172	New Hope Tract	9.73E-02	3	5	0.038	4	
Orwood_Tract	0.925	20	Orwood Tract	4.81E-02	2	4	0.006	3	
Palm_Tract	0.925	16	Palm Tract	3.46E-02	2	4	0.004	3	
		119	Paradise Junction	2.93E-02		4			
		118	Pescadero	2.93E-02		4			
Peter Pocket	0.000	72	Peter Pocket	3.06E-02	1	4	0.000	3	
		79	Peter's Pocket West	2.82E-02	1	4	0.000	3	Use Peter Pocket Life Loss
Pico_Naglee_Tract	3.700	126	Pico Naglee Tract	4.88E-03	3	1	0.003	3	
Pierson_Tract	0.925	149	Pierson Tract	2.01E-02	2	3	0.003	3	

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
Prospect_Island	0.000			0.00000	1		0.000	1	
Quimby_Island	0.925	11	Quimby Island	2.91E-02	2	4	0.004	3	
		166	RD 17 (Mossdale)	5.79E-02		5			
Rindge_Tract	0.000	143	Rindge Tract	4.61E-02	1	4	0.000	3	
Rio_Blanco_Tract	13.875	183	Rio Blanco Tract	1.54E-02	4	3	0.030	4	
	0.000	1003	Roberts Island	5.52E-02	1	5	0.000	3	Use Lower_ and Middle_Roberts_Island Life Loss
Rough_and_Ready_Island	0.000	153	Rough and Ready Island	3.44E-02	1	4	0.000	3	
Ryer Island	0.000	210	Ryer Island	3.32E-02	1	4	0.000	3	
		196	Sacramento Pocket Area	5.90E-03		2			

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
Sargent_Barnhart_Tract 2	96.200	191	Sargent Barnhart Tract	7.43E-02	5	5	1.000	5	Use Sargent Barnhart Tract Failure Rates
Sargent_Barnhart_Tract 3	2.775			0.00000	3	5	0.029	4	Use Sargent Barnhart Tract Failure Rates
		131	Schafter-Pintail Tract	4.61E-01		5			
Sherman_Island	14.800	1015	Sherman Island	9.46E-02	4	5	0.196	5	
Shima_Tract	195.175	187	Shima Tract	2.36E-02	5	3	0.644	5	
Shin_Kee_Tract	0.925	182	Shin Kee Tract	4.77E-02	2	4	0.006	3	
		203	Simmons-Wheeler Island	1.06E-01		5			
		1	SM-1	4.90E-01		5			
		123	SM-123	4.85E-01		5			

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
		124	SM-124	4.85E-01		5			
		132	SM-132	4.61E-01		5			
		133	SM-133	4.55E-02		4			
		134	SM-134	4.55E-02		4			
		198	SM-198	2.83E-02		4			
		2	SM-2	4.90E-01		5			
		202	SM-202	3.15E-01		5			
		204	SM-204	1.36E-01		5			
		39	SM-39	4.74E-01		5			

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
		40	SM-40	3.80E-01		5			
		41	SM-41	5.01E-01		5			
		42	SM-42	4.78E-01		5			
		43	SM-43	3.04E-02		4			
		44	SM-44	8.18E-02		5			
		45	SM-45	5.96E-02		5			
		46	SM-46	3.15E-01		5			
		47	SM-47	6.01E-02		5			
		48	SM-48	1.08E-01		5			

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
		49	SM-49	8.92E-02		5			
		50	SM-50	6.39E-02		5			
		51	SM-51	2.58E-02		4			
		54	SM-54	6.80E-02		5			
		55	SM-55	4.61E-01		5			
		56	SM-56	4.61E-01		5			
		57	SM-57	4.89E-01		5			
		58	SM-58	4.90E-01		5			
		59	SM-59	5.23E-02		5			

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
		60	SM-60	4.89E-01		5			
		84	SM-84	4.61E-01		5			
		85	SM-85-Grizzly Island	4.61E-01		5			
Smith_Tract	148.000	157	Smith Tract	3.91E-02	5	4	0.810	5	
	109.150	1016	Smith Tract - Lincoln Village Tract	4.11E-02	5	4	0.628	5	Use Lincoln Village Tract Life Loss
		114	Stark Tract	1.74E-05		1			
Staten_Island	0.925	174	Staten Island	6.78E-02	2	5	0.009	4	
		1008	Stewart Tract	1.52E-02		3			
Sutter Island	0.925	146	Sutter Island	1.47E-02	2	3	0.002	3	

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
Terminous_Tract 1	0.000	87	Terminous Tract	4.57E-02	1	4	0.006	3	Use Terminous_Tract 2 Life Loss
Terminous_Tract 2	0.925			4.57E-02	2	4	0.006	3	Use Terminous_Tract Failure Rate
	0.925	86	Terminous Tract East	1.83E-02	2	3	0.002	3	Use Terminous_Tract 2 Life Loss
Twitchell_Island	0.925	179	Twitchell Island	5.60E-02	2	5	0.007	4	
Tyler_Island 2	0.000	63	Tyler Island	8.39E-02	1	5	0.000	3	
Union_Island 1	0.000	117	Union Island	2.78E-02	1	4	0.000	3	Use Union_Island 1 Life Loss
	0.000	112	Union Island East	7.01E-05	1	1	0.000	1	Use Union_Island 1 Life Loss
	0.000	113	Union Island South East	1.62E-03	1	1	0.000	1	Use Union_Island 1 Life Loss
		1006	Upper Andrus Island	5.82E-02		5			

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
Upper_Roberts_Island	0.000	115	Upper Roberts Island	1.65E-02	1	3	0.000	2	
		200	Van Sickle Island	1.04E-01		5			
Veale_Tract 1	1.850	129	Veale Tract 1	1.59E-02	3	3	0.004	3	
Venice_Island	0.925	150	Venice Island	7.31E-02	2	5	0.009	4	
Victoria_Island	0.000	21	Victoria Island	5.73E-02	1	5	0.000	3	
Walnut_Grove	2.775	62	Walnut Grove	1.09E-02	3	3	0.004	3	
		165	Walthal Tract	3.43E-02		4			
Webb_Tract	0.925	4	Webb Tract	4.83E-02	2	4	0.006	3	
		158	Weber Tract	1.63E-02		3			

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
		135	West Sacramento 1	5.90E-03		2			
		1004	West Sacramento 2	5.90E-03		2			
Woodward_Island	0.000	19	Woodward Island	4.83E-02	1	4	0.000	3	
Wright-Elmwood_Tract	2.775	190	Wright-Elmwood Tract	2.88E-02	3	4	0.011	4	
Zone 14	0.925				2				
Zone 148	0.000				1				
Zone 162	0.925				2				
Zone 186	0.000				1				
Zone 216	0.925				2				

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
Zone 81	0.000				1				

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Table B-3. Life Loss Risk Calculations, sorted by Life Loss Index

From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
Sargent_Barnhart_Tract 2	96.200	191	Sargent Barnhart Tract	7.43E-02	5	5	1.000	5	Use Sargent Barnhart Tract Failure Rates
Smith_Tract	148.000	157	Smith Tract	3.91E-02	5	4	0.810	5	
Shima_Tract	195.175	187	Shima Tract	2.36E-02	5	3	0.644	5	
Lincoln_Village_Tract	109.150			4.11E-02	5	4	0.628	5	Use Smith Tract - Lincoln Village Tract Failure Rate
	109.150	1016	Smith Tract - Lincoln Village Tract	4.11E-02	5	4	0.628	5	Use Lincoln Village Tract Life Loss
Boggs_Tract	90.650	159	Boggs Tract	1.82E-02	5	3	0.231	5	
Sherman_Island	14.800	1015	Sherman Island	9.46E-02	4	5	0.196	5	
Bethel_Island	11.100	10	Bethel Island	6.96E-02	4	5	0.108	5	
Bishop_Tract	19.425	1013	Bishop Tract	1.98E-02	4	3	0.054	4	

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
New_Hope_Tract	2.775	172	New Hope Tract	9.73E-02	3	5	0.038	4	
Rio_Blanco_Tract	13.875	183	Rio Blanco Tract	1.54E-02	4	3	0.030	4	
Sargent_Barnhart_Tract 3	2.775			0.00000	3	5	0.029	4	Use Sargent Barnhart Tract Failure Rates
Byron_Tract 1	1.850	127	Byron Tract	4.51E-02	3	4	0.012	4	Use Byron_Tract 1 Life Loss
Wright-Elmwood_Tract	2.775	190	Wright-Elmwood Tract	2.88E-02	3	4	0.011	4	
Venice_Island	0.925	150	Venice Island	7.31E-02	2	5	0.009	4	
Jersey_Island	0.925	9	Jersey Island	6.96E-02	2	5	0.009	4	
Hotchkiss_Tract 1	1.850	108	Hotchkiss Tract	3.48E-02	3	4	0.009	4	Use Hotchkiss_Tract 1 Life Loss
Staten_Island	0.925	174	Staten Island	6.78E-02	2	5	0.009	4	

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
Libby_McNeil_Tract 1	3.700	168	Libby McNeil Tract 1	1.52E-02	3	3	0.008	3	
	3.700	167	Libby McNeil Tract 2	1.52E-02	3	3	0.008	3	Use Libby_McNeil_Tract 1 Life Loss
Brack_Tract	0.925	176	Brack Tract	6.01E-02	2	5	0.008	4	
Brannan-Andrus Island	0.925	1007	Brannan-Andrus Island	5.82E-02	2	5	0.008	4	
Twitchell_Island	0.925	179	Twitchell Island	5.60E-02	2	5	0.007	4	
Empire_Tract	0.925	5	Empire Tract	5.02E-02	2	5	0.006	4	
Webb_Tract	0.925	4	Webb Tract	4.83E-02	2	4	0.006	3	
Orwood_Tract	0.925	20	Orwood Tract	4.81E-02	2	4	0.006	3	
Shin_Kee_Tract	0.925	182	Shin Kee Tract	4.77E-02	2	4	0.006	3	
Bouldin_Island	0.925	177	Bouldin Island	4.65E-02	2	4	0.006	3	

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
Terminous_Tract 2	0.925			4.57E-02	2	4	0.006	3	Use Terminous_Tract Failure Rate
Terminous_Tract 1	0.000	87	Terminous Tract	4.57E-02	1	4	0.006	3	Use Terminous_Tract 2 Life Loss
Bradford_Island	0.925	6	Bradford Island	4.45E-02	2	4	0.006	3	
Holland_Tract	0.925	13	Holland Tract	4.28E-02	2	4	0.006	3	
Netherlands 2	0.925	1000	Netherlands	4.07E-02	2	4	0.005	3	
Grand Island	0.925	147	Grand Island	3.59E-02	2	4	0.005	3	
Hotchkiss_Tract 2	0.925			3.48E-02	2	4	0.005	3	Use Hotchkiss Tract Failure Rates
Palm_Tract	0.925	16	Palm Tract	3.46E-02	2	4	0.004	3	
Canal Ranch	0.925	175	Canal Ranch	3.41E-02	2	4	0.004	3	
Walnut_Grove	2.775	62	Walnut Grove	1.09E-02	3	3	0.004	3	

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
Veale_Tract 1	1.850	129	Veale Tract 1	1.59E-02	3	3	0.004	3	
King_Island	0.925	7	King Island	2.94E-02	2	4	0.004	3	
Quimby_Island	0.925	11	Quimby Island	2.91E-02	2	4	0.004	3	
Coney_Island	0.925	32	Coney Island	2.36E-02	2	3	0.003	3	
Fabian_Tract	0.925	163	Fabian Tract	2.35E-02	2	3	0.003	3	
Clifton Court Forebay	0.925	1010	Clifton Court Forebay South	2.15E-02	2	3	0.003	3	Use Clifton Court Forebay Life Loss
Clifton Court Forebay Water	0.925			2.15E-02	2	3	0.003	3	Use Clifton Court Forebay South Failure Rate
Glanville_Tract	0.925	170	Glanville Tract	2.11E-02	2	3	0.003	3	
Pierson_Tract	0.925	149	Pierson Tract	2.01E-02	2	3	0.003	3	

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
Pico_Naglee_Tract	3.700	126	Pico Naglee Tract	4.88E-03	3	1	0.003	3	
	0.925	86	Terminous Tract East	1.83E-02	2	3	0.002	3	Use Terminous_Tract 2 Life Loss
		162	Fabian Tract South West 2	1.81E-02	2	3	0.002	3	Use Fabian_Tract Life Loss
Sutter Island	0.925	146	Sutter Island	1.47E-02	2	3	0.002	3	
		216	Fabian Tract South West 1	1.13E-02	2	3	0.001	3	Use Fabian_Tract Life Loss
Tyler_Island 2	0.000	63	Tyler Island	8.39E-02	1	5	0.000	3	
McDonald_Tract	0.000	12	McDonald Tract	6.20E-02	1	5	0.000	3	
Jones_Tract-Upper_and_Lower	0.000	17	Jones Tract-Upper and Lower	5.88E-02	1	5	0.000	3	
Victoria_Island	0.000	21	Victoria Island	5.73E-02	1	5	0.000	3	
Mandeville_Island	0.000	144	Mandeville Island	5.69E-02	1	5	0.000	3	

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
Lower_Roberts_Island	0.000			5.52E-02	1	5	0.000	3	Use Roberts Island Failure Rate
Middle_Roberts_Island	0.000			5.52E-02	1	5	0.000	3	Use Roberts Island Failure Rate
	0.000	1003	Roberts Island	5.52E-02	1	5	0.000	3	Use Lower_ and Middle_Roberts_Island Life Loss
Medford_Island	0.000	152	Medford Island	5.37E-02	1	5	0.000	3	
Bacon_Island	0.000	15	Bacon Island	5.12E-02	1	5	0.000	3	
Woodward_Island	0.000	19	Woodward Island	4.83E-02	1	4	0.000	3	
Little_Egbert_Tract	0.000	68	Little Egbert Tract	4.76E-02	1	4	0.000	3	
Rindge_Tract	0.000	143	Rindge Tract	4.61E-02	1	4	0.000	3	
Cache_Haas_Tract 2	0.000	89	Cache Haas Tract 2	4.28E-02	1	4	0.000	3	Use Cache_Haas_Tract 1 Life Loss

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
Cache_Haas_Tract 1	0.000	88	Cache Haas Tract 1	3.99E-02	1	4	0.000	3	
McCormack_Williamson_Tract	0.000	169	McCormack Williamson Tract	3.70E-02	1	4	0.000	3	
Rough_and_Ready_Island	0.000	153	Rough and Ready Island	3.44E-02	1	4	0.000	3	
Ryer Island	0.000	210	Ryer Island	3.32E-02	1	4	0.000	3	
Peter Pocket	0.000	72	Peter Pocket	3.06E-02	1	4	0.000	3	
Hastings_Tract 2	0.000	1001	Hastings Tract	2.89E-02	1	4	0.000	3	Use Hastings_Tract 2 Life Loss
		79	Peter's Pocket West	2.82E-02	1	4	0.000	3	Use Peter Pocket Life Loss
Union_Island 1	0.000	117	Union Island	2.78E-02	1	4	0.000	3	Use Union_Island 1 Life Loss
	0.000	80	Cache Haas Tract 1 East	2.64E-02	1	4	0.000	3	Use Cache_Haas_Tract 1 Life Loss
		69	Egbert Tract East	2.63E-02	1	4	0.000	3	Use Egbert_Tract Life Loss

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
		82	Hastings Tract South West	2.63E-02	1	4	0.000	3	Use Hastings_Tract 2 Life Loss
Egbert_Tract	0.000	70	Egbert Tract	2.37E-02	1	3	0.000	2	
Merritt Island	0.000	141	Merritt Island	2.17E-02	1	3	0.000	2	
Upper_Roberts_Island	0.000	115	Upper Roberts Island	1.65E-02	1	3	0.000	2	
Deadhorse Island	0.000	173	Deadhorse Island	1.20E-02	1	3	0.000	2	
	0.000	113	Union Island South East	1.62E-03	1	1	0.000	1	Use Union_Island 1 Life Loss
	0.000	112	Union Island East	7.01E-05	1	1	0.000	1	Use Union_Island 1 Life Loss
Prospect_Island	0.000			0.00000	1		0.000	1	
		41	SM-41	5.01E-01		5			
		1	SM-1	4.90E-01		5			

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
		2	SM-2	4.90E-01		5			
		58	SM-58	4.90E-01		5			
		57	SM-57	4.89E-01		5			
		60	SM-60	4.89E-01		5			
		123	SM-123	4.85E-01		5			
		124	SM-124	4.85E-01		5			
		42	SM-42	4.78E-01		5			
		39	SM-39	4.74E-01		5			
		131	Schafter-Pintail Tract	4.61E-01		5			
		132	SM-132	4.61E-01		5			

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
		55	SM-55	4.61E-01		5			
		56	SM-56	4.61E-01		5			
		84	SM-84	4.61E-01		5			
		85	SM-85-Grizzly Island	4.61E-01		5			
		40	SM-40	3.80E-01		5			
		202	SM-202	3.15E-01		5			
		46	SM-46	3.15E-01		5			
		204	SM-204	1.36E-01		5			
		48	SM-48	1.08E-01		5			
		203	Simmons-Wheeler Island	1.06E-01		5			

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
		201	Honker Bay Club	1.04E-01		5			
		200	Van Sickle Island	1.04E-01		5			
		49	SM-49	8.92E-02		5			
		44	SM-44	8.18E-02		5			
		54	SM-54	6.80E-02		5			
		50	SM-50	6.39E-02		5			
		47	SM-47	6.01E-02		5			
		45	SM-45	5.96E-02		5			
		1006	Upper Andrus Island	5.82E-02		5			
		166	RD 17 (Mossdale)	5.79E-02		5			

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
		1002	Drexler Tract	5.52E-02		5			
		59	SM-59	5.23E-02		5			
		133	SM-133	4.55E-02		4			
		134	SM-134	4.55E-02		4			
		165	Walthal Tract	3.43E-02		4			
		43	SM-43	3.04E-02		4			
		119	Paradise Junction	2.93E-02		4			
		118	Pescadero	2.93E-02		4			
		198	SM-198	2.83E-02		4			
		51	SM-51	2.58E-02		4			

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
		109	Dutch Slough East	2.52E-02		4			
		14	Dutch Slough West	2.34E-02		3			
		158	Weber Tract	1.63E-02		3			
		1009	Mossdale R.D. No. 2107	1.52E-02		3			
		1008	Stewart Tract	1.52E-02		3			
		148	Elk Grove South West	1.25E-02		3			
		171	Cosumnes River Area	1.00E-02		3			
		120	McMullin Ranch	8.90E-03		2			
		77	Elk Grove South East	6.46E-03		2			
		1012	Atlas Tract	6.16E-03					

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
		196	Sacramento Pocket Area	5.90E-03		2			
		135	West Sacramento 1	5.90E-03		2			
		1004	West Sacramento 2	5.90E-03		2			
		1014	McMullin Ranch-River Junction Tract	2.90E-03		1			
		75	N. of Glanville Tract	2.31E-03		1			
		1005	Elk Grove	1.76E-03		1			
		78	Elk Grove South	1.76E-03		1			
		197	Elk Grove West	1.76E-03		1			
		121	Kasson District	1.73E-03		1			

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From Appendix 12c DRMS Draft Report 4		From Table 13-8 from DRMS Draft 4 Report			Calculations				Notes
Zone	Maximum Mean Life Loss	URS_ID	URS Name	Annual Mean No. of Failures	Life Loss Category	Failure Rate Category	Life Loss Risk Index	Risk Category (Table 4-1)	
		185	Atlas Tract East	5.53E-04					
		114	Stark Tract	1.74E-05		1			
Zone 14	0.925				2				
Zone 162	0.925				2				
Zone 216	0.925				2				
Zone 148	0.000				1				
Zone 186	0.000				1				
Zone 81	0.000				1				

APPENDIX B

Table B-4. Damage Costs Calculations, Sorted Alphabetically

From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
			Atlas Tract	0.01		2			
			Atlas Tract East	0.000553		1			
Bacon_Island	Bacon_Island	28.8	Bacon Island	0.0512	2	5	0.012	4	
Bethel_Island	Bethel_Island	169.7	Bethel Island	0.0696	4	5	0.096	5	
Bishop_Tract	Bishop_Tract	89.7	Bishop Tract	0.0198	3	3	0.014	3	
Bixler_Tract	Veale_Tract 1	0.8		0.0159	1	3	0.000	2	Use Veale Tract Failure Probability
Boggs_Tract	Zone 159	732.9	Boggs Tract	0.0182	5	3	0.109	5	
Bouldin_Island	Bouldin_Island	20.0	Bouldin Island	0.0465	2	4	0.008	3	

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Brack_Tract	Brack_Tract	5.1	Brack Tract	0.0601	1	5	0.003	3	
Bradford_Island	Bradford_Island	15.2	Bradford Island	0.0445	2	4	0.006	3	
Brannan-Andrus Island	Brannan-Andrus Island	145.8	Brannan-Andrus Island	0.0582	4	5	0.069	5	
Browns_Island	Browns_Island	0.0			1		0.000	1	
Byron_Tract 1	Byron_Tract 1	42.0	Byron Tract	0.0451	2	4	0.015	3	Use Byron Tract Failure Probability
Byron_Tract 2	Byron_Tract 2	19.5		0.0451	2	4	0.007	3	Use Byron Tract Failure Probability
Byron_Tract 3	Byron_Tract 3	29.2		0.0451	2	4	0.011	3	Use Byron Tract Failure Probability
Cache_Haas_Tract 1	Moore Tract 3	38.2	Cache Haas Tract 1	0.0399	2	4	0.012	3	

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
		38.2		0.0264	2	4	0.008	3	Use Cache_Haas_ Tract 1 Damages
Cache_Haas_Tract 2	Moore Tract 1	2.9	Cache Haas Tract 2	0.0428	1	4	0.001	3	
Canal Ranch	Canal Ranch	9.4	Canal Ranch	0.0341	1	4	0.003	3	
Chipps_Island	Chipps_Island	0.0			1		0.000	1	
Clifton Court Forebay Water	Clifton Court Forebay Water	3.9		0.0215	1	3	0.001	2	Use Clifton Court Forebay South Failure Probability
		3.9	Clifton Court Forebay South	0.0215	1	3	0.001	2	Use Clifton Court Forebay Water Damages
Coney_Island	Coney_Island	14.6	Coney Island	0.0236	2	3	0.003	3	
			Cosumnes River Area	0.01		3	0.000		

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Deadhorse Island	Deadhorse Island	0.9	Deadhorse Island	0.012	1	3	0.000	2	
Decker_Island	Decker_Island	1.5			1		0.000	1	
Discovery_Bay	Discovery_Bay	760.744		0.0451	5	4	0.280	5	Use Byron Tract Failure Probability
			Drexler Tract	0.0552		5	0.000		
			Dutch Slough East	0.0252		4	0.000		
			Dutch Slough West	0.0234		3	0.000		
Egbert_Tract	Zone 70	11.1	Egbert Tract	0.0237	2	3	0.002	3	
		11.1		0.0263	2	4	0.002	3	Use Damage from Egbert_Tract
Elk_Grove 1	Zone 76	429.3	Elk Grove	0.00176	4	1	0.006	4	

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
		429.3		0.00176	4	1	0.006	4	Use Damage from Elk_Grove 1
		429.3		0.00646	4	2	0.023	4	Use Damage from Elk_Grove 1
		429.3		0.0125	4	3	0.044	4	Use Damage from Elk_Grove 1
		429.3		0.00176	4	1	0.006	4	Use Damage from Elk_Grove 1
Empire_Tract	Empire_Tract	8.4	Empire Tract	0.0502	1	5	0.003	3	
Fabian_Tract	Fabian_Tract	24.7	Fabian Tract	0.0235	2	3	0.005	3	
		24.7		0.0113	2	3	0.002	3	Use Damage from Fabian_Tract
		24.7		0.0181	2	3	0.004	3	Use Damage from Fabian_Tract
Fay Island	Fay Island	0.0			1		0.000	1	

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Glanville_Tract	Glanville_Tract	28.3	Glanville Tract	0.0211	2	3	0.005	3	
Gliole_District	Netherlands 2	7.3		0.0407	1	4	0.002	3	Use Netherlands Failure Probability
Grand Island	Grand Island	163.0	Grand Island	0.0359	4	4	0.048	4	
Hastings_Tract 1	Hastings_Tract 1	0.0	Hastings Tract	0.0289	1	4	0.000	3	
Hastings_Tract 2	Hastings_Tract 2	7.2	Hastings Tract South West	0.0263	1	4	0.002	3	
Holland_Land	Netherlands 5	3.5		0.0407	1	4	0.001	3	Use Netherlands Failure Probability
Holland_Tract	Holland_Tract	13.1	Holland Tract	0.0428	2	4	0.005	3	
Honker_Bay_Club	SM-201	2.0	Honker Bay Club	0.104	1	5	0.002	3	

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
			Hotchkiss Tract	0.0348		4	0.000		
Hotchkiss_Tract 1	Hotchkiss_Tract 1	71.0		0.0348	3	4	0.020	4	Use Hotchkiss Tract Failure Probability
Hotchkiss_Tract 2	Hotchkiss_Tract 2	1.3		0.0348	1	4	0.000	3	Use Hotchkiss Tract Failure Probability
Jersey_Island	Jersey_Island	15.8	Jersey Island	0.0696	2	5	0.009	4	
Jones_Tract-Upper_and_Lower	Jones_Tract	105.5	Jones Tract-Upper and Lower	0.0588	4	5	0.051	5	
Kasson_District	Zone 121	4.5	Kasson District	0.00173	1	1	0.000	1	
King_Island	King_Island	29.2	King Island	0.0294	2	4	0.007	3	
Libby_McNeil_Tract 1	Pierson District 3	13.7	Libby McNeil Tract 1	0.0152	2	3	0.002	3	

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Libby_McNeil_Tract 2	Pierson District 2	0.9	Libby McNeil Tract 2	0.0152	1	3	0.000	2	
Liberte Island	Liberte Island	9.6			1		0.000	1	
Lincoln_Village_Tract	Sargent_Barnhart_Tract 2	742.7		0.0411	5	4	0.249	5	Use Smith Tract _ Lincoln Village Tract Failure Probability
Lisbon_District	Netherlands 4	66.9		0.0407	3	4	0.022	4	Use Netherlands Failure Probability
Little Holland Tract	Little Holland Tract	0.0			1		0.000	1	
Little_Egbert_Tract	Zone 68	15.4	Little Egbert Tract	0.0476	2	4	0.006	3	
Lower_Roberts_Island	Roberts_Island 2	1.1		0.0552	1	5	0.000	3	Use Roberts Island Failure Probability
Mandeville_Island	Mandeville_Island	5.2	Mandeville Island	0.0569	1	5	0.002	3	

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
McCormack_Williamson_Tract	McCormack_Williamson_Tract	4.1	McCormack Williamson Tract	0.037	1	4	0.001	3	
McDonald_Tract	McDonald_Tract	23.8	McDonald Tract	0.062	2	5	0.012	4	
		26.0	McMullin Ranch	0.0089	2	2	0.002	2	Use McMullin Ranch-River Junction Tract Damage
McMullin_Ranch-River_Junction Tract	Zone 161	26.0	McMullin Ranch-River Junction Tract	0.0029	2	1	0.001	2	
Medford_Island	Medford_Island	7.6	Medford Island	0.0537	1	5	0.003	3	
Merritt Island	Merritt Island	32.1	Merritt Island	0.0217	2	3	0.006	3	
Middle_Roberts_Island	Roberts_Island 1	110.2		0.0552	4	5	0.050	5	Use Roberts Island Failure Probability
			Mossdale R.D. No. 2107	0.0152		3	0.000		

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
			N. of Glanville Tract	0.00231		1	0.000		
Netherlands 1	Netherlands 1	3.6	Netherlands	0.0407	1	4	0.001	3	Use Netherlands Failure Probability
Netherlands 2	Netherlands 3	120.5		0.0407	4	4	0.040	4	Use Netherlands Failure Probability
New_Hope_Tract	New_Hope_Tract	38.4	New Hope Tract	0.0973	2	5	0.030	4	
Orwood_Tract	Palm-Orwood South	49.3	Orwood Tract	0.0481	2	4	0.019	3	
Palm_Tract	Palm-Orwood North	15.9	Palm Tract	0.0346	2	4	0.004	3	
Paradise Junction	Paradise Junction	46.9	Paradise Junction	0.0293	2	4	0.011	3	
Pescadero	Pescadero	86.3	Pescadero	0.0293	3	4	0.021	4	
Peter Pocket	Peter Pocket	1.6	Peter Pocket	0.0306	1	4	0.000	3	

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
		1.6		0.0282	1	4	0.000	3	Use Peter Pocket Damage
Pico_Naglee_Tract	Zone 126	112.9	Pico Naglee Tract	0.00488	4	1	0.004	4	
Pierson_Tract	Pierson District 1	58.1	Pierson Tract	0.0201	3	3	0.010	3	
Pittsburg	Zone 209	50.4			3		0.000	3	
Prospect_Island	Prospect_Island	1.6			1		0.000	1	
Quimby_Island	Quimby_Island	1.0	Quimby Island	0.0291	1	4	0.000	3	
RD 17 (Mossdale)	RD 17 Mossdale	375.8	RD 17 (Mossdale)	0.0579	4	5	0.177	5	
Rindge_Tract	Rindge_Tract	22.3	Rindge Tract	0.0461	2	4	0.008	3	
Rio_Blanco_Tract	Rio_Blanco_Tract	8.4	Rio Blanco Tract	0.0154	1	3	0.001	2	

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Roberts_Island	Roberts_Island 3	0.1	Roberts Island	0.0552	1	5	0.000	3	
Rough_and_Ready_Island	Rough_and_Ready_Island	51.2	Rough and Ready Island	0.0344	3	4	0.014	4	
Ryer Island	Ryer Island	42.0	Ryer Island	0.0332	2	4	0.011	3	
Sacramento_Pocket_Area	Zone 196	9,414.6	Sacramento Pocket Area	0.0059	5	2	0.453	5	
			Sargent Barnhart Tract	0.0743			0.000		
Sargent_Barnhart_Tract 1	Sargent_Barnhart_Tract 1	47.0		0.0743	2	5	0.028	4	Use Sargent Barnhart Tract Failure Probability
Sargent_Barnhart_Tract 2	Wright-Elmwood_Tract-Sargent Barnhart Tract	965.4		0.0743	5	5	0.585	5	Use Sargent Barnhart Tract Failure Probability
Sargent_Barnhart_Tract 3	Sargent_Barnhart_Tract 3	15.1		0.0743	2	5	0.009	4	Use Sargent Barnhart Tract Failure Probability

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Schafter-Pintail Tract	SM-131	2.8	Schafter-Pintail Tract	0.461	1	5	0.011	3	
Sherman_Island	Sherman_Island	51.4	Sherman Island	0.0946	3	5	0.040	4	
Shima_Tract	Shima_Tract	567.2	Shima Tract	0.0236	5	3	0.109	5	
Shin_Kee_Tract	Shin_Kee_Tract	7.0	Shin Kee Tract	0.0477	1	4	0.003	3	
Simmons-Wheeler_Island	SM-203	0.2	Simmons-Wheeler Island	0.106	1	5	0.000	3	
			SM-1	0.49		5	0.000		
SM-123	SM-123	18.2	SM-123	0.485	2	5	0.072	4	
SM-124	SM-124	252.9	SM-124	0.485	4	5	1.000	5	
SM-132	SM-132	0.2	SM-132	0.461	1	5	0.001	3	

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
SM-133	SM-133	0.0	SM-133	0.0455	1	4	0.000	3	
SM-134	SM-134	0.0	SM-134	0.0455	1	4	0.000	3	
SM-198	SM-198	3.9	SM-198	0.0283	1	4	0.001	3	
SM-199	SM-199	1.4			1		0.000	1	
			SM-2	0.49		5	0.000		
SM-202	SM-202	0.2	SM-202	0.315	1	5	0.000	3	
			SM-204	0.136		5	0.000		
SM-39	SM-39	15.9	SM-39	0.474	2	5	0.061	4	
SM-40	SM-40	1.6	SM-40	0.38	1	5	0.005	3	

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
SM-41	SM-41	3.8	SM-41	0.501	1	5	0.016	3	
SM-42	SM-42	1.8	SM-42	0.478	1	5	0.007	3	
SM-43	SM-43	0.2	SM-43	0.0304	1	4	0.000	3	
SM-44	SM-44	5.0	SM-44	0.0818	1	5	0.003	3	
			SM-45	0.0596		5	0.000		
SM-46	SM-46	0.5	SM-46	0.315	1	5	0.001	3	
SM-47	SM-47	0.0	SM-47	0.0601	1	5	0.000	3	
SM-48	SM-48	25.3	SM-48	0.108	2	5	0.022	4	
SM-49	SM-49	28.3	SM-49	0.0892	2	5	0.021	4	

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
			SM-50	0.0639		5	0.000		
SM-51	SM-51	0.0	SM-51	0.0258	1	4	0.000	3	
SM-52	SM-52	4.3			1		0.000	1	
SM-53	SM-53	0.0			1		0.000	1	
SM-54	SM-54	75.1	SM-54	0.068	3	5	0.042	4	
SM-55	SM-55	5.0	SM-55	0.461	1	5	0.019	3	
SM-56	SM-56	3.2	SM-56	0.461	1	5	0.012	3	
SM-57	SM-57	13.8	SM-57	0.489	2	5	0.055	4	
SM-58	SM-58	0.8	SM-58	0.49	1	5	0.003	3	

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
SM-59	SM-59	1.7	SM-59	0.0523	1	5	0.001	3	
SM-60	SM-60	7.8	SM-60	0.489	1	5	0.031	3	
SM-84	SM-84	10.8	SM-84	0.461	2	5	0.041	4	
SM-85-Grizzly_Island	SM-85	15.5	SM-85-Grizzly Island	0.461	2	5	0.058	4	
Smith_Tract	Zone 157	733.2	Smith Tract	0.0391	5	4	0.234	5	
			Smith Tract - Lincoln Village Tract	0.0411		4	0.000		See Lincoln Village
Stark_Tract	Union_Island 4	4.8	Stark Tract	1.74E-05	1	1	0.000	1	
Staten_Island	Staten_Island	11.2	Staten Island	0.0678	2	5	0.006	4	
Stewart_Tract	Stewart_Tract	33.8	Stewart Tract	0.0152	2	3	0.004	3	

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Sutter Island	Sutter Island	22.4	Sutter Island	0.0147	2	3	0.003	3	
Terminous_Tract 1	Terminous_Tract 1	12.1	Terminous Tract	0.0457	2	4	0.004	3	Use Terminous Tract 1 Damage
Terminous_Tract 2	Terminous_Tract 2	41.0			2	4	0.015	3	Use Terminous Tract Failure Probability
Terminous_Tract 3	Terminous_Tract 3	0.6			1	4	0.000	3	Use Terminous Tract Failure Probability
			Terminous Tract East	0.0183		3	0.000		
Twitchell_Island	Twitchell_Island	10.5	Twitchell Island	0.056	2	5	0.005	4	
Tyler_Island 2	Tyler_Island 2	81.5	Tyler Island	0.0839	3	5	0.056	4	
Union_Island 1	Union_Island 1	63.8	Union Island	0.0278	3	4	0.014	4	Use Union Island Failure Probability

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Union_Island 2	Union_Island 2	0.6		0.0278	1	4	0.000	3	Use Union Island Failure Probability
Union_Island 3	Union_Island 3	6.2		0.0278	1	4	0.001	3	Use Union Island Failure Probability
Union_Island 4	Union_Island 5	0.7		0.0278	1	4	0.000	3	Use Union Island Failure Probability
			Union Island East	7.01E-05		1	0.000		
			Union Island South East	0.00162		1	0.000		
			Upper Andrus Island	0.0582		5	0.000		
Upper_Roberts_Island	Roberts_Island 4	35.4	Upper Roberts Island	0.0165	2	3	0.005	3	
Van_Sickle_Island	Van_Sickle_Island	30.5	Van Sickle Island	0.104	2	5	0.026	4	

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Veale_Tract 1	Veale_Tract 2	12.2	Veale Tract 1	0.0159	2	3	0.002	3	
Veale_Tract 2	Veale_Tract 3	4.0		0.0159	1	3	0.001	2	Use Veale_Tract 1 Failure Probability
Venice_Island	Venice_Island	12.8	Venice Island	0.0731	2	5	0.008	4	
Victoria_Island	Victoria_Island	41.5	Victoria Island	0.0573	2	5	0.019	4	
Walnut_Grove	Tyler_Island 1	40.1	Walnut Grove	0.0109	2	3	0.004	3	
Walthal_Tract	Walthal	32.7	Walthal Tract	0.0343	2	4	0.009	3	
Water Canal	Water Canal	0.0			1		0.000	1	
Water Zone 1	Water Zone 1	171.6			4		0.000	4	
Water Zone 2	Water Zone 2	386.0			4		0.000	4	

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Water Zone 3	Water Zone 3	45.7			2		0.000	2	
Water Zone 4	Water Zone 4	31.8			2		0.000	2	
Water Zone 5	Water Zone 5	31.3			2		0.000	2	
Webb_Tract	Webb_Tract	0.4	Webb Tract	0.0483	1	4	0.000	3	
			Weber Tract	0.0163		3	0.000		
West Sacramento North	West Sacramento North	1807.75		0.0059	5	2	0.087	5	Use West Sacramento 1 Failure Probability
West Sacramento South 1	West Sacramento South 1	461.4		0.0059	4	2	0.022	4	Use West Sacramento 1 Failure Probability
West Sacramento South 2	West Sacramento South 2	1.5		0.0059	1	2	0.000	2	Use West Sacramento 1 Failure Probability

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
			West Sacramento 1	0.0059		2	0.000		
			West Sacramento 2	0.0059		2	0.000		
Woodward_Island	Woodward_Island	16.1	Woodward Island	0.0483	2	4	0.006	3	
Wright-Elmwood_Tract	Wright-Elmwood_Tract	10.8	Wright-Elmwood Tract	0.0288	2	4	0.003	3	
Yolo_Bypass	Moore Tract 2	56.2			3		0.000	3	
Zone 120	Zone 120	26.5			2		0.000	2	
Zone 122	Zone 122	0.1			1		0.000	1	
Zone 14	Zone 14	0.4			1		0.000	1	
Zone 148	Zone 148	12.7			2		0.000	2	

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Zone 155	Zone 155	0.3			1		0.000	1	
Zone 158 (Smith Tract_2)	Zone 158	264.9		0.0391	4	4	0.084	4	Use Smith Tract Failure Probability
Zone 160	Zone 160	11.1			2				
Zone 162	Zone 162	3.5			1				
Zone 171	Zone 171	20.0			2				
Zone 185	Zone 185	521.8			5				
Zone 186	Zone 186	3.3			1				
Zone 197	Zone 197	30.0			2				
Zone 206	Zone 206	168.6			4				

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Zone 207	Zone 207	7.4			1				
Zone 214	Zone 214	0.3			1				
Zone 216	Zone 216	0.5			1				
Zone 31	Zone 31	0.4			1				
Zone 33	Zone 33	0.2			1				
Zone 36	Zone 36	6.9			1				
Zone 37	Zone 37	308.4			4				
Zone 38	Zone 38	70.4			3				
Zone 64	Zone 64	6.8			1				

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Zone 65	Zone 65	0.3			1				
Zone 69	Zone 69	0.8			1				
Zone 74	Zone 74	17.1			2				
Zone 75	Zone 75	16.2			2				
Zone 77	Zone 77	9.7			1				
Zone 78	Zone 78	16.5			2				
Zone 79	Zone 79	6.9			1				
Zone 80	Zone 80	8.6			1				
Zone 81	Zone 81	6.3			1				

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Zone 82	Zone 82	5.0			1				
Zone 90	Zone 90	58.2			3				

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Table B-5. Damage Costs Calculations, Sorted by Damage Risk Index

From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
SM-124	SM-124	252.9	SM-124	0.485	4	5	1.000	5	
Sargent_Barnhart_Tract 2	Wright-Elmwood_Tract-Sargent Burnhart Tract	965.4		0.0743	5	5	0.585	5	Use Sargent Barnhart Tract Failure Probability
Sacramento_Pocket_Area	Zone 196	9,414.6	Sacramento Pocket Area	0.0059	5	2	0.453	5	
Discovery_Bay	Discovery_Bay	760.744		0.0451	5	4	0.280	5	Use Byron Tract Failure Probability
Lincoln_Village_Tract	Sargent_Barnhart_Tract 2	742.7		0.0411	5	4	0.249	5	Use Smith Tract _ Lincoln Village Tract Failure Probability
Smith_Tract	Zone 157	733.2	Smith Tract	0.0391	5	4	0.234	5	
RD 17 (Mossdale)	RD 17 Mossdale	375.8	RD 17 (Mossdale)	0.0579	4	5	0.177	5	
Shima_Tract	Shima_Tract	567.2	Shima Tract	0.0236	5	3	0.109	5	

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Boggs_Tract	Zone 159	732.9	Boggs Tract	0.0182	5	3	0.109	5	
Bethel_Island	Bethel_Island	169.7	Bethel Island	0.0696	4	5	0.096	5	
West Sacramento North	West Sacramento North	1807.75		0.0059	5	2	0.087	5	Use West Sacramento 1 Failure Probability
Zone 158 (Smith Tract_2)	Zone 158	264.9		0.0391	4	4	0.084	4	Use Smith Tract Failure Probability
SM-123	SM-123	18.2	SM-123	0.485	2	5	0.072	4	
Brannan-Andrus Island	Brannan-Andrus Island	145.8	Brannan-Andrus Island	0.0582	4	5	0.069	5	
SM-39	SM-39	15.9	SM-39	0.474	2	5	0.061	4	
SM-85-Grizzly_Island	SM-85	15.5	SM-85-Grizzly Island	0.461	2	5	0.058	4	
Tyler_Island 2	Tyler_Island 2	81.5	Tyler Island	0.0839	3	5	0.056	4	

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
SM-57	SM-57	13.8	SM-57	0.489	2	5	0.055	4	
Jones_Tract-Upper_and_Lower	Jones_Tract	105.5	Jones Tract-Upper and Lower	0.0588	4	5	0.051	5	
Middle_Roberts_Island	Roberts_Island 1	110.2		0.0552	4	5	0.050	5	Use Roberts Island Failure Probability
Grand Island	Grand Island	163.0	Grand Island	0.0359	4	4	0.048	4	
		429.3	Elk Grove South West	0.0125	4	3	0.044	4	Use Damage from Elk_Grove 1
SM-54	SM-54	75.1	SM-54	0.068	3	5	0.042	4	
SM-84	SM-84	10.8	SM-84	0.461	2	5	0.041	4	
Netherlands 2	Netherlands 3	120.5		0.0407	4	4	0.040	4	Use Netherlands Failure Probability
Sherman_Island	Sherman_Island	51.4	Sherman Island	0.0946	3	5	0.040	4	

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
SM-60	SM-60	7.8	SM-60	0.489	1	5	0.031	3	
New_Hope_Tract	New_Hope_Tract	38.4	New Hope Tract	0.0973	2	5	0.030	4	
Sargent_Barnhart_Tract 1	Sargent_Barnhart_Tract 1	47.0		0.0743	2	5	0.028	4	Use Sargent Barnhart Tract Failure Probability
Van_Sickle_Island	Van_Sickle_Island	30.5	Van Sickle Island	0.104	2	5	0.026	4	
		429.3	Elk Grove South East	0.00646	4	2	0.023	4	Use Damage from Elk_Grove 1
SM-48	SM-48	25.3	SM-48	0.108	2	5	0.022	4	
West Sacramento South 1	West Sacramento South 1	461.4		0.0059	4	2	0.022	4	Use West Sacramento 1 Failure Probability
Lisbon_District	Netherlands 4	66.9		0.0407	3	4	0.022	4	Use Netherlands Failure Probability

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Pescadero	Pescadero	86.3	Pescadero	0.0293	3	4	0.021	4	
SM-49	SM-49	28.3	SM-49	0.0892	2	5	0.021	4	
Hotchkiss_Tract 1	Hotchkiss_Tract 1	71.0		0.0348	3	4	0.020	4	Use Hotchkiss Tract Failure Probability
Victoria_Island	Victoria_Island	41.5	Victoria Island	0.0573	2	5	0.019	4	
Orwood_Tract	Palm-Orwood South	49.3	Orwood Tract	0.0481	2	4	0.019	3	
SM-55	SM-55	5.0	SM-55	0.461	1	5	0.019	3	
SM-41	SM-41	3.8	SM-41	0.501	1	5	0.016	3	
Byron_Tract 1	Byron_Tract 1	42.0	Byron Tract	0.0451	2	4	0.015	3	Use Byron Tract Failure Probability
Terminous_Tract 2	Terminous_Tract 2	41.0			2	4	0.015	3	Use Terminous Tract Failure Probability

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Bishop_Tract	Bishop_Tract	89.7	Bishop Tract	0.0198	3	3	0.014	3	
Union_Island 1	Union_Island 1	63.8	Union Island	0.0278	3	4	0.014	4	Use Union Island Failure Probability
Rough_and_Ready_Island	Rough_and_Ready_Island	51.2	Rough and Ready Island	0.0344	3	4	0.014	4	
Cache_Haas_Tract 1	Moore Tract 3	38.2	Cache Haas Tract 1	0.0399	2	4	0.012	3	
SM-56	SM-56	3.2	SM-56	0.461	1	5	0.012	3	
Bacon_Island	Bacon_Island	28.8	Bacon Island	0.0512	2	5	0.012	4	
McDonald_Tract	McDonald_Tract	23.8	McDonald Tract	0.062	2	5	0.012	4	
Ryer Island	Ryer Island	42.0	Ryer Island	0.0332	2	4	0.011	3	
Paradise Junction	Paradise Junction	46.9	Paradise	0.0293	2	4	0.011	3	

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From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
			Junction						
Byron_Tract 3	Byron_Tract 3	29.2		0.0451	2	4	0.011	3	Use Byron Tract Failure Probability
Schafter-Pintail Tract	SM-131	2.8	Schafter-Pintail Tract	0.461	1	5	0.011	3	
Pierson_Tract	Pierson District 1	58.1	Pierson Tract	0.0201	3	3	0.010	3	
Walthal_Tract	Walthal	32.7	Walthal Tract	0.0343	2	4	0.009	3	
Sargent_Barnhart_Tract 3	Sargent_Barnhart_Tract 3	15.1		0.0743	2	5	0.009	4	Use Sargent Barnhart Tract Failure Probability
Jersey_Island	Jersey_Island	15.8	Jersey Island	0.0696	2	5	0.009	4	
Rindge_Tract	Rindge_Tract	22.3	Rindge Tract	0.0461	2	4	0.008	3	
		38.2	Cache Haas Tract 1 East	0.0264	2	4	0.008	3	Use Cache_Haas_ Tract 1 Damages

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Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Venice_Island	Venice_Island	12.8	Venice Island	0.0731	2	5	0.008	4	
Bouldin_Island	Bouldin_Island	20.0	Bouldin Island	0.0465	2	4	0.008	3	
Byron_Tract 2	Byron_Tract 2	19.5		0.0451	2	4	0.007	3	Use Byron Tract Failure Probability
King_Island	King_Island	29.2	King Island	0.0294	2	4	0.007	3	
SM-42	SM-42	1.8	SM-42	0.478	1	5	0.007	3	
Woodward_Island	Woodward_Island	16.1	Woodward Island	0.0483	2	4	0.006	3	
Staten_Island	Staten_Island	11.2	Staten Island	0.0678	2	5	0.006	4	
Elk_Grove 1	Zone 76	429.3	Elk Grove	0.00176	4	1	0.006	4	
		429.3	Elk Grove South	0.00176	4	1	0.006	4	Use Damage from Elk_Grove 1

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Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
		429.3	Elk Grove West	0.00176	4	1	0.006	4	Use Damage from Elk_Grove 1
Little_Egbert_Tract	Zone 68	15.4	Little Egbert Tract	0.0476	2	4	0.006	3	
Merritt Island	Merritt Island	32.1	Merritt Island	0.0217	2	3	0.006	3	
Bradford_Island	Bradford_Island	15.2	Bradford Island	0.0445	2	4	0.006	3	
Glanville_Tract	Glanville_Tract	28.3	Glanville Tract	0.0211	2	3	0.005	3	
SM-40	SM-40	1.6	SM-40	0.38	1	5	0.005	3	
Twitchell_Island	Twitchell_Island	10.5	Twitchell Island	0.056	2	5	0.005	4	
Upper_Roberts_Island	Roberts_Island 4	35.4	Upper Roberts Island	0.0165	2	3	0.005	3	

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Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Fabian_Tract	Fabian_Tract	24.7	Fabian Tract	0.0235	2	3	0.005	3	
Holland_Tract	Holland_Tract	13.1	Holland Tract	0.0428	2	4	0.005	3	
Palm_Tract	Palm-Orwood North	15.9	Palm Tract	0.0346	2	4	0.004	3	
Pico_Naglee_Tract	Zone 126	112.9	Pico Naglee Tract	0.00488	4	1	0.004	4	
Terminous_Tract 1	Terminous_Tract 1	12.1	Terminous Tract	0.0457	2	4	0.004	3	Use Terminous Tract 1 Damage
Stewart_Tract	Stewart_Tract	33.8	Stewart Tract	0.0152	2	3	0.004	3	
		24.7	Fabian Tract South West 2	0.0181	2	3	0.004	3	Use Damage from Fabian_Tract
Walnut_Grove	Tyler_Island 1	40.1	Walnut Grove	0.0109	2	3	0.004	3	
Empire_Tract	Empire_Tract	8.4	Empire Tract	0.0502	1	5	0.003	3	

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Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
SM-44	SM-44	5.0	SM-44	0.0818	1	5	0.003	3	
Medford_Island	Medford_Island	7.6	Medford Island	0.0537	1	5	0.003	3	
SM-58	SM-58	0.8	SM-58	0.49	1	5	0.003	3	
Coney_Island	Coney_Island	14.6	Coney Island	0.0236	2	3	0.003	3	
Shin_Kee_Tract	Shin_Kee_Tract	7.0	Shin Kee Tract	0.0477	1	4	0.003	3	
Sutter Island	Sutter Island	22.4	Sutter Island	0.0147	2	3	0.003	3	
Canal Ranch	Canal Ranch	9.4	Canal Ranch	0.0341	1	4	0.003	3	
Wright-Elmwood_Tract	Wright-Elmwood_Tract	10.8	Wright-Elmwood Tract	0.0288	2	4	0.003	3	
Brack_Tract	Brack_Tract	5.1	Brack Tract	0.0601	1	5	0.003	3	

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Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Mandeville_Island	Mandeville_Island	5.2	Mandeville Island	0.0569	1	5	0.002	3	
Gliole_District	Netherlands 2	7.3		0.0407	1	4	0.002	3	Use Netherlands Failure Probability
		11.1	Egbert Tract East	0.0263	2	4	0.002	3	Use Damage from Egbert_Tract
		24.7	Fabian Tract South West 1	0.0113	2	3	0.002	3	Use Damage from Fabian_Tract
Egbert_Tract	Zone 70	11.1	Egbert Tract	0.0237	2	3	0.002	3	
		26.0	McMullin Ranch	0.0089	2	2	0.002	2	Use McMullin Ranch-River Junction Tract Damage
Honker_Bay_Club	SM-201	2.0	Honker Bay Club	0.104	1	5	0.002	3	
Libby_McNeil_Tract 1	Pierson District 3	13.7	Libby McNeil Tract 1	0.0152	2	3	0.002	3	

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Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Veale_Tract 1	Veale_Tract 2	12.2	Veale Tract 1	0.0159	2	3	0.002	3	
Hastings_Tract 2	Hastings_Tract 2	7.2	Hastings Tract South West	0.0263	1	4	0.002	3	
Union_Island 3	Union_Island 3	6.2		0.0278	1	4	0.001	3	Use Union Island Failure Probability
McCormack_Williamson_Tract	McCormack_Williamson_Tract	4.1	McCormack Williamson Tract	0.037	1	4	0.001	3	
SM-46	SM-46	0.5	SM-46	0.315	1	5	0.001	3	
Netherlands 1	Netherlands 1	3.6	Netherlands	0.0407	1	4	0.001	3	Use Netherlands Failure Probability
Holland_Land	Netherlands 5	3.5		0.0407	1	4	0.001	3	Use Netherlands Failure Probability
Rio_Blanco_Tract	Rio_Blanco_Tract	8.4	Rio Blanco Tract	0.0154	1	3	0.001	2	

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Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Cache_Haas_Tract 2	Moore Tract 1	2.9	Cache Haas Tract 2	0.0428	1	4	0.001	3	
SM-198	SM-198	3.9	SM-198	0.0283	1	4	0.001	3	
SM-59	SM-59	1.7	SM-59	0.0523	1	5	0.001	3	
Clifton Court Forebay Water	Clifton Court Forebay Water	3.9		0.0215	1	3	0.001	2	Use Clifton Court Forebay South Failure Probability
		3.9	Clifton Court Forebay South	0.0215	1	3	0.001	2	Use Clifton Court Forebay Water Damages
SM-132	SM-132	0.2	SM-132	0.461	1	5	0.001	3	
McMullin_Ranch-River_Junction Tract	Zone 161	26.0	McMullin Ranch-River Junction Tract	0.0029	2	1	0.001	2	
Veale_Tract 2	Veale_Tract 3	4.0		0.0159	1	3	0.001	2	Use Veale_Tract 1 Failure Probability

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Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Lower_Roberts_Island	Roberts_Island 2	1.1		0.0552	1	5	0.000	3	Use Roberts Island Failure Probability
SM-202	SM-202	0.2	SM-202	0.315	1	5	0.000	3	
Peter Pocket	Peter Pocket	1.6	Peter Pocket	0.0306	1	4	0.000	3	
Hotchkiss_Tract 2	Hotchkiss_Tract 2	1.3		0.0348	1	4	0.000	3	Use Hotchkiss Tract Failure Probability
		1.6	Peter's Pocket West	0.0282	1	4	0.000	3	Use Peter Pocket Damage
Terminous_Tract 3	Terminous_Tract 3	0.6			1	4	0.000	3	Use Terminous Tract Failure Probability
Quimby_Island	Quimby_Island	1.0	Quimby Island	0.0291	1	4	0.000	3	
Union_Island 4	Union_Island 5	0.7		0.0278	1	4	0.000	3	Use Union Island Failure Probability
Webb_Tract	Webb_Tract	0.4	Webb Tract	0.0483	1	4	0.000	3	

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Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Simmons-Wheeler_Island	SM-203	0.2	Simmons-Wheeler Island	0.106	1	5	0.000	3	
Union_Island 2	Union_Island 2	0.6		0.0278	1	4	0.000	3	Use Union Island Failure Probability
Libby_McNeil_Tract 2	Pierson District 2	0.9	Libby McNeil Tract 2	0.0152	1	3	0.000	2	
Bixler_Tract	Veale_Tract 1	0.8		0.0159	1	3	0.000	2	Use Veale Tract Failure Probability
Deadhorse Island	Deadhorse Island	0.9	Deadhorse Island	0.012	1	3	0.000	2	
West Sacramento South 2	West Sacramento South 2	1.5		0.0059	1	2	0.000	2	Use West Sacramento 1 Failure Probability
Kasson_District	Zone 121	4.5	Kasson District	0.00173	1	1	0.000	1	
Roberts_Island	Roberts_Island 3	0.1	Roberts Island	0.0552	1	5	0.000	3	

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Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
SM-43	SM-43	0.2	SM-43	0.0304	1	4	0.000	3	
Stark_Tract	Union_Island 4	4.8	Stark Tract	0.0000174	1	1	0.000	1	
Hastings_Tract 1	Hastings_Tract 1	0.0	Hastings Tract	0.0289	1	4	0.000	3	
Browns_Island	Browns_Island	0.0			1		0.000	1	
Chipps_Island	Chipps_Island	0.0			1		0.000	1	
			Cosumnes River Area	0.01		3	0.000		
Decker_Island	Decker_Island	1.5			1		0.000	1	
			Drexler Tract	0.0552		5	0.000		
			Dutch Slough East	0.0252		4	0.000		

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Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
			Dutch Slough West	0.0234		3	0.000		
Fay Island	Fay Island	0.0			1		0.000	1	
			Hotchkiss Tract	0.0348		4	0.000		
Liberte Island	Liberte Island	9.6			1		0.000	1	
Little Holland Tract	Little Holland Tract	0.0			1		0.000	1	
			Mossdale R.D. No. 2107	0.0152		3	0.000		
			N. of Glanville Tract	0.00231		1	0.000		
Pittsburg	Zone 209	50.4			3		0.000	3	

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Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Prospect_Island	Prospect_Island	1.6			1		0.000	1	
			Sargent Barnhart Tract	0.0743			0.000		
			SM-1	0.49		5	0.000		
SM-133	SM-133	0.0	SM-133	0.0455	1	4	0.000	3	
SM-134	SM-134	0.0	SM-134	0.0455	1	4	0.000	3	
SM-199	SM-199	1.4			1		0.000	1	
			SM-2	0.49		5	0.000		
			SM-204	0.136		5	0.000		
			SM-45	0.0596		5	0.000		

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Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
SM-47	SM-47	0.0	SM-47	0.0601	1	5	0.000	3	
			SM-50	0.0639		5	0.000		
SM-51	SM-51	0.0	SM-51	0.0258	1	4	0.000	3	
SM-52	SM-52	4.3			1		0.000	1	
SM-53	SM-53	0.0			1		0.000	1	
			Smith Tract - Lincoln Village Tract	0.0411		4	0.000		See Lincoln Village
			Terminous Tract East	0.0183		3	0.000		
			Union Island East	0.0000701		1	0.000		

From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
			Union Island South East	0.00162		1	0.000		
			Upper Andrus Island	0.0582		5	0.000		
Water Canal	Water Canal	0.0			1		0.000	1	
Water Zone 1	Water Zone 1	171.6			4		0.000	4	
Water Zone 2	Water Zone 2	386.0			4		0.000	4	
Water Zone 3	Water Zone 3	45.7			2		0.000	2	
Water Zone 4	Water Zone 4	31.8			2		0.000	2	
Water Zone 5	Water Zone 5	31.3			2		0.000	2	
			Weber Tract	0.0163		3	0.000		

From Tables 12.7 and 12.8 in DRMS Draft 4 Report, 2008.			From Table 13.8 from DRMS Draft 4 Report, 2008.		Calculations				Notes
Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
			West Sacramento 1	0.0059		2	0.000		
			West Sacramento 2	0.0059		2	0.000		
Yolo_Bypass	Moore Tract 2	56.2			3		0.000	3	
Zone 120	Zone 120	26.5			2		0.000	2	
Zone 122	Zone 122	0.1			1		0.000	1	
Zone 14	Zone 14	0.4			1		0.000	1	
Zone 148	Zone 148	12.7			2		0.000	2	
Zone 155	Zone 155	0.3			1		0.000	1	
			Atlas Tract	0.01		2			

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Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
			Atlas Tract East	0.000553		1			
Zone 160	Zone 160	11.1			2				
Zone 162	Zone 162	3.5			1				
Zone 171	Zone 171	20.0			2				
Zone 185	Zone 185	521.8			5				
Zone 186	Zone 186	3.3			1				
Zone 197	Zone 197	30.0			2				
Zone 206	Zone 206	168.6			4				
Zone 207	Zone 207	7.4			1				

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Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Zone 214	Zone 214	0.3			1				
Zone 216	Zone 216	0.5			1				
Zone 31	Zone 31	0.4			1				
Zone 33	Zone 33	0.2			1				
Zone 36	Zone 36	6.9			1				
Zone 37	Zone 37	308.4			4				
Zone 38	Zone 38	70.4			3				
Zone 64	Zone 64	6.8			1				
Zone 65	Zone 65	0.3			1				

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Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Zone 69	Zone 69	0.8			1				
Zone 74	Zone 74	17.1			2				
Zone 75	Zone 75	16.2			2				
Zone 77	Zone 77	9.7			1				
Zone 78	Zone 78	16.5			2				
Zone 79	Zone 79	6.9			1				
Zone 80	Zone 80	8.6			1				
Zone 81	Zone 81	6.3			1				
Zone 82	Zone 82	5.0			1				

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Island Name	Old Island Name	Total Asset Damages* $M	URS Name	Annual Mean No. of Failures	Damages Category	Failure Rate Category	Risk Index	Damages Risk Category	
Zone 90	Zone 90	58.2			3				