FLOOD INSURANCE STUDY

FEDERAL EMERGENCY MANAGEMENT AGENCY

VOLUME 1 OF 1

CITY AND COUNTY OF SAN FRANCISCO, CALIFORNIA

AND INCORPORATED AREAS

COMMUNITY NAME	COMMUNITY NUMBER
SAN FRANCISCO, CITY AND COUNTY OF	**060298**

PRELIMINARY
11/12/2015

EFFECTIVE:

MONTH DD, YYYY

FLOOD INSURANCE STUDY NUMBER
060298V000A

Version Number 2.3.2.0

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FLOOD INSURANCE STUDY REPORT
CITY AND COUNTY OF SAN FRANCISCO, CALIFORNIA

SECTION 1.0 – INTRODUCTION

1.1 The National Flood Insurance Program

The National Flood Insurance Program (NFIP) is a voluntary Federal program that enables property owners in participating communities to purchase insurance protection against losses from flooding. This insurance is designed to provide an alternative to disaster assistance to meet the escalating costs of repairing damage to buildings and their contents caused by floods.

For decades, the national response to flood disasters was generally limited to constructing flood-control works such as dams, levees, sea-walls, and the like, and providing disaster relief to flood victims. This approach did not reduce losses nor did it discourage unwise development. In some instances, it may have actually encouraged additional development. To compound the problem, the public generally could not buy flood coverage from insurance companies, and building techniques to reduce flood damage were often overlooked.

In the face of mounting flood losses and escalating costs of disaster relief to the general taxpayers, the U.S. Congress created the NFIP. The intent was to reduce future flood damage through community floodplain management ordinances, and provide protection for property owners against potential losses through an insurance mechanism that requires a premium to be paid for the protection.

The U.S. Congress established the NFIP on August 1, 1968, with the passage of the National Flood Insurance Act of 1968. The NFIP was broadened and modified with the passage of the Flood Disaster Protection Act of 1973 and other legislative measures. It was further modified by the National Flood Insurance Reform Act of 1994 and the Flood Insurance Reform Act of 2004. The NFIP is administered by the Federal Emergency Management Agency (FEMA), which is a component of the Department of Homeland Security (DHS).

Participation in the NFIP is based on an agreement between local communities and the Federal Government. If a community adopts and enforces floodplain management regulations to reduce future flood risks to new construction and substantially improved structures in Special Flood Hazard Areas (SFHAs), the Federal Government will make flood insurance available within the community as a financial protection against flood losses. The community's floodplain management regulations must meet or exceed criteria established in accordance with Title 44 Code of Federal Regulations (CFR) Part 60.3, *Criteria for Land Management and Use*.

SFHAs are delineated on the community's Flood Insurance Rate Maps (FIRMs). Under the NFIP, buildings that were built before the flood hazard was identified on the community's FIRMs are generally referred to as "Pre-FIRM" buildings. When the NFIP was created, the U.S. Congress recognized that insurance for Pre-FIRM buildings would be prohibitively expensive if the premiums were not subsidized by the Federal Government. Congress also recognized that most of these floodprone buildings were built by individuals who did not have sufficient knowledge of the flood hazard to make informed decisions. The NFIP requires that full actuarial rates reflecting the complete flood risk be charged on all buildings constructed or substantially improved on or after the effective date of the initial FIRM for the community or after December 31, 1974, whichever is later. These buildings are generally referred to as "Post-FIRM" buildings.

1.2 Purpose of this Flood Insurance Study Report

This Flood Insurance Study (FIS) Report presents information on the existence and severity of flood hazards for the study area. The studies described in this report developed flood hazard data that will be used to establish actuarial flood insurance rates and to assist communities in efforts to implement sound floodplain management.

In some states or communities, floodplain management criteria or regulations may exist that are more restrictive than the minimum Federal requirements. Contact your State NFIP Coordinator to ensure that any higher State standards are included in the community's regulations.

1.3 Jurisdictions Included in the Flood Insurance Study Project

This FIS Report covers the entire geographic area of the City and County of San Francisco, California.

The jurisdictions that are included in this project area, along with the Community Identification Number (CID) for each community and the 8-digit Hydrologic Unit Codes (HUC-8) sub-basins affecting each, are shown in Table 1. The Flood Insurance Rate Map (FIRM) panel numbers that affect each community are listed. If the flood hazard data for the community is not included in this FIS Report, the location of that data is identified.

Table 1: Listing of NFIP Jurisdictions

Community	CID	HUC-8 Sub-Basin(s)	Located on FIRM Panel(s)	If Not Included, Location of Flood Hazard Data
San Francisco, City and County of	060298	18050002, 18050004, 18050006	06075C0020A[1], 06075C0040A[1], 06075C0065A[1], 06075C0092A, 06075C0094A, 06075C0105A[1], 06075C0106A, 06075C0107A[1], 06075C0108A, 06075C0109A, 06075C0111A, 06075C0112A, 06075C0113A[1], 06075C0114A[1], 06075C0116A, 06075C0117A, 06075C0118A[1], 06075C0119A, 06075C0126A[1], 06075C0128A, 06075C0136A, 06075C0137A, 06075C0138A[1], 06075C0139A, 06075C0145A[1],	

Table 1: Listing of NFIP Jurisdictions, continued

Community	CID	HUC-8 Sub-Basin(s)	Located on FIRM Panel(s)	If Not Included, Location of Flood Hazard Data
San Francisco, City and County of (continued)	060298	18050002, 18050004, 18050006	06075C0160A[1], 06075C0180A[1], 06075C0207A, 06075C0209A, 06075C0230A[1], 06075C0231A[1], 06075C0232A, 06075C0233A[1], 06075C0234A, 06075C0244A, 06075C0251A, 06075C0252A[1], 06075C0253A, 06075C0254A[1], 06075C0260A[1], 06075C0263A, 06075C0281A[1], 06075C0282A, 06075C0301A, 06075C0302A[1], 06075C0304A[1]	

[1] Panel Not Printed

1.4 Considerations for using this Flood Insurance Study Report

The NFIP encourages State and local governments to implement sound floodplain management programs. To assist in this endeavor, each FIS Report provides floodplain data, which may include a combination of the following: 10-, 4-, 2-, 1-, and 0.2-percent annual chance flood elevations (the 1% annual chance flood elevation is also referred to as the Base Flood Elevation (BFE)); delineations of the 1% annual chance and 0.2% annual chance floodplains; and 1% annual chance floodway. This information is presented on the FIRM and/or in many components of the FIS Report, including Flood Profiles, Floodway Data tables, Summary of Non-Coastal Stillwater Elevations tables, and Coastal Transect Parameters tables (not all components may be provided for a specific FIS).

This section presents important considerations for using the information contained in this FIS Report and the FIRM, including changes in format and content. Figures 1, 2, and 3 present information that applies to using the FIRM with the FIS Report.

- Part or all of this FIS Report may be revised and republished at any time. In addition, part of this FIS Report may be revised by a Letter of Map Revision (LOMR), which does not involve republication or redistribution of the FIS Report. Refer to Section 6.5 of this FIS Report for information about the process to revise the FIS Report and/or FIRM.

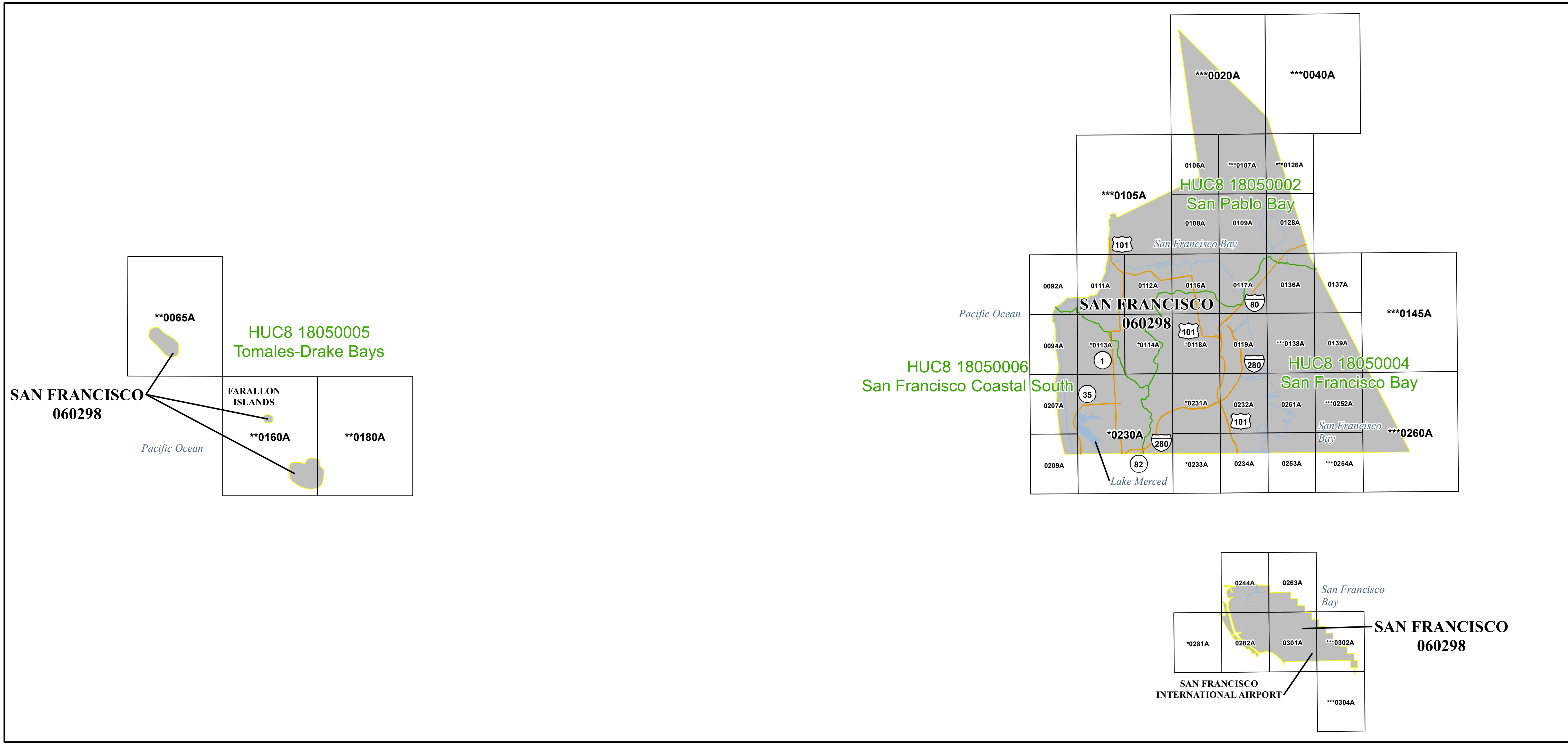
It is, therefore, the responsibility of the user to consult with community officials by contacting the community repository to obtain the most current FIS Report components. Communities participating in the NFIP have established repositories of flood hazard data for floodplain management and flood insurance purposes. Community map repository addresses are provided in Table 31, "Map Repositories," within this FIS Report.

- New FIS Reports are frequently developed for multiple communities, such as entire counties. A countywide FIS Report incorporates previous FIS Reports for individual communities and the unincorporated area of the county (if not jurisdictional) into a single document and supersedes those documents for the purposes of the NFIP.

  The initial Countywide FIS Report for the City and County of San Francisco became effective on Month DD, YYYY. Refer to Table 28 for information about subsequent revisions to the FIRMs.

- FEMA has developed a *Guide to Flood Maps* (FEMA 258) and online tutorials to assist users in accessing the information contained on the FIRM. These include how to read panels and step-by-step instructions to obtain specific information. To obtain this guide and other assistance in using the FIRM, visit the FEMA Web site at www.fema.gov/online-tutorials.

The FIRM Index in Figure 1 shows the overall FIRM panel layout within the City and County of San Francisco, and also displays the panel number and effective date for each FIRM panel in the county. Other information shown on the FIRM Index includes community boundaries, flooding sources, watershed boundaries, and United States Geological Survey (USGS) Hydrologic Unit Code – 8 (HUC-8) codes.



N

1 inch = 18,750 feet 1:225,000

0 5,000 10,000 20,000 30,000 40,000 feet

Map Projection:
Universal Transverse Mercator Zone 10 North;
North American Datum 1983

THE INFORMATION DEPICTED ON THIS MAP AND SUPPORTING DOCUMENTATION ARE ALSO AVAILABLE IN DIGITAL FORMAT AT

HTTP://MSC.FEMA.GOV

SEE FLOOD INSURANCE STUDY FOR ADDITIONAL INFORMATION

* PANEL NOT PRINTED - NO SPECIAL FLOOD HAZARD AREAS
** PANEL NOT PRINTED - AREA IN ZONE D
*** PANEL NOT PRINTED - OPEN WATER AREA

COUNTY LOCATOR

NATIONAL FLOOD INSURANCE PROGRAM

FLOOD INSURANCE RATE MAP INDEX

CITY AND COUNTY OF SAN FRANCISCO, CALIFORNIA

PANELS PRINTED:

0092, 0094, 0106, 0108, 0109, 0111, 0112, 0116, 0117, 0119, 0128, 0136, 0137, 0139, 0207, 0209, 0232, 0234, 0244, 0251, 0253, 0263, 0282, 0301

U.S. DEPARTMENT OF HOMELAND SECURITY

FEMA

MAP NUMBER
060298IND0A

EFFECTIVE DATE

Each FIRM panel may contain specific notes to the user that provide additional information regarding the flood hazard data shown on that map. However, the FIRM panel does not contain enough space to show all the notes that may be relevant in helping to better understand the information on the panel. Figure 2 contains the full list of these notes.

Figure 2: FIRM Notes to Users

NOTES TO USERS

For information and questions about this map, available products associated with this FIRM including historic versions of this FIRM, how to order products, or the National Flood Insurance Program in general, please call the FEMA Map Information eXchange at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA Flood Map Service Center website at msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the website. Users may determine the current map date for each FIRM panel by visiting the FEMA Flood Map Service Center website or by calling the FEMA Map Information eXchange.

Communities annexing land on adjacent FIRM panels must obtain a current copy of the adjacent panel as well as the current FIRM Index. These may be ordered directly from the Flood Map Service Center at the number listed above.

For community and countywide map dates, refer to Table 28 in this FIS Report.

To determine if flood insurance is available in the community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

PRELIMINARY FIS REPORT: FEMA maintains information about map features, such as street locations and names, in or near designated flood hazard areas. Requests to revise information in or near designated flood hazard areas may be provided to FEMA during the community review period, at the final Consultation Coordination Officer's meeting, or during the statutory 90-day appeal period. Approved requests for changes will be shown on the final printed FIRM.

The map is for use in administering the NFIP. It may not identify all areas subject to flooding, particularly from local drainage sources of small size. Consult the community map repository to find updated or additional flood hazard information.

BASE FLOOD ELEVATIONS: For more detailed information in areas where Base Flood Elevations (BFEs) and/or floodways have been determined, consult the Flood Profiles and Floodway Data and/or Summary of Non-Coastal Stillwater Elevations tables within this FIS Report. Use the flood elevation data within the FIS Report in conjunction with the FIRM for construction and/or floodplain management.

Coastal Base Flood Elevations shown on the map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD88). Coastal flood elevations are also provided in the Coastal Transect Parameters table in the FIS Report for this jurisdiction. Elevations shown in the Coastal Transect Parameters table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on the FIRM.

Figure 2. FIRM Notes to Users

FLOODWAY INFORMATION: Boundaries of the floodways were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the FIS Report for this jurisdiction.

FLOOD CONTROL STRUCTURE INFORMATION: Certain areas not in Special Flood Hazard Areas may be protected by flood control structures. Refer to Section 4.3 "Non-Levee Flood Protection Measures" of this FIS Report for information on flood control structures for this jurisdiction.

PROJECTION INFORMATION: The projection used in the preparation of the map was Universal Transverse Mercator (UTM) Zone 10N. The horizontal datum was NAD83, GRS1980 spheroid. Differences in datum, spheroid, projection or State Plane zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of the FIRM.

ELEVATION DATUM: Flood elevations on the FIRM are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at www.ngs.noaa.gov/ or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

Local vertical monuments may have been used to create the map. To obtain current monument information, please contact the appropriate local community listed in Table 31 of this FIS Report.

BASE MAP INFORMATION: Base map information shown on the FIRM was derived from USGS LiDAR dated 2010 and Coastal California digital imagery dated 2011. USDA NAIP imagery dated 2012 is used in areas not covered by the Coastal California digital imagery. For information about base maps, refer to Section 6.2 “Base Map” in this FIS Report.

Corporate limits shown on the map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after the map was published, map users should contact appropriate community officials to verify current corporate limit locations.

NOTES FOR FIRM INDEX

REVISIONS TO INDEX: As new studies are performed and FIRM panels are updated within the City and County of San Francisco, California, corresponding revisions to the FIRM Index will be incorporated within the FIS Report to reflect the effective dates of those panels. Please refer to Table 28 of this FIS Report to determine the most recent FIRM revision date for each community. The most recent FIRM panel effective date will correspond to the most recent index date.

Figure 2. FIRM Notes to Users

SPECIAL NOTES FOR SPECIFIC FIRM PANELS This Notes to Users section was created specifically for the City and County of San Francisco, California**,** effective Month DD, YYYY.
FLOOD RISK REPORT: A Flood Risk Report (FRR) may be available for many of the flooding sources and communities referenced in this FIS Report. The FRR is provided to increase public awareness of flood risk by helping communities identify the areas within their jurisdictions that have the greatest risks. Although non-regulatory, the information provided within the FRR can assist communities in assessing and evaluating mitigation opportunities to reduce these risks. It can also be used by communities developing or updating flood risk mitigation plans. These plans allow communities to identify and evaluate opportunities to reduce potential loss of life and property. However, the FRR is not intended to be the final authoritative source of all flood risk data for a project area; rather, it should be used with other data sources to paint a comprehensive picture of flood risk.

Each FIRM panel contains an abbreviated legend for the features shown on the maps. However, the FIRM panel does not contain enough space to show the legend for all map features. Figure 3 shows the full legend of all map features. Note that not all of these features may appear on the FIRM panels in the City and County of San Francisco.

Figure 3: Map Legend for FIRM

SPECIAL FLOOD HAZARD AREAS: *The 1% annual chance flood, also known as the base flood or 100-year flood, has a 1% chance of happening or being exceeded each year. Special Flood Hazard Areas are subject to flooding by the 1% annual chance flood. The Base Flood Elevation is the water surface elevation of the 1% annual chance flood. The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights. See note for specific types. If the floodway is too narrow to be shown, a note is shown.*

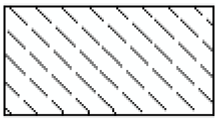
	Special Flood Hazard Areas subject to inundation by the 1% annual chance flood (Zones A, AE, AH, AO, AR, A99, V and VE)
Zone A	The flood insurance rate zone that corresponds to the 1% annual chance floodplains. No base (1% annual chance) flood elevations (BFEs) or depths are shown within this zone.
Zone AE	The flood insurance rate zone that corresponds to the 1% annual chance floodplains. Base flood elevations derived from the hydraulic analyses are shown within this zone.
Zone AH	The flood insurance rate zone that corresponds to the areas of 1% annual chance shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot BFEs derived from the hydraulic analyses are shown at selected intervals within this zone.
Zone AO	The flood insurance rate zone that corresponds to the areas of 1% annual chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average whole-foot depths derived from the hydraulic analyses are shown within this zone.
Zone AR	The flood insurance rate zone that corresponds to areas that were formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
Zone A99	The flood insurance rate zone that corresponds to areas of the 1% annual chance floodplain that will be protected by a Federal flood protection system where construction has reached specified statutory milestones. No base flood elevations or flood depths are shown within this zone.
Zone V	The flood insurance rate zone that corresponds to the 1% annual chance coastal floodplains that have additional hazards associated with storm waves. Base flood elevations are not shown within this zone.
Zone VE	Zone VE is the flood insurance rate zone that corresponds to the 1% annual chance coastal floodplains that have additional hazards associated with storm waves. Base flood elevations derived from the coastal analyses are shown within this zone as static whole-foot elevations that apply throughout the zone.

Figure 3: Map Legend for FIRM

	Regulatory Floodway determined in Zone AE.
OTHER AREAS OF FLOOD HAZARD	
	Shaded Zone X: Areas of 0.2% annual chance flood hazards and areas of 1% annual chance flood hazards with average depths of less than 1 foot or with drainage areas less than 1 square mile.
	Future Conditions 1% Annual Chance Flood Hazard – Zone X: The flood insurance rate zone that corresponds to the 1% annual chance floodplains that are determined based on future-conditions hydrology. No base flood elevations or flood depths are shown within this zone.
	Area with Reduced Flood Risk due to Levee: Areas where an accredited levee, dike, or other flood control structure has reduced the flood risk from the 1% annual chance flood.
OTHER AREAS	
	Zone D (Areas of Undetermined Flood Hazard): The flood insurance rate zone that corresponds to unstudied areas where flood hazards are undetermined, but possible.
NO SCREEN	Unshaded Zone X: Areas of minimal flood hazard.
FLOOD HAZARD AND OTHER BOUNDARY LINES	
(ortho) (vector)	Flood Zone Boundary (white line on ortho-photography-based mapping; gray line on vector-based mapping)
	Limit of Study
	Jurisdiction Boundary
	Limit of Moderate Wave Action (LiMWA): Indicates the inland limit of the area affected by waves greater than 1.5 feet
GENERAL STRUCTURES	
Aqueduct *Channel* *Culvert* *Storm Sewer*	Channel, Culvert, Aqueduct, or Storm Sewer
Dam *Jetty* *Weir*	Dam, Jetty, Weir
	Levee, Dike, or Floodwall
Bridge	Bridge

Figure 3: Map Legend for FIRM

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AND OTHERWISE PROTECTED AREAS (OPA): *CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.*

 CBRS AREA 09/30/2009	Coastal Barrier Resources System Area: Labels are shown to clarify where this area shares a boundary with an incorporated area or overlaps with the floodway.
 OTHERWISE PROTECTED AREA 09/30/2009	Otherwise Protected Area

REFERENCE MARKERS

22.0 ●	River mile Markers

CROSS SECTION & TRANSECT INFORMATION

(B) 20.2	Lettered Cross Section with Regulatory Water Surface Elevation (BFE)
(5280) 21.1	Numbered Cross Section with Regulatory Water Surface Elevation (BFE)
17.5	Unlettered Cross Section with Regulatory Water Surface Elevation (BFE)
(8) - - - - - -	Coastal Transect

——-———-	Profile Baseline: Indicates the modeled flow path of a stream and is shown on FIRM panels for all valid studies with profiles or otherwise established base flood elevation.
——--————--	Coastal Transect Baseline: Used in the coastal flood hazard model to represent the 0.0-foot elevation contour and the starting point for the transect and the measuring point for the coastal mapping.
~~ 513 ~~~~	Base Flood Elevation Line
ZONE AE (EL 16)	Static Base Flood Elevation value (shown under zone label)
ZONE AO (DEPTH 2)	Zone designation with Depth
ZONE AO (DEPTH 2) (VEL 15 FPS)	Zone designation with Depth and Velocity

Figure 3: Map Legend for FIRM

BASE MAP FEATURES	
Missouri Creek	River, Stream or Other Hydrographic Feature
234	Interstate Highway
234	U.S. Highway
234	State Highway
234	County Highway
MAPLE LANE	Street, Road, Avenue Name, or Private Drive if shown on Flood Profile
RAILROAD	Railroad
	Horizontal Reference Grid Line
	Horizontal Reference Grid Ticks
+	Secondary Grid Crosshairs
Land Grant	Name of Land Grant
7	Section Number
R. 43 W. T. 22 N.	Range, Township Number
$^{42}76^{000m}$E	Horizontal Reference Grid Coordinates (UTM)
365000 FT	Horizontal Reference Grid Coordinates (State Plane)
80° 16’ 52.5”	Corner Coordinates (Latitude, Longitude)

SECTION 2.0 – FLOODPLAIN MANAGEMENT APPLICATIONS

2.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1% annual chance (100-year) flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2% annual chance (500-year) flood is employed to indicate additional areas of flood hazard in the community.

Each flooding source included in the project scope has been studied and mapped using professional engineering and mapping methodologies that were agreed upon by FEMA and the City and County of San Francisco as appropriate to the risk level. Flood risk is evaluated based on factors such as known flood hazards and projected impact on the built environment. Engineering analyses were performed for each studied flooding source to calculate its 1% annual chance flood elevations; elevations corresponding to other floods (e.g. 10-, 4-, 2-, 0.2-percent annual chance, etc.) may have also been computed for certain flooding sources. Engineering models and methods are described in detail in Section 5.0 of this FIS Report. The modeled elevations at cross sections were used to delineate the floodplain boundaries on the FIRM; between cross sections, the boundaries were interpolated using elevation data from various sources. More information on specific mapping methods is provided in Section 6.0 of this FIS Report.

Depending on the accuracy of available topographic data (Table 23), study methodologies employed (Section 5.0), and flood risk, certain flooding sources may be mapped to show both the 1% and 0.2% annual chance floodplain boundaries, regulatory water surface elevations (BFEs), and/or a regulatory floodway. Similarly, other flooding sources may be mapped to show only the 1% annual chance floodplain boundary on the FIRM, without published water surface elevations. In cases where the 1% and 0.2% annual chance floodplain boundaries are close together, only the 1% annual chance floodplain boundary is shown on the FIRM. Figure 3, "Map Legend for FIRM", describes the flood zones that are used on the FIRMs to account for the varying levels of flood risk that exist along flooding sources within the project area. Table 2 and Table 3 indicate the flood zone designations for each flooding source and each community within the City and County of San Francisco, California, respectively.

Table 2, "Flooding Sources Included in this FIS Report," lists each flooding source, including its study limits, affected communities, mapped zone on the FIRM, and the completion date of its engineering analysis from which the flood elevations on the FIRM and in the FIS Report were derived. Descriptions and dates for the latest hydrologic and hydraulic analyses of the flooding sources are shown in Table 13. Floodplain boundaries for these flooding sources are shown on the FIRM (published separately) using the symbology described in Figure 3. On the map, the 1% annual chance floodplain corresponds to the SFHAs. The 0.2% annual chance floodplain shows areas that, although out of the regulatory floodplain, are still subject to flood hazards.

Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data. The procedures to remove these areas from the SFHA are described in Section 6.5 of this FIS Report.

Table 2: Flooding Sources Included in this FIS Report

Flooding Source	Community	Downstream Limit	Upstream Limit	HUC-8 Sub-Basin(s)	Length (mi) (streams or coastlines)	Area (mi^2) (estuaries or ponding)	Floodway (Y/N)	Zone shown on FIRM	Date of Analysis
Pacific Ocean	San Francisco, City and County of	San Mateo County Boundary	Marin County Boundary	18050005, 18050006	9	N/A	N	AE, VE, D, X	October 2014
San Francisco Bay	San Francisco, City and County of	Entire bay shoreline within City-County, & San Francisco International Airport shoreline	Entire bay shoreline within City-County, & San Francisco International Airport shoreline	18050002, 18050004	45	N/A	N	AE, AO, VE, D, X	July 2015

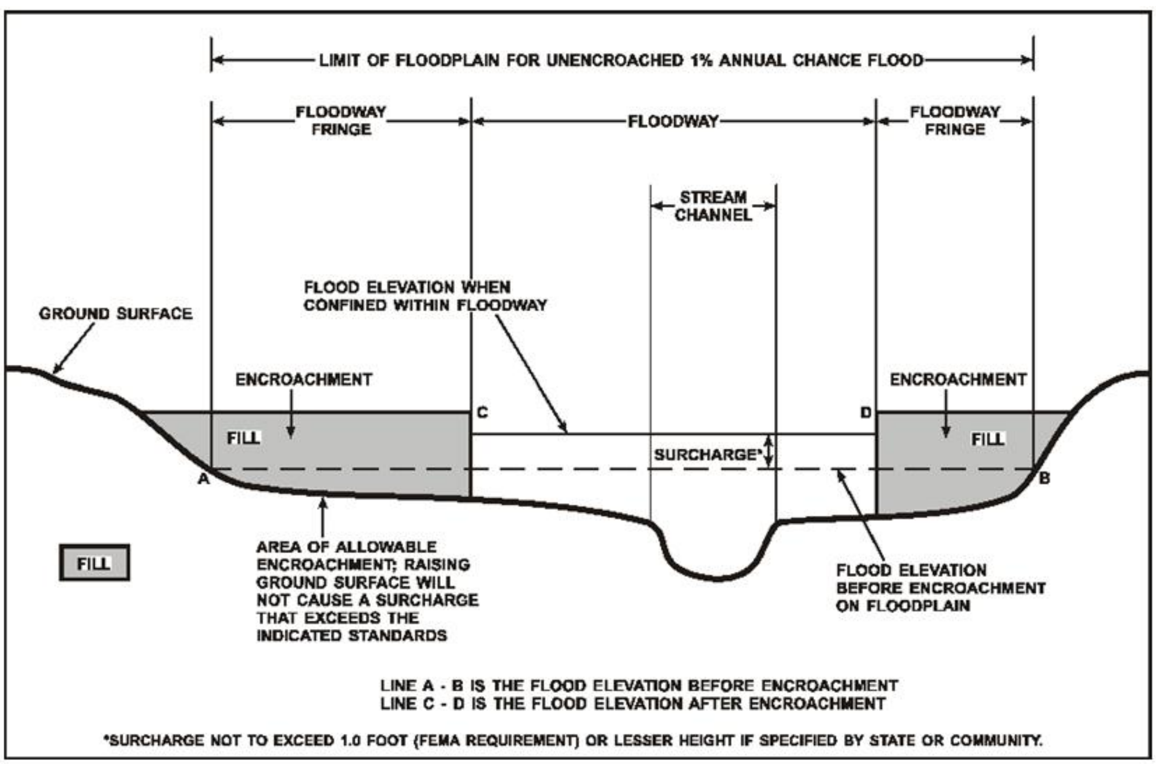
2.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard.

For purposes of the NFIP, a floodway is used as a tool to assist local communities in balancing floodplain development against increasing flood hazard. With this approach, the area of the 1% annual chance floodplain on a river is divided into a floodway and a floodway fringe based on hydraulic modeling. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment in order to carry the 1% annual chance flood. The floodway fringe is the area between the floodway and the 1% annual chance floodplain boundaries where encroachment is permitted. The floodway must be wide enough so that the floodway fringe could be completely obstructed without increasing the water surface elevation of the 1% annual chance flood more than 1 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 4.

To participate in the NFIP, Federal regulations require communities to limit increases caused by encroachment to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this project are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway projects.

Figure 4: Floodway Schematic



2.3 Base Flood Elevations

The hydraulic characteristics of flooding sources were analyzed to provide estimates of the elevations of floods of the selected recurrence intervals. The Base Flood Elevation (BFE) is the elevation of the 1% annual chance flood. These BFEs are most commonly rounded to the whole foot, as shown on the FIRM, but in certain circumstances or locations they may be rounded to 0.1 foot. Cross section lines shown on the FIRM may also be labeled with the BFE rounded to 0.1 foot. Whole-foot BFEs derived from engineering analyses that apply to coastal areas, areas of ponding, or other static areas with little elevation change may also be shown at selected intervals on the FIRM.

Cross sections with BFEs shown on the FIRM correspond to the cross sections shown in the Floodway Data table and Flood Profiles in this FIS Report. BFEs are primarily intended for flood insurance rating purposes. For construction and/or floodplain management purposes, users are cautioned to use the flood elevation data presented in this FIS Report in conjunction with the data shown on the FIRM.

2.4 Non-Encroachment Zones

This section is not applicable to this Flood Risk Project.

2.5 Coastal Flood Hazard Areas

For most areas along rivers, streams, and small lakes, BFEs and floodplain boundaries are based on the amount of water expected to enter the area during a 1% annual chance flood and the geometry of the floodplain. Floods in these areas are typically caused by storm events. However, for areas on or near ocean coasts, large rivers, or large bodies of water, BFE and floodplain boundaries may need to be based on additional components, including storm surges and waves. Communities on or near ocean coasts face flood hazards caused by offshore seismic events as well as storm events.

Coastal flooding sources that are included in this Flood Risk Project are shown in Table 2.

2.5.1 Water Elevations and the Effects of Waves

Specific terminology is used in coastal analyses to indicate which components have been included in evaluating flood hazards.

The stillwater elevation (SWEL or still water level) is the surface of the water resulting from astronomical tides, storm surge, coastal oceanographic processes, and freshwater inputs, but excluding wave setup contribution or the effects of waves.

- *Astronomical tides* are periodic rises and falls in large bodies of water caused by the rotation of the earth and by the gravitational forces exerted by the earth, moon and sun.
- *Storm surge* is the additional water depth that occurs during large storm events. These events can bring air pressure changes and strong winds that force water up against the shore.
- *Coastal oceanographic processes* are processes that significantly elevate SWL on the west coast. These processes include Kelvin Waves and the thermal expansion of seawater, which often occur during El Niño events. These are regional-scale, geophysical waves that differ from typical wind-driven surface gravity waves.
- *Freshwater inputs* include rainfall that falls directly on the body of water, runoff from surfaces and overland flow, and inputs from rivers.

The 1% annual chance stillwater elevation is the stillwater elevation that has been calculated for a storm surge from a 1% annual chance storm. The 1% annual chance storm surge can be determined from analyses of tidal gage records, statistical study of regional historical storms, or other modeling approaches. Stillwater elevations for storms of other frequencies can be developed using similar approaches.

The total stillwater elevation (also referred to as the mean water level) is the stillwater elevation plus wave setup contribution but excluding the effects of waves.

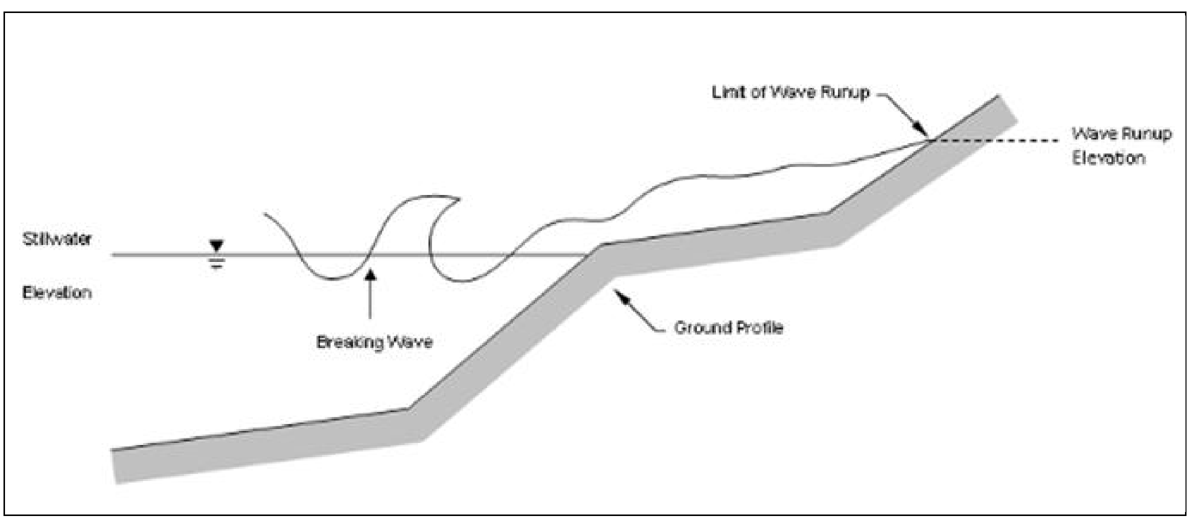
- *Wave setup* is the increase in stillwater elevation at the shoreline caused by the reduction of waves in shallow water. It occurs as breaking wave momentum is transferred to the water column.

Like the stillwater elevation, the total stillwater elevation is based on a storm of a particular frequency, such as the 1% annual chance storm. Wave setup is typically estimated using standard engineering practices or calculated using models, since tidal gages are often sited in areas sheltered from wave action and do not capture this information.

Coastal analyses may examine the effects of overland waves by analyzing storm-induced erosion, overland wave propagation, wave runup, and/or wave overtopping.

- *Storm-induced erosion* is the modification of existing topography by erosion caused by a specific storm event, as opposed to general erosion that occurs at a more constant rate.
- *Overland wave propagation* describes the combined effects of variation in ground elevation, vegetation, and physical features on wave characteristics as waves move onshore.
- *Wave runup* is the uprush of water from wave action on a shore barrier. It is a function of the roughness and geometry of the shoreline at the point where the stillwater elevation intersects the land.
- *Wave overtopping* refers to wave runup that occurs when waves pass over the crest of a barrier.

Figure 5: Wave Runup Transect Schematic



2.5.2 Floodplain Boundaries and BFEs for Coastal Areas

For coastal communities along the Atlantic and Pacific Oceans, the Gulf of Mexico, the Great Lakes, and the Caribbean Sea, flood hazards must take into account how storm surges, waves, and extreme tides interact with factors such as topography and vegetation. Storm surge and waves must also be considered in assessing flood risk for certain communities on rivers or large inland bodies of water.

Beyond areas that are affected by waves and tides, coastal communities can also have riverine floodplains with designated floodways, as described in previous sections.

Floodplain Boundaries

In many coastal areas, storm surge is the principle component of flooding. The extent of the 1% annual chance floodplain in these areas is derived from the total stillwater elevation (stillwater elevation including storm surge plus wave setup) for the 1% annual chance storm. The methods that were used for calculation of total stillwater elevations for coastal areas are described in Section 5.3 of this FIS Report. Location of total stillwater elevations for coastal areas are shown in Figure 8, “1% Annual Chance Stillwater Levels for Coastal Areas.”

In some areas, the 1% annual chance floodplain is determined based on the limit of wave runup or wave overtopping for the 1% annual chance storm surge. The methods that were used for calculation of wave hazards are described in Section 5.3 of this FIS Report.

Table 26 presents the types of coastal analyses that were used in mapping the 1% annual chance floodplain in coastal areas.

Coastal BFEs

Coastal BFEs are calculated as the total stillwater elevation (stillwater elevation including storm surge plus wave setup) for the 1% annual chance storm plus the additional flood hazard from overland wave effects (storm-induced erosion, overland wave propagation, wave runup and wave overtopping).

Where they apply, coastal BFEs are calculated along transects extending from offshore to the limit of coastal flooding onshore. Results of these analyses are accurate until local topography, vegetation, or development type and density within the community undergoes major changes.

Parameters that were included in calculating coastal BFEs for each transect included in this FIS Report are presented in Table 17, “Coastal Transect Parameters.” The locations of transects are shown in Figure 9, “Transect Location Maps.” More detailed information about the methods used in coastal analyses and the results of intermediate steps in the coastal analyses are presented in Section 5.3 of this FIS Report. Additional information on specific mapping methods is provided in Section 6.4 of this FIS Report.

2.5.3 Coastal High Hazard Areas

Certain areas along the open coast and other areas may have higher risk of experiencing structural damage caused by wave action and/or high-velocity water during the 1% annual chance flood. These areas will be identified on the FIRM as Coastal High Hazard Areas.

- *Coastal High Hazard Area (CHHA)* is a SFHA extending from offshore to the inland limit of the primary frontal dune (PFD) or any other area subject to damages caused by wave action and/or high-velocity water during the 1% annual chance flood.

- *Primary Frontal Dune (PFD)* is a continuous or nearly continuous mound or ridge of sand with relatively steep slopes immediately landward and adjacent to the beach. The PFD is subject to erosion and overtopping from high tides and waves during major coastal storms.

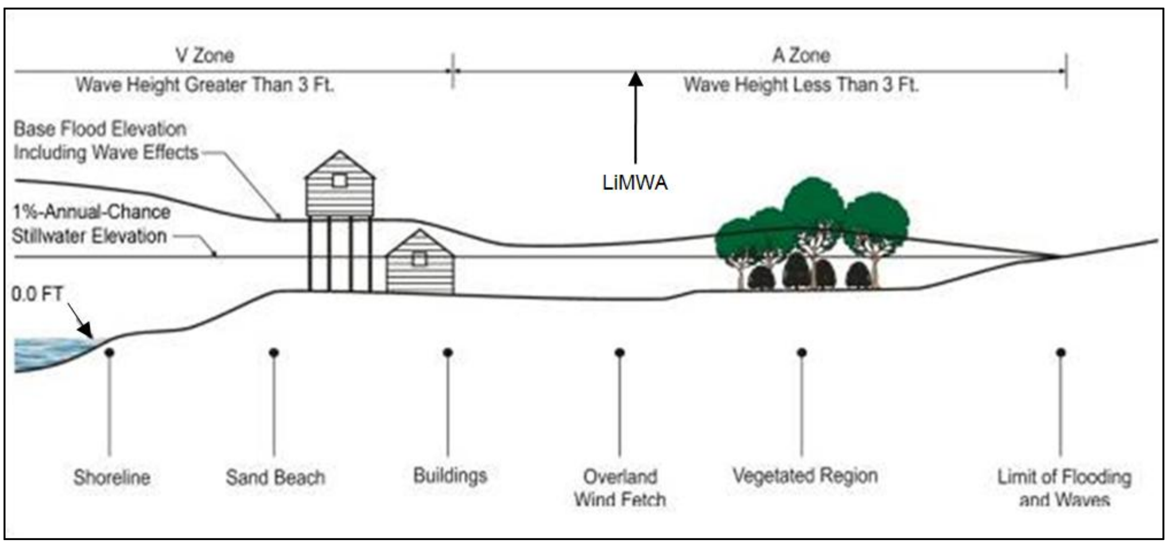
CHHAs are designated as “V” zones (for “velocity wave zones”) and are subject to more stringent regulatory requirements and a different flood insurance rate structure. The areas of greatest risk are shown as VE on the FIRM. Zone VE is further subdivided into elevation zones and shown with BFEs on the FIRM.

The landward limit of the PFD occurs at a point where there is a distinct change from a relatively steep slope to a relatively mild slope; this point represents the landward extension of Zone VE. Areas of lower risk in the CHHA are designated with Zone V on the FIRM. More detailed information about the identification and designation of Zone VE is presented in Section 6.4 of this FIS Report.

Areas that are not within the CHHA but are SFHAs may still be impacted by coastal flooding and damaging waves; these areas are shown as “A” zones on the FIRM.

Figure 6, “Coastal Transect Schematic,” illustrates the relationship between the base flood elevation, the 1% annual chance stillwater elevation, and the ground profile as well as the location of the Zone VE and Zone AE areas in an area without a PFD subject to overland wave propagation. This figure also illustrates energy dissipation and regeneration of a wave as it moves inland.

Figure 6: Coastal Transect Schematic



Methods used in coastal analyses in this Flood Risk Project are presented in Section 5.3 and mapping methods are provided in Section 6.4 of this FIS Report.

Coastal floodplains are shown on the FIRM using the symbology described in Figure 3, “Map Legend for FIRM.” In many cases, the BFE on the FIRM is higher than the stillwater elevations shown in Table 17 due to the presence of wave effects. The higher elevation should be used for construction and/or floodplain management purposes.

2.5.4 Limit of Moderate Wave Action

This section is not applicable to this Flood Risk Project.

SECTION 3.0 – INSURANCE APPLICATIONS

3.1 National Flood Insurance Program Insurance Zones

For flood insurance applications, the FIRM designates flood insurance rate zones as described in Figure 3, “Map Legend for FIRM.” Flood insurance zone designations are assigned to flooding sources based on the results of the hydraulic or coastal analyses. Insurance agents use the zones shown on the FIRM and depths and base flood elevations in this FIS Report in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

The 1% annual chance floodplain boundary corresponds to the boundary of the areas of special flood hazards (e.g. Zones A, AE, V, VE, etc.), and the 0.2% annual chance floodplain boundary corresponds to the boundary of areas of additional flood hazards.

Table 3 lists the flood insurance zones in the City and County of San Francisco.

Table 3: Flood Zone Designations by Community

Community	Flood Zone(s)
San Francisco, City and County of	AE, AO, D, VE, X

3.2 Coastal Barrier Resources System

This section is not applicable to this Flood Risk Project.

Table 4: Coastal Barrier Resources System Information

[Not Applicable to this Flood Risk Project]

SECTION 4.0 – AREA STUDIED

4.1 Basin Description

Table 5 contains a description of the characteristics of the HUC-8 sub-basins within which each community falls. The table includes the main flooding sources within each basin, a brief description of the basin, and its drainage area.

Table 5: Basin Characteristics

HUC-8 Sub-Basin Name	HUC-8 Sub-Basin Number	Primary Flooding Source	Description of Affected Area	Drainage Area (square miles)
San Pablo Bay	18050002	San Francisco Bay	Covers the northern half of the community; shoreline extends from the northwestern corner along the open Pacific coast to just north of the San Francisco-Oakland Bay Bridge in the San Francisco Bay. The coastal floodplain of the north-facing shoreline is heavily developed in low-lying areas susceptible to flooding. Key drainage features include: Lobos Creek which drains to Baker Beach, Dragonfly Creek with drains to the San Francisco Bay, and the Tennessee Hollow watershed which drains to the tidal marsh at Crissy Field.	2,652
San Francisco Bay	18050004	San Francisco Bay	Covers the southern half of the community; includes the majority of the San Francisco Bay shoreline inside the community. The coastal floodplain is relatively narrow and is heavily developed in low-lying areas susceptible to flooding. Islais Creek, Yosemite Creek, and Mission Creek are the principal creeks in San Francisco, but are mostly culverted underground.	2,965
Tomales-Drake Bays	18050005	Pacific Ocean	Covers the Farallon Islands, which are characterized by rocky terrain and are almost entirely undeveloped.	1,979
San Francisco Coastal South	18050006	Pacific Ocean	Encompasses the majority of the open Pacific coast shoreline in the community. The shoreline is characterized by beaches, rocky outcrops, and bluffs from the San Mateo county line at Fort Funston to Lands End in the northwestern corner of San Francisco. The rocky section of coast in the northwestern corner of this basin is generally undeveloped. The fairly straight section of coastline south of Lands End to Fort Funston consists of a relatively wide sandy beach backed by seawalls and dunes. The backshore and inland areas are heavily developed. The watershed contains Lake Merced, a key waterbody that has no direct connection to the Pacific Ocean.	1,746

4.2 Principal Flood Problems

Table 6 contains a description of the principal flood problems that have been noted for the City and County of San Francisco by flooding source.

Table 6: Principal Flood Problems

Flooding Source	Description of Flood Problems
Pacific Ocean	The northern section of the open coast shoreline, from the Golden Gate Bridge to Point Lobos, consists mostly of federal or state property (typically former military facilities or park lands). This segment has several stretches of wave-cut rocky cliffs as well as an approximately 0.7 mile long stretch of sandy beach known as Baker Beach. Some parcels have additional retaining walls built higher on the cliff slope to prevent slumping and landsliding caused by runoff and groundwater (BakerAECOM OPC 2012, Griggs et al. 2005). The cliffs are generally composed of serpentinite, graywacke (a type of sandstone), and large rocks and boulders (Hayes and Michel 2010). The rocky cliffs are generally resistant to wave attack but are prone to landslides and cliff retreat (Griggs et al. 2005).
Pacific Ocean	The relatively straight section of coastline between the Cliff House and Fort Funston consists of a relatively wide sandy beach backed by seawalls and dunes known as Ocean Beach. The beach is publicly owned and the backshore is heavily developed. The O'Shaughnessy Seawall and Esplanade were constructed section by section from 1919 to 1929. The seawall extends approximately 4,600 feet from the base of the Cliff House southward to Lincoln Way. South of the seawall is an area of active coastal foredunes that extends approximately 4,400 feet from Lincoln Way to Noriega Street. South of Noriega Street the 2,900 ft long Great Highway Seawall was constructed between 1988 and 1993 and extends approximately from Noriega Street to Santiago Street. A relatively short (660 ft) seawall between Santiago and Taraval Streets was constructed in 1941 and is mostly buried by sand (Wiegel 2002). In the active dune areas sand is chronically washed and blown off the dunes during winter storms requiring periodic to annual closure of the Great Highway for sand removal. (BakerAECOM OPC 2012).
Pacific Ocean	The southern portion of Ocean Beach between Sloat Boulevard and Fort Funston is particularly vulnerable to erosion. In this reach, the broad sandy beaches of Ocean Beach transition into the steep, high, unconsolidated sandy bluffs of the Merced and Colma formations (Hayes and Michel 2010). The section of the Great Highway (and buried infrastructure) immediately landward of the coastal bluffs has been repeatedly threatened by undermining. The area south of Sloat Boulevard has a history of erosion control measures, including sand and rock placement at the base of the bluffs to protect eroding parking lots, the roadway, and threatened infrastructure. This included construction of a 600-foot rock revetment in 1997 and a 440-foot revetment in 2010.

Table 6: Principal Flood Problems, continued

Flooding Source	Description of Flood Problems
Pacific Ocean and San Francisco Bay	The most severe storms typically occur when elevated storm water levels coincide with a significant high tide event. This requires a combination of high tides and waves. Storms that occur during El Niño events are particularly severe as water levels are typically elevated during El Niño winters. On the open coast, damage was more severe during the 1982-1983 El Niño winter compared to the 1997-1998 El Niño winter because there were more coincident wave and high tide events so that the total duration of elevated water levels was longer and overall coastal exposure to storm total water level was higher (Griggs and Brown 1998). During the 1982-1983 and 1997-1998 El Niño winters, abnormally high seas and storm surges caused millions of dollars worth of damage in the San Francisco Bay area (California Climate Change Center 2006).
Pacific Ocean	There were several large storm events during the 1982-1983 El Niño that affected the open coast. The early storms initiated erosion and left the beaches eroded and threatened by subsequent storms. Eight storms had offshore significant wave heights that exceeded 13 feet. Maximum offshore significant wave heights approached 23 feet and several times wind gusts exceeded 60 mph. The worst periods of storminess occurred at the end of January and February 1983. During the 1982-1983 El Niño, a sewer outfall that was under construction was threatened as the beach eroded dramatically at Ocean Beach. Stone debris, including headstones from a cemetery, was dumped to temporarily protect the outfall. The offshore construction derrick barge Betty L, which was working on the outfall project, was grounded at Ocean Beach during consecutive large storms (Ott Water Engineers 1984). South of Sloat Boulevard, stones were placed to protect the bluff toe in several locations after the bluffs retreated as much as 40 feet during the 1994-1995 winter. The armoring was not intended to be a permanent solution, and quarry stone armor had to be placed to protect the eroding bluffs again after the 1997-1998 El Niño winter. During a March storm, an erosion gully eroded the bluffs to within 15 feet of the highway. 10 to 15 vertical feet of sand were eroded off of the beach and the bluff retreated up to 16 feet in front of the south parking lot at Sloat Boulevard. During the 1998-1999 winter storms the bluffs eroded up to 50 feet between the south lot and Fort Funston (ESA 2005). Recent erosion during the mild El Niño during the 2009-2010 winter further threatened the road and infrastructure south of Sloat Boulevard leading to the placement of a 450-foot long rock revetment to protect the bluffs (BakerAECOM OPC 2012).
Pacific Ocean	The entire open coast is subject to tsunami, with 1964 being the last major event on the California coast, and several smaller (but still damaging) tsunamis since then, including the recent Japanese Tohoku tsunami in March 2011 (BakerAECOM OPC 2012).

Table 6: Principal Flood Problems, continued

Flooding Source	Description of Flood Problems
San Francisco Bay	Flooding regularly occurs along The Embarcadero during astronomical high tides, such as that which occurred on December 2012. These "king" tides occur on a predictable schedule several times a year. Research conducted by the U.S. Geological Survey projects a sea level rise of 16 inches by mid-century and 55 inches at the end of the century. According to the Multi-Jurisdictional Local Hazard Mitigation Plan for the San Francisco Bay Area, this change will affect the San Francisco Bay shoreline and increase the risk of levee failures (ABAG 2010). The San Francisco International Airport is at risk from sea level rise as well as residential, commercial properties, especially marinas and piers, and recreational areas along the entire bay and ocean coastline.
Various flooding sources	The past history of flooding in San Francisco indicates that floods in low-lying areas not adjacent to shorelines are associated with severe storms. Sewer overflows, equipment breakdowns in the aging system, and subsidence of areas located on fill or bay mud all contribute to localized flooding. A block on Folsom Street was flooded in 2009 when heavy rains overwhelmed storm sewers. The city replaced pumps in the area, but in April 2012, two apartment buildings and three businesses were flooded in the same block. Similar flooding in December 2012 closed a public transit station and intersections throughout the city (SF Examiner 2012). Major disaster declarations for flooding that included San Francisco County were issued for the April 1995 (DR-1046), December 1996 (DR-1155), and February 1998 (DR-1203) incidents (FEMA 2013). The San Francisco Public Utilities Commission owns several above ground reservoirs and tanks within San Francisco. Failure of these reservoirs as a result of earthquakes would inundate limited areas of the city (SFPUC 2012).

Table 7 contains information about historic flood elevations in the communities within the City and County of San Francisco.

Table 7: Historic Flooding Elevations

[Not Applicable to this Flood Risk Project]

4.3 Non-Levee Flood Protection Measures

Table 8 contains information about non-levee flood protection measures within the City and County of San Francisco such as dams, jetties, and or dikes. Levees are addressed in Section 4.4 of this FIS Report.

Table 8: Non-Levee Flood Protection Measures

Flooding Source	Structure Name	Type of Measure	Location	Description of Measure
Pacific Ocean	China Beach Seawall	Seawall	Transect 21. China Beach, adjacent to the Sea Cliff neighborhood.	Structure is well engineered and is expected to withstand the 1% event. Publically maintained; has survived decades of coastal storm events. Structure dates to pre-1970s and is located in a semi-sheltered area.
Pacific Ocean	O'Shaughnessy Seawall	Seawall	Transects 14 & 15. Ocean Beach; extends along Great Highway north of Balboa Street to north of Lincoln Way.	Structure is well engineered and is expected to withstand the 1% event. Publically maintained; has survived decades of coastal storm events. Constructed 1919 – 1929.
Pacific Ocean	Sutro Baths Ruins	Revetment + Seawall	Transect 17. Near Seal Rock; part of the Golden Gate National Recreation Area.	Ruins of an old pool complex; Detailed structure condition is unknown and performance of the structure during 1% event is uncertain.
Pacific Ocean	Taraval Seawall	Buried Seawall	Transect 9. Lower Great Highway Park; extends along the Great Highway between Noriega and Taraval Streets.	Structure is well engineered and is expected to withstand the 1% event. Publically maintained; has survived decades of coastal storm events. Constructed 1941.
Pacific Ocean	Unnamed	Retaining Wall	Transect 22.	Small, discontinuous coastal structure.

Table 8: Non-Levee Flood Protection Measures, continued

Flooding Source	Structure Name	Type of Measure	Location	Description of Measure
Pacific Ocean	Unnamed	Revetment	Transect 6.	Revetment placed in 1998 under emergency conditions. Originally intended to be a minimal and temporary structure. Evidence of erosion above revetment crown, displacement of stones, and settlement. Revetment does not meet coastal engineering design standards (Moffat & Nichol 2005). Detailed structure condition is unknown and performance of this unpermitted structure during the 1% event is uncertain.
Pacific Ocean	Unnamed	Revetment	Transect 3.	Structure was recently constructed in 2010 under emergency conditions, is not permitted by the Coastal Commission, and has no history of storm performance. Structure does not extend up the full height of the bluff and is flanked by unarmored segments of highly erodible bluffs to the north and south. Detailed structure condition is unknown and performance of this unpermitted structure during the 1% event is uncertain.
Pacific Ocean	Unnamed	Rubble/ Riprap	Transects 5 – 7.	Structures are in poor condition, and are not anticipated to withstand the 1% event.
Pacific Ocean	Unnamed	Seawall	Transects 10 & 11.	Structure is well engineered and is expected to withstand the 1% event. Publically maintained; has survived decades of coastal storm events. Constructed 1988 – 1993.
San Francisco Bay	N/A	Breakwater	Various locations	Not high enough to prevent flooding

Table 8: Non-Levee Flood Protection Measures, continued

Flooding Source	Structure Name	Type of Measure	Location	Description of Measure
Various flooding sources	N/A	Bridges, culverts, bank and erosion protection	Various locations	Flood protection measures are generally limited to bridge, culvert and levee construction and bank and erosion protection.
Various flooding sources	N/A	Culverts	Various locations	A majority of the city's natural watercourses, such as Islais Creek and Mission Creek, have been directed into culverts and built over. Over 90% of San Francisco is served by a combined sewer system which conveys wastewater and stormwater in the same set of sewer pipes (City and County of San Francisco, 2012). Only about 10% of the city is served by separate storm sewer systems.

4.4 Levees

For purposes of the NFIP, FEMA only recognizes levee systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. This information must be supplied to FEMA by the community or other party when a flood risk study or restudy is conducted, when FIRMs are revised, or upon FEMA request. FEMA reviews the information for the purpose of establishing the appropriate FIRM flood zone.

Levee systems that are determined to reduce the risk from the 1% annual chance flood are accredited by FEMA. FEMA can also grant provisional accreditation to a levee system that was previously accredited on an effective FIRM and for which FEMA is awaiting data and/or documentation to demonstrate compliance with Section 65.10. These levee systems are referred to as Provisionally Accredited Levees, or PALs. Provisional accreditation provides communities and levee owners with a specified timeframe to obtain the necessary data to confirm the levee's certification status. Accredited levee systems and PALs are shown on the FIRM using the symbology shown in Figure 3 and in Table 9. If the required information for a PAL is not submitted within the required timeframe, or if information indicates that a levee system not longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA.

FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. The USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, the USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are ineligible for rehabilitation assistance under Public Law 84-99.

FEMA coordinated with the USACE, the local communities, and other organizations to compile a list of levees that exist within Flood County. Table 9, “Levees,” lists all accredited levees, PALs, and de-accredited levees shown on the FIRM for this FIS Report. Other categories of levees may also be included in the table. The Levee ID shown in this table may not match numbers based on other identification systems that were listed in previous FIS Reports. Levees identified as PALs in the table are labeled on the FIRM to indicate their provisional status.

Please note that the information presented in Table 9 is subject to change at any time. For that reason, the latest information regarding any USACE structure presented in the table should be obtained by contacting USACE and accessing the USACE national levee database. For levees owned and/or operated by someone other than the USACE, contact the local community shown in Table 31.

Table 9: Levees

Community	Flooding Source	Levee Location	Levee Owner	USACE Levee	Levee ID	Covered Under PL84-99 Program?	FIRM Panel(s)
San Francisco, City and County of	San Francisco Bay	N/A	Various private ownership	No	N/A	No	0602980232A, 0602980234A, 0602980251A, 0602980253A

Levees have been constructed for various locations along the bayfront. No projects are being maintained or operated by the USACE in San Francisco County.

SECTION 5.0 – ENGINEERING METHODS

For the flooding sources in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude that are expected to be equaled or exceeded at least once on the average during any 10-, 25-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 25-, 50-, 100-, and 500-year floods, have a 10-, 4-, 2-, 1-, and 0.2% annual chance, respectively, of being equaled or exceeded during any year.

Although the recurrence interval represents the long-term, average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood that equals or exceeds the 100-year flood (1-percent chance of annual exceedance) during the term of a 30-year mortgage is approximately 26 percent (about 3 in 10); for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

5.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak elevation-frequency relationships for floods of the selected recurrence intervals for each flooding source studied. Hydrologic analyses are typically performed at the watershed level. Depending on factors such as watershed size and shape, land use and urbanization, and natural or man-made storage, various models or methodologies may be applied. A summary of the hydrologic methods applied to develop the discharges used in the hydraulic analyses for each stream is provided in Table 13. Greater detail (including assumptions, analysis, and results) is available in the archived project documentation.

Table 10: Summary of Discharges

[Not Applicable to this Flood Risk Project]

Figure 7: Frequency Discharge-Drainage Area Curves

[Not Applicable to this Flood Risk Project]

Table 11: Summary of Non-Coastal Stillwater Elevations

[Not Applicable to this Flood Risk Project]

Table 12: Stream Gage Information used to Determine Discharges

[Not Applicable to this Flood Risk Project]

5.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals. Base flood elevations on the FIRM represent the elevations shown on the Flood Profiles and in the Floodway Data tables in the FIS Report. Rounded whole-foot elevations may be shown on the FIRM in coastal areas, areas of ponding, and other areas with static base flood elevations. These whole-foot elevations may not exactly reflect the elevations derived from the hydraulic analyses. Flood elevations shown on the FIRM are primarily intended for flood insurance rating purposes. For construction and/or floodplain management purposes, users are cautioned to use the flood elevation data presented in this FIS Report in conjunction with the data shown on the FIRM.

A summary of the methods used in hydraulic analyses performed for this project is provided in Table 13. Roughness coefficients are provided in Table 14. Roughness coefficients are values representing the frictional resistance water experiences when passing overland or through a channel. They are used in the calculations to determine water surface elevations. Greater detail (including assumptions, analysis, and results) is available in the archived project documentation.

Table 13: Summary of Hydrologic and Hydraulic Analyses

[Not Applicable to this Flood Risk Project]

Table 14: Roughness Coefficients

[Not Applicable to this Flood Risk Project

5.3 Coastal Analyses

For the areas of the City and County of San Francisco that are impacted by coastal flooding processes, coastal flood hazard analyses were performed to provide estimates of coastal BFEs. Coastal BFEs reflect the increase in water levels during a flood event due to extreme tides and storm surge as well as overland wave effects.

The following subsections provide summaries of how each coastal process was considered for this FIS Report. Greater detail (including assumptions, analysis, and results) is available in the archived project documentation. Table 15 summarizes the methods and/or models used for the coastal analyses. Refer to Section 2.5.1 for descriptions of the terms used in this section.

Table 15: Summary of Coastal Analyses

Flooding Source	Study Limits From	Study Limits To	Hazard Evaluated	Model or Method Used	Date Analysis was Completed
Pacific Ocean	Southern Marin County Boundary	Northern San Mateo County Boundary	Wave Setup and Runup	FEMA Pacific Guidelines 2005; Stockdon, DIM, TAW	August, 2014
Pacific Ocean	Southern Marin County Boundary	Northern San Mateo County Boundary	SWEL[1]	Tide Frequency Analysis	August, 2014
San Francisco Bay	Entire shoreline with the City and County of San Francisco	Entire shoreline with the City and County of San Francisco	Overland Wave Propagation	WHAFIS Version 4 (FEMA, 1988; Divoky, 2007)	July 2015
San Francisco Bay	Entire shoreline with the City and County of San Francisco	Entire shoreline with the City and County of San Francisco	Wave Setup and Runup	DIM/TAW/SPM (FEMA, 2005/ van der Meer 2002/ USACE, 1984)	July 2015
San Francisco Bay	Entire shoreline within the City and County of San Francisco	Entire shoreline within the City and County of San Francisco	Stillwater Level and Deepwater Wave Conditions	MIKE 21 Flow Model (HD), MIKE 21 Spectral Wave (SW)	July 2015

[1]The stillwater level (SWL) is the time-varying offshore water level in the absence of wave effects and should not be confused with the stillwater elevation (SWEL) which refers to the statistically determined constant flood elevation (the 1-percent annual chance SWEL).

5.3.1 Stillwater Elevations

The stillwater elevations for the 1% annual chance flood were determined for areas subject to coastal flooding. The models and methods that were used to determine stillwater elevations for the Pacific Ocean and for the San Francisco Bay are listed in Table 15. With the response-based approach that was used for this study area, there is not a single stillwater level that is associated with the 1-percent annual chance runup elevation. Therefore, the total water levels used for each transect in the open Pacific coast and San Francisco Bay coastal analyses are shown in Table 17, "Coastal Transect Parameters." The stillwater elevation for the open Pacific coast is 9.0 ft NAVD 88, and the stillwater elevations for the San Francisco Bay range from 9.4 ft NAVD 88 to 10.3 ft NAVD 88. Refer to the Intermediate Data Submittals (BakerAECOM 2012, 2013, 2014a, 2014b, 2015a, 2015b) for full details on how stillwater elevations have been applied to both the open Pacific Coast and San Francisco Bay analyses. Figure 8 shows the stillwater elevations for the 1% annual chance flood that was determined for the open Pacific coast and San Francisco Bay study areas.

Figure 8: 1% Annual Chance Stillwater Elevations for Coastal Areas

For the Pacific Ocean, recorded annual maxima from long-term tide stations were used in a regional frequency analysis for the statistical determination of the 1-percent annual chance SWELs for mapping and analysis purposes. Observed tide gage records are assumed to be representative of the stillwater level. Although tide stations along the California open Pacific coast are sparse, the spatial variability of regional storms and other influences, such as El Niño coastal processes, are adequately captured in the tide station records given the spatial density of tide stations relative to the size of the storm systems. The tide frequency analysis component of the study determined the 50-, 20-, 10-, 4-, 2-, 1-, and 0.2-percent annual chance SWEL conditions.

The 1-percent SWEL is used in isolated portions of the open Pacific coast study area as a base water level for sheltered waters analyses and for backwater flooding and inundation mapping in lagoons, rivers, creeks, and embayments. However, because the City and County of San Francisco open Pacific Coast study area does not include any tidally-influenced backwater areas, the SWELs are reported in this FIS, but are not used directly for any portion of the analysis. It is important to note that the hourly records of stillwater level were used in determination of the hourly records of total water level, and ultimately the 1-percent annual chance total water levels for each flood zone. The data sources and calculations of the stillwater level components are described in the following sections.

For San Francisco Bay, storm surge, swell-wave and wind-waves were modeled at a regional scale using numerical models to deterministically predict water levels and wave conditions in the bay. The regional modeling was conducted in two phases. The first phase focused on the North and Central Bay (DHI 2011); the second phase focused on the South Bay (DHI 2013). Coastal flooding hazards were then evaluated with one-dimensional (1D) transect-based models. Results from the North/Central Bay study were used in the coastal flood hazard analysis for the all areas of San Francisco County except San Francisco International Airport (transects 27 – 80). The South Bay results were used for San Francisco International Airport (transects 81 – 89).

Astronomical Tide

For both the open Pacific coast and San Francisco Bay, tide data was collected at coastal tide gages. These data were obtained from the NOAA National Ocean Service (NOS).

Storm Surge

Storm surge can be modeled based on characteristics of actual storms responsible for significant coastal flooding. The characteristics of these storms are typically determined by statistical study of the regional historical record of storms or by statistical study of tidal gages.

When historic records are used to calculate storm surge, characteristics such as the strength, size, track, etc., of storms are identified by site.

For San Francisco Bay, storm surge was modeled at a regional scale using numerical models to predict both SWLs and wave conditions in the bay. The regional modeling was conducted in two phases. The first phase focused on the North and Central Bay (DHI 2011); the second phase focused on the South Bay (DHI 2013). Coastal flooding hazards were then evaluated with one-dimensional (1D) transect-based models. Results from the North/Central Bay study were used in the coastal flood hazard analysis for the all areas of San Francisco County except San Francisco International Airport (transects 27 – 80). The South Bay results were used for San Francisco International Airport (transects 81 – 89).

Tthe MIKE 21 Flow Model (HD) and MIKE 21 Spectral Wave (SW) model developed by DHI Water & Environment were used for both the regional storm surge and wave modeling. Both models included the effects of astronomical tide, storm surge, and riverine discharge. The methodologies and model setup of the two regional modeling studies were very similar. Two notable differences between the two studies are the simulation period and the wave models. The North/Central Bay study simulated a 31-yr period from 1973 to 2003 and modeled both long period, Pacific Ocean swell and short period, locally generated wind-waves (seas). The South Bay study simulated a 54-yr period from 1956 to 2009 and only modeled the short period, locally generated wind-waves. The South Bay study did not model swell waves because swell from the Pacific Ocean does not penetrate that far south into the bay. The frequency and magnitude of storm surge and wave heights were derived statistically from the synthesized 31- or 54-year records.

Tidal gages can be used as historic records of storms when the available tidal gage record for the area represents all SWL components. Table 16 provides the gage name, managing agency, gage type, gage identifier, start date, end date, and statistical methodology applied to each gage used to determine the stillwater elevations.

For the open Pacific Coast, SWL data for tide stations along the CA coast were obtained from the NOAA National Ocean Service (NOS); however, existing tide station records along the coast provide an incomplete record, both spatially and temporally. Temporal gaps in the records were filled using an approach that applied the relationships of observed tidal residuals between neighboring tide stations to estimate residual components at stations with missing data. Using these correlations and an understanding of the spatial variability of regional storms, the gaps in tide station records were empirically reconstructed to provide a continuous hourly time series of SWLs for the 1960–2009 hindcast period at each long-term tide station in the open Pacific coast study area. SWL time series were evaluated for observed mean sea level trends and adjusted to the current National Datum Epoch of 1983–2001.

Once the hourly SWL hindcast was reconstructed at each long-term tide station, the reconstructed time series were applied along spatially homogeneous reaches of the coastline as input to the 1-D transect-based wave hazard analyses. For some open Pacific coastal reaches, it was determined that the nearest long-term tide station did not adequately represent the local tidal characteristics (e.g., tide range and phase) due to smaller-scale effects (e.g. bathymetry, coastline shape) in the region. For these reaches, predicted tides from short-term subordinate stations were combined with the reconstructed residual time series from the long-term tide stations to produce a representative SWL hindcast for use in the 1-D analysis.

Table 16: Tide Gage Analysis Specifics

Gage Name	Managing Agency of Tide Gage Record	Gage Type	Start Date	End Date	Statistical Methodology
San Francisco (9414290)	NOAA	Tide	June 30, 1854	Present	GEV
Ocean Beach (9414275)	NOAA	Tide	April 20, 1994	Present	GEV

Wave Setup Analysis

This section is not applicable to this Flood Risk Project.

5.3.2 Waves

For San Francisco Bay, water level and wave information from the regional hydrodynamic and wave models was used as input to the 1-D flood hazard analyses. Wave setup, runup, overtopping, and overland wave propagation were analyzed at representative transects. Transect profile elevations were based on the National Oceanic and Atmospheric Administration (NOAA) 2010 Northern San Francisco Bay Area LiDAR, collected February to April, 2010 (NOAA 2010). Bathymetric information was derived from USACE dredging surveys (USACE SFBay) and NOAA/ National Ocean Service (NOS) Geophysical Data System (GEODAS 2007) bathymetric data. In areas where the two datasets overlapped, the USACE data was given priority.

Survey data obtained between mid April and mid May 2011 were provided by San Francisco International Airport for a newly constructed shoreline protection and storm drainage system surrounding the airport. These data were used to supplement the older LiDAR data to reflect the existing conditions at the airport with the new structures.

For the open Pacific coast, to provide adequate wave input data for the 1-D transect-based wave hazard analyses, a continuous 50-year hourly deepwater and nearshore wave hindcast was developed for the period of January 1, 1960 to December 31, 2009 at multiple points along the CA coastline. The offshore wave modeling was performed by OWI in collaboration with BakerAECOM. The purpose of the deepwater wave modeling was to provide boundary condition wave spectra to drive the subsequent shelf-scale wave transformation modeling. The OWI wave modeling system combined existing and new OWI work products, including model grid development, wind forcing, wind field reanalysis for accurate representation of storms, data quality control, and validation of results using buoy and altimeter wind and wave data. OWI's wave modeling effort consisted of three nested model grid components of sequentially higher resolution to resolve wave conditions at varying spatial scales, including the basin (global), regional (Northeast Pacific Ocean), and coastal (California) grids. In order to drive the nearshore wave transformation model, directional spectra from the COASTAL model were archived at offshore output locations.

The nearshore wave transformation modeling was performed by the SIO Coastal Data Information Program (CDIP) research group, in collaboration with BakerAECOM. The purpose of the nearshore wave modeling was to transform the deepwater wave conditions, provided by OWI, nearshore wave conditions at the edge of the surf zone, in approximately 10 – 15 m (33 – 49 feet) water depth. The output from the nearshore wave transformation model provided the input conditions for the 1-D transect-based wave hazard analyses. The nearshore wave hindcasts were based on the SIO SHELF model. The SHELF model was validated against nearshore wave data from historical nearshore observational data collected by the SIO CDIP research group over the past several decades. Generally, nearshore wave hindcast output points along the California open Pacific coast are located along the 15 m depth contour at approximately 200 m alongshore spacing. For the City and County of San Francisco, the proximity of the Golden Gate ebb shoal and complex nearshore bathymetry necessitated output at the 10 m depth contour to better parallel the shoreline.

5.3.3 Coastal Erosion

A single storm episode can cause extensive erosion in coastal areas. For the open Pacific coast, storm-induced dune erosion was evaluated to determine the retreat of existing dunes due to the 1-percent annual chance TWL event. Dune erosion was evaluated by applying a combination of the MK&A geometric model and K&D time convolution model to dune-backed transects. Event-based duen retreat was first calculated using average strom conditions for the most likely winter profile and then subsequently for the 1-percent annal chance TWL event.

The dunes within the open Pacific coast study area are relatively tall and wide and are predicted to undergo minimal retreat during the base flood event. A comparison of the eroded dune profile crests to the TWL demonstrated that no eroded dune profiles were overtopped by the base flood event. As no dunes are predicted to completely erode or overtop during the base flood event, the heel of the PFD was selected as the landward boundary of the VE Zone.

Storm-induced erosion was not considered to be a component of the coastal flood hazard for the San Francisco Bay shoreline. The Primary Frontal Dune designation was not applied to the dunes of Crissy Field because the San Francisco Bay shoreline is not considered an "open coast."

5.3.4 Wave Hazard Analyses

Overland wave hazards were evaluated to determine the combined effects of ground elevation, vegetation, and physical features on overland wave propagation and wave runup. These analyses were performed at representative transects along all shorelines for which waves were expected to be present during the floods of the selected recurrence intervals. The results of these analyses were used to determine elevations for the 1% annual chance flood.

Transect locations were chosen with consideration given to the physical land characteristics as well as development type and density so that they would closely represent conditions in their locality. Additional consideration was given to changes in the total stillwater elevation. Transects were spaced close together in areas of complex topography and dense development or where total stillwater elevations varied. In areas having more uniform characteristics, transects were spaced at larger intervals. Transects shown in Figure 9, "Transect Location Map," are also depicted on the FIRM. Table 17 provides the total water level for each transect.

Wave Height Analysis

Wave height analyses were performed to determine wave heights and corresponding wave crest elevations for the areas inundated by coastal flooding and subject to overland wave propagation hazards. Refer to Figure 6 for a schematic of a coastal transect evaluated for overland wave propagation hazards.

Wave heights and wave crest elevations were modeled using the methods and models listed in Table 15, "Summary of Coastal Analyses".

Due to the steep shoreline and backshore features along the open Pacific coast, overland wave propagation was not computed for the open Pacific coast study area of the City and County of San Francisco.

For San Francisco Bay, overland wave propagation was evaluated for two transects that are inundated by the base flood (Transects 55 and 57). Overland wave propagation was modeled for two scenarios. The two scenarios were compared along the transect and the more hazardous condition for a given point was used to determine BFEs and flood zone designations.

Wave Setup and Runup Analysis

Wave setup and runup analyses were performed to determine the height and extent of runup during the 1-percent annual chance event. Wave setup and runup elevations were modeled using the methods and models listed in Table 15.

The maximum vertical extent of the combined SWL, wave steup, and wave runup is also referred to as the TWL. For San Francisco Bay, annual TWL maxima were selected from the hindcast time series at each transect, and an extreme value analysis (EVA) with the generalized extreme value (GEV) distribution was employed to determine the 1-percent annual chance TWL. For the open Pacific Coast, a peaks over threshold (POT) EVA was used with the hourly TWL data to determine the 1-percent annual chance TWL at most transects.

Wave overtopping was evaluated at transects where the TWL elevation exceeded a barrier crest, such as a structure, bluff, or dune. Wave overtopping was conducted using the splash overtopping equations in the Pacific Guidelines and the Cox-Machemehl equation for bore overtopping.

For the open Pacific coast, large expanses of the Open Pacific Coast are unpopulated (or populated well inland and/or above any coastal hazard) or held in the public trust as park lands or preserves and are not subject to future development. Limited detail study coastal analyses were adopted in some areas to provide reasonable estimates of coastal flood hazards while avoiding extensive data collection and analysis. In these areas, broad-scale representative analyses were conducted and adopted to determine coastal BFEs. In limited detail study areas, BFEs were developed by applying the results from a nearby, detailed analysis transect with similar characteristics (e.g., shoretype, topography, beach slope, wave exposure, etc.).

Much of the northern San Francisco Bay shoreline seaward of the Embarcadero is built out over water on piles. To reflect this, the SFHA boundary is mapped along the Embarcadero between Fisherman's Wharf and Pier 40. Waves were assumed to propagate beneath and between commercial piers with minimal damping effects north of 22nd Street, and wave runup was evaluated at the shoreline. Industrial piers and wharfs south of 22nd Street south are large engineered structures that are partially built on land and partially over water. They were considered an extension of the shoreline and wave runup was evaluated at the faces of these structures.

Overtopping analysis results indicate that areas landward of barrier crests that are affected by wave overtopping are narrow, on the order of 5-25 ft. Limitations of map scale does not allow for mapping these narrow overtopping zones independently. Therefore, instead of mapping these overtopping zones as Zone AO, the overtopping zones were combined with the Zone AE or Zone VE mapped at the shoreline based on runup. In other words, the Zone AE or Zone VE boundary is mapped set back from the crest of the barrier by a distance equal to the width of the overtopping zone.

The overtopping analysis does not explicitly evaluate ponding that may occur as a result of overtopping. Therefore, for structures that experience overtopping and that have negatively sloping ground and depressions just landward of the structure, a Zone AO (Depth 1 ft.) was mapped to indicate areas of sheetflow and ponding.

Table 17: Coastal Transect Parameters

Flood Source	Coastal Transect	XY Coordinates (Meters, NAD 1983 UTM Zone 10N)		Total Water Level (ft NAVD88)				
				10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Pacific Ocean	1	543229.8378	4173788.8401	16.6	17.5	18.2	19	20.7
Pacific Ocean	2	542925.2091	4174968.4332	17.1	17.7	18.2	18.6	19.4
Pacific Ocean	3	542788.0145	4175681.9235	15.6	16.3	16.7	17.2	18.1
Pacific Ocean	4	542769.9752	4175817.5214	14.6	15.5	16.3	17.1	19.4
Pacific Ocean	5	542726.2542	4176037.1948	20.7	21.5	22.1	22.6	23.7
Pacific Ocean	6	542692.6666	4176257.7449	23.5	24.4	25.0	25.6	26.9
Pacific Ocean	7	542652.1093	4176457.0693	18	18.8	19.5	20.1	21.4
Pacific Ocean	8	542593.4329	4176802.0880	19.8	20.6	21.2	21.7	22.7
Pacific Ocean	9	542524.5997	4177301.0702	19.8	20.9	21.7	22.5	24.5
Pacific Ocean	10	542415.5556	4177822.0669	19.4	20.4	21.2	22	23.7
Pacific Ocean	11	542349.2064	4178150.7959	20.8	21.9	22.6	23.3	24.9
Pacific Ocean	12	542343.1611	4178536.5596	15.2	15.9	16.3	16.7	17.7
Pacific Ocean	13	542268.8345	4179182.2584	17.7	18.9	19.9	20.9	23.5
Pacific Ocean	14	542299.2944	4179867.9634	15	15.7	16.1	16.5	17.4
Pacific Ocean	15	542165.0433	4180733.2359	15.3	15.7	16	16.3	16.7
Pacific Ocean	16	542171.5650	4181384.6277	21.8	23	23.8	24.6	26.4
Pacific Ocean	17	542158.5942	4181512.5697	25.5	26.5	27.1	27.7	28.6
Pacific Ocean	18	543000.6552	4182254.7739	16	16.8	17.3	17.8	18.8
Pacific Ocean	19	543950.7343	4182602.1207	16.9	17.7	18.3	18.8	20

Table 17: Coastal Transect Parameters, continued

Flood Source	Coastal Transect	XY Coordinates (Meters, NAD 1983 UTM Zone 10N)		Total Water Level (ft NAVD88)				
				10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Pacific Ocean	20	544258.1123	4182657.5868	13.2	14.1	14.8	15.6	17.9
Pacific Ocean	21	544654.1545	4182771.9080	14.3	14.8	15.2	15.5	16.3
Pacific Ocean	22	545011.6633	4182922.4648	14.6	15.1	15.4	15.8	16.4
Pacific Ocean	23	545129.8671	4182988.4539	17.7	18.6	19.3	19.9	21.4
Pacific Ocean	24	545295.5459	4183126.5901	14.6	15	15.3	15.5	16
Pacific Ocean	25	545409.9578	4183472.8273	14.2	14.6	14.9	15.1	15.6
Pacific Ocean	26	545671.3313	4184181.0519	15.5	16.2	16.7	17.1	18.1
San Francisco Bay	27	546012.5653	4184978.2941	*	*	*	22.9	*
San Francisco Bay	28	546098.2719	4184917.3458	*	*	*	12.9	*
San Francisco Bay	29	546563.5969	4184724.3068	*	*	*	14.6	*
San Francisco Bay	30	546967.9651	4184469.3608	*	*	*	11.8	*
San Francisco Bay	31	547621.8335	4184380.5332	*	*	*	11.6	*
San Francisco Bay	32	548312.8345	4184489.2108	*	*	*	11.6	*
San Francisco Bay	33	549180.8301	4184679.5092	*	*	*	15.1	*
San Francisco Bay	34	549531.2750	4184593.5247	*	*	*	15.0	*
San Francisco Bay	35	550119.6114	4184596.8005	*	*	*	14.9	*
San Francisco Bay	36	550317.4032	4184695.4858	*	*	*	17.9	*
San Francisco Bay	37	550800.5081	4184586.4245	*	*	*	15.7	*
San Francisco Bay	38	551107.9585	4184719.9677	*	*	*	13.2	*

Table 17: Coastal Transect Parameters, continued

Flood Source	Coastal Transect	XY Coordinates (Meters, NAD 1983 UTM Zone 10N)		Total Water Level (ft NAVD88)				
				10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
San Francisco Bay	39	551628.6783	4184817.9906	*	*	*	13.2	*
San Francisco Bay	40	552071.5177	4184723.0248	*	*	*	12.4	*
San Francisco Bay	41	552545.7254	4184486.3037	*	*	*	11.0	*
San Francisco Bay	42	552980.6676	4183846.3529	*	*	*	10.3	*
San Francisco Bay	43	553138.1310	4183629.1208	*	*	*	10.1	*
San Francisco Bay	44	553353.9430	4183342.2506	*	*	*	11.2	*
San Francisco Bay	45	553717.2394	4182899.9289	*	*	*	11.3	*
San Francisco Bay	46	553918.0439	4182092.4927	*	*	*	13.5	*
San Francisco Bay	47	553930.6604	4181588.8386	*	*	*	13.0	*
San Francisco Bay	48	554026.1796	4180698.2785	*	*	*	11.4	*
San Francisco Bay	49	554091.5748	4180091.3839	*	*	*	12.1	*
San Francisco Bay	50	554444.1615	4179429.4275	*	*	*	14.8	*
San Francisco Bay	51	554501.3465	4179228.7482	*	*	*	11.3	*
San Francisco Bay	52	554361.4475	4178683.1921	*	*	*	11.7	*
San Francisco Bay	53	554856.5016	4178503.7091	*	*	*	11.6	*
San Francisco Bay	54	554980.9932	4178282.0536	*	*	*	13.3	*
San Francisco Bay	55	555039.7654	4177913.9701	*	*	*	9.9[1]	*
San Francisco Bay	56	555410.4210	4177570.5711	*	*	*	11.9	*
San Francisco Bay	57	555355.7555	4176838.0663	*	*	*	10.0[1]	*

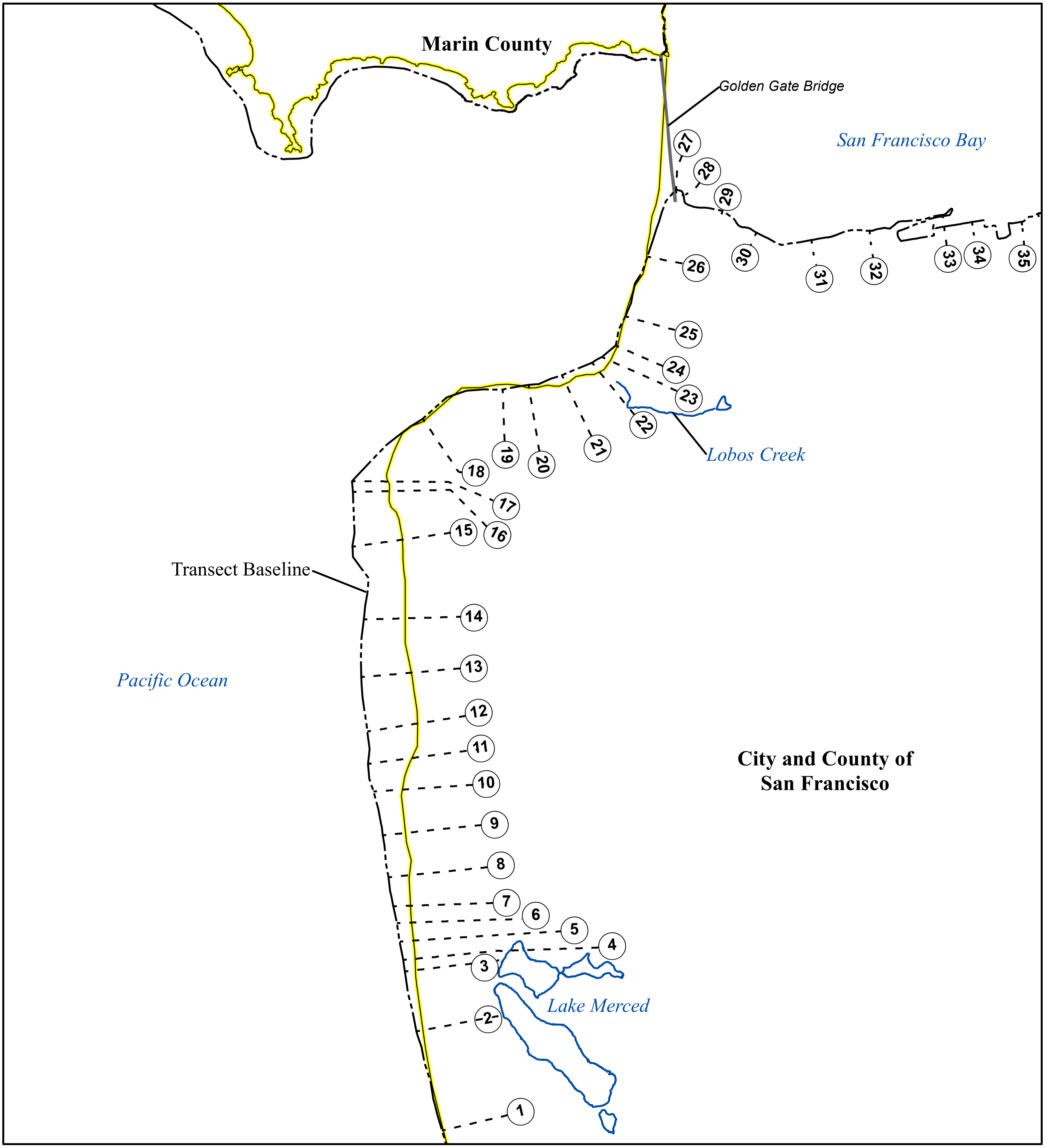
Table 17: Coastal Transect Parameters, continued

Flood Source	Coastal Transect	XY Coordinates (Meters, NAD 1983 UTM Zone 10N)		Total Water Level (ft NAVD88)				
				10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
San Francisco Bay	58	555063.5706	4176776.8492	*	*	*	12.7	*
San Francisco Bay	59	555409.4198	4176422.2832	*	*	*	11.8	*
San Francisco Bay	60	556015.5374	4176227.1997	*	*	*	11.5	*
San Francisco Bay	61	556616.5672	4175714.0859	*	*	*	15.2	*
San Francisco Bay	62	556091.5431	4174614.6757	*	*	*	14.5	*
San Francisco Bay	63	555404.4977	4174813.2239	*	*	*	10.7	*
San Francisco Bay	64	554621.9133	4175180.3192	*	*	*	10.1	*
San Francisco Bay	65	554769.5391	4174654.1969	*	*	*	10.0	*
San Francisco Bay	66	554741.5856	4174151.8898	*	*	*	10.6	*
San Francisco Bay	67	554358.7655	4173723.3759	*	*	*	11.1	*
San Francisco Bay	68	553550.5706	4173691.1403	*	*	*	12.7	*
San Francisco Bay	69	550609.1139	4186802.4489	*	*	*	19.7	*
San Francisco Bay	70	550864.9139	4186800.1632	*	*	*	15.9	*
San Francisco Bay	71	554690.8156	4186951.0291	*	*	*	13.6	*
San Francisco Bay	72	555342.8298	4187336.1716	*	*	*	11.5[2]	*
San Francisco Bay	73	555880.0405	4186688.3294	*	*	*	10.5	*
San Francisco Bay	74	555990.0708	4186038.3939	*	*	*	11.5[2]	*
San Francisco Bay	75	555750.8378	4185794.4540	*	*	*	10.7	*
San Francisco Bay	76	556238.1261	4185118.2013	*	*	*	12.2	*

Table 17: Coastal Transect Parameters, continued

Flood Source	Coastal Transect	XY Coordinates (Meters, NAD 1983 UTM Zone 10N)		Total Water Level (ft NAVD88)				
				10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
San Francisco Bay	77	555348.1541	4184836.0467	*	*	*	15.2	*
San Francisco Bay	78	554893.1997	4186284.4535	*	*	*	11.9	*
San Francisco Bay	79	558828.3806	4182199.1161	*	*	*	12.2	*
San Francisco Bay	80	551112.5693	4190712.9409	*	*	*	12.9	*
San Francisco Bay	81	554436.1217	4165825.6069	*	*	*	13.9	*
San Francisco Bay	82	553919.9406	4165156.2420	*	*	*	10.9	*
San Francisco Bay	83	554147.7442	4164824.0567	*	*	*	10.5	*
San Francisco Bay	84	555216.9333	4164772.9104	*	*	*	10.2	*
San Francisco Bay	85	556402.8301	4163573.2168	*	*	*	10.6	*
San Francisco Bay	86	556773.2033	4162954.0145	*	*	*	11.6	*
San Francisco Bay	87	555262.5243	4162807.2040	*	*	*	14.0	*
San Francisco Bay	88	555205.7775	4162167.1241	*	*	*	9.9	*
San Francisco Bay	89	555726.4578	4161813.2124	*	*	*	9.8	*

* Not calculated for this Flood Risk Project
[1] Stillwater elevation (ft NAVD88) (BakerAECOM 2015a, 2015b)
[2] Value has been rounded to the nearest tenth of a foot derived from the coastal modeling results



1 inch = 5,000 feet 1:60,000

N

0 1,500 3,000 6,000 9,000 12,000 Feet

Map Projection:
Universal Transverse Mercator, Zone 10N;
North American Datum 1983

COUNTY LOCATOR

NATIONAL FLOOD INSURANCE PROGRAM

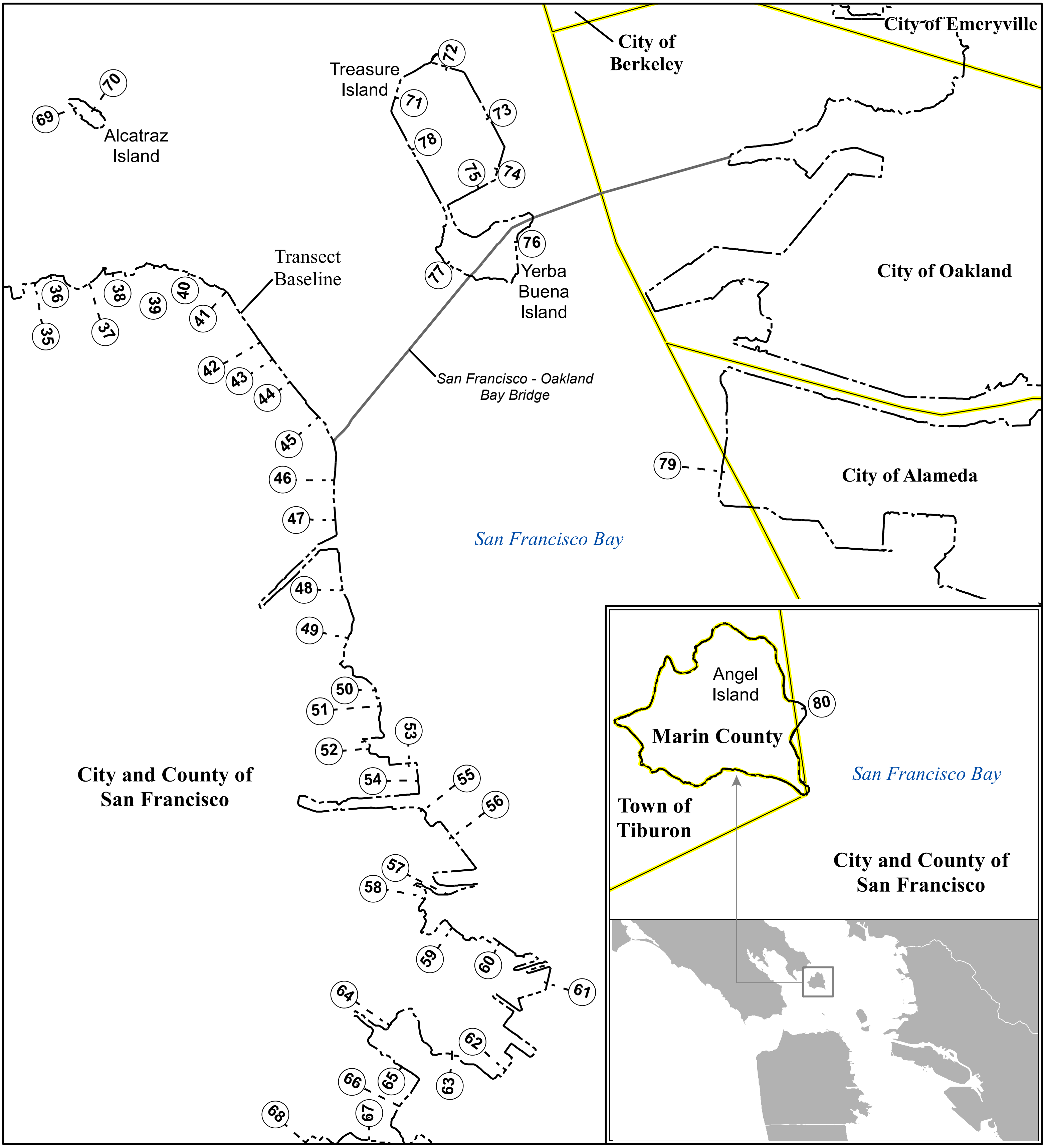
Figure 9. Transect Locator Map #1

CITY AND COUNTY OF SAN FRANCISCO, CALIFORNIA

PANELS WITH TRANSECTS:

0092, 0094, 0106, 0108, 0109, 0111, 0112, 0116, 0117, 0119, 0128, 0136, 0137, 0207, 0209, 0232, 0234, 0244, 0251, 0253, 0263, 0282, 0301

FEMA



1 inch = 5,333 feet 1:64,000

N

0 1,600 3,200 6,400 9,600 12,800 Feet

Map Projection:
Universal Transverse Mercator, Zone 10N;
North American Datum 1983

COUNTY LOCATOR

NATIONAL FLOOD INSURANCE PROGRAM

Figure 9. Transect Locator Map #2

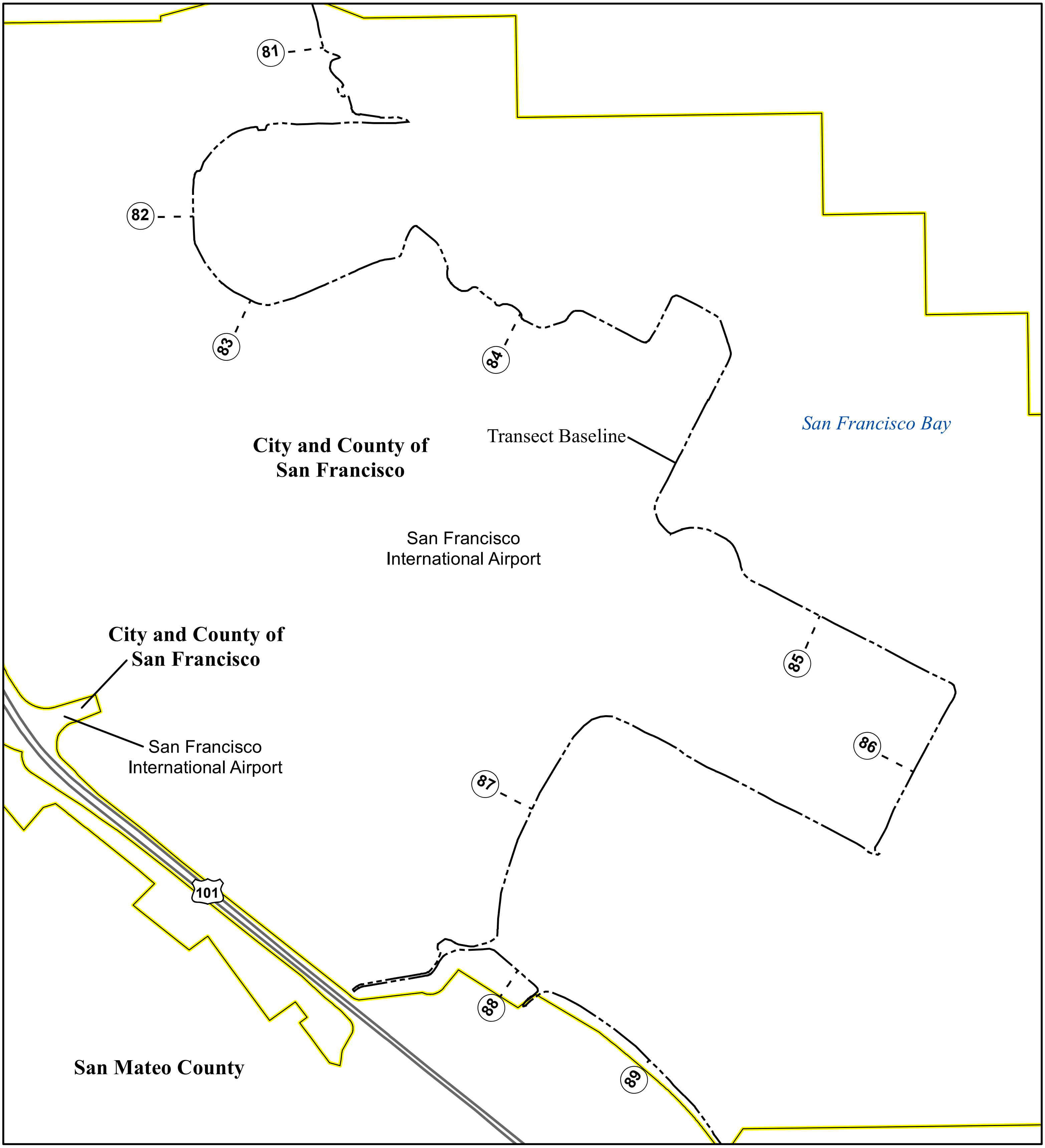
CITY AND COUNTY OF SAN FRANCISCO, CALIFORNIA

PANELS WITH TRANSECTS:

0092, 0094, 0106, 0108, 0109, 0111, 0112, 0116, 0117, 0119, 0128, 0136, 0137, 0207, 0209, 0232, 0234, 0244, 0251, 0253, 0263, 0282, 0301

U.S. DEPARTMENT OF HOMELAND SECURITY

FEMA



1 inch = 1,667 feet 1:20,000

N

0 500 1,000 2,000 3,000 4,000 Feet

Map Projection:
Universal Transverse Mercator, Zone 10N;
North American Datum 1983

COUNTY LOCATOR

NATIONAL FLOOD INSURANCE PROGRAM

Figure 9. Transect Locator Map #3

CITY AND COUNTY OF SAN FRANCISCO, CALIFORNIA

PANELS WITH TRANSECTS:

0092, 0094, 0106, 0108, 0109, 0111, 0112, 0116, 0117, 0119, 0128, 0136, 0137, 0207, 0209, 0232, 0234, 0244, 0251, 0253, 0263, 0282, 0301

FEMA

5.4 Alluvial Fan Analyses

This section is not applicable to this Flood Risk Project.

Table 18: Summary of Alluvial Fan Analyses
[Not Applicable to this Flood Risk Project]

Table 19: Results of Alluvial Fan Analyses
[Not Applicable to this Flood Risk Project]

SECTION 6.0 – MAPPING METHODS

6.1 Vertical and Horizontal Control

All FIS Reports and FIRMs are referenced to a specific vertical datum. The vertical datum provides a starting point against which flood, ground, and structure elevations can be referenced and compared. Until recently, the standard vertical datum used for newly created or revised FIS Reports and FIRMs was the National Geodetic Vertical Datum of 1929 (NGVD29). With the completion of the North American Vertical Datum of 1988 (NAVD88), many FIS Reports and FIRMs are now prepared using NAVD88 as the referenced vertical datum.

Flood elevations shown in this FIS Report and on the FIRMs are referenced to NAVD88. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. For information regarding conversion between NGVD29 and NAVD88 or other datum conversion, visit the National Geodetic Survey website at www.ngs.noaa.gov, or contact the National Geodetic Survey (NGS) at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

Temporary vertical monuments are often established during the preparation of a flood hazard analysis for the purpose of establishing local vertical control. Although these monuments are not shown on the FIRM, they may be found in the archived project documentation associated with the FIS Report and the FIRMs for this community. Interested individuals may contact FEMA to access these data.

To obtain current elevation, description, and/or location information for benchmarks in the area, please contact information services Branch of the NGS at (301) 713-3242, or visit their website at www.ngs.noaa.gov.

The datum conversion locations and values that were calculated for the City and County of San Francisco are provided in Table 20.

Table 20: Countywide Vertical Datum Conversion

[Not Applicable to this Flood Risk Project]

Table 21: Stream-Based Vertical Datum Conversion

[Not Applicable to this Flood Risk Project]

6.2 Base Map

The FIRMs and FIS Report for this project have been produced in a digital format. The flood hazard information was converted to a Geographic Information System (GIS) format that meets FEMA's FIRM database specifications and geographic information standards. This information is provided in a digital format so that it can be incorporated into a local GIS and be accessed more easily by the community. The FIRM Database includes most of the tabular information contained in the FIS Report in such a way that the data can be associated with pertinent spatial features. For example, the information contained in the Floodway Data table and Flood Profiles can be linked to the cross sections that are shown on the FIRMs. Additional information about the FIRM Database and its contents can be found in FEMA's *Guidelines and Standards for Flood Risk Analysis and Mapping*, www.fema.gov/guidelines-and-standards-flood-risk-analysis-and-mapping.

Base map information shown on the FIRM was derived from the sources described in Table 22.

Table 22: Base Map Sources

Data Type	Data Provider	Data Date	Data Scale	Data Description
Digital Orthophoto	California Coastal Services, Coastal California LiDAR & Digital Imagery collection	2011	Not Available	Base Map orthoimagery
Digital Orthophoto	USDA/NAIP	2012	1:24,000	Used in areas where Coastal California imagery was not available
Political boundaries	California Spatial Information Library (CASIL)	2002	Not Available	Political boundaries, City and County of San Francisco
Political boundaries	San Mateo County	2001	1:24,000	Political boundaries, San Francisco International Airport
Public Land Survey System (PLSS)	USGS	2010	Not Available	PLSS (Township, Range, Section) information
Transportation Features	City and County of San Francisco	2007	Not Available	Roads and Railroads
Surface Water Features	USGS	2002	Not Available	Surface Water Features

6.3 Floodplain and Floodway Delineation

The FIRM shows tints, screens, and symbols to indicate floodplains and floodways as well as the locations of selected cross sections used in the hydraulic analyses and floodway computations.

For riverine flooding sources, the mapped floodplain boundaries shown on the FIRM have been delineated using the flood elevations determined at each cross section; between cross sections, the boundaries were interpolated using the topographic elevation data described in Table 23. For each coastal flooding source studied as part of this FIS Report, the mapped floodplain boundaries on the FIRM have been delineated using the flood and wave elevations determined at each transect;

between transects, boundaries were delineated using land use and land cover data, the topographic elevation data described in Table 23, and knowledge of coastal flood processes. In ponding areas, flood elevations were determined at each junction of the model; between junctions, boundaries were interpolated using the topographic elevation data described in Table 23.

In cases where the 1% and 0.2% annual chance floodplain boundaries are close together, only the 1% annual chance floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

The floodway widths presented in this FIS Report and on the FIRM were computed for certain stream segments on the basis of equal conveyance reduction from each side of the floodplain. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. Table 2 indicates the flooding sources for which floodways have been determined. The results of the floodway computations for those flooding sources have been tabulated for selected cross sections and are shown in Table 24, "Floodway Data."

Table 23: Summary of Topographic Elevation Data used in Mapping

		Source for Topographic Elevation Data					
Community	Flooding Source	Description	Scale	Contour Interval	$RMSE_z$	$Accuracy_z$	Citation
City and County of San Francisco	Pacific Ocean	Light Detection and Ranging data (LiDAR), point cloud data	1m resolution	N/A	N/A	N/A	USGS 2010
City and County of San Francisco	Pacific Ocean	Light Detection and Ranging data (LiDAR), point cloud data	1m resolution	N/A	N/A	N/A	NOAA 2010a
City and County of San Francisco	Pacific Ocean	Bathymetric Data	2 – 10m DEM	N/A	N/A	N/A	CSMP 2011
City and County of San Francisco	Pacific Ocean	Bathymetric Data	10 – 30m DEM	N/A	N/A	N/A	NGDC-NOAA
City and County of San Francisco	San Francisco Bay	Light Detection and Ranging data (LiDAR)	N/A	N/A	N/A	N/A	NOAA 2010b
City and County of San Francisco	San Francisco Bay	Bathymetry, Survey Dredging Data	N/A	N/A	N/A	N/A	USACE SFBay

BFEs shown at cross sections on the FIRM represent the 1% annual chance water surface elevations shown on the Flood Profiles and in the Floodway Data tables in the FIS Report. Rounded whole-foot elevations may be shown on the FIRM in coastal areas, areas of ponding, and other areas with static base flood elevations.

Table 24: Floodway Data

[Not Applicable to this Flood Risk Project]

Table 25: Flood Hazard and Non-Encroachment Data for Selected Streams

[Not Applicable to this Flood Risk Project]

6.4 Coastal Flood Hazard Mapping

Flood insurance zones and BFEs including the wave effects were identified on each transect based on the results from the onshore wave hazard analyses. Between transects, elevations were interpolated using topographic maps, land-use and land-cover data, and knowledge of coastal flood processes to determine the aerial extent of flooding. Sources for topographic data are shown in Table 23.

Zone VE is subdivided into elevation zones and BFEs are provided on the FIRM.

The limit of Zone VE shown on the FIRM is defined as the farthest inland extent of any of these criteria (determined for the 1% annual chance flood condition):

- The *primary frontal dune zone* is defined in 44 CFR Section 59.1 of the NFIP regulations. The primary frontal dune represents a continuous or nearly continuous mound or ridge of sand with relatively steep seaward and landward slopes that occur immediately landward and adjacent to the beach. The primary frontal dune zone is subject to erosion and overtopping from high tides and waves during major coastal storms. The inland limit of the primary frontal dune zone occurs at the point where there is a distinct change from a relatively steep slope to a relatively mild slope.

- The *wave runup zone* occurs where the (eroded) ground profile is 3.0 feet or more below the 2-percent wave runup elevation.

- The *wave overtopping splash zone* is the area landward of the crest of an overtopped barrier, in cases where the potential 2-percent wave runup exceeds the barrier crest elevation by 3.0 feet or more.

- The *breaking wave height zone* occurs where 3-foot or greater wave heights could occur (this is the area where the wave crest profile is 2.1 feet or more above the total stillwater elevation).

- The *high-velocity flow zone* is landward of the overtopping splash zone (or area on a sloping beach or other shore type), where the product of depth of flow times the flow velocity squared (hv^2) is greater than or equal to 200 ft^3/sec^2. This zone may only be used on the Pacific Coast.

The SFHA boundary indicates the limit of SFHAs shown on the FIRM as either “V” zones or “A” zones.

Areas inundated by stillwater flooding with minimal wave hazard effects were mapped as Zone AE and the flood hazard boundary is located at the point where the ground elevation equals the stillwater elevation. In areas subject to wave runup, the flood hazard boundary is located at the point where the ground elevation equals the runup elevation, or where overtopping occurs, the boundary is located at the inland extent of overtopping. The Base Flood Elevation (BFE) in these areas is rounded to the nearest whole-foot, though the boundary is mapped using precision to the tenth of a foot. In San Francisco Bay, between transects 38 – 47, the floodplain boundary is mapped along the Embarcadero, or farther inland if warranted based on overtopping or inundation. Inundation flooding is mapped inland to the point where it meets continuous high ground or encounters flooding from another flooding source. Salt marsh berms and shoreline armoring structures are not considered barriers to flood inundation regardless of height or continuity.

Since the open Pacific coast study area within the City and County of San Francisco does not include any tidally-influenced backwater areas, stillwater elevations are reported, but are not used directly for any portion of the hazard zone mapping for the City and County of San Francisco.

For San Francisco Bay, structures surrounding Treasure Island, San Francisco International Airport, and the Alameda Naval Complex are not accredited with providing protection from the base flood and therefore inundation mapping is extended behind these structures.

The dominant wave hazard for the open Pacific coast is wave runup. Much of the San Francisco Bay shoreline of San Francisco County is lined by piers, wharfs, seawalls and revetments. The dominant wave hazard for all of these types of shorelines is wave runup. Reaches of shoreline where the dominant wave hazard is wave runup are distinguished with shore-perpendicular Special Flood Hazard Area (SFHA)/Flood Zone Boundary Lines (also known as Zone Break Lines or Gutters) separating segments of shoreline with differing runup elevations. The placement of the gutter lines is based on engineering judgment that took into account the slope of the ground, the orientation of the shoreline relative to the predominate wind and wave forces, and the presence of shore protection structures, such as revetments, that affect flood hazards at the shoreline.

The BFE for a runup reach is the 1-percent annual chance wave runup elevation. The flood zone designation of Zone VE or Zone AE is based on the magnitude of wave runup above the stillwater level. A VE Zone is mapped for transects with runup heights greater than 3 feet; an AE Zone is mapped for transects with runup heights less than 3 feet. This 3-foot runup height flood zone designation criterion was created to augment the existing guidance based on runup depth and is documented in Operating Guidance No. 9-13 Operating Guidance for Designation of Zone VE based on Wave Runup Height.

With the response-based approach that was used for this study, there is not a single stillwater level that is associated with the 1-percent annual chance runup elevation. Therefore, a runup height for the 1-percent annual chance runup elevation cannot be explicitly calculated. Instead, the flood zone designation is based on the runup heights for the 31 runup annual maxima that were used in the extreme value analysis. If the runup height above the stillwater was greater than 3 feet for at least one of the annual maxima, that transect and the associated reach of shoreline was designated Zone VE. If none of the annual maxima events had a runup height greater than 3 feet, the reach was mapped as Zone AE.

Overtopped zones may be merged in with adjacent zones due to limitations of map scale. Refer to the Open Coast and San Francisco Bay coastal modeling and mapping reports (BakerAECOM 2012, 2013, 2014, 2015a, 2015b) for further details. Mapping of transect 47 reflects the wave sheltering effects of the breakwaters surrounding South Beach Yacht Club, which was not accounted for in the analysis.

For the open Pacific coast, one runup transition zone was used to create a more gradual change in BFE between Transects 15 and 16. One limited detail study area was applied between Transects 21 and 22. One transect experienced overtopping and associated landward flood hazards as a result. Multiple transects experienced dune retreat during the base flood event but none were fully eroded. At these locations, FEMA's Primary Frontal Dune VE Zone mapping criterion was applied.

Table 26 indicates the coastal analyses used for floodplain mapping and the criteria used to determine the inland limit of the open-coast Zone VE and the SFHA boundary at each transect.

Table 26: Summary of Coastal Transect Mapping Considerations

		Wave Runup Analysis	Wave Height Analysis		
Coastal Transect	Primary Frontal Dune (PFD) Identified	Zone Designation and BFE (ft NAVD88)	Zone Designation and BFE (ft NAVD88)	Zone VE Limit	SFHA Boundary
1		VE 19	N/A	Runup	Runup
2		VE 19	N/A	Runup	Runup
3		VE 17	N/A	Runup	Runup
4		VE 17	N/A	Runup	Runup
5		VE 23	N/A	Runup	Runup
6		VE 26	N/A	Runup	Runup
7		VE 20	N/A	Runup	Runup
8	ü	VE 22	N/A	PFD	PFD
9	ü	VE 23	N/A	PFD	PFD
10		VE 22	N/A	Runup	Runup
11		VE 23	N/A	Runup	Runup
12	ü	VE 17	N/A	PFD	PFD
13	ü	VE 21	N/A	PFD	PFD
14		VE 17	N/A	Runup	Runup
15		VE 16	N/A	Runup	Runup
16		VE 25	N/A	Runup	Runup
17		VE 28	N/A	Runup	Overtopping
18		VE 18	N/A	Runup	Runup
19		VE 19	N/A	Runup	Runup
20		VE 16	N/A	Runup	Runup
21		VE 16	N/A	Runup	Runup
22		VE 16	N/A	Runup	Runup
23	ü	VE 20	N/A	PFD	PFD

Table 26: Summary of Coastal Transect Mapping Considerations, continued

Coastal Transect	Primary Frontal Dune (PFD) Identified	Wave Runup Analysis	Wave Height Analysis	Zone VE Limit	SFHA Boundary
		Zone Designation and BFE (ft NAVD88)	Zone Designation and BFE (ft NAVD88)		
24	ü	VE 16	N/A	PFD	PFD
25		VE 15	N/A	Runup	Runup
26		VE 17	N/A	Runup	Runup
27		VE 23	N/A	Runup	Overtopping
28		VE 13	N/A	Runup	Runup
29		VE 15	N/A	Runup	Overtopping
30		VE 12	AE 10[1]	Runup	SWEL
31		VE 12	AE 10[1]	Runup	SWEL
32		VE 12	N/A	Runup	Runup
33		VE 15	AE 10[1]	Runup	SWEL
34		VE 15	N/A	N/A	Overtopping
35		VE 15	N/A	N/A	Runup
36		VE 18	N/A	Runup	Runup
37		VE 16 AE 11	N/A	Runup	Runup
38		VE 13 AE 11	N/A	Runup	Runup
39		VE 13	N/A	Runup	Overtopping
40		VE 12 AE 10	N/A	Runup	SWEL
41		VE 11	N/A	Runup	Overtopping
42		AE 10	N/A	N/A	Runup
43		AE 10	N/A	N/A	Overtopping
44		VE 11	N/A	Runup	Overtopping
45		VE 11	AE 10[1]	Runup	SWEL
46		VE 14	N/A	Runup	Overtopping
47		VE 14	AE 10[1,2]	Runup	SWEL
48		AE 11	N/A	N/A	Overtopping
49		VE 12	N/A	Runup	Runup
50		VE 15	N/A	Runup	Overtopping

Table 26: Summary of Coastal Transect Mapping Considerations, continued

Coastal Transect	Primary Frontal Dune (PFD) Identified	Wave Runup Analysis	Wave Height Analysis	Zone VE Limit	SFHA Boundary
		Zone Designation and BFE (ft NAVD88)	Zone Designation and BFE (ft NAVD88)		
51		VE 11	N/A	Runup	Runup
52		AE 12	N/A	N/A	Runup
53		AE 12	N/A	N/A	Runup
54		VE 13	AE 10[1]	Runup	SWEL
55		N/A	VE 11 AE 10	Wave Height	SWEL
56		VE 12	N/A	Runup	Runup
57		N/A	VE 12 AE 10	Wave Height	SWEL
58		VE 13	N/A	Runup	Runup
59		AE 12	N/A	N/A	Runup
60		VE 12	N/A	Runup	Runup
61		VE 15	N/A	Runup	Overtopping
62		VE 15	N/A	Runup	Overtopping
63		AE 11	N/A	N/A	Overtopping
64		N/A	AE 10	N/A	SWEL
65		N/A	AE 10	N/A	SWEL
66		AE 11	N/A	N/A	Runup
67		AE 11	AE 10[1]	N/A	SWEL
68		VE 13	N/A	Runup	Runup
69		VE 20	N/A	Runup	Overtopping
70		VE 16	N/A	Runup	Runup
71		VE 14	AE 10[1]	Runup	SWEL
72		VE 11[3]	N/A	Runup	Overtopping
73		AE 11	N/A	N/A	Runup
74		AE 11[3]	AE 10[1]	N/A	SWEL
75		AE 11	N/A	N/A	Runup
76		VE 12	N/A	Runup	Overtopping
77		VE 15	N/A	Runup	Runup
78		VE 12	AE 10[1]	Runup	SWEL

Table 26: Summary of Coastal Transect Mapping Considerations, continued

Coastal Transect	Primary Frontal Dune (PFD) Identified	Wave Runup Analysis Zone Designation and BFE (ft NAVD88)	Wave Height Analysis Zone Designation and BFE (ft NAVD88)	Zone VE Limit	SFHA Boundary
79		VE 12	AE 10[1]	Runup	Overtopping
80		VE 13	N/A	Runup	Runup
81		VE 14	AE 10[1]	Runup	SWEL
82		AE 11	AE 10[1]	N/A	SWEL
83		AE 10	N/A	N/A	SWEL
84		N/A	AE 10	N/A	SWEL
85		AE 11	AE 10[1]	N/A	SWEL
86		AE 12	AE 10[1]	N/A	SWEL
87		VE 14	AE 10[1]	Runup	SWEL
88		N/A	AE 10	N/A	SWEL
89		N/A	AE 10	N/A	SWEL

[1] 1-percent annual chance coastal stillwater elevation
[2] Mapping reflects sheltering from breakwaters not accounted for in analysis
[3] Value in this table and on the FIRM has been rounded to the nearest whole foot derived from the coastal modeling results

6.5 FIRM Revisions

This FIS Report and the FIRM are based on the most up-to-date information available to FEMA at the time of its publication; however, flood hazard conditions change over time. Communities or private parties may request flood map revisions at any time. Certain types of requests require submission of supporting data. FEMA may also initiate a revision. Revisions may take several forms, including Letters of Map Amendment (LOMAs), Letters of Map Revision Based on Fill (LOMR-Fs), Letters of Map Revision (LOMRs) (referred to collectively as Letters of Map Change (LOMCs)), Physical Map Revisions (PMRs), and FEMA-contracted restudies. These types of revisions are further described below. Some of these types of revisions do not result in the republishing of the FIS Report. To assure that any user is aware of all revisions, it is advisable to contact the community repository of flood-hazard data (shown in Table 31, "Map Repositories").

6.5.1 Letters of Map Amendment

A LOMA is an official revision by letter to an effective NFIP map. A LOMA results from an administrative process that involves the review of scientific or technical data submitted by the owner or lessee of property who believes the property has incorrectly been included in a designated SFHA. A LOMA amends the currently effective FEMA map and establishes that a specific property is not located in a SFHA. A LOMA cannot be issued for properties located on the PFD (primary frontal dune).

To obtain an application for a LOMA, visit www.fema.gov/floodplain-management/letter-map-amendment-loma and download the form "MT-1 Application Forms and Instructions for Conditional and Final Letters of Map Amendment and Letters of Map Revision Based on Fill". Visit the "Flood Map-Related Fees" section to determine the cost, if any, of applying for a LOMA.

FEMA offers a tutorial on how to apply for a LOMA. The LOMA Tutorial Series can be accessed at www.fema.gov/online-tutorials.

For more information about how to apply for a LOMA, call the FEMA Map Information eXchange; toll free, at 1-877-FEMA MAP (1-877-336-2627).

6.5.2 Letters of Map Revision Based on Fill

A LOMR-F is an official revision by letter to an effective NFIP map. A LOMR-F states FEMA's determination concerning whether a structure or parcel has been elevated on fill above the base flood elevation and is, therefore, excluded from the SFHA.

Information about obtaining an application for a LOMR-F can be obtained in the same manner as that for a LOMA, by visiting www.fema.gov/floodplain-management/letter-map-amendment-loma for the "MT-1 Application Forms and Instructions for Conditional and Final Letters of Map Amendment and Letters of Map Revision Based on Fill" or by calling the FEMA Map Information eXchange, toll free, at 1-877-FEMA MAP (1-877-336-2627). Fees for applying for a LOMR-F, if any, are listed in the "Flood Map-Related Fees" section.

A tutorial for LOMR-F is available at www.fema.gov/online-tutorials.

6.5.3 Letters of Map Revision

A LOMR is an official revision to the currently effective FEMA map. It is used to change flood zones, floodplain and floodway delineations, flood elevations and planimetric features. All requests for LOMRs should be made to FEMA through the chief executive officer of the community, since it is the community that must adopt any changes and revisions to the map. If the request for a LOMR is not submitted through the chief executive officer of the community, evidence must be submitted that the community has been notified of the request.

To obtain an application for a LOMR, visit www.fema.gov/national-flood-insurance-program-flood-hazard-mapping/mt-2-application-forms-and-instructions and download the form "MT-2 Application Forms and Instructions for Conditional Letters of Map Revision and Letters of Map Revision". Visit the "Flood Map-Related Fees" section to determine the cost of applying for a LOMR. For more information about how to apply for a LOMR, call the FEMA Map Information eXchange; toll free, at 1-877-FEMA MAP (1-877-336-2627) to speak to a Map Specialist.

Previously issued mappable LOMCs (including LOMRs) that have been incorporated into the City and County of San Francisco FIRM are listed in Table 27.

Table 27: Incorporated Letters of Map Change

[Not Applicable to this Flood Risk Project]

6.5.4 Physical Map Revisions

Physical Map Revisions (PMRs) are an official republication of a community's NFIP map to effect changes to base flood elevations, floodplain boundary delineations, regulatory floodways and planimetric features. These changes typically occur as a result of structural works or improvements, annexations resulting in additional flood hazard areas or correction to base flood elevations or SFHAs.

The community's chief executive officer must submit scientific and technical data to FEMA to support the request for a PMR. The data will be analyzed and the map will be revised if warranted. The community is provided with copies of the revised information and is afforded a review period. When the base flood elevations are changed, a 90-day appeal period is provided. A 6-month adoption period for formal approval of the revised map(s) is also provided.

For more information about the PMR process, please visit www.fema.gov and visit the "Flood Map Revision Processes" section.

6.5.5 Contracted Restudies

The NFIP provides for a periodic review and restudy of flood hazards within a given community. FEMA accomplishes this through a national watershed-based mapping needs assessment strategy, known as the Coordinated Needs Management Strategy (CNMS). The CNMS is used by FEMA to assign priorities and allocate funding for new flood hazard analyses used to update the FIS Report and FIRM. The goal of CNMS is to define the validity of the engineering study data within a mapped inventory. The CNMS is used to track the assessment process, document engineering gaps and their resolution, and aid in prioritization for using flood risk as a key factor for areas identified for flood map updates. Visit www.fema.gov to learn more about the CNMS or contact the FEMA Regional Office listed in Section 8 of this FIS Report.

6.5.6 Community Map History

The current FIRM presents flooding information for the entire geographic area of the City and County of San Francisco. Previously, separate FIRMs, Flood Hazard Boundary Maps (FHBMs) and/or Flood Boundary and Floodway Maps (FBFMs) may have been prepared for the incorporated communities and the unincorporated areas in the county that had identified SFHAs. Current and historical data relating to the maps prepared for the project area are presented in Table 28, "Community Map History." A description of each of the column headings and the source of the date is also listed below.

- *Community Name* includes communities falling within the geographic area shown on the FIRM, including those that fall on the boundary line, nonparticipating communities, and communities with maps that have been rescinded. Communities with No Special Flood Hazards are indicated by a footnote. If all maps (FHBM, FBFM, and FIRM) were rescinded for a community, it is not listed in this table unless SFHAs have been identified in this community.

- *Initial Identification Date (First NFIP Map Published)* is the date of the first NFIP map that identified flood hazards in the community. If the FHBM has been converted to a FIRM, the initial FHBM date is shown. If the community has never been mapped, the upcoming effective date or "pending" (for Preliminary FIS Reports) is shown. If the community is listed in Table 28 but not identified on the map, the community is treated as if it were unmapped.

- *Initial FHBM Effective Date* is the effective date of the first Flood Hazard Boundary Map (FHBM). This date may be the same date as the Initial NFIP Map Date.

- *FHBM Revision Date(s)* is the date(s) that the FHBM was revised, if applicable.

- *Initial FIRM Effective Date* is the date of the first effective FIRM for the community.

- *FIRM Revision Date(s)* is the date(s) the FIRM was revised, if applicable. This is the revised date that is shown on the FIRM panel, if applicable. As countywide studies are completed or revised, each community listed should have its FIRM dates updated accordingly to reflect the date of the countywide study. Once the FIRMs exist in countywide format, as Physical Map Revisions (PMR) of FIRM panels within the county are completed, the FIRM Revision Dates in the table for each community affected by the PMR are updated with the date of the PMR, even if the PMR did not revise all the panels within that community.

Table 28: Community Map History

Community Name	Initial Identification Date	Initial FHBM Effective Date	FHBM Revision Date(s)	Initial FIRM Effective Date	FIRM Revision Date(s)
San Francisco, City and County of[1]	07/26/1974	N/A	N/A	MM/DD/YYYY	N/A

[1] This community did not have a FIRM prior to the first countywide FIRM for the City and County of San Francisco

SECTION 7.0 – CONTRACTED STUDIES AND COMMUNITY COORDINATION

7.1 Contracted Studies

Table 29 provides a summary of the contracted studies, by flooding source, that are included in this FIS Report.

Table 29: Summary of Contracted Studies Included in this FIS Report

Flooding Source	FIS Report Dated	Contractor	Number	Work Completed Date	Affected Communities
Pacific Ocean	MM/DD/YYYY	BakerAECOM	Contract HSFEHQ-09-D-0368, Task HSFE09-10-J-0002	October 2014	San Francisco, City and County of
San Francisco Bay	MM/DD/YYYY	BakerAECOM	Contract HSFEHQ-09-D-0368, Task HSFE09-09-J-0001	July 14, 2015	San Francisco, City and County of

7.2 Community Meetings

The dates of the community meetings held for this Flood Risk Project and previous Flood Risk Projects are shown in Table 30. These meetings may have previously been referred to by a variety of names (Community Coordination Officer (CCO), Scoping, Discovery, etc.), but all meetings represent opportunities for FEMA, community officials, study contractors, and other invited guests to discuss the planning for and results of the project.

Table 30: Community Meetings

Community	FIS Report Dated	Date of Meeting	Meeting Type	Attended By
San Francisco, City and County of	MM/DD/YYYY	02/23/2011	Project Kickoff	FEMA, the community, California Coastal Commission, USACE, and the study contractor
		12/12/2013	Flood Risk Review, Open Pacific Coast	FEMA, the community, and the study contractor
		05/07/2013	Flood Risk Review, San Francisco Bay	FEMA, the community, USACE, and the study contractor
		01/14/2016	CCO Meeting	FEMA, the community, USACE, and the study contractor

SECTION 8.0 – ADDITIONAL INFORMATION

Information concerning the pertinent data used in the preparation of this FIS Report can be obtained by submitting an order with any required payment to the FEMA Engineering Library. For more information on this process, see www.fema.gov.

In the Port of San Francisco, select water surface elevations for the coastal mapping behind breakwaters was revised per topographic and bathymetric data provided by the City and County of San Francisco. This data was applied to the draft Floodplain Mapping dataset in June and July of 2015 by BakerAECOM, and was subjected to the standard FEMA QAQC review and approval process. These revised elevations are reflected on the current FIRM panels (BakerAECOM 2015a, 2015b).

Detailed descriptions of the analysis and results for the open Pacific coast can be found in the Intermediate Data Submittals #'s 1 – 4 (BakerAECOM 2012, 2013, 2014a, 2014b). Detailed descriptions of the analysis and results for San Francisco Bay can be found in the Central San Francisco Bay Coastal Flood Hazard Study Coastal Analysis and Floodplain Mapping Reports (BakerAECOM 2015a, 2015b).

No previous effective FIS reports have been prepared for the City and County of San Francisco, CA. With the exception of the 2008 Del Norte County coastal study update (Danish Hydraulic Institute (DHI) 2008), the most recent coastal flood studies for the California coastline generally date from the 1980s. The northern and central CA study was performed by Ott Water Engineers, Inc. (1984) and is documented in a report, *Northern California Coastal Flood Studies*, which analyzed coastal flood hazards in the northern counties from Del Norte to Monterey, excluding San Francisco County. San Francisco County was not included in the Ott Water study because the community was not participating in the NFIP at that time.

A probabilistic tsunami hazard assessment will be conducted as a pilot study in Crescent City (Del Norte County) to determine the feasibility of modeling and mapping tsunami flood and wave inundation in the NFIP (BakerAECOM 2012). Future data or study applications for other coastal California communities based on this pilot study are not yet determined.

Table 31 is a list of the locations where FIRMs for the City and County of San Francisco can be viewed. Please note that the maps at these locations are for reference only and are not for distribution. Also, please note that only the maps for the community listed in the table are available at that particular repository. A user may need to visit another repository to view maps from an adjacent community.

Table 31: Map Repositories

Community	Address	City	State	Zip Code
San Francisco, City and County of	Office of the City Administrator City Hall, Room 362 1 Dr. Carlton B. Goodlett Place	San Francisco	CA	94102

The National Flood Hazard Layer (NFHL) dataset is a compilation of effective FIRM databases and LOMCs. Together they create a GIS data layer for a State or Territory. The NFHL is updated as studies become effective and extracts are made available to the public monthly. NFHL data can be viewed or ordered from the website shown in Table 32.

Table 32 contains useful contact information regarding the FIS Report, the FIRM, and other relevant flood hazard and GIS data. In addition, information about the State NFIP Coordinator and GIS Coordinator is shown in this table. At the request of FEMA, each Governor has designated an agency of State or territorial government to coordinate that State's or territory's NFIP activities. These agencies often assist communities in developing and adopting necessary floodplain management measures. State GIS Coordinators are knowledgeable about the availability and location of State and local GIS data in their state.

Table 32: Additional Information

FEMA and the NFIP	
FEMA and FEMA Engineering Library website	www.fema.gov/national-flood-insurance-program-flood-hazard-mapping/engineering-library
NFIP website	www.fema.gov/national-flood-insurance-program
NFHL Dataset	msc.fema.gov
FEMA Region IX	Federal Emergency Management Agency 1111 Broadway, Suite 1200 Oakland, CA 94607-4052 800-323-5248
Other Federal Agencies	
USGS website	www.usgs.gov
Hydraulic Engineering Center website	www.hec.usace.army.mil
State Agencies and Organizations	
State NFIP Coordinator	James Eto California Dept. of Water Resources 3464 El Camino Avenue Suite 200 Sacramento, CA 95821 916-574-1409 jeto@water.ca.gov
State GIS Coordinator	David Harris Agency Information Officer California Resources Agency 1416 Ninth Street, Room 1311 Sacramento, CA 95814 (916) 445-5088 david.harris@resources.ca.gov

SECTION 9.0 – BIBLIOGRAPHY AND REFERENCES

Table 33 includes sources used in the preparation of and cited in this FIS Report as well as additional studies that have been conducted in the study area.

Table 33: Bibliography and References

Citation in this FIS	Publisher/ Issuer	*Publication Title,* "Article," Volume, Number, etc.	Author/Editor	Place of Publication	Publication Date/ Date of Issuance	Link
ABAG 2010	Association of Bay Area Governments (ABAG)	*Multi-Jurisdicitonal Local Hazard Mitigation Plan for the San Francisco Bay Area. Update of 2005 Plan*			2010	Accessed 7/9/2013 http://quake.abag.ca.gov/mitigation/
BakerAECOM 2012	FEMA Region IX	*Intermediate Data Submittal #1 - Scoping and Data Review. San Francisco County, CA. California Coastal Analysis and Mapping Project Open Pacific Coast Study*	BakerAECOM	Oakland, CA	February 13, 2012	
BakerAECOM 2013	FEMA Region IX	*Intermediate Data Submittal #2 - Offshore Waves and Water Levels. Northern and Central California. California Coastal Analysis and Mapping Project Open Pacific Coast Study*	BakerAECOM	Oakland, CA	January 14, 2013	
BakerAECOM 2014a	FEMA Region IX	*Intermediate Data Submittal #3 - Nearshore Hydraulics. San Francisco County, California. California Coastal Analysis and Mapping Project Open Pacific Coast Study*	BakerAECOM	Oakland, CA	September 2014	
BakerAECOM 2014b	FEMA Region IX	*Intermediate Data Submittal #4 – Draft Flood Hazard Mapping. San Francisco County, California. California Coastal Analysis and Mapping Project Open Pacific Coast Study*	BakerAECOM	Oakland, CA	October 2014	

Table 33: Bibliography and References, continued

Citation in this FIS	Publisher/ Issuer	*Publication Title,* "Article," Volume, Number, etc.	Author/Editor	Place of Publication	Publication Date/ Date of Issuance	Link
BakerAECOM 2015a	FEMA Region IX	*A Central San Francisco Bay Coastal Flood Hazard Study-San Francisco County, California Coastal Analysis Report*	BakerAECOM	Oakland, CA	June 9, 2015	
BakerAECOM 2015b	FEMA Region IX	*A Central San Francisco Bay Coastal Flood Hazard Study-San Francisco County, California Floodplain Mapping Report*	BakerAECOM	Oakland, CA	July 14, 2015	
California Climate Change Center 2006	California Climate Change Center	Excerpts from *Our Changing Climate: A Summary Report from the California Climate Change Center*. Draft report.				Accessed 7/8/2013 http://www.climatechoices.org/impacts_coasts/
City and County of San Francisco, 2012	City and County of San Francisco	"SF Better Streets: Stormwater Overview."	"sfbetterstreets.org"		2012	Accessed 7/8/2013 http://www.sfbetterstreets.org/find-project-types/greening-and-stormwater-management/stormwater-overview/
CSMP 2011	California Seafloor Mapping Program	Hydrographic survey data bathymetry; 2 – 10m DEM	Fugro EarthData, Inc.		2005 – 2011	http://seafloor.csumb.edu/csmp/csmp.html
DHI 2008	Federal Emergency Management Agency	*Del Norte County Final FIS*	Danish Hydraulic Institute		September 2008	

Table 33: Bibliography and References, continued

Citation in this FIS	Publisher/ Issuer	*Publication Title,* "Article," Volume, Number, etc.	Author/Editor	Place of Publication	Publication Date/ Date of Issuance	Link
DHI 2011	FEMA	*Regional Coastal Hazard Modeling Study for North and Central San Francisco Bay, Final Draft Report*	Danish Hydraulic Institute, Nolte Associates, and Fugro		October 2011	Prepared for Federal Emergency Management Agency as part of the FEMA Services Group (DHI, Nolte Associates and Fugro)
DHI 2013	FEMA	*Regional Coastal Hazard Modeling Study for South San Francisco Bay, Final Draft Report*	DHI, Nolte Associates and Fugro		January 2013	
Divoky 2007		*Supplementary WHAFIS Documentation: WHAFIS 4.0 A Revision of FEMA's WHAFIS 3.0 Program*	Divoky, D.	Atlanta, GA	2007	
FEMA 1988	FEMA	*Wave Height Analysis for Flood Insurance Studies (Technical Documentation for WHAFIS Program Version 3.0)*	FEMA	Washington, DC	1988	
FEMA 2005	FEMA	*Final Draft Guidelines for Coastal Flood Hazard Analysis and Mapping for the Pacific Coast of the United States*	FEMA		2005	www.fema.gov
FEMA 2013	FEMA	*FEMA Disaster Declarations, 1990 - 2013*				Accessed 7/3/2013 http://www.fema.gov/disaster/
GEODAS 2007	National Oceanic and Atmospheric Administration	*Geophysical Data System (GEODAS) bathymetric data*			1960-2007	

Table 33: Bibliography and References, continued

Citation in this FIS	Publisher/ Issuer	*Publication Title,* "Article," Volume, Number, etc.	Author/Editor	Place of Publication	Publication Date/ Date of Issuance	Link
Griggs et al. 2005	Shore and Beach	*Erosion and shoreline damage along the central California coast: a comparison between the 1997-98 and 0982-83 winters.* Vol. 66, pp. 18-23	Griggs, G. and K. Brown		1998	
Moffat & Nichol 2005	San Francisco Department of Public Works and U.S. Army Corps of Engineers	*Ocean Beach-Great Highway Storm Damage Protection Project Final Report*	Moffat & Nichol		May 31, 2005	
NGDC-NOAA	National Geophysical Data Center	Tsunami Inundation Bathymetry, 10 – 30m DEM	National Oceanic and Atmospheric Administration			http://www.ngdc.noaa.gov/mgg/inundation/tsunami/inundation.html
NOAA 2010a	National Oceanic and Atmospheric Administration	Airborne Topographic LiDAR data, California Open Pacific Coast, Northern portion of the City and County of San Francisco				
NOAA 2010b	National Oceanic and Atmospheric Administration	Northern San Francisco Bay, California LiDAR; Classified LiDAR Point Cloud Data			February-April 2010	
Ott Water Engineers 1984		*Northern California Coastal Flood Studies.* 115 pp				
SFPUC 2012	San Francisco Public Utilities Commission	*General Plan of the City and county of San Francisco: Community Safety*			October 2012	

Table 33: Bibliography and References, continued

Citation in this FIS	Publisher/ Issuer	*Publication Title,* "Article," Volume, Number, etc.	Author/Editor	Place of Publication	Publication Date/ Date of Issuance	Link
SF Examiner 2012	SF Examiner	"Third storm of the week brings flooding to San Francisco Streets"			December 8, 2012	Accessed 7/3/2013 http://www.sfexaminer.com/
USACE 1984	U.S. Army Engineer Waterways Experiment Station, U.S. Government Printing Office	*Shore Protection Manual*, Volumes 1 – 3, 532 pp	U.S. Army Corps of Engineers	Washington, D.C	1984	
USACE SFBay	U.S. Army Corps of Engineers	Bathymetry; dredging survey data	USACE			
USGS 2010	United States Geological Survey	Airborne Topographic LiDAR data, California Open Pacific Coast, Southern portion of the City and County of San Francisco	Fugro EarthData, Inc.		2009 – 2011	
van der Meer, J.W. 2002		Wave Run-up and Overtopping at Dikes. Technical Report, Technical Advisory Committee for Water Retaining Structures (TAW)	van der Meer, J.W.	Delft, The Netherlands	2002	
Wiegel 2002	Shore and Beach	*Large Quantity of Sand Blown Inland Over Top of Seawall. Vol. 70, No. 2. pp. 11-12*	Wiegel, R.L.		April 2002	