US Army Corps of Engineers®

LAS GALLINAS CREEK, CA
Preliminary Flood Damage Analysis

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San Francisco District

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1. Introduction

1.1. Purpose

The purpose of this report is to provide a preliminary estimate of the “pre-project” (or “without-project”) flooding damage in the Santa Venetia community which occurs as a result of overflows from Las Gallinas Creek, including flows from tidal events. For practical reasons (cost), this estimate is intended to be preliminary, and it has been completed with a level of detail that is somewhat less than would generally be expected of a U.S. Army Corps of Engineers (USACE) flood risk management feasibility study. More detailed hydrologic, hydraulic, elevation, and economic data would improve the accuracy and reliability of the damage estimate. Also, whereas a more complete USACE analysis would, among other things, identify the project alternative that maximizes net national monetary benefits (known as National Economic Development, or NED), this analysis simply estimates without-project flooding damages to better understand the likelihood of there being a Federal interest in a flood risk management project under the without-project conditions. A full NED analysis would evaluate projects of various types and scales to find the project alternative which maximizes the net economic benefits to the national economy.

1.2. Methodology Overview

The principal guidance referenced for this analysis comes from the USACE “*Planning Guidance Notebook*” (PGN), ER 1105-2-100, with specific guidance from Appendix D – Economic and Social Considerations. Additional guidance on risk-based analysis has been obtained from USACE ER 1105-2-101, *Risk Analysis for Flood Damage Reduction Studies*, dated January 3, 2006. Flood damage to structures and contents was estimated within the Hydrologic Engineering Center’s Flood Damage Analysis model (HEC-FDA) version 1.2.5. This model has been certified for use in USACE flood risk management studies. Benefits and costs are expressed in average annual terms at 2012 price levels.

By policy, USACE Flood Risk Management studies must evaluate the flooding problem (and potential measures to reduce the risk of flooding) against four “accounts”—the National Economic Development (NED), Regional Economic Development (RED), Environmental Quality (EQ), and Other Social Effects (OSE) accounts. While all four accounts are generally ultimately considered in the evaluation of potential Federal investments, this without-project flood damage analysis focuses primarily on the NED account, and briefly addresses the RED and OSE accounts. The PGN describes the NED account as such:

> *Contributions to national economic development (NED) are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and the rest of the Nation. Contributions to NED include increases in the net value of those goods and services that are marketed, and also of those that may not be marketed.*

The NED account is exclusively concerned with national net economic damages, and thus does not include local or regional economic transfers. For example, according to the PGN, the prevention of income loss results in a contribution to national economic development only to the extent that such loss cannot be compensated for by postponement of an activity or transfer of the activity to other establishments. Local or regional economic benefits of project construction are intended to be captured in the RED and OSE accounts. The NED damage categories considered for this study are Structure and Content Damages.

In areas with previous flood damage and with experience in the evacuation of inundated (or potentially inundated) areas, if there is at least a minimal amount of warning time, many automobiles tend to be moved from the floodplain to eliminate the risk of damage. Given the history of flooding in the area and the small distance between the floodplain and higher ground in the project area, it is likely that the residents in the floodplain would move many of the automobiles out of the floodplain before they were damaged by the floodwaters, although many would remain. Because in USACE flood risk management studies the damage to automobiles typically amounts to less than 5% of the total direct flood damage estimated, for practical reasons and to minimize the cost of the study effort no automobile damages are calculated for this preliminary analysis.

The water-surface profile data consists of stage-probability data for each of the eight exceedance probabilities—50%, 20%, 10%, 4%, 2%, 1%, 0.4% and 0.2% events. This report uses exceedance probabilities to characterize floods. The exceedance probability is the reciprocal of what is often referred to as the “return period.” The return period (or recurrence interval) of an annual maximum flood has a return period of X years if its magnitude is equaled or exceeded once, on the average, every X years. As an example, a 100-year return period means that there is a 1% (1/100) probability of an occurrence in any one year.

The structure elevations were provided to the USACE by the Marin County Flood Control and Water Conservation District (District). All elevations are in feet and are referenced to the National Geodetic Vertical Datum of 1929 (NGVD29).

2. Study Area Value at Risk from Flooding

2.1. Historical Flooding

Las Gallinas Creek has overflowed its banks three times since 1982[1]; once in 1982 and twice in 1983. During the 1982 event, tidal and fluvial waters combined to flood 50 homes in the study area. The two flood events in 1983 flooded 160 and 100 homes, respectively. Since that time, a wooden floodwall has been completed, and a pump system continues to be maintained to reduce the depth and impact of tidal or fluvial events that breach or overtop the existing levees and floodwall.

2.2. Structures at Risk from Flooding

The inventory field work was completed by USACE economists and planners in 2009. Figure 1 is an aerial photograph of the study area with the structure types shown. The structure types were provided by the District.

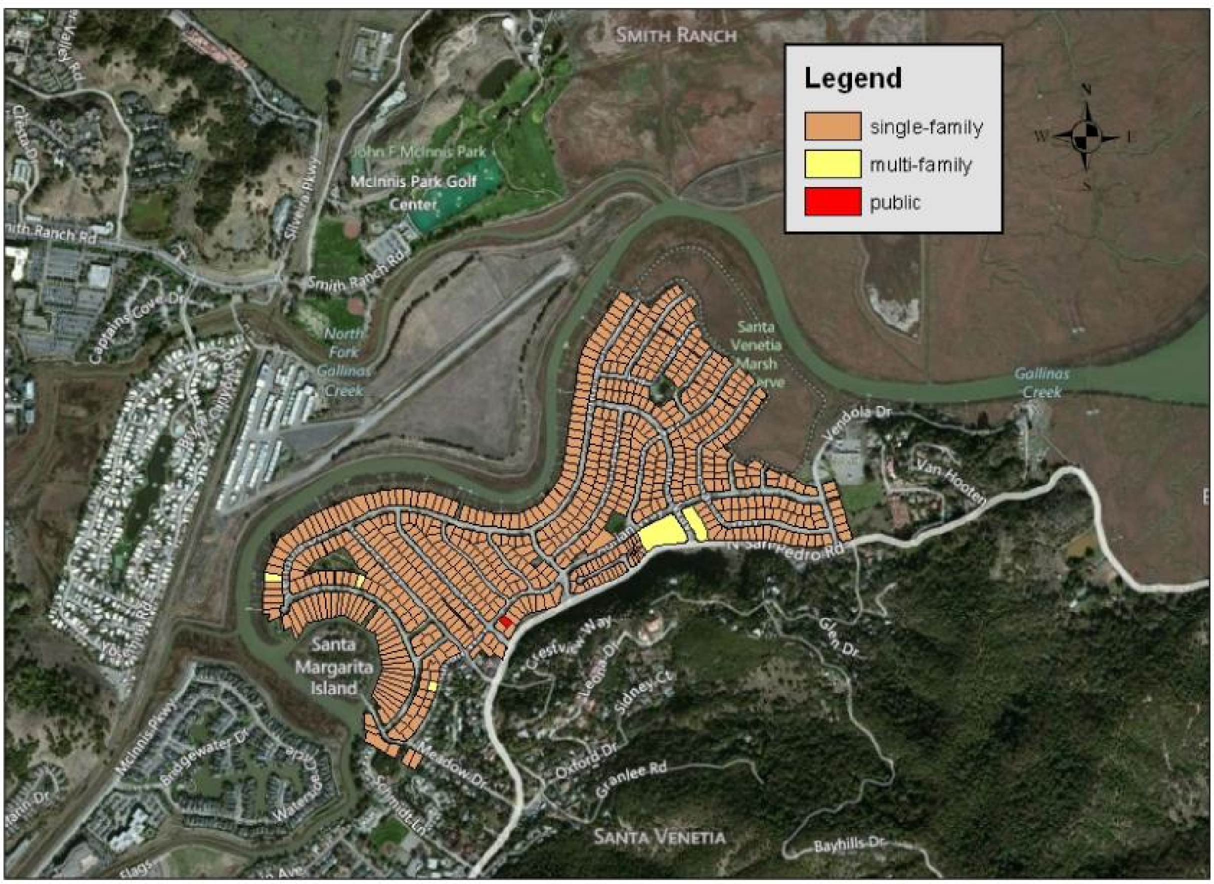

Figure 1: Structure Types in the Study Area

[1] Historical flood information taken from the 2003 USACE Initial Appraisal Report.

For the damage analysis, the structures in the floodplain were classified as one of the following:

1-story Single Family Residential (SFR1)
2-story Single Family Residential (SFR2)
1-story Multi-Family Residential (MFR1)
2-story Multi Family Residential (MFR2)

In reality there are additional sub-categories of residential properties in the floodplain (condominiums, duplexes, triplexes, etc.), but because most of the accepted relationships used to quantify flooding damage have been developed for a broader category of structure, no attempt was made to further subdivide the structure inventory.

Also, there are a few schools and churches within the study area that have not been included into this preliminary analysis. The GIS parcel data obtained listed such structures as “tax exempt” and thus had not collected the characteristics that allow the county to assess property taxes. Should this study go forward and result in a Detailed Project Report or other feasibility-level document, public structures will be added to the damageable property.

The calculation of structure value in a floodplain can be done several ways, each having their advantages and disadvantages. One method, estimating the Depreciated Replacement Value (DRV) of the structures in the floodplain, involves integrating the following data: the structure type, the size of the structure, the unit cost of construction as measured in cost per square foot, and an allowance for deterioration as measured as a percent of total value. An alternative way of calculating the total structure value in the floodplain would be to use tax assessment records on each parcel’s improvement value. While this assessment information is readily available, California’s Proposition 13, which limits increased assessments until a home is sold, results in unequal valuations of one home relative to another. It is primarily for this reason that this study will use the Depreciated Replacement Cost method. More information on the different structure valuation methods can be found in IWR Report 95-R-9, *Procedural Guidelines for Estimating Residential and Business Structure Value for Use in Flood Damage Estimations*. The Depreciated Replacement Cost method requires visits to the structures themselves to attain the necessary information—e.g., foundation height, structure type, and structure condition.

The valuation of the structures in the floodplain requires information on structure type, construction quality, current condition, and number of stories[2]. Once collected, this information was utilized to calculate the structure DRVs. Base per square-foot construction cost estimates for each structure type were determined by utilizing the Marshall and Swift Real Estate Valuation Service method according to the following procedure:

- Construction quality and current condition of all structures included in the floodplain inventory were noted from field surveys completed by USACE economists and planners in 2009. For a given structure type, the per square foot construction cost (replacement cost)

[2] Structure first floor elevation was also recorded for each structure visited as part of the field inventory work. While this data is not relevant for the structure valuation, it is a critical variable in the estimate of flooding damage.

was determined using the most current Marshall & Swift Valuation Service data. This per square foot cost estimate reflects the construction quality of the structure. The per square foot costs, which are based on a national average, were modified to reflect local cost conditions using Marshall & Swift local cost multipliers.

- This current, locally adjusted cost per square foot was then adjusted additionally for the condition of the structure, which determines the appropriate depreciation factor to apply. Professional judgment was used to classify structures into one of seven current condition categories: new, excellent, good, average, fair, poor, or dilapidated. Most of the structures in the study area were judged to be average to good condition, which correlates to an estimated depreciation percentage of between 15% to 28% depreciation relative to new construction[3]. Average condition is defined as "a structure which has some evidence of deferred maintenance and normal obsolescence with age. Few minor repairs and refinishing required." Good condition is defined as "a structure in which no obvious maintenance is required but neither is everything new."[4]

Table 1 displays the structure inventory for the .2% annual chance exceedence (ACE), or 500-year floodplain. The .2% floodplain is larger in extent than the 1% floodplain, and its consideration is consistent with standard practice for USACE flood damage analyses. HEC-FDA output helped to determine which structures incur damage during the different flood events. The structure values were calculated using the depreciated replacement cost method described above; content value estimates were derived by assuming their value to be 50% of the structure value.[5]

Table 1: Structure & Content Value in the Floodplain

TYPE	PARCEL COUNTS	STRUCT DRV (1,000s)	CONTENTS (1,000s)	TOTAL BY TYPE (1,000s)
SFR-1	593	$63,173	$31,586	$94,759
SFR-2	52	$14,660	$7,330	$21,990
MFR-1	2	$277	$416	$693
MFR-2	1	$1,331	$2,000	$3,331
TOTAL	648	$79,441	$41,332	$120,773

First floor elevations (FFE, or finished floor elevations) were also obtained from the District. Figure 2 shows the reported FFE (in NGVD29) of the structures in the study area. The mean FFE is 4.8 ft and 75% of the structures have a FFE at or below 5.8 ft.

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3 Tables 7 through 9 of IWR Report 95-R-9, '*Procedural Guidelines for Estimating Residential and Business Structure Value for Use in Flood Damage Estimations*'.
4 ibid - same as footnote 3
5 This assumption is consistent with standard practice for USACE studies where no detailed survey has been conducted. The estimate of damage to contents does not directly use this percentage assumption, but instead uses structure value and a content depth damage function that is defined within USACE Economic Guidance Memorandum (EGM) 04-01, *Generic Depth-Damage Relationships for Residential Structures.*

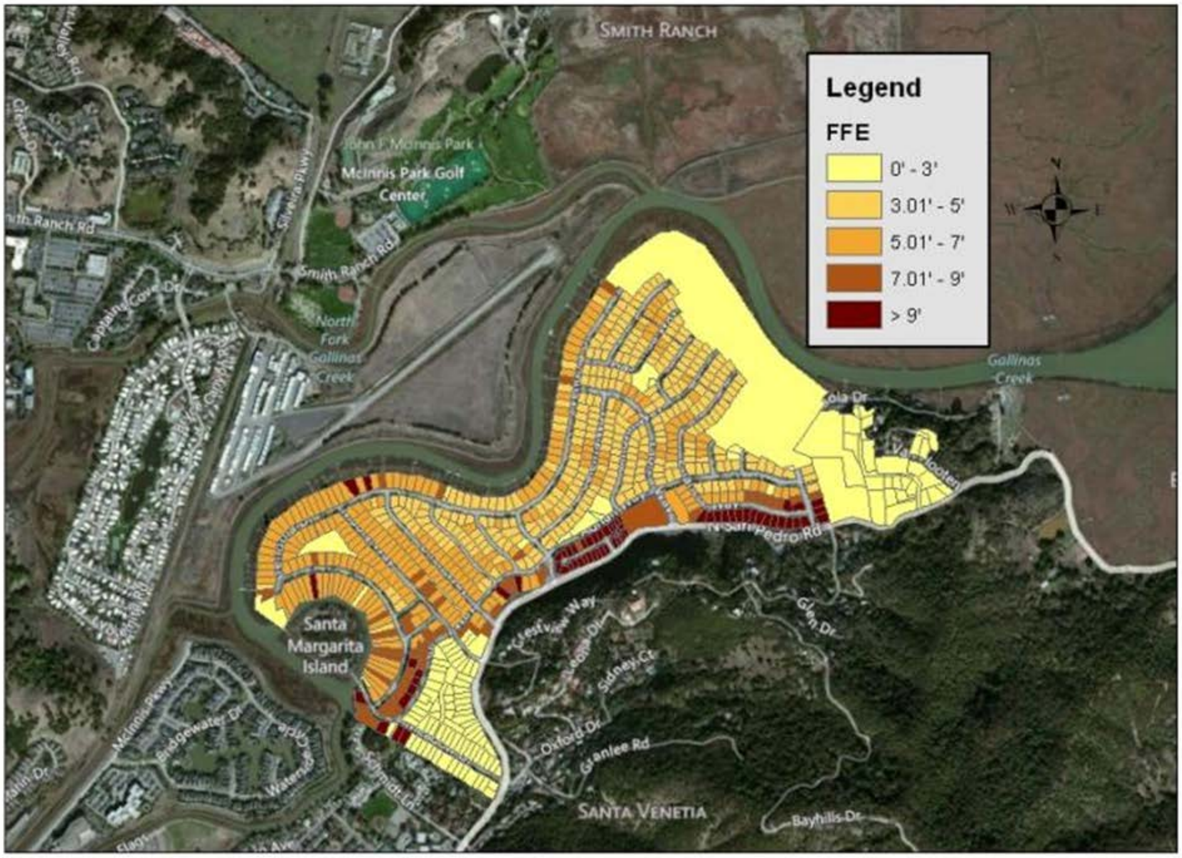


Figure 2: First Floor Elevation (feet)

3. Depth-Damage Relationships

Flooding can cause a myriad of significant damages to structures of all types. Water can cause a structure's structural components to shift or warp—including the studs and foundation. Water can also damage the wiring, gas lines, and septic system. For high water, ceilings may sag under the weight of trapped water or soggy drywall, wet floorboards can bend and buckle, and the roof may leak or break. Most of the structures in the floodplains that are studied in this analysis are wood frame, and this type of structure will suffer greater exterior damages than those made of brick or masonry. In all types of residential housing, though, flooding will most likely destroy the interior walls. Soaked wallboard becomes so weak that it must be replaced, as do most kinds of wall insulation, and any plywood in the walls is likely to swell and peel apart. Water can also dissolve the mortar in a chimney, which creates leaks and thus a risk of carbon monoxide poisoning once the heat comes back on.

Also, floods often deposit dirt and microorganisms throughout the house. Silt and sediment can create short circuits in the electrical system as build-up collects in walls and in the spaces behind each switch box and outlet. Appliances, furnaces, and lighting fixtures also fill with mud, making them dangerous to use. Anything that gets soaked with water may contain sewage contaminants or provide a substrate for mold. Most upholstered items, carpets, and bedding must be thrown away.

Damages to structures and contents were determined based on depth of flooding relative to the structure's first-floor elevation. To compute these damages, depth-damage curves were used. These curves assign loss as a percentage of value for each parcel or structure. The deeper the relative depth, the greater the percentage of value damaged. The paragraphs and figures below describe the assumed depth-damage relationships for the primary structure types and their contents.

The relationship between depth of flooding and structure and content damage varies by structure type. For all SFRs and MFRs, this analysis uses the relationships developed by the USACE Institute for Water Resources (IWR), and published in the Economic Guidance Memorandum (EGM) 04-01 (see footnote 5). For SFRs and MFRs, the content damage percentages are shown as a percentage of total structure value, whereas the MH content value is shown as percentage of the estimated content value. The tables and figures below describe and display the curves for single-story and two-story residential structures. For any given depth of flooding, the damage to the structure and contents as a percentage of total value is lower for two-story structures than for single-story structures because a greater percentage of the structure and contents is located above the flood water.

Table 2: Generic SFR and MFR Depth Damage Curves (no basements)

Flood Depth Relative to Finished Floor (ft)	Single-Story Residences		Two-Story Residences	
	Structure	*Contents*	*Structure*	*Contents*
-2.0	0%	0%	0%	0%
-1.0	2.5%	2.4%	3.0%	1.0%
0.0	13.4%	8.1%	9.3%	5.0%
1.0	23.3%	13.3%	15.2%	8.7%
2.0	32.1%	17.9%	20.9%	12.2%
3.0	40.1%	22.0%	26.3%	15.5%
4.0	47.1%	25.7%	31.4%	18.5%
5.0	53.2%	28.8%	36.2%	21.3%
6.0	58.6%	31.5%	40.7%	23.9%
7.0	63.2%	33.8%	44.9%	26.3%
8.0	67.2%	35.7%	48.8%	28.4%

Source: USACE Economic Guidance Memorandum 04-01;
Content damage estimated as a percentage of structure value
Per EGM, contents value set equal to structure value when using these depth-damage curves.

Figures 3 and 4 show the relationship between the depth of flooding relative to the finished floor elevation and the assumed percentage of damage to structures and contents (relative to the depreciated replacement value).

Figure 3: 1-Story SFR and MFR Depth-Damage Curves

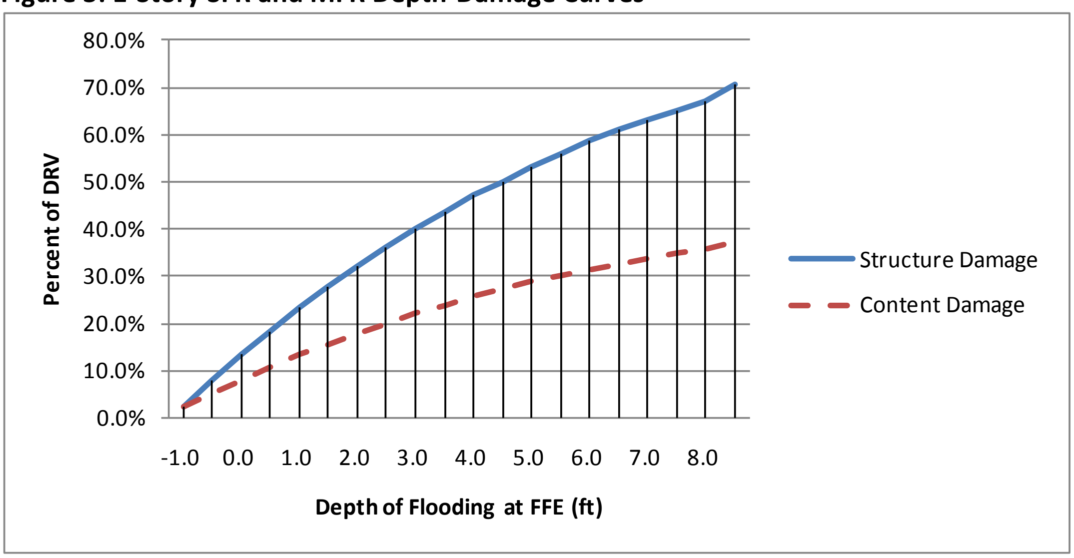
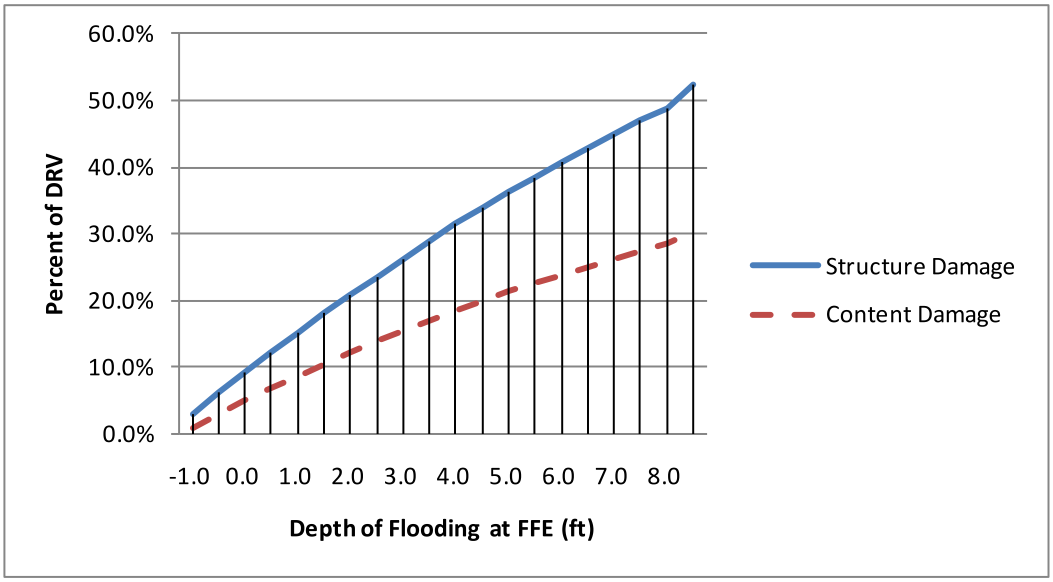


Figure 4: 2-Story SFR and MFR Depth-Damage Curves



4. Levee and Floodwall Assumptions

As mentioned previously, following record high tides in 1983, an approximately 2 foot high wooden floodwall structure (termed 'Redwood floodwall' in the figure below) was built to reduce the likelihood of flooding in the study area. The wall was constructed to approximately 7.5 ft (NGVD29). Since being installed, it has successfully held back floods lower than that elevation, and no floods have exceeded that elevation. The figure below shows a cross section of levee with wooden floodwall included.

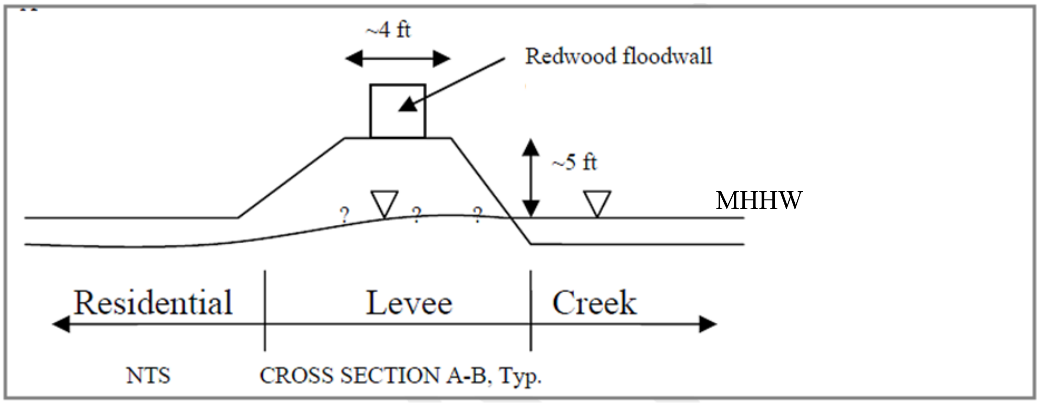


Figure 5: Typical Cross Section of Levee and Wooden Floodwall
Source: USACE Engineers, 'Site Observations to Las Gallinas Levee System', January 2006

While the wall has held up against prior floods, a recent geotechnical report (Kleinfelder, 2013) estimates that there is a significant chance that the floodwall could fail before being overtopped under the current conditions.

Figure 6 shows the plot of flood elevation against the probability of floodwall failure. In the figure, 'exterior stage' refers to the elevation of water in the creek (NGVD 29).

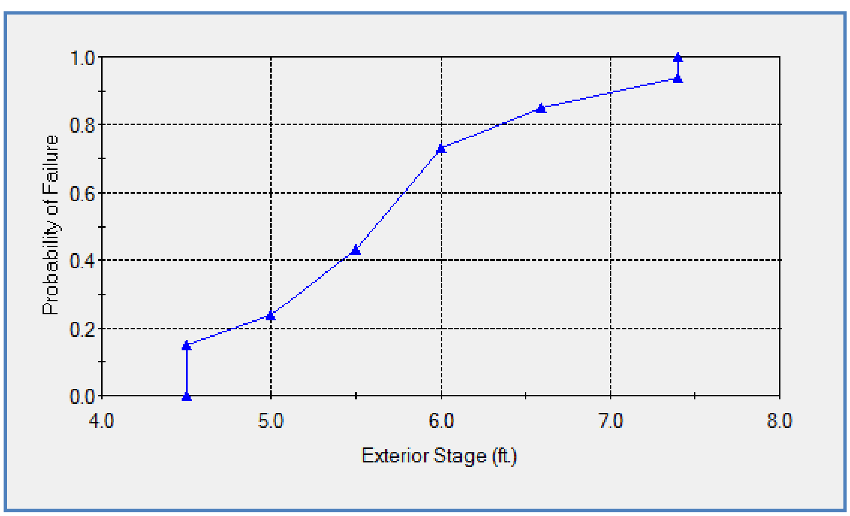


Figure 6: Levee Failure Function - Existing Condition

5. Hydrologic & Hydraulic Engineering Inputs to the Damage Model

Figures 7, 8, and 9 are plots of the exceedence probability-stage data used in the damage modeling in the HEC-FDA program. Along with the levee failure functions, these are the primary engineering inputs to the flood damage model. They consist of numerous water surface elevations and their corresponding estimated likelihoods. These inputs were provided by the Corps' Water Resources Section to the Corps' Economics Section for use in this flood damage analysis. The complete hydrologic, hydraulic, and coastal engineering appendix (completed December 2013) describes in detail the development of the engineering inputs to the damage analysis.

Data for two scenarios was provided for use in the damage analysis. As described below, the scenarios vary in their assumptions regarding the assumed future rate of sea-level rise (SLR).

1) *Current Conditions + Low SLR*. This scenario assumes that mean sea-level rises approximately .5 feet over the next fifty years. This rate of change is consistent with USACE guidance on a "low scenario" of sea-level rise to be used in scenario analysis[6]. This rate approximates an extrapolation of the observed historic rate of change.

2) *Current Conditions + High SLR*. This scenario assumes that mean sea-level rises by approximately 2.2 feet over the next fifty years. This rate of sea-level rise is consistent with what USACE guidance identifies as the high scenario for future sea-level rise.

For both scenarios, the FDA model includes both an exterior/interior stage curve (developed by the Corps' Water Resources Section) and a geotechnical fragility curve (developed by the District's contractor and reviewed by Corps' Geotechnical Section). The interior/exterior refers to the relationship between the elevation of the water in the creek (exterior) and the flood elevation of the water in the floodplain (interior) during a flood event. When the elevation of the water in the floodplain is not expected to be equivalent to the elevation in the creek, the actual relationship needs to be specified in the model.

In the figures below, the Year Zero plot represents the current condition, while the Year 50 Low and the Year 50 High represent estimated future conditions under the two different sea-level rise scenarios. For each event (represented by the exceedence probability), the corresponding stage (elevation) at the mean (or average) discharge is shown by the red line. The uncertainty in the results is represented by the blue and green lines that correspond to plus and minus two standard deviations from the mean.

As the figures show, the mean water surface elevation (stage) is higher under the low scenario as compared to the existing conditions, and the elevation under the high scenario is greater still. For example, a 1% event under existing conditions is estimated to be associated with a stage of approximately 6.5', while under the low and high future scenarios with sea-level rise the stage is estimated to be approximately 7' and 8.5', respectively.

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[6] Engineering Circular 1165-2-212

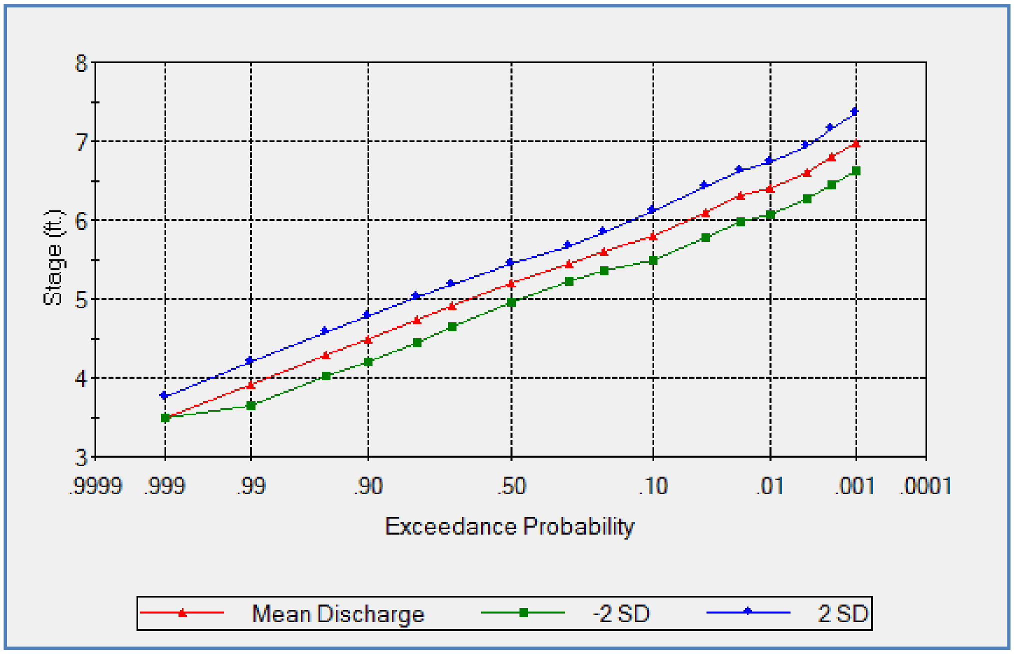

Figure 7: Year Zero Plot of Exceedence Probability vs. Stage

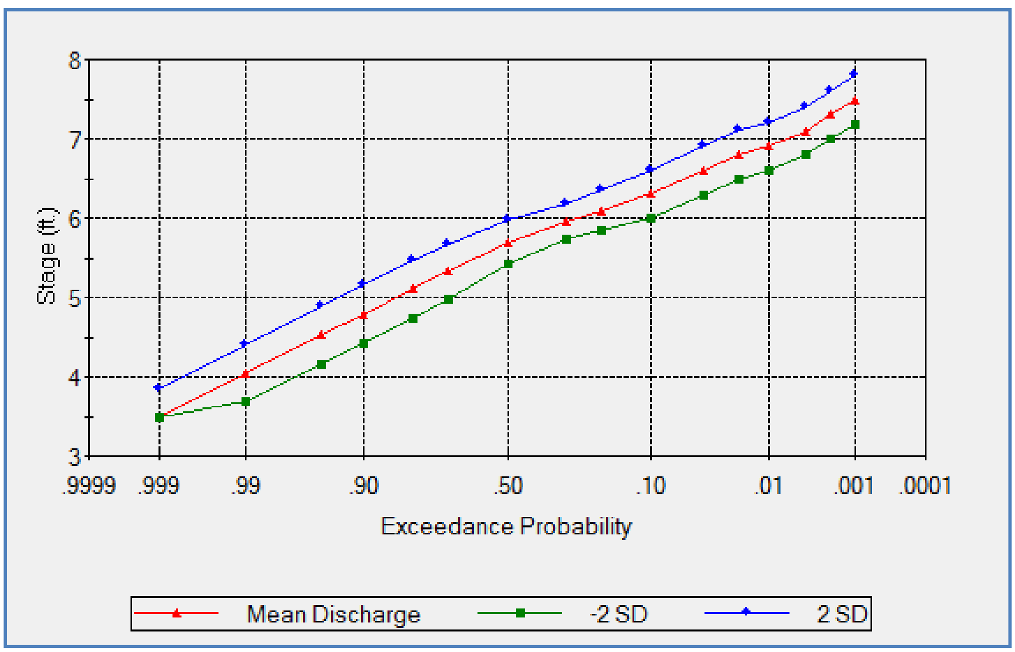

Figure 8: Year 50 Plot of Exceedence Probability vs. Stage, Low SLR Scenario

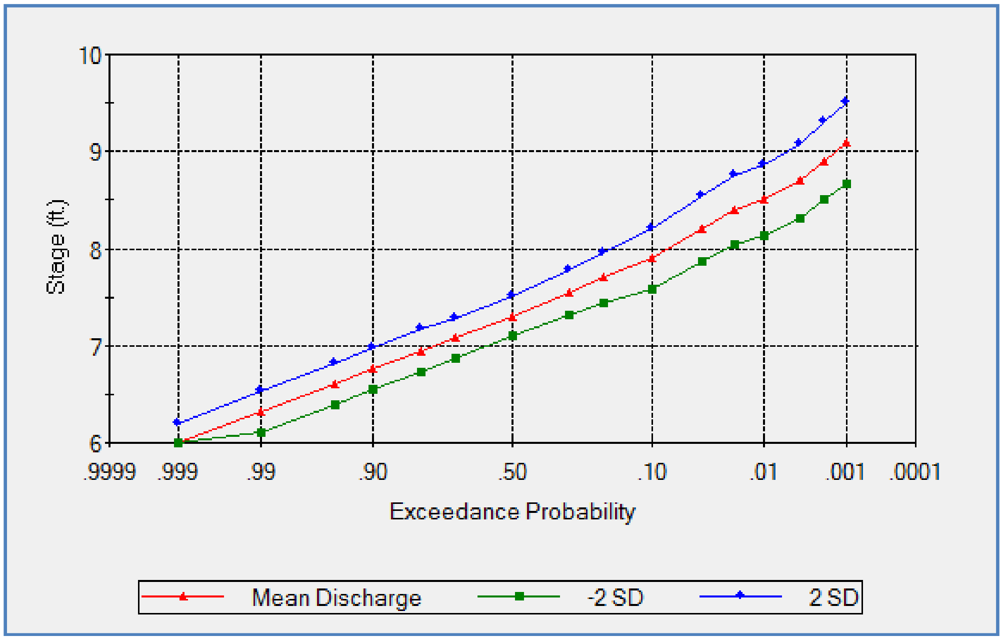

Figure 9: Year 50 Plot of Exceedence Probability vs. Stage, High SLR Scenario

6. HEC-FDA Model Results

The USACE HEC-FDA v. 1.2.5 computer program was used to calculate preliminary damages to the buildings and their contents located in the floodplain.

Because of the probabilistic and temporal nature of flood damage analysis, the final results are typically expressed in Equivalent Annual Damage (EAD). EAD is the summation of various modeled flood events (represented by an annual probability) multiplied by the damages associated with each event. It is the integral of damages, and increases in future damage are discounted by the current Federal water resources discount rate (3.5%). The results are displayed in Table 3 below. It is important to note that it is not expected that these damages will occur annually, but rather these are estimated to be the average annual value of flood damage if total flood damage were averaged over a long time horizon[7].

Table 3: Equivalent Annual Flood Damage

Scenario	EAD (1,000s)
Current Conditions + Low SLR	$89
Current Conditions + High SLR	$1,035

[7] As an illustration, if over a ten-year period there were one flood event that caused $1M in damage, the average annual value would be $1M divided by 10, or $100k.

7. Summary of Findings

The purpose of this preliminary flood damage analysis is to describe the economic damages from future flood events in the town of Santa Venetia as a result of flooding from Las Gallinas Creek. This damage estimate will be the basis for understanding the likelihood that there is a Federal interest in a flood risk management project in the area. Economic justification (benefit-cost ratio greater than unity) is one measure of Federal interest in a project. The others are a) a solution can be found that is within USACE congressional authority, and b) a project is feasible to engineer and construct, and c) there is a willing cost-sharing partner.

Since future sea-level rise is uncertain, and since the possible range is large, the analysis considers both a “low” scenario and a “high” scenario. The basis for these scenarios comes from USACE guidance, and in particular Engineering Circular 1165-2-212. Considering the low and the high scenarios should effectively bracket the possible outcomes when considering the range of sea-level rise and how it will contribute to flood risk in the study area.

The results are described below. The damages were estimated in the HEC-FDA program, which is certified for use in Corps studies. The calculation of total project economic justification is equal to the present value of the estimated annual stream of benefits (the EAD as estimated by the HEC-FDA model).

1) Current Conditions + Low Sea-Level Rise: The Equivalent Annual Damages under this scenario amount to just less than $100k. Under this scenario, for a project to have at least a 1:1 benefit-cost ratio, a project that effectively eliminated the flood risk would have to cost $2.2M or less.

2) Current Conditions + High Sea-Level Rise: The Equivalent Annual Damages under this scenario amount to just more than $1M. Under this scenario, for a project to have at least a 1:1 benefit-cost ratio, a project that effectively eliminated the flood risk would have to cost $24M or less.

Figure 10 displays the results graphically.

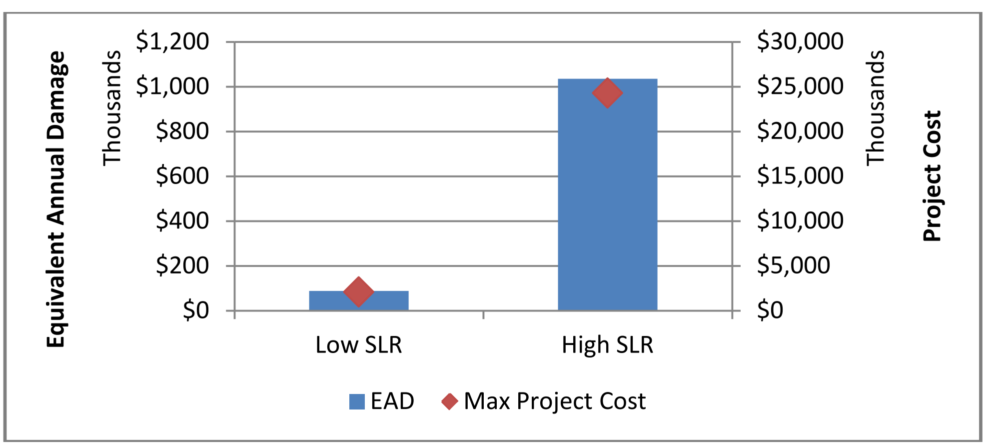

Figure 10: Equivalent Annual Damage & Maximum Project Cost for Economic Justification

As described previously, the damage modeling was completed for two sea-level rise scenarios that effectively bracket (high likelihood of bracketing) the range of possible increase over the next fifty years. USACE guidance suggests considering a third, intermediate sea-level rise scenario as well. Sea-level rise under the intermediate scenario is slightly higher than under the low scenario. For example, the rise in mean sea level over fifty years is approximately .5, .9, and 2.3 feet for the low, intermediate, and high scenarios, respectively[8]. The figure below shows the relative sea-level change (RSLC) for the each of the three scenarios.

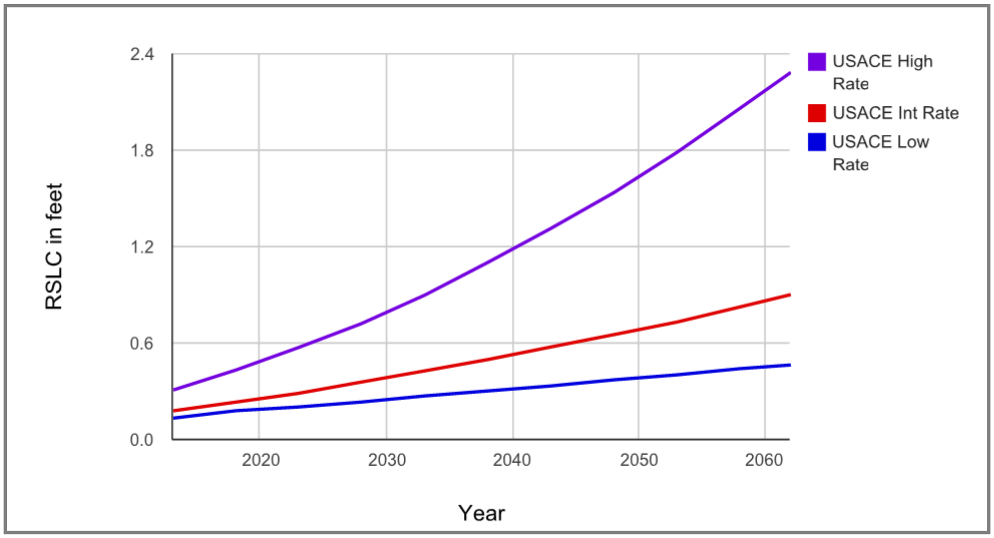

Figure 11: Relative Sea-Level Change over Time
Source: USACE Responses to Climate Change Program (www.corpsclimate.us)

Because sea-level rise under the intermediate scenario is much more similar to the low scenario than the high scenario, a flood damage analysis using data for the intermediate scenario would be expected to show damages that are similar to the low scenario, albeit slightly higher. Thus, it is concluded that currently only under the high sea-level rise scenario would a project that costs more than a few million dollars be economically justified for construction on the basis of a reduction in future flood damages.

[8] Source: http://www.corpsclimate.us/ccaceslcurves.cfm