CALENDAR FOR THE BOARD OF DIRECTORS

CONTRA COSTA COUNTY FIRE PROTECTION DISTRICT

BOARD CHAMBERS ROOM 107, ADMINISTRATION BUILDING, 651 PINE STREET
MARTINEZ, CALIFORNIA 94553-1229

KAREN MITCHOFF, *CHAIR*
JOHN GIOIA, *VICE CHAIR*
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DIANE BURGIS
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DAVID J. TWA, CLERK OF THE BOARD AND COUNTY ADMINISTRATOR, (925) 335-1900
JEFF CARMAN, FIRE CHIEF

PERSONS WHO WISH TO ADDRESS THE BOARD DURING PUBLIC COMMENT OR WITH RESPECT TO AN ITEM THAT IS ON THE AGENDA, WILL BE LIMITED TO TWO (2) MINUTES.

The Board Chair may reduce the amount of time allotted per speaker at the beginning of each item or public comment period depending on the number of speakers and the business of the day.
Your patience is appreciated.

A closed session may be called at the discretion of the Board Chair.

Staff reports related to open session items on the agenda are also accessible on line at www.co.contra-costa.ca.us.

SPECIAL MEETING
AGENDA
June 12, 2018

10:30 A.M. Convene and call to order.

CONSIDER CONSENT ITEMS (Items listed as C.1 through C.4 on the following agenda) – Items are subject to removal from Consent Calendar by request of any Director or on request for discussion by a member of the public. **Items removed from the Consent Calendar will be considered with the Discussion Items.**

DISCUSSION ITEMS

D. 1 CONSIDER Consent Items previously removed.

D. 2 PUBLIC COMMENT (2 Minutes/Speaker)

D.3 CONSIDER adopting Resolution 2018/1 accepting all of Volume 1 and the Contra Costa County Fire Protection District's portion of Volume 2 of the Contra Costa County Operational Area Hazard Mitigation Plan Update. (Robert Marshall, Fire Marshal)

D.4 CONSIDER accepting a verbal update from the Fire Chief of Fire Prevention Bureau inspection performance and mandated inspections. (Jeff Carman, Fire Chierf)

D.5 CONSIDER accepting a report from the Fire Chief providing a status summary for ongoing Fire District activities and initiatives. (Jeff Carman, Fire Chief)

CONSENT ITEMS

C.1 APPROVE and AUTHORIZE the Fire Chief, or designee, to apply for and accept grant funding from the California Fire Foundation, in an amount not to exceed $15,000, for the purchase of helicopter equipment. (100% Restricted Donation)

C.2 APPROVE and AUTHORIZE the Fire Chief, or designee, to apply for and accept grant funding from the U.S. Department of Homeland Security, Federal Emergency Management Agency and the California Governor's Office of Emergency Services, Hazard Mitigation Grant Program, in an amount not to exceed $2,000,000, for the purchase and installation of nine emergency generators. (75% Federal, 25% District match)

C.3 Contra Costa County Fire Protection District (7300): APPROVE Appropriation and Revenue Adjustment No. 5079 authorizing new revenue in the amount of $1,261,500 from the May 2018 residual distribution of the Redevelopment Property Tax Trust Fund and appropriating it for tenant improvements and rent payments during fiscal year 2017-18 for the new Contra Costa County Fire Protection District Administrative Office located at 4005 Port Chicago Highway, Suite 250, in Concord, California. (100% Redevelopment Property Tax Trust Fund allocation)

C.4 APPROVE and AUTHORIZE the Fire Chief, or designee, to execute a Software License and Interface Development Agreement with Tablet Command, Inc., in an amount not to exceed $575,000, for the development, use, and support of computer aided dispatch incident command software and for the period July 1, 2018, through June 30, 2023. (92% User and Ancillary Agency Fees, 5% District General Fund, 3% EMS Transport Fund)

GENERAL INFORMATION

The Board meets in its capacity as the Board of Directors of the Contra Costa County Fire Protection District pursuant to Ordinance Code Section 24-2.402. Persons who wish to address the Board of Directors should complete the form provided for that purpose and furnish a copy of any written statement to the Clerk.

Any disclosable public records related to an open session item on a regular meeting agenda and distributed by the Clerk of the Board to a majority of the members of the Board of Directors less than 72 hours prior to that meeting are available for public inspection at 651 Pine Street, First Floor, Room 106, Martinez, CA 94553, during normal business hours. All matters listed under CONSENT ITEMS are considered by the Board of Directors to be routine and will be enacted by one motion. There will be no separate discussion of these items unless requested by a member of the Board or a member of the public prior to the time the Commission votes on the motion to adopt. Persons who wish to speak on matters set for PUBLIC HEARINGS will be heard when the Chair calls for comments from those persons who are in support thereof or in opposition thereto.

After persons have spoken, the hearing is closed and the matter is subject to discussion and action by the Board. Comments on matters listed on the agenda or otherwise within the purview of the Board of Directors can be submitted to the office of the Clerk of the Board via mail: Contra Costa County Fire Protection District Board of Directors, 651 Pine Street Room 106, Martinez, CA 94553; by fax: 925-335-1913.

The District will provide reasonable accommodations for persons with disabilities planning to attend Board meetings who contact the Clerk of the Board at least 24 hours before the meeting, at (925) 335-1900; TDD (925) 335-1915. An assistive listening device is available from the Clerk, Room 106. Copies of recordings of all or portions of a Board meeting may be purchased from the Clerk of the Board. Please telephone the Office of the Clerk of the Board, (925) 335-1900, to make the necessary arrangements. Applications for personal subscriptions to the Board Agenda may be obtained by calling the Office of the Clerk of the Board, (925) 335-1900. The Board of Directors' agenda and meeting materials are available for inspection at least 96 hours prior to each meeting at the Office of the Clerk of the Board, 651 Pine Street, Room 106, Martinez, California.

Subscribe to receive to the weekly Board Agenda by calling the Office of the Clerk of the Board, (925) 335-1900 or using the County's on line subscription feature at the County's Internet Web Page, where agendas and supporting information may also be viewed:

www.co.contra-costa.ca.us

ADVISORY COMMISSION

The Contra Costa County Fire Protection District Advisory Fire Commission is scheduled to meet next on Monday, August 13, 2018 at 7:00 p.m. at the District Training Center, 2945 Treat Blvd., Concord, CA 94518.

AGENDA DEADLINE: Thursday, 12 noon, 12 days before the Tuesday Board meetings.

Glossary of Acronyms, Abbreviations, and other Terms (in alphabetical order):

The Contra Costa County Fire Protection District has a policy of making limited use of acronyms, abbreviations, and industry-specific language in its Board of Supervisors meetings and written materials. Following is a list of commonly used language that may appear in oral presentations and written materials associated with Board meetings:

AB Assembly Bill
ABAG Association of Bay Area Governments
ACA Assembly Constitutional Amendment
ADA Americans with Disabilities Act of 1990
AFSCME American Federation of State County and Municipal Employees
ARRA American Recovery & Reinvestment Act of 2009
BAAQMD Bay Area Air Quality Management District
BART Bay Area Rapid Transit District
BayRICS Bay Area Regional Interoperable Communications System
BGO Better Government Ordinance
BOC Board of Commissioners

CALTRANS California Department of Transportation
CAER Community Awareness Emergency Response
CAL-EMA California Emergency Management Agency
CAO County Administrative Officer or Office
CCE Community Choice Energy
CBC California Building Code
CCCPFD (ConFire) Contra Costa County Fire Protection District
CCHP Contra Costa Health Plan
CCTA Contra Costa Transportation Authority
CCRMC Contra Costa Regional Medical Center
CCWD Contra Costa Water District
CFC California Fire Code
CFDA Catalog of Federal Domestic Assistance
CEQA California Environmental Quality Act
CIO Chief Information Officer
COLA Cost of living adjustment
ConFire (CCCFPD) Contra Costa County Fire Protection District
CPA Certified Public Accountant
CPF – California Professional Firefighters
CPI Consumer Price Index
CSA County Service Area
CSAC California State Association of Counties
CTC California Transportation Commission
dba doing business as
EBMUD East Bay Municipal Utility District
ECCFPD East Contra Costa Fire Protection District
EIR Environmental Impact Report
EIS Environmental Impact Statement
EMCC Emergency Medical Care Committee
EMS Emergency Medical Services
et al. et alii (and others)
FAA Federal Aviation Administration
FEMA Federal Emergency Management Agency
FTE Full Time Equivalent
FY Fiscal Year
GIS Geographic Information System
HCD (State Dept of) Housing & Community Development
HHS (State Dept of) Health and Human Services
HOV High Occupancy Vehicle
HR Human Resources
HUD United States Department of Housing and Urban Development
IAFF International Association of Firefighters
ICC International Code Council
IFC International Fire Code
Inc. Incorporated
IOC Internal Operations Committee
ISO Industrial Safety Ordinance
JPA Joint (exercise of) Powers Authority or Agreement

Lamorinda Lafayette-Moraga-Orinda Area
LAFCo Local Agency Formation Commission
LLC Limited Liability Company
LLP Limited Liability Partnership
Local 1 Public Employees Union Local 1
Local 1230 Contra Costa County Professional Firefighters Local 1230
MAC Municipal Advisory Council
MBE Minority Business Enterprise
MIS Management Information System
MOE Maintenance of Effort
MOU Memorandum of Understanding
MTC Metropolitan Transportation Commission
NACo National Association of Counties
NEPA National Environmental Policy Act
NFPA National Fire Protection Association
OES-EOC Office of Emergency Services-Emergency Operations Center
OPEB Other Post Employment Benefits
OSHA Occupational Safety and Health Administration
PACE Property Assessed Clean Energy
PARS Public Agencies Retirement Services
PEPRA Public Employees Pension Reform Act
RFI Request For Information
RFP Request For Proposal
RFQ Request For Qualifications
SB Senate Bill
SBE Small Business Enterprise
SEIU Service Employees International Union
SUASI Super Urban Area Security Initiative
SWAT Southwest Area Transportation Committee
TRANSPAC Transportation Partnership & Cooperation (Central)
TRANSPLAN Transportation Planning Committee (East County)
TRE or **TTE** Trustee
TWIC Transportation, Water and Infrastructure Committee
UASI Urban Area Security Initiative
UCOA United Chief Officers Association
vs. versus (against)
WAN Wide Area Network
WBE Women Business Enterprise
WCCTAC West Contra Costa Transportation Advisory Committee

Contra Costa County

To: Contra Costa County Fire Protection District Board of Directors

From: Jeff Carman, Chief, Contra Costa County Fire Protection District

Date: June 12, 2018

Subject: Resolution 2018-1 Accepting all of Volume 1 and the CCCFPD's Portion of Volume 2 of the CCC LHMP

RECOMMENDATION(S):

ADOPT Resolution 2018/1 accepting all of Volume 1 and the Contra Costa County Fire Protection District's portion of Volume 2 of the Contra Costa County Operational Area Hazard Mitigation Plan Update.

FISCAL IMPACT:

No direct fiscal impact. Adoption gives the District and the County grant eligibility for disaster mitigation projects.

BACKGROUND:

Hazard Mitigation Planning in Contra Costa County:

In November of 2016, a coalition of Contra Costa County cities and special districts embarked on a planning process to prepare for and lessen the impacts of specified natural hazards by updating the Contra Costa County Operational Area Hazard Mitigation Plan. Responding to federal mandates in the Disaster Mitigation Act of 2000 (Public Law 106-390), the partnership was formed to pool resources and to create a uniform hazard mitigation strategy that can be consistently applied to the defined planning area and used to ensure eligibility for specified grant funding success.

This effort represents the third comprehensive update to the initial hazard mitigation plan, approved by the

☑ APPROVE ☐ OTHER

☑ RECOMMENDATION OF CNTY ADMINISTRATOR ☐ RECOMMENDATION OF BOARD COMMITTEE

Action of Board On: **06/12/2018** ☐ APPROVED AS RECOMMENDED ☐ OTHER

Clerks Notes:

VOTE OF SUPERVISORS

I hereby certify that this is a true and correct copy of an action taken and entered on the minutes of the Board of Supervisors on the date shown.

ATTESTED: June 12, 2018

David J. Twa, County Administrator and Clerk of the Board of Supervisors

By: , Deputy

Contact: Robert Marshall, Fire Marshal (925) 260-6881

cc:

Federal Emergency Management Agency (FEMA) in November of 2005 and developed in partnership with the Association of Bay Area Governments (ABAG), as well as a return to a truly regional effort following the 2010 planning process. The 35 member coalition of partners involved in this program includes unincorporated Contra Costa County, 14 city and town governments and 20 special purpose districts. The planning area for the hazard mitigation plan was defined as the Contra Costa County Operational Area. The result of the organizational effort will be a FEMA and California Office of Emergency Services (CalOES) approved multi-jurisdictional, multi-hazard mitigation plan.

Mitigation is defined in this context as any sustained action taken to reduce or eliminate long-term risk to life and property from a hazard event. Mitigation planning is the systematic process of learning about the hazards that can affect the community, setting clear goals, identifying appropriate actions and following through with an effective mitigation strategy. Mitigation encourages long-term reduction of hazard vulnerability and can reduce the enormous cost of disasters to property owners and all levels of government. Mitigation can also protect critical community facilities, reduce exposure to liability, and minimize post-disaster community disruption.

The hazard identification and profiling in the hazard mitigation plan addresses the following hazards of concern within the planning area:

1.

BACKGROUND: (CONT'D)

Dam failure

- Drought
- Earthquake
- Flood
- Landslide
- Severe weather
- Tsunami
- Wildfire

Climate change is incorporated as a summary assessment of current and anticipated impacts for each identified hazard of concern.

With the exception of dam failure, this plan does not provide a full risk assessment of human-caused hazards. However, brief, qualitative discussions of the following hazards of interest are included: terrorism, cyber threats, hazardous materials release, pipeline and tank failure, airline incidents.

A Planning Team consisting of local officials has taken the lead in developing the hazard mitigation plan. All participating local jurisdictions have been responsible for assisting in the development of the hazard and vulnerability assessments and the mitigation action strategies for their respective jurisdictions and organizations. The Plan presents the accumulated information in a unified framework to ensure a comprehensive and coordinated plan covering the entire Contra Costa County Operational Area planning area. Each jurisdiction has been responsible for the review and approval of their individual sections of the Plan.

Additionally, the plan has been aligned with the goals, objectives and priorities of the State's multi-hazard mitigation plan.

A 13 member Steering Committee (SC) composed of representative stakeholders was formed early in the planning process to guide the development of the Plan. In addition, residents were asked to contribute by sharing local knowledge of their individual area's vulnerability to natural hazards based on past occurrences. Public involvement has been solicited via a comprehensive public outreach campaign that included two rounds of public meetings, web-based information, a questionnaire, and multiple social media updates.

Why adopt this Plan?

Once the hazard mitigation plan is adopted by all of the jurisdictional partners and approved by FEMA, the partnership will collectively and individually become eligible to apply for hazard mitigation project funding from both the Pre-Disaster Mitigation Grant Program (PDM) and the Hazard Mitigation Grant Program (HMGP).

What is the Pre-Disaster Mitigation competitive grant program?

The PDM competitive grant program provides funds to State, Tribal, and local governments for pre-disaster mitigation planning and projects primarily addressing natural hazards. Cost-Effective pre-disaster mitigation activities reduce risk to life and property from natural hazard events before a natural disaster strikes, thus reducing overall risks to the population and structures, while also reducing reliance on funding from actual disaster declarations. Funds will be awarded on a competitive basis for mitigation planning and project applications intended to make local governments more resistant to the impacts of future natural disasters *(For more details on this program see Attachment 1).*

What is the Hazard Mitigation Grant Program?

Authorized under Section 404 of the Stafford Act, the HMGP administered by FEMA provides grants to States and local governments to implement long-term hazard mitigation measures after a major disaster declaration. The purpose of the program is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during the immediate recovery from a disaster *(For more details on this program see Attachment 1).*

Where do we go from here?

Upon adoption of Volume I and Contra Costa County Fire Protection District's Annex of Volume II of the Contra Costa County Operational Area Hazard Mitigation Plan Update (HMP) and subsequent approval of said plan by CalOES and FEMA, the District will be eligible to apply for specified grants. The grant funds are made available to states and local governments and can be used to implement the long-term hazard mitigation measures specified within the District's annex of the HMP before and after a major disaster declaration. The HMP is considered a living document such that, as awareness of additional hazards develops and new strategies and projects are conceived to offset or prevent losses due to natural disasters, the HMP will be evaluated and revised on a continual 5-year time frame.

ATTACHMENTS

Resolution No. 2018/1

Attachment 1- Hazard Mitigation Grant Program (HMGP) Pre-Disaster Mitigation Grant Program (PDM) FACT SHEET

Attachment 2- Contra Costa County Draft LHMP Final_Vol1

Attachment 3- Ch 19 Contra Costa County FPD Draft LHMP annex

THE BOARD OF DIRECTORS OF THE CONTRA COSTA COUNTY FIRE PROTECTION DISTRICT

Adopted this Resolution on 06/12/2018 by the following vote:

AYE:

NO:

ABSENT:

ABSTAIN:

RECUSE:

Resolution No. 2018/1

Adoption of the Contra Costa County Hazard Mitigation Plan Update as the Contra Costa County Fire Protection District Hazard Mitigation Plan,

WHEREAS, all of Contra Costa County has exposure to natural hazards that increase the risk to life, property, environment and the County's economy; and **WHEREAS**; pro-active mitigation of known hazards before a disaster event can reduce or eliminate long-term risk to life and property; and **WHEREAS**, The Disaster Mitigation Act of 2000 (Public Law 106-390) established new requirements for pre- and post-disaster hazard mitigation programs; and **WHEREAS**; a coalition of Contra Costa County, Cities, Towns and Special Districts with like planning objectives has been formed to pool resources and create consistent mitigation strategies within the Contra Costa County Operational Area planning area; and **WHEREAS**, the coalition has completed a planning process that engages the public, assesses the risk and vulnerability to the impacts of natural hazards, develops a mitigation strategy consistent with a set of uniform goals and objectives, and creates a plan for implementing, evaluating and revising this strategy;

NOW, THEREFORE, BE IT RESOLVED that the CONTRA COSTA COUNTY FIRE PROTECTION DISTRICT BOARD OF DIRECTORS:

1. Adopts in its entirety, Volume I and the introduction, Chapter 19 - the Contra Costa County Fire Protection District jurisdictional annex, and the appendices of Volume II of the Contra Costa County Operational Area Hazard Mitigation Plan (HMP).
2. Will use the adopted and approved portions of the HMP to guide pre- and post-disaster mitigation of the hazards identified.
3. Will coordinate the strategies identified in the HMP with other planning programs and mechanisms under its jurisdictional authority.
4. Will continue its support of the Steering Committee and continue to participate in the Planning Partnership as described by the HMP.
5. Will help to promote and support the mitigation successes of all HMP Planning Partners.

Contact: Robert Marshall, Fire Marshal (925) 260-6881

I hereby certify that this is a true and correct copy of an action taken and entered on the minutes of the Board of Supervisors on the date shown.

ATTESTED: June 12, 2018

David J. Twa, County Administrator and Clerk of the Board of Supervisors

By: , Deputy

cc:

Attachment 1

Hazard Mitigation Grant Program (HMGP)
Pre-Disaster Mitigation Grant Program (PDM)

FACT SHEET

I. HAZARD MITIGATION GRANT PROGRAM (HMGP)

What is the Hazard Mitigation Grant Program?

HMGP is authorized by Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended (the Stafford Act), Title 42, United States Code (U.S.C.) 5170c. The key purpose of HMGP is to provide the opportunity to take critical mitigation measures to reduce future loss of life and property during the reconstruction process following a disaster.

HMGP is available, when authorized under a Presidential major disaster declaration, in the Tribe or areas of the State requested by the Governor. The amount of HMGP funding available is based upon the estimated total Federal assistance provided by FEMA for disaster recovery under the Presidential major disaster declaration.

Who is eligible to apply?

Hazard Mitigation Grant Program funding is only available to applicants that reside within a Presidentially declared disaster area. Eligible applicants are

- State and local governments
- Indian tribes or other tribal organizations
- Certain non-profit organizations

What types of projects can be funded by the HMGP?

HMGP funds may be used to fund projects that will reduce or eliminate the losses from future disasters. Projects must provide a long-term solution to a problem, for example, elevation of a home to reduce the risk of flood damages as opposed to buying sandbags and pumps to fight the flood. In addition, a project's potential savings must be more than the cost of implementing the project. Funds may be used to protect either public or private property or to purchase property that has been subjected to, or is in danger of, repetitive damage. Examples of projects include, but are not limited to:

- Acquisition of real property for willing sellers and demolition or relocation of buildings to convert the property to open space use
- Retrofitting structures and facilities to minimize damages from high winds, earthquake, flood, wildfire, or other natural hazards
- Elevation of flood prone structures
- Safe room construction
- Development and initial implementation of vegetative management programs
- Minor flood control projects that do not duplicate the flood prevention activities of other Federal agencies
- Localized flood control projects, such as certain ring levees and floodwall systems, that are designed specifically to protect critical facilities
- Post-disaster building code related activities that support building code officials during the reconstruction process

What are the minimum project criteria?

There are five issues you must consider when determining the eligibility of a proposed project.

- Does your project conform to your State's Hazard Mitigation Plan?
- Does your project provide a beneficial impact on the disaster area i.e. the State?
- Does your application meet the environmental requirements?
- Does your project solve a problem independently?
- Is your project cost-effective?

II. PRE-DISASTER MITIGATION GRANT PROGRAM (PDM)

What is the Pre-Disaster Mitigation competitive grant program?

The Pre-Disaster Mitigation (PDM) competitive grant program provides funds to State, Tribal, and local governments for pre-disaster mitigation planning and projects primarily addressing natural hazards. Cost-effective pre-disaster mitigation activities reduce risk to life and property from natural hazard events before a natural disaster strikes, thus reducing overall risks to the population and structures, while also reducing reliance on funding from actual disaster declarations. Funds will be awarded on a competitive basis to successful applicants for mitigation planning and project applications intended to make local governments more resistant to the pacts of future natural disasters.

Who can apply for a PDM competitive grant?

Eligible PDM competitive grant applicants include state and territorial emergency management agencies, or a similar office of the State, District of Columbia, U.S. Virgin Islands, Commonwealth of Puerto Rico, Guam, American Samoa, Commonwealth of the Northern Mariana Islands, and Federally-recognized Indian Tribal governments.

- ✓ Eligible Sub-applicants include State agencies; Federally-recognized Indian Tribal governments; and local governments (including State recognized Indian Tribal governments and Alaska native villages).
- ✓ Applicants can apply for PDM competitive grant funds directly to FEMA, while Sub-applicants must apply for funds through an eligible Applicant.
- ✓ Private non-profit organizations are not eligible to apply for PDM but may ask the appropriate local government to submit an application for the proposed activity on their behalf.

What are eligible PDM projects?

Multi-hazard mitigation projects must primarily focus on natural hazards but also may address hazards caused by non-natural forces. **Funding is restricted to a maximum of $3M Federal share per project.** The following are eligible mitigation projects:

- ✓ Acquisition or relocation of hazard-prone property for conversion to open space in perpetuity;

- ✓ Structural and non-structural retrofitting of existing buildings and facilities (including designs and feasibility studies when included as part of the construction project) for wildfire, seismic, wind or flood hazards (e.g., elevation, flood proofing, storm shutters, hurricane clips);

- ✓ Minor structural hazard control or protection projects that may include vegetation management, Stormwater management (e.g., culverts, floodgates, retention basins), or shoreline/landslide stabilization; and,

- ✓ Localized flood control projects, such as certain ring levees and floodwall systems, that are designed specifically to protect critical facilities and that do not constitute a section of a larger flood control system.

Mitigation Project Requirements

Projects should be technically feasible (see Section XII. Engineering Feasibility) and ready to implement. Engineering designs for projects must be included in the application to allow FEMA to assess the effectiveness and feasibility of the proposed project. The project cost estimate should complement the engineering design, including all anticipated costs. FEMA has several formats that it uses in cost estimating for projects. Additionally, other Federal agencies' approaches to project cost estimating can be used as long as the method provides for a complete and accurate estimate. FEMA can provide technical assistance on engineering documentation and cost estimation (see Section XIII.D. Engineering Feasibility).

Mitigation projects also must meet the following criteria:

1. Be cost-effective and substantially reduce the risk of future damage, hardship, loss, or suffering resulting from a major disaster, consistent with 44 CFR 206.434(c)(5) and related guidance, and have a Benefit-Cost Analysis that results in a benefit-cost ratio of 1.0 or greater (see Section X. Benefit-Cost Analysis). **Mitigation projects with a benefit-cost ratio less than 1.0 will not be considered for the PDM competitive grant program**;
2. Be in conformance with the current FEMA-approved State hazard mitigation plan;
3. Solve a problem independently or constitute a functional portion of a solution where there is assurance that the project as a whole will be completed, consistent with 44 CFR 206.434(b)(4);
4. Be in conformance with 44 CFR Part 9, Floodplain Management and Protection of Wetlands, and 44 CFR Part 10, consistent with 44 CFR 206.434(c)(3);
5. Not duplicate benefits available from another source for the same purpose, including assistance that another Federal agency or program has the primary authority to provide (see Section VII.C. Duplication of Benefits and Programs);
6. Be located in a community that is participating in the NFIP if they have been identified through the NFIP as having a Special Flood Hazard Area (a FHBM or FIRM has been issued). In addition, the community must not be on probation, suspended or withdrawn from the NFIP; and,
7. Meet the requirements of Federal, State, and local laws.

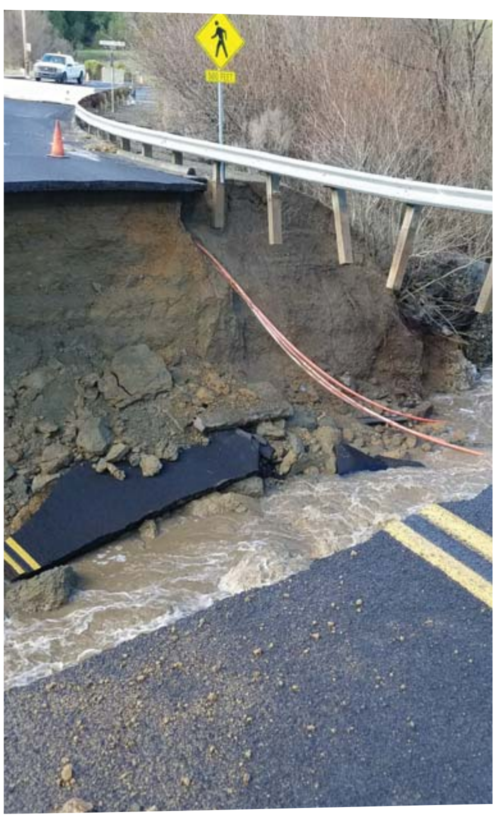
What are examples of Ineligible PDM Projects?

The following mitigation projects are ***not*** eligible for the PDM program:

- ✓ Major flood control projects such as dikes, levees, floodwalls, seawalls, groins, jetties, dams, waterway channelization, beach nourishment or re-nourishment;
- ✓ Warning systems;
- ✓ Engineering designs that are not integral to a proposed project;
- ✓ Feasibility studies that are not integral to a proposed project;
- ✓ Drainage studies that are not integral to a proposed project;
- ✓ Generators that are not integral to a proposed project;
- ✓ Phased or partial projects;
- ✓ Flood studies or flood mapping; and,
- ✓ Response and communication equipment.

CONTRA COSTA COUNTY HAZARD MITIGATION PLAN

Volume 1—Planning Area-Wide Elements



Draft Final
January 2018

TETRA TECH

Contra Costa County Hazard Mitigation Plan

Volume 1—Planning-Area-Wide Elements

January 2018

PREPARED FOR

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PREPARED BY

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Tetra Tech Project #103S4848

CONTENTS

Appendices

Tables

Figures

ACKNOWLEDGMENTS

County of Contra Costa

- Rick Kovar, Emergency Services Manager, Contra Costa County Office of Emergency Services
- Marcelle Indelicato, Senior Emergency Planner, Contra Costa County Office of Emergency Services
- Will Nelson, Principle Planner, Contra Costa County Department of Conservation and Development
- Chris Howard, Principal GIS Planner, Contra Costa County Department of Conservation and Development
- Betsy Burkhart, County Administrator Public Information Officer
- Jimmy Lee, Contra Costa County Sheriff's Office, Public Information Officer

Consultants

- Rob Flaner, CFM, Tetra Tech, Inc., Project Manager
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- Kari Valentine, CFM, Tetra Tech, Inc., Planner
- Stephen Veith, MUP, Tetra Tech, Inc., GIS/Hazus Analyst
- Dan Portman, Tetra Tech, Inc., Technical Editor

Stakeholders

- Steven Spedowfski, Senior Analyst, Engineering Department, City of San Ramon
- Jeff Collins, Business and Operations, Antioch Unified School District
- Chris Lau, Contra Costa County Flood Control and Water Conservation District
- Shari Deutsch, Risk Manager, Central Contra Costa Sanitary District
- Jeff Hebel, Emergency Services Manager, Town of Danville
- Michael Bond, Battalion Chief, City of El Cerrito
- Debbie Vanek, San Ramon Valley Fire Protection District
- Bryan Walley, Search and Rescue & CERT Volunteer
- Larry Fong, Search and Rescue & CERT Volunteer
- Libby MontesNation, Emergency Coordinator, West Contra Costa Unified School District

Special Acknowledgments

The development of this plan would not have been possible without the dedication and commitment to this process by the Hazard Mitigation Plan Steering Committee. The dedication of this volunteer committee to allocate their time to this process is greatly appreciated. Also, the citizens of Contra Costa County are commended for their participation in the outreach strategy identified by the Steering Committee. This outreach success will set the course to the successful implementation of this plan during its next performance period.

EXECUTIVE SUMMARY

HAZARD MITIGATION OVERVIEW

Hazard mitigation is the use of long-term and short-term policies, programs, projects, and other activities to alleviate the death, injury, and property damage that can result from a disaster. Contra Costa County and a partnership of local governments within the county have developed a hazard mitigation plan to reduce risks from natural disasters in the Contra Costa County Operational Area—defined as the unincorporated county and incorporated jurisdictions within the geographical boundaries of the county. The plan complies with federal and state hazard mitigation planning requirements to establish eligibility for funding under Federal Emergency Management Agency (FEMA) grant programs.

UPDATING THE CONTRA COSTA COUNTY PLAN

This plan is a comprehensive update of the 2011 Contra Costa County Hazard Mitigation Plan, which covered the unincorporated county, 10 municipalities and 25 special purpose districts. FEMA approved the 2011 plan on February 27, 2012, and it expired on February 27, 2017. The current update meets federal requirements for updating hazard mitigation plans on a five-year cycle. It represents the third iteration of the Contra Costa County hazard mitigation plan, which was initially part of a 2005 regional planning effort sponsored by the Association of Bay Area Governments. Thirty-five planning partners participated in this update (one fewer than the 2011 plan), as listed in Tables ES-1 and ES-2.

Table ES-1. Municipal Planning Partners

Jurisdiction	Point of Contact	Title
County of Contra Costa	Marcelle Indelicato	Senior Emergency Planner
City of Antioch	Lt. Desmond Bittner	Lieutenant Police Department
City of Brentwood	Lt. Doug Silva	Lieutenant Police Department
City of Concord	Margaret Romiti	Manager, Office of the Chief
Town of Danville	Jeff Hebel	Emergency Services Manager
City of El Cerrito	Michael Bond	Battalion Chief
City of Lafayette	Niroop Srivatsa	Plan and Building Services Dept. Director
City of Martinez	Manjit Sappal	Chief of Police
Town of Moraga	Ellen Clark	Planning Director
City of Orinda	Daisy Allen	Associate Planner
City of Pleasant Hill	Shawn Knapp	Associate Engineer
City of Richmond	Richard Mitchell	Planning Director
City of San Pablo	Ronalyn Nonato	Public Works Assistant Engineer
City of San Ramon	Steven Spedowfski	Engineering Dept., Senior Analyst
City of Walnut Creek	Steve Waymire	Emergency Coordinator

Table ES-2. Special Purpose District Planning Partners

District	Point of Contact	Title
Antioch Unified School District	Jeff Collins	Director, Maintenance, Operations and Transportation
Bethel Island Municipal Improvement District	Jeff Butzlaff	District Manager
Contra Costa County Fire Protection District	Lewis Broshard	Chief Support Services
Contra Costa County Flood Control and Water Conservation District	Chris Lau	Senior Civil Engineer
Contra Costa County Office of Education	John F. Hild	Director, General Services
Contra Costa Water District	Joe Piro	Senior Engineer, Operations and Maintenance Department
Central Contra Costa Sanitary District	Shari Deutsch	Risk Manager
Crockett Community Services District	Dale McDonald	General Manager
Delta Diablo (sanitation district)	Phil Govea	Director of Engineering
Diablo Water District	Nacho Mendoza	Water Operations Manager
Eastern Contra Costa Transit Authority (Tri Delta Transit)	Ann Hutcheson	Director of Administrative Services
Ironhouse Sanitary District	Chad Davisson	General Manager
Kensington Fire Protection District	Michael Bond	Battalion Chief
Kensington Police Protection and Community Services District	Ricky Hull	Police Department Chief
Pleasant Hill Recreation and Park District	Mark Blair	Accounting Supervisor
Reclamation District 830, Jersey Island	David Smith	Maintenance Superintendent
San Ramon Geological Hazard Abatement District	Steven Spedowfski	Senior Analyst
San Ramon Valley Fire Protection District	Christina Kiefer	Fire Marshal
San Ramon Valley Unified School District	Craig Cesco	Director, Maintenance and Grounds
West Contra Costa Unified School District	Luis Freese	District Engineering Officer

PLAN DEVELOPMENT APPROACH

Organization

A core planning team consisting of a contract consultant and Contra Costa County Office of Emergency Services staff was assembled to facilitate this plan update. A planning partnership was formed by engaging eligible local governments within the Operational Area and making sure they understood their expectations for compliance under the updated plan. A 13-member steering committee was assembled to oversee the plan update, consisting of both governmental and non-governmental stakeholders within the Operational Area. Coordination with other county, state, and federal agencies involved in hazard mitigation occurred throughout the plan update process. Organization efforts included a review of the 2011 Contra Costa County Hazard Mitigation Plan, the California statewide hazard mitigation plan, and existing programs that may support hazard mitigation actions.

Public Outreach

The planning team implemented a multi-media public involvement strategy utilizing the outreach capabilities of the planning partnership that was approved by the Steering Committee. The strategy included public meetings, a hazard mitigation survey, a project website, the use of social media (Facebook, Twitter and Nextdoor) and multiple media releases.

Plan Document Development

The planning team and Steering Committee assembled a document to meet federal hazard mitigation planning requirements for all partners. The updated plan contains two volumes. Volume 1 contains components that apply to all partners and the broader Operational Area. Volume 2 contains all components that are jurisdiction-specific. Each planning partner has a dedicated annex in Volume 2.

Adoption

Once pre-adoption approval has been granted by the California Office of Emergency Services and FEMA Region IX, the final adoption phase will begin. Each planning partner will individually adopt the updated plan.

RISK ASSESSMENT

Risk assessment is the process of measuring the potential loss of life resulting from natural hazards, as well as personal injury, economic injury and property damage, in order to determine the vulnerability of people, buildings, and infrastructure to natural hazards. For this update, risk assessment models were enhanced with new data and technologies that have become available since 2011. The Steering Committee used the risk assessment to rank risk and to gauge the potential impacts of each hazard of concern in the Operational Area. The risk assessment included the following:

- Hazard identification and profiling
- Assessment of the impact of hazards on physical, social, and economic assets
- Identification of particular areas of vulnerability
- Estimates of the cost of potential damage.

Based on the risk assessment, hazards were ranked for the risk they pose to the overall Operational Area, as shown in Table ES-3. Each planning partner also ranked hazards for its own area. Table ES-4 summarizes the categories of high, medium and low (relative to other rankings) based on the numerical ratings that each jurisdiction assigned each hazard. The results indicate the following general patterns:

- The earthquake hazard was most commonly ranked as high.
- The flood, landslide and severe weather hazards were most commonly ranked as medium.
- The dam failure and drought hazards were most commonly ranked as low.

Table ES-3. Hazard Risk Ranking

Hazard Ranking	Hazard Event	Category
1	Earthquake	High
2	Landslide	High
3	Severe Weather	Medium
4	Wildfire	Medium
5	Dam and Levee Failure	Medium
6	Flood	Medium
7	Sea Leve Rise	Low
7	Tsunami	Low
8	Drought	Low

Table ES-4. Summary of Hazard Ranking Results

	Number of Jurisdictions Assigning Ranking to Hazard			
	High	Medium	Low	Not Ranked
Dam Failure and Levee	2	4	24	5
Drought	3	2	28	2
Earthquake	34	1	0	0
Flood	8	20	6	1
Landslide	15	12	6	2
Sea Level Rise	0	4	8	23
Severe weather	7	23	5	0
Tsunami	0	0	7	28
Wildfire	8	8	19	0

MITIGATION GOALS AND OBJECTIVES

The Steering Committee reviewed and updated the goals from the 2011 Contra Costa County Hazard Mitigation Plan and confirmed a set of objectives. The following guiding principle guided the Steering Committee and planning partners in selecting actions contained in this plan update:

> *To reduce the vulnerability from hazards within the planning area in a cost-effective manner, within the capabilities of the partnership.*

Goals

The Steering Committee and planning partners established the following goals for the plan update:

1. Save (or protect) lives and reduce injury.
2. Increase resilience of infrastructure and critical facilities.
3. Avoid (minimize, or reduce) damage to property.
4. Encourage the development and implementation of long-term, cost-effective and environmentally sound mitigation projects.
5. Build and support capacity to enable local government and the public to prepare for, respond to and recover from the impact of natural hazards.

The effectiveness of a mitigation strategy is assessed by determining how well these goals are achieved.

Objectives

Each selected objective meets multiple goals, serving as a stand-alone measurement of the effectiveness of a mitigation action, rather than as a subset of a goal. The objectives also are used to help establish priorities. The objectives are as follows:

1. Increase resilience of infrastructure and critical facilities.
2. Sustain reliable local emergency operations and facilities during and after a disaster.
3. Inform the public on the risk from hazards of concern and increase awareness, preparation, mitigation, response, and recovery activities to promote public safety.
4. Minimize the impacts of known hazards on current and future land uses by providing incentives for hazard mitigation.

5. Prevent or discourage new development in hazardous areas or ensure that, if building occurs in high-risk areas, it is done in a way to minimize risk.
6. At the local government level, continually improve understanding of the location and potential impacts of hazards, using the best available data and science.
7. Encourage all development to meet applicable standards for life safety
8. Monitor plan progress annually to integrate the local hazard mitigation plan with the results of disaster- and hazard-specific planning efforts.
9. Promote development and use of floodplain management best practices through programs such as CRS.
10. Provide or improve flood protection with flood control structures and drainage maintenance plans.
11. Enhance codes and their enforcement where feasible, so that new construction can withstand the impacts of known hazards and to lessen the impact of development on the environment’s ability to absorb the impact of natural hazards.
12. Consider the impacts of known hazards in all planning mechanisms that address current and future land uses within the planning area.
13. Eliminate or minimize disruption of local government operations caused by known hazards.
14. Consider open space land uses within identified high-hazard risk zones.
15. Retrofit, acquire or relocate identified high-risk structures, including those known to experience repetitive losses.
16. Establish a partnership among all levels of government and the business community to improve and implement methods to protect property
17. Encourage hazard mitigation measures that promote and enhance natural processes and minimize adverse impacts on the ecosystem.
18. Promote and implement hazard mitigation plans and projects that are consistent with state, regional, and local climate action and adaptation goals, policies, and programs.

MITIGATION ACTION PLAN

The planning partnership selected a range of appropriate mitigation actions to work toward achieving the goals set forth in this plan update. Mitigation actions presented in this update are activities designed to reduce or eliminate losses resulting from natural hazards. The update process resulted in the identification of 522 mitigation actions for implementation by individual planning partners, as presented in Volume 2 of this plan. In addition, the Steering Committee and planning partners identified countywide actions benefiting the whole partnership, as listed in Table ES-5.

IMPLEMENTATION

The Steering Committee developed a plan implementation and maintenance strategy that includes annual progress reporting, a strategy for continued public involvement, a commitment to plan integration with other relevant plans and programs, and a recommitment from the planning partnership to actively maintain the plan over the five-year performance period.

Full implementation of the recommendations of this plan will require time and resources. The measure of the plan’s success will be its ability to adapt to changing conditions. The County of Contra Costa and its planning partners will assume responsibility for adopting the recommendations of this plan and committing resources toward implementation. The framework established by this plan commits all planning partners to pursue actions when the benefits of a project exceed its costs. The planning partnership developed this plan with extensive public input, and public support of the actions identified in this plan will help ensure the plan’s success.

Table ES-5. Area-Wide Hazard Mitigation Actions

Action Number and Description	Priority
Action #CW-1—Continue to maintain a County-wide hazard mitigation website that will store the hazard mitigation plan and provide the public an opportunity to monitor plan implementation progress. Each planning partner can support this initiative by including an initiative in its action plan of creating a link to the County hazard mitigation website.	High
Action #CW-2—Leverage public outreach partnering capabilities in the planning area (such as CERT) to promote a uniform and consistent message on the importance of proactive hazard mitigation.	High
Action #CW-3—Coordinate mitigation planning and project efforts in the planning area to leverage all resources available to the planning partnership.	High
Action #CW-4—Where appropriate, support retrofitting, purchase, or relocation of structures in hazard-prone areas to protect the structures from future damage, with repetitive loss and severe repetitive loss properties as a priority. Seek opportunities to leverage partnerships in the planning area in these pursuits.	Medium
Action #CW-5—Continue to update hazard mapping with best available data and science as it evolves, within the capabilities of the partnership. Support FEMA's RiskMAP initiative.	Medium
Action #CW-6—To the extent possible based on available resources, provide coordination and technical assistance in applying for grant funding.	High
Action #CW-7—A steering committee will remain as a working body over time to monitor progress of the hazard mitigation plan, provide technical assistance to planning partners, manage data, and oversee the update of the plan according to schedule. This body will continue to operate under the ground rules established at its inception.	High

Contra Costa County Hazard Mitigation Plan

PART 1—PLANNING PROCESS AND COMMUNITY PROFILE

1. INTRODUCTION TO HAZARD MITIGATION PLANNING

1.1 WHY PREPARE THIS PLAN?

1.1.1 The Big Picture

Hazard mitigation is defined as any action taken to reduce or alleviate the loss of life, personal injury, and property damage that can result from a disaster. It involves long- and short-term actions implemented before, during and after disasters. Hazard mitigation activities include planning efforts, policy changes, programs, studies, improvement projects, and other steps to reduce the impacts of hazards.

For many years, federal disaster funding focused on relief and recovery after disasters occurred, with limited funding for hazard mitigation planning in advance. The Disaster Mitigation Act (DMA; Public Law 106-390), passed in 2000, shifted the federal emphasis toward planning for disasters before they occur. The DMA requires state and local governments to develop hazard mitigation plans as a condition for federal disaster grant assistance. Regulations developed to fulfill the DMA's requirements are included in Title 44 of the Code of Federal Regulations (44 CFR).

The responsibility for hazard mitigation lies with many, including private property owners, commercial interests, and local, state and federal governments. The DMA encourages cooperation among state and local authorities in pre-disaster planning. The enhanced planning network called for by the DMA helps local governments to articulate accurate needs for mitigation, resulting in faster allocation of funding and more cost-effective risk-reduction projects.

The DMA also promotes sustainability in hazard mitigation. To be sustainable, hazard mitigation needs to incorporate sound management of natural resources and address hazards and mitigation in the largest possible social and economic context.

1.1.2 Purposes for Planning

Contra Costa County prepared a hazard mitigation plan in compliance with the DMA that was last updated in 2011 (Contra Costa County, 2011) The 2011 update, which was adopted and approved in April 2012, identifies resources, information, and strategies for reducing risk from natural hazards. It called for ongoing updates on a five-year cycle. This update fulfills that requirement.

The County prepared this update in partnership with local municipalities and special-purpose districts. One of the benefits of such multi-jurisdictional planning is the ability to pool resources and eliminate redundant activities within a planning area that has uniform risk exposure and vulnerabilities. The Federal Emergency Management Agency (FEMA) encourages multi-jurisdictional planning under its guidance for the DMA. Elements and strategies in the plan were selected because they meet a program requirement and because they best meet the needs of all the planning partners and their citizens.

The *2017 Contra Costa County Hazard Mitigation Plan* will help guide and coordinate mitigation activities throughout the planning area. It was developed to meet the following objectives:

- Meet or exceed requirements of the DMA.
- Enable all planning partners to continue using federal grant funding to reduce risk through mitigation.
- Meet the needs of each planning partner as well as state and federal requirements.
- Create a risk assessment that focuses on local hazards of concern.
- Meet the planning requirements of the Federal Emergency Management Agency's (FEMA's) Community Rating System (CRS), allowing planning partners that participate in the CRS program to maintain or enhance their CRS classifications.
- Coordinate existing plans and programs so that high-priority projects to mitigate possible disaster impacts are funded and implemented.

1.2 WHO WILL BENEFIT FROM THIS PLAN?

All citizens and businesses of Contra Costa County are the ultimate beneficiaries of this hazard mitigation plan. The plan reduces risk for those who live in, work in, and visit the planning area. It provides a viable planning framework for all foreseeable natural hazards. Participation in development of the plan by key stakeholders helped ensure that outcomes will be mutually beneficial. The resources and background information in the plan are applicable across the planning area, and the plan's goals and recommendations can lay groundwork for the development and implementation of local mitigation activities and partnerships.

1.3 CONTENTS OF THIS PLAN

This plan has been set up in two volumes so that elements that are jurisdiction-specific can easily be distinguished from those that apply to the whole planning area:

- Volume 1—Volume 1 includes all federally required elements of a disaster mitigation plan that apply to the entire planning area. This includes the description of the planning process, public involvement strategy, goals and objectives, planning area hazard risk assessment, planning area mitigation actions, and a plan maintenance strategy.
- Volume 2—Volume 2 includes all federally required jurisdiction-specific elements, in annexes for each participating jurisdiction. It includes a description of the participation requirements established by the Steering Committee, as well as instructions and templates that the partners used to complete their annexes. Volume 2 also includes "linkage" procedures for eligible jurisdictions that did not participate in development of this plan but wish to adopt it in the future.

Both volumes include elements required under federal guidelines. DMA compliance requirements are cited at the beginning of subsections as appropriate to illustrate compliance.

The following appendices provided at the end of Volume 1 include information or explanations to support the main content of the plan:

- Appendix A—Public outreach information used in preparation of this update
- Appendix B—A description of data and methods used to prepare mapping for the risk assessment.
- Appendix C—Plan adoption resolutions from Planning Partners.
- Appendix D—Template for progress reports to be completed as this plan is implemented.

All planning partners will adopt Volume 1 in its entirety and at least the following parts of Volume 2: Part 1; each partner's jurisdiction-specific annex; and the appendices.

2. PLAN UPDATE—WHAT HAS CHANGED

1.1 THE PREVIOUS PLAN

The *2011 Contra Costa County Hazard Mitigation Plan* was prepared for a planning partnership that consisted of Contra Costa County, 10 cities within the county, and 25 special-purpose districts within the county. The 2011 plan was developed from an initial hazard mitigation plan developed by the Association of Bay Area Governments (ABAG), in which Contra Costa County and some of the local jurisdictions had participated. The Contra Costa County Department of Public Works and Office of Emergency Services (OES) determined that a new countywide hazard mitigation plan would better suit the needs and capabilities of the County and its planning partners than an update under ABAG. The update process created a new stand-alone plan for the County and its planning partners. The updated plan differed from the initial plan as follows:

- The stand-alone plan focused only on Contra Costa County rather than being a subset of a larger regional effort.
- The risk assessment provided risk and vulnerability information that directly support the measurement of "cost-effectiveness" required under FEMA mitigation grant programs.
- Newly available data and tools provided for a more detailed and accurate risk assessment.
- The plan met requirements of FEMA's CRS program for reducing flood insurance premiums.
- The plan allowed all planning partners to meet the requirements of California Assembly Bill 2140, which requires integration of hazard mitigation plans into general plans.
- The County and planning partners engaged citizens directly in a coordinated approach to gage their perception of risk and support of the concept of risk reduction through mitigation.
- The plan identified mitigation actions that are fundable under Hazard Mitigation Assistance grants and that meet multiple measurable objectives.

The 2011 plan recommended 11 countywide mitigation actions and hundreds of actions specific to the individual planning partners. The actions address the following identified hazards of concern:

- Dam failure
- Drought
- Earthquake
- Flood
- Landslide and other mass movement
- Severe weather
- Wildfire.

2.2 WHY UPDATE?

2.2.1 Federal Eligibility

Title 44 of the Code of Federal Regulations (44 CFR) stipulates that hazard mitigation plans must present a schedule for monitoring, evaluating, and updating the plan. This provides an opportunity to reevaluate recommendations, monitor the impacts of actions that have been accomplished, and determine if there is a need to change the focus of mitigation strategies. A jurisdiction covered by a plan that has expired is not able to pursue elements of federal funding under the Robert T. Stafford Act for which a current hazard mitigation plan is a prerequisite.

2.2.2 Changes in Development

Hazard mitigation plan updates must be revised to reflect changes in development within the planning area during the previous performance period of the plan (44 CFR Section 201.6(d)(3)). The plan must describe changes in development in hazard-prone areas that increased or decreased vulnerability for each jurisdiction since the last plan was approved. If no changes in development impacted the jurisdiction's overall vulnerability, plan updates may validate the information in the previously approved plan. The intent of this requirement is to ensure that the mitigation strategy continues to address the risk and vulnerability of existing and potential development and takes into consideration possible future conditions that could impact vulnerability.

The planning area experienced a 17.1-percent increase in population between 2000 and 2015, an average annual growth rate of 1.1 percent per year. Participating planning partners have adopted general plans that govern land-use decisions and policy-making, as well as building codes and specialty ordinances based on state and federal mandates. This plan update assumes that some new development triggered by the increase in population occurred in hazard areas. Because all such new development would have been regulated pursuant to local programs and codes, it is assumed that vulnerability did not increase even if exposure did.

2.2.3 New Analysis Capabilities

The risk assessment for the 2011 plan used both quantitative and qualitative analyses. Building count data and annualized average loss estimates were provided for some, but not all, hazards of concern. These estimates were predominantly reported at the countywide scale. The updated risk assessment provides more detailed information on exposed population and building counts for each hazard of concern. This update also expands the level of detail in multiple-scenario loss estimation modeling for earthquake, flood, landslide, wildfire, and sea level rise. Exposure and vulnerability estimates are presented at the jurisdictional level. This enhanced risk assessment, together with the full participation of every local jurisdiction in the county, allows for a more detailed understanding of the ways risk in the planning area is changing over time.

2.3 THE UPDATED PLAN—WHAT IS DIFFERENT?

The updated plan differs from the initial plan in a variety of ways. Table 2-1 indicates the major changes between the two plans as they relate to 44 CFR planning requirements.

Table 2-1. Plan Changes Crosswalk

44 CFR Requirement	Previous Plan	Updated Plan
§201.6(b): In order to develop a more comprehensive approach to reducing the effects of natural disasters, the planning process shall include: *(1) An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval;* *(2) An opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academia and other private and non-profit interests to be involved in the planning process; and* *(3) Review and incorporation, if appropriate, of existing plans, studies, reports, and technical information.*	The 2011 plan followed an outreach strategy utilizing multiple media developed and approved by the Steering Committee. This strategy involved: • Public participation on an oversight Steering Committee. • Establishment of a plan informational website. • Press releases. • Use of a public information survey Stakeholders were identified and coordinated with throughout the process. A comprehensive review of relevant plans and programs was performed by the planning team.	Building upon the success of the 2011 plan, the 2017 planning effort deployed the same public engagement methodology. Enhancements included: • Utilization of social media • Web deployed survey • Enhanced press coverage As with the 2011 plan, the 2016 planning process identified key stakeholders and coordinated with them throughout the process. A comprehensive review of relevant plans and programs was performed by the planning team.
§201.6(c)(2): The plan shall include a risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.	The 2011 plan included a comprehensive risk assessment of seven hazards of concern. Risk was defined as (probability x impact), where impact is the impact on people, property and economy of the planning area. All planning partners ranked risk as it pertains to their jurisdiction. The potential impacts of climate change are discussed for each hazard.	The same methodology, using new, updated data, was deployed for the 2017 plan update. The risk assessment was expanded to include a profile of the tsunami hazard due to new data on risk and vulnerability from the State of California. Additionally, the risk assessment includes a detailed profile of potential impacts of climate change on the assessed hazards of concern. A qualitative profile of non-natural hazards was included. These hazards were profiled only and not fully assessed or ranked as with the natural hazards.
§201.6(c)(2)(i): [The risk assessment shall include a] description of the … location and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.	The 2011 plan presented a risk assessment of each hazard of concern. Each chapter included the following components: • Hazard profile, including maps of extent and location, historical occurrences, frequency, severity and warning time. • Secondary hazards • Climate change impacts • Exposure of people, property, critical facilities and environment • Vulnerability of people, property, critical facilities and environment. • Future trends in development • Scenarios • Issues	The same format, using updated data, was deployed for the 2017 plan update. Climate change was addressed as a stand-alone chapter.

44 CFR Requirement	Previous Plan	Updated Plan
§201.6(c)(2)(ii): [The risk assessment shall include a] description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i). This description shall include an overall summary of each hazard and its impact on the community	Vulnerability was assessed for all hazards of concern. The Hazus computer model (version MR-3) was used for the dam failure, earthquake, and flood hazards. These were Level 2 analyses using city and county data. Site-specific data on County-identified critical facilities were entered into the Hazus model. Loss outputs were generated for other hazards by applying an estimated damage function to an asset inventory extracted from Hazus.	The same methodology was deployed for the 2017 plan update, using updated data. Hazus version 3.2 was utilized for all analyses. Vulnerability for the tsunami hazard was not modeled using Hazus because version 4.0 had not yet been released at the time of the risk assessment.
§201.6(c)(2)(ii): [The risk assessment] must also address National Flood Insurance Program insured structures that have been repetitively damaged floods	The 2011 plan included a CRS level of detail repetitive loss area analysis based on 2011 repetitive loss data and the 2010 CRS Coordinators Manual.	The 2017 plan included a CRS level of detail repetitive loss area analysis based on 2016 repetitive loss data and the 2013 CRS Coordinators Manual.
§201.6(c)(2)(ii)(A): The plan should describe vulnerability in terms of the types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard area.	A complete inventory of the numbers and types of buildings exposed was generated for each hazard of concern. The Steering Committee defined "critical facilities" for the planning area, and these were inventoried by exposure. Each hazard chapter provides a discussion on future development trends.	The same methodology was deployed for the 2017 plan update, using updated data.
§201.6(c)(2)(ii)(B): [The plan should describe vulnerability in terms of an] estimate of the potential dollar losses to vulnerable structures identified in paragraph (c)(2)(i)(A) and a description of the methodology used to prepare the estimate.	Loss estimates were generated for all hazards of concern. These were generated by Hazus for the dam failure, earthquake and flood hazards. For the other hazards, loss estimates were generated by applying a regionally relevant damage function to the exposed inventory. In all cases, a damage function was applied to an asset inventory. The asset inventory was the same for all hazards and was generated in Hazus.	The same methodology was deployed for the 2017 plan update, using updated data.
§201.6(c)(2)(ii)(C): [The plan should describe vulnerability in terms of] providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.	There is a discussion of future development trends as they pertain to each hazard of concern. This discussion looks predominantly at the existing land use and the current regulatory environment that dictates this land use.	The same methodology was deployed for the 2017 plan update, using updated data. In addition, a look at the change in risk due to new development over the performance period of the plan was performed for each hazard of concern.
§201.6(c)(3): The plan shall include a mitigation strategy that provides the jurisdiction's blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs and resources, and its ability to expand on and improve these existing tools.	The 2011 plan contained a guiding principle, goals, objectives and actions. The guiding principal, goals and objectives were regional and covered all planning partners. Each planning partner identified actions that could be implemented within its capabilities. The actions were jurisdiction-specific and strove to meet multiple objectives. All objectives met multiple goals and stand alone as components of the plan. Each planning partner completed an assessment of its regulatory, technical and financial capabilities.	The same methodology for setting goals, objectives and actions was applied to the 2017 plan update. The Steering Committee reviewed and reconfirmed the guiding principle, goals and objectives for the plan. Each planning partner used the progress reporting from the plan maintenance and evaluated the status of actions identified in the 2011 plan. Actions that were completed or no longer considered to be feasible were removed. The balance of the actions were carried over to the 2016 plan and in some cases, new actions were added to the action plan.

44 CFR Requirement	Previous Plan	Updated Plan
§201.6(c)(3)(i): [The hazard mitigation strategy shall include a] description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.	The Steering Committee identified a guiding principle, five goals and 18 objectives. These were completely new goals and objectives targeted specifically for this hazard mitigation plan. They were not carried over from any other planning document and were identified based upon the capabilities of the planning partnership. These planning components supported the actions identified in the plan.	The same methodology for setting goals, objectives and actions was applied to the 2017 plan update. The Steering Committee reviewed and reconfirmed the guiding principle, goals and objectives for the plan with minor wording changes.
§201.6(c)(3)(ii): [The mitigation strategy shall include a] section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure.	The 2011 plan includes a hazard mitigation catalog that was developed through a facilitated process. This catalog identifies actions that manipulate the hazard, reduce exposure to the hazard, reduce vulnerability, or increase mitigation capability. The catalog further segregates actions by scale of implementation. A table in the action plan section analyzes each action by mitigation type to illustrate the range of actions selected.	The mitigation catalog was reviewed and updated by the Steering Committee for the 2017 update. Additional mitigation actions were added for the tsunami hazard, which was a new hazard assessed for this plan update. As with the 2011 plan, the catalog is included in the 2017 plan to represent the comprehensive range of alternatives considered by each planning partner. The analysis of mitigation action was again used in jurisdictional annexes to the plan.
§201.6(c)(3)(ii): [The mitigation strategy] must also address the jurisdiction's participation in the National Flood Insurance Program, and continued compliance with the program's requirements, as appropriate.	All municipal planning partners that participate in the National Flood Insurance Program identified an action stating their commitment to maintain compliance and good standing under the program. Communities that participate in the Community Rating System identified actions to maintain or enhance their standing under the CRS.	The same methodology was deployed for the 2017 plan update, using updated data.
§201.6(c)(3)(iii): [The mitigation strategy shall describe] how the actions identified in Section (c)(3)(ii) will be prioritized, implemented, and administered by the local jurisdiction. Prioritization shall include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.	Each recommended action was prioritized using a qualitative methodology based on the objectives the project will meet, the timeline for completion, how the project will be funded, the impact of the project, the benefits of the project and the costs of the project.	The same methodology was deployed for the 2017 plan update, using updated data.
§201.6(c)(4)(i): [The plan maintenance process shall include a] section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle.	The 2011 plan details a plan maintenance strategy that involved a protocol for annual progress reporting by all planning partners. The strategy identifies triggers for plan updates, integration with other plans and programs and identifies protocol for continuing public involvement.	The 2011 plan maintenance strategy was carried over to this plan update.
§201.6(c)(4)(ii): [The plan shall include a] process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms such as comprehensive or capital improvement plans, when appropriate.	The 2011 plan details recommendations for incorporating the plan into other planning mechanisms such as: • Comprehensive Plan • Emergency Response Plan • Capital Improvement Programs • Municipal Code • Continuity of Operations Plan	This component of the plan maintenance strategy from the 2011 plan was carried over to the 2017 plan.

44 CFR Requirement	Previous Plan	Updated Plan
§201.6(c)(4)(iii): [The plan maintenance process shall include a] discussion on how the community will continue public participation in the plan maintenance process.	The 2011 plan details a strategy for continuing public involvement	This component of the plan maintenance strategy from the 2011 plan was carried over to the 2017 plan.
§201.6(c)(5): [The local hazard mitigation plan shall include] documentation that the plan has been formally adopted by the governing body of the jurisdiction requesting approval of the plan (e.g., City Council, County Commission, Tribal Council).	All planning partners that fully met their “participation” requirements as defined by the planning process formally adopted the plan. Appendix D presents the resolutions of all planning partners that adopted this plan	All planning partners that fully met their “participation” requirements as defined by the planning process formally adopted the plan. Appendix C presents the resolutions of all planning partners that adopted this plan

3. PLAN UPDATE APPROACH

The process followed to develop the 2017 *Contra Costa County Hazard Mitigation Plan* had the following primary objectives:

- Secure grant funding
- Form a planning team
- Establish a planning partnership
- Define the planning area
- Establish a steering committee
- Coordinate with other agencies
- Review existing programs
- Engage the public.

These objectives are discussed in the following sections.

3.1 GRANT FUNDING

This planning effort was supplemented by a FEMA Hazard Mitigation Assistance grant in fiscal year 2015. Contra Costa County OES was the applicant agent for the grant. It covered 75 percent of the cost for development of this plan; the planning partners covered the balance through in-kind contributions.

3.2 DEFINING STAKEHOLDERS

At the beginning of the planning process, the planning team identified a list of stakeholders to engage during the update of the Contra Costa County Hazard Mitigation Plan. For this planning process, “stakeholder” was defined as any person or public or private entity that owns or operates facilities that would benefit from the mitigation actions of this plan, and/or has an authority or capability to support mitigation actions identified by this plan. Stakeholders were separated into two categories:

- **Participatory Stakeholders**—Stakeholders that actively participated in the planning process as planning partners or members of the Steering Committee.
- **Coordinating Stakeholders**—Stakeholders that were not able to commit to actively participating in the process as a participatory stakeholder, but were kept apprised of plan development milestones or were able to provide data that was used in the plan development.

3.3 FORMATION OF THE PLANNING TEAM

Contra Costa County OES hired Tetra Tech, Inc. to assist with development and implementation of the plan. The Tetra Tech project manager assumed the role of the lead planner, reporting directly to the Contra Costa County OES project manager. A planning team was formed to lead the planning effort, made up of the following members:

- Marcelle Indelicato, Senior Emergency Planner, Contra Costa County Office of Emergency Services
- Will Nelson, Principle Planner, Contra Costa County Department of Conservation and Development
- Rob Flaner, Tetra Tech
- Kristen Gelino, Tetra Tech
- Jessica Cerutti, Tetra Tech
- Carol Bauman, Tetra Tech

3.4 ESTABLISHMENT OF THE PLANNING PARTNERSHIP

Contra Costa County OES opened this planning effort to all eligible local governments within the planning area. The planning team made a presentation at a stakeholder meeting on November 10, 2016 to introduce the mitigation planning process and solicit planning partners. Key meeting objectives were as follows:

- Provide an overview of the Disaster Mitigation Act.
- Describe the reasons for a plan.
- Outline the hazard mitigation work plan.
- Outline planning partner expectations.
- Seek commitment to the planning partnership.
- Seek volunteers for the Steering Committee.

Each jurisdiction wishing to join the planning partnership was asked to provide a “letter of intent to participate” that designated a point of contact for the jurisdiction and confirmed the jurisdiction’s commitment to the process and understanding of expectations. Linkage procedures have been established (see Volume 2 of this plan) for any jurisdiction wishing to link to the *Contra Costa County Hazard Mitigation Plan* in the future. The municipal planning partners covered under this plan are shown in Table 3-1. The special purpose district planning partners are shown in Table 3-2.

Table 3-1. Municipal Planning Partners

Jurisdiction	Point of Contact	Title
County of Contra Costa	Marcelle Indelicato	Senior Emergency Planner
City of Antioch	Lt. Desmond Bittner	Lieutenant Police Department
City of Brentwood	Lt. Doug Silva	Lieutenant Police Department
City of Concord	Margaret Romiti	Manager, Office of the Chief
Town of Danville	Jeff Hebel	Emergency Services Manager
City of El Cerrito	Michael Bond	Battalion Chief
City of Lafayette	Niroop Srivatsa	Plan and Building Services Dept. Director
City of Martinez	Manjit Sappal	Chief of Police
Town of Moraga	Ellen Clark	Planning Director
City of Orinda	Daisy Allen	Associate Planner
City of Pleasant Hill	Shawn Knapp	Associate Engineer
City of Richmond	Richard Mitchell	Planning Director
City of San Pablo	Ronalyn Nonato	Public Works Assistant Engineer
City of San Ramon	Steven Spedowfski	Engineering Dept., Senior Analyst
City of Walnut Creek	Steve Waymire	Emergency Coordinator

Table 3-2. Special Purpose District Planning Partners

District	Point of Contact	Title
Antioch Unified School District	Jeff Collins	Director, Maintenance, Operations and Transportation
Bethel Island Municipal Improvement District	Jeff Butzlaff	District Manager
Contra Costa County Fire Protection District	Lewis Broshard	Chief Support Services
Contra Costa County Flood Control and Water Conservation District	Chris Lau	Senior Civil Engineer
Contra Costa County Office of Education	John F. Hild	Director, General Services
Contra Costa Water District*	Joe Piro	Senior Engineer, Operations and Maintenance Department
Central Contra Costa Sanitary District	Shari Deutsch	Risk Manager
Crockett Community Services District*	Dale McDonald	General Manager
Delta Diablo (sanitation district)	Phil Govea	Director of Engineering
Diablo Water District	Nacho Mendoza	Water Operations Manager
Eastern Contra Costa Transit Authority (Tri Delta Transit)	Ann Hutcheson	Director of Administrative Services
Ironhouse Sanitary District	Chad Davisson	General Manager
Kensington Fire Protection District	Michael Bond	Battalion Chief
Kensington Police Protection and Community Services District	Ricky Hull	Police Department Chief
Pleasant Hill Recreation and Park District	Mark Blair	Accounting Supervisor
Reclamation District 830, Jersey Island	David Smith	Maintenance Superintendent
San Ramon Geological Hazard Abatement District*	Steven Spedowfski	Senior Analyst
San Ramon Valley Fire Protection District	Christina Kiefer	Fire Marshal
San Ramon Valley Unified School District*	Craig Cesco	Director, Maintenance and Grounds
West Contra Costa Unified School District	Luis Freese	District Engineering Officer

* Represents a new planning partner for the 2017 update.

3.5 DEFINING THE PLANNING AREA

The planning area was defined to consist of the unincorporated county, incorporated cities, and special purpose districts within the geographical boundary of Contra Costa County. All partners to this plan have jurisdictional authority within this planning area. A map showing the geographic boundary of the defined planning area for this plan update is provided in Chapter 4, along with a description of planning area characteristics.

3.6 THE STEERING COMMITTEE

Hazard mitigation planning enhances collaboration and support among diverse parties whose interests can be affected by hazard losses. A key element of the public engagement strategy for this plan update was the formation of a stakeholder steering committee to oversee all phases of the update. The members of this committee included planning partner representatives, citizens, and other stakeholders from within the planning area. The planning team assembled a list of candidates representing interests within the planning area that could have recommendations for the plan or be impacted by its recommendations. The planning partners confirmed a committee of 13 members at the kickoff meeting. Table 3-3 lists the Steering Committee members.

Table 3-3. Steering Committee Members

Name	Title	Jurisdiction/Agency
Marcelle Indelicato	Senior Planner	Contra Costa County Office of Emergency Services
Larry Fong	Citizen Volunteer	American Red Cross Bay Area Chapter
Jeffrey Collins	Director, Maintenance, Operations & Transportation	Antioch Unified School District
Shari Deutsch[b]	Risk Manager	Central Sanitation District
Steven Spedowfski[a]	Engineering Dept., Senior Analyst	City of San Ramon
Betsy Burkhart	Public Information Officer	Contra Costa County Administrator's Office
Will Nelson	Principle Planner	Contra Costa County Department of Conservation & Development
Chris Lau	Senior Civil Engineer	Contra Costa County Public Works
Michael Bond	Battalion Chief	El Cerrito Fire Department
Debbi Vanek	Fire Marshal	San Ramon Valley Fire Protection District
Jeffrey Hebel	Emergency Services Manager	Town of Danville
Bryan Walley	Volunteer	Sheriff's Office Search and Rescue
Libby MontesNation	Emergency Coordinator	West Contra Costa Unified School District

a = Chairperson
b = Vice-Chairperson

Leadership roles and ground rules were established during the Steering Committee's initial meeting on November 10, 2016. The Steering Committee agreed to meet on the second Thursday of every month as needed throughout the course of the plan's development. The planning team facilitated each Steering Committee meeting, which addressed a set of objectives based on an established work plan. The Steering Committee met nine times from November of 2016 through August 2017. Meeting agendas, notes and attendance logs are available for review upon request. All Steering Committee meetings were open to the public and were advertised as such on the hazard mitigation plan website. Agendas were posted to the website prior to each scheduled Steering Committee meeting, and meeting summaries were posted to the hazard mitigation plan website following their approval by the Steering Committee.

3.7 COORDINATION WITH STAKEHOLDERS AND AGENCIES

Opportunities for involvement in the planning process must be provided to neighboring communities, local and regional agencies involved in hazard mitigation, agencies with authority to regulate development, businesses, academia, and other private and nonprofit interests (44 CFR, Section 201.6(b)(2)).

Agency coordination was accomplished by the planning team as follows:

- **Steering Committee Involvement**—Agency representatives were invited to participate on the Steering Committee.
- **Agency Notification**—The following agencies were invited to participate in the plan development process from the beginning and were kept apprised of plan development milestones:
  - Alameda County Emergency Management Association (ALCO-EMA), President
  - American Red Cross Bay Area Chapter
  - Antioch Unified School District
  - Association of Bay Area Governments, Resilience Program Coordinator
  - Bay Area Rapid Transit, Emergency Manager
  - California Department of Water Resources, California State National Flood Insurance Program Coordinator

- ➢ California Office of Emergency Services, Emergency Services Coordinator
- ➢ Central Contra Costa Sanitary District
- ➢ City of San Ramon
- ➢ Contra Costa Consolidated Fire District
- ➢ Contra Costa County CERT
- ➢ Dublin San Ramon Services District, Associate Engineer
- ➢ East Bay Municipal Utility District, Risk Manager
- ➢ East Bay Parks and Recreation District, Assistant Finance Officer
- ➢ FEMA Region IX, Lead Community Planner
- ➢ Pacific Gas and Electric (PG&E)
- ➢ San Ramon Valley Fire District
- ➢ U.S. Army Corps of Engineers, Sacramento District, Deputy District Engineer for Project Management
- ➢ U.S. Geological Survey, Science Advisor
- ➢ West Contra Costa Unified School District

These agencies received meeting announcements, meeting agendas, and meeting minutes by e-mail throughout the plan development process and were provided the option to attend meetings. Some agencies supported the effort by attending meetings or providing feedback on issues.

- **Pre-Adoption Review**—All the agencies listed above were provided an opportunity to review and comment on this plan, primarily through the hazard mitigation plan website (see Section 3.9). All were sent an e-mail message informing them that draft portions of the plan were available for review. Upon completion of a public comment period, a complete draft plan was sent to the California Office of Emergency Services for a pre-adoption review to ensure program compliance.

Special involvement in and assistance with the planning process was provided by the following federal and state agencies:

- FEMA Region IX provided updated planning guidance, provided summary and detailed data for the planning area from the National Flood Insurance Program (NFIP) (including repetitive loss information), and conducted plan review.
- The U.S. Geological Survey (USGS) provided ShakeMaps to support the earthquake risk assessment.
- The California Governor’s Office of Emergency Services (Cal OES) facilitated FEMA review, provided updated planning guidance, and reviewed the draft and final versions of the plan prior to FEMA review.
- The California Department of Forestry and Fire Protection (CAL FIRE) provided fire severity mapping to support the wildfire risk assessment.
- The California Department of Water Resources provided information on NFIP compliance for local cities.

3.8 REVIEW OF EXISTING PROGRAMS

Hazard mitigation planning must include review and incorporation, if appropriate, of existing plans, studies, reports and technical information (44 CFR, Section 201.6(b)(3)). Chapter 4 of this plan provides a review of laws and ordinances in effect within the planning area that can affect hazard mitigation actions. In addition, the following programs can affect mitigation within the planning area:

- California Fire Code.
- The California Fire Alliance
- 2016 California Building Code.
- California State Hazard Mitigation Forum.

- Adapting to Rising Tides
- Local Capital Improvement Programs.
- Local Emergency Operations Plan.
- Local General Plans.
- Housing Element.
- Safety Element.
- Local Zoning Ordinances.
- Local Coastal Program Policies.

An assessment of all planning partners' regulatory, technical and financial capabilities to implement hazard mitigation actions is presented in Chapter 4 and in the individual jurisdiction-specific annexes in Volume 2. Many of these relevant plans, studies and regulations are cited in the capability assessment.

3.9 PUBLIC INVOLVEMENT

Broad public participation in the planning process helps ensure that diverse points of view about local needs are considered and addressed. The public must have opportunities to comment on disaster mitigation plans during the drafting stages and prior to plan approval (44 CFR, Section 201.6(b)(1)). The Community Rating System expands on these requirements by making CRS credits available for optional public involvement activities.

3.9.1 Strategy

The strategy for involving the public in this plan emphasized the following elements:

- Include members of the public on the Steering Committee.
- Use a survey to determine if the public's perception of risk and support of hazard mitigation has changed since the initial planning process.
- Attempt to reach as many planning area citizens as possible using multiple media.
- Identify and involve planning area stakeholders.

Stakeholders and the Steering Committee

Stakeholders are the individuals, agencies and jurisdictions that have a vested interest in the recommendations of the hazard mitigation plan, including all planning partners. The effort to include stakeholders in this process included stakeholder participation on the Steering Committee. The planning team vetted all the following potential stakeholders to actively participate in the plan update process:

- **Federal Agencies**—FEMA Region IX provided updated planning guidance, provided summary and detailed data from the National Flood Insurance Program (including repetitive loss information), and conducted plan review. Representatives from the U.S. Geological Survey served as subject matter advisors for the Steering Committee.
- **State Agencies**—The Governor's Office of Emergency Services (Cal OES) facilitated FEMA review, provided updated planning guidance, and reviewed the draft and final versions of the plan prior to FEMA review.

- **Regional and Local Stakeholders**—The following organizations received information about the planning process and invitations to provide input, and elected to participate in the planning process as members or subject matter advisors to the Steering Committee:
  - City Antioch
  - City of Brentwood
  - City of Concord
  - City of Clayton
  - Town of Crocket
  - City of Danville
  - City of El Cerrito
  - City of Lafayette
  - City of Martinez
  - Town of Moraga
  - City of Oakley
  - City of Orinda
  - City of Pinole
  - City of Pittsburg
  - City of Pleasant Hill
  - City of Richmond
  - City of San Pablo
  - City of San Ramon
  - City of Walnut Creek
  - Antioch Unified School District
  - Bay Area Rapid Transit
  - Bethel Island Municipal Improvement District
  - Contra Costa Consolidated Fire protection District
  - CCC Flood Control and Water Conservation District
  - CCC Office of Education
  - Central Contra Costa Sanitary District
  - Contra Costa Water District
  - Delta Diablo Sanitation District
  - Diablo Water District
  - Dublin San Ramon Services District
  - East Bay Municipal Utility District
  - East Bay Regional Parks District
  - Ironhouse Sanitary District
  - Kensington Police Protection and Community Services District
  - Kensington Fire Protection District
  - Moraga-Orinda Fire Protection District
  - Pleasant Hill Recreation and Park District
  - Reclamation District 830, Jersey Island
  - Rodeo / Hercules Fire Protection District
  - San Ramon Geological Hazard Abatement District
  - San Ramon Valley Fire Protection District
  - San Ramon Valley Unified School District
  - CERT
  - Tri Delta Transit
  - West Contra Costa Unified School District

Internet

At the beginning of the plan development process, a website was created to keep the public posted on plan development milestones and to solicit relevant input (see Figure 3-1): http://www.contracosta.ca.gov/6415/Local-Hazard-Mitigation-Plan. The site's address was publicized in all press releases, mailings, surveys and public meetings. Each planning partner established a link to this site on its own agency website. Information on the plan development process, the Steering Committee, a plan survey, and drafts of the plan was made available to the public on the site throughout the process. Contra Costa County intends to keep a website active after the plan's completion to keep the public informed about successful mitigation projects and future plan updates.

Survey

A hazard mitigation plan survey (see Figure 3-2) was developed by the planning team with guidance from the Steering Committee. The survey was used to gauge household preparedness for natural hazards and the level of knowledge of tools and techniques that assist in reducing risk and loss from natural hazards. This survey was designed to help identify areas vulnerable to one or more natural hazards. The answers to its 18 questions helped guide the Steering Committee in selecting goals, objectives and mitigation strategies. The survey was made available on the hazard mitigation plan website and advertised throughout the course of the planning process.

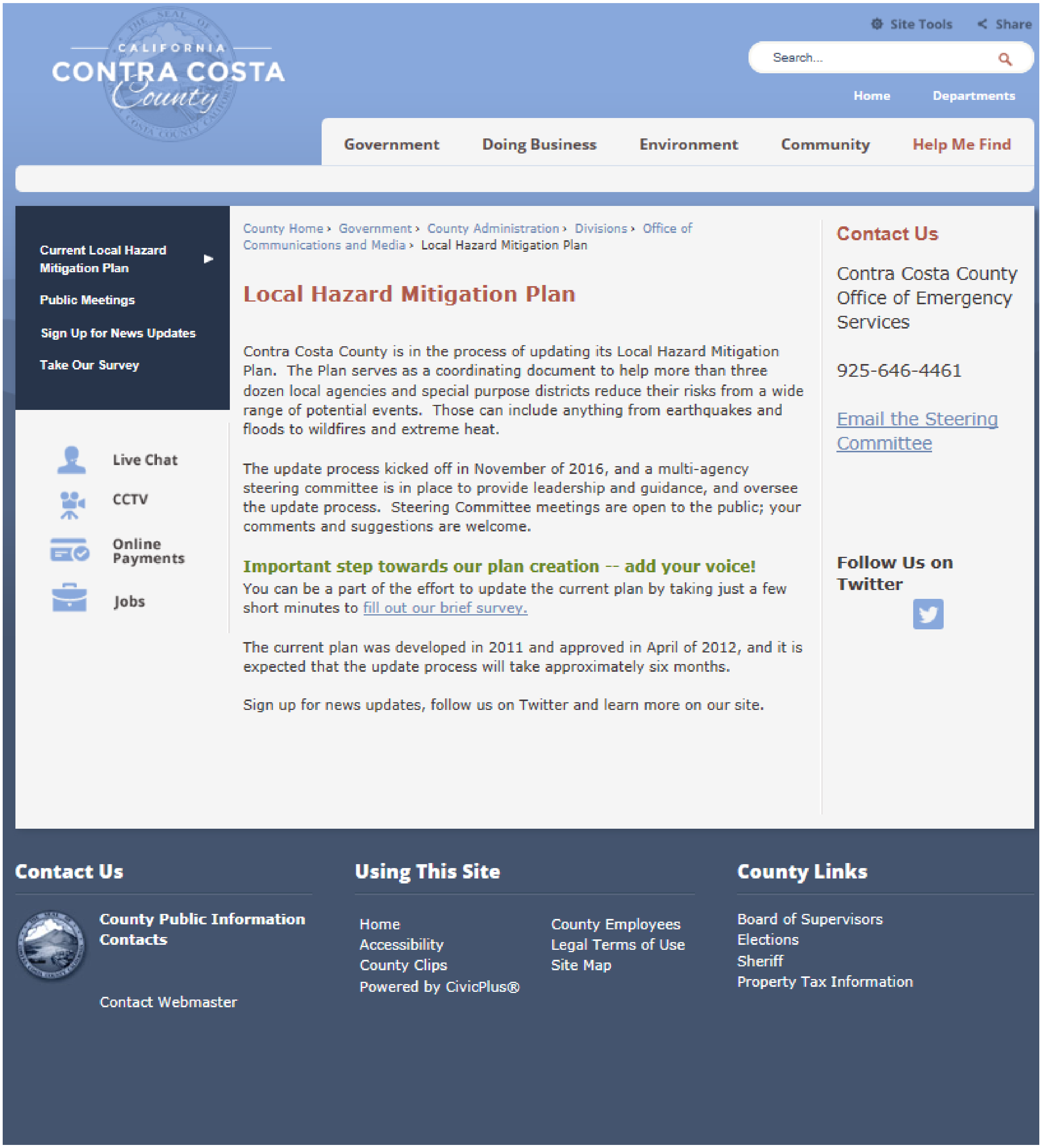


Figure 3-1. Sample Page from Hazard Mitigation Plan Web Site

Contra Costa Local Hazard Mitigation Plan Survey

1. Survey Introduction

Contra Costa County Hazard Mitigation Questionnaire

A range of natural and human-caused disasters can affect any community. Contra Costa County and its special districts and incorporated cities work diligently to mitigate threats and prepare for disasters. Natural disasters are those hazards that occur as a force of nature, such as a flood or earthquake. Non-natural disasters are those that occur as part of an intentional act or failure of technology. For the purpose of this plan, non-natural hazards also include health hazards, such as epidemics.

To maintain a high level of preparedness, we need your help to identify and plan for future disasters by completing this survey.

Thank you for taking the time to participate in the 2017 Hazard Mitigation Survey!

Contra Costa Local Hazard Mitigation Plan Survey

2. Hazard Knowledge

First, this set of questions is about your experience and knowledge of natural and human-caused hazards and steps your household has taken to prepare for disasters:

1. Which of the following natural hazard events have you experienced in Contra Costa? (Check all that apply)

- ☐ Dam/Levee Failure
- ☐ Drought
- ☐ Earthquake
- ☐ Flood
- ☐ Landslide & Mass Movements (sinkholes, geologic hazards)
- ☐ Severe Weather (high wind, heavy rain, lightning, etc.)
- ☐ Wildfire
- ☐ None
- ☐ Other (please specify)

Figure 3-2. Sample Page from Survey Distributed to the Public

The results of the survey were provided to each of the planning partners in toolkits used to support the jurisdictional annex process (as described in the introduction to Volume 2 of this plan). Each planning partner was able to use the survey results to help identify actions as follows:

- Gauge the public's perception of risk and identify what citizens are concerned about.
- Identify the best ways to communicate with the public.
- Determine the level of public support for different mitigation strategies.
- Understand the public's willingness to invest in hazard mitigation.

During the course of this planning process, 656 completed surveys were submitted. The complete survey and a summary of its findings can be found in Appendix A of this volume.

Press Releases

Press releases were distributed over the course of the plan's development as key milestones were achieved and prior to each public meeting. All press releases can be viewed on the plan website at: http://www.contracosta.ca.gov/6418/Sign-Up-for-News-Updates . The press releases are summarized as follows:

- December 15, 2016—Press Release #1 to announce initiation of the plan update process and establishment of the plan information website.
- February 13, 2017—Press Release #2, mid-term report on the status of the update to the hazard mitigation plan.
- April 13, 2017—Press Release #3 to announce the hazard mitigation survey
- August 30, 2017—Press Release #4 to announce the 14-day public comment period.

Public Comment on the Plan

A 14-day public comment period, from September 1 to September 15, 2017, gave the public an opportunity to comment on the draft plan update prior to its submittal to Cal OES. The principle avenue for public comment on the draft plan was the website established for this plan update. Additionally, public meetings were held on September 11, 2017 in Martinez and on September 12, 2017 in San Ramon to allow an opportunity to provide comment on the draft plan update. These meetings were advertised via a county-wide press release distributed by the Contra Costa County Public Information Officer. At each public meeting, a 30-minute presentation was given, followed by a period for questions and answers by those in attendance. Meeting attendance is summarized in Table 3-4. Comments received on the draft plan are available upon request. All comments were reviewed by the planning team and incorporated into the draft plan as appropriate.

Table 3-4. Summary of Public Meetings

Date	Location	Number of Citizens in Attendance	Number of Comments Received
8/11/2017	Martinez	4	1
8/12/2017	San Ramon	32	2
9/1 to 9/15	Public Comment period	N/A	15
Total		36	18

3.9.2 Public Involvement Results

The public involvement strategy used for this plan update introduced the concept of mitigation to the public and provided the Steering Committee with feedback to use in developing the plan. All citizens of the planning area were provided ample opportunities to provide comment during all phases of this plan update process. Details of attendance and comments received from the public meetings are summarized in Table 3-4. Detailed analysis of the survey findings is presented in Appendix A; a summary is as follows:

- Number of hard copy surveys received—19
- Number of surveys completed via the internet— 643
- Total surveys analyzed— 662
- Surveys were received from each municipality in the County
- Survey respondents ranked earthquake as the hazard of highest concern, followed by drought and wildfire.
- The majority of respondents expect to receive information on immediate threats caused by hazards from the radio, followed by television, and the Contra Costa County Community Warning System.
- Over 60 percent of respondents stated that they had considered the impact a natural disaster could have on their home before they moved into the home.
- Over 50 percent of respondents were not sure if they had hazard-specific insurance coverage
- 42 “write-in” comments received from the surveys were provided to the Steering Committee.

All survey results were provided to the Steering Committee for them to review in support of confirming the guiding principle, goals, objectives and county-wide actions for this plan update. Additionally, the survey results were included in the toolkit provided to each planning partner through the jurisdictional annex process described in Volume 2. Each planning partner was instructed to use the survey results to help frame mitigation actions and public outreach strategies to include in their action plans.

3.10 PLAN DEVELOPMENT CHRONOLOGY/MILESTONES

Table 3-5 summarizes important milestones in the plan update process.

Table 3-5. Plan Development Chronology/Milestones

Date	Event	Description	Attendance
2015			
12/2	Organize Resources	County OES holds kickoff meeting for potential planning partners to inform them of the next steps in the plan update process, solicit commitment to participate, explain expectations, and organize resources for the update.	27
2016			
4/27	Organize Resources	County releases request for proposals for a technical support contractor to facilitate the update to the hazard mitigation plan.	N/A
7/5	Organize Resources	County selects Tetra Tech as its technical assistance contractor to facilitate the plan update process.	N/A
11/10	Steering Committee Meeting #1	• Review work plan • Organize Steering Committee • Establish ground rules • Initiate plan review • Discuss options for public outreach strategy	17
12/15	Steering Committee Meeting #2	• Review Steering Committee charter • Review of previous Contra Costa hazard mitigation plan and California plan • Guiding principal, goals, and objectives • Identification of hazards of concern and scenarios to assess • Public involvement strategy	10
2017			
1/12	Steering Committee Meeting #3	• Risk assessment update • Confirm guiding principal, goals, and objectives • Review critical facilities definition • Confirm final public survey for deployment	14
1/19	Planning Partner Coordination	Bulletin sent out to all planning partners to inform them of the phased jurisdictional annex process and the 2/9 Steering Committee meeting that was being opened to all planning partners to update them on the plan update process.	N/A
1/20	Public Outreach	Web-based public outreach survey deployed via Survey Monkey with web-links distributed via the hazard mitigation website and social media.	N/A
2/9	Steering Committee Meeting #4	Meeting was open to the entire planning partnership. The objectives were as follows: • Final confirmation of critical facility definition • Brief update on overall status of the plan update • Earthquake scenario discussion led by U.S. Geological Survey • Initiate the phased deployment of jurisdictional annex process • Authorize deployment of the survey	39
2/10	Public Outreach	Release hazard mitigation survey	N/A
3/9	Steering Committee Meeting #5	• Risk assessment update • Review results of Phase 1 of the jurisdictional annex process • Review general building stock results from the risk assessment • Discuss public meeting dates, times and venues • Community Development Block Grant briefing by John Mizerak, Tetra Tech	14
4/13	Steering Committee Meeting #6	• Risk assessment update, general building stock results • Review status of Phase 2 of the jurisdictional annex process • “Strengths, Weaknesses, Opportunities and Obstacles” session to confirm mitigation catalog • Plan maintenance strategy alternatives, BATool demonstration • DR-4301,4305 and 4308 discussion	12

Date	Event	Description	Attendance
5/11	Steering Committee Meeting #7	• Risk assessment update, dam failure results • Critical facility results • Hazard mitigation survey status, next steps • DR-4301, 4305, and 4308 grant opportunities • National policy briefing	15
6/7	Jurisdictional Annex Workshops	A morning and afternoon session was held at Central Contra Costa Sanitary District facilities to go over Phase 3 of jurisdictional annex process.	19
6/8	Steering Committee Meeting #8	• Identify countywide initiatives • Hazard mitigation survey results • California Environmental Quality Act discussion for public comment period • Review 75% draft of Volume 1 • Timeline for public comment period	12
6/14	Jurisdictional Annex Workshops	A morning and afternoon session was held at the City of Concord facilities to go over Phase 3 of jurisdictional annex process.	27
8/10	Steering Committee Meeting #9	• Reasons for delay in public comment period • Revisit plan maintenance strategy • Internal review of final plan protocol • Identify dates for public meetings • Plan submittal timeline	24
8/30	Public Outreach	Press release announcing the timeframe for the public comment period	N/A
9/1	Public Outreach	Initiate public comment period	N/A
9/11	Public Meeting #1	Public Meeting #1 at Central Contra Costa Sanitary District	4
9/12	Public Meeting #2	Public Meeting # 2 at San Ramon City Council Meeting	32
9/15	Public Outreach	Public comment period is closed	N/A
9/22	Plan submittal	Pre-adoption review draft of the plan submitted to Cal OES.	N/A
TBD	APA	Approval Pending Adoption (APA) provided by FEMA	N/A
TBD	Adoption	Adoption Window opens for planning partnership	N/A
TBD	Approval	Final Plan approval issued by FEMA region IX	N/A

4. CONTRA COSTA COUNTY PROFILE

4.1 GEOGRAPHIC OVERVIEW

Contra Costa County is located in the east bay area of central California (see Figure 4-1). Although the county is just east of the major metropolitan populations of San Francisco and Oakland, about 50 percent of its land is designated as non-urban. The County seat is the City of Martinez, in the northwest part of the county.

Contra Costa County is the ninth most populous county in the state. The major population centers include Antioch, Concord and Richmond. The western and northern coastlines are highly urbanized, while the interior regions are primarily residential areas with commercial development and light industry. Educational services, health care and social assistance services are important base industries; the county is home to several educational institutions and health care facilities.

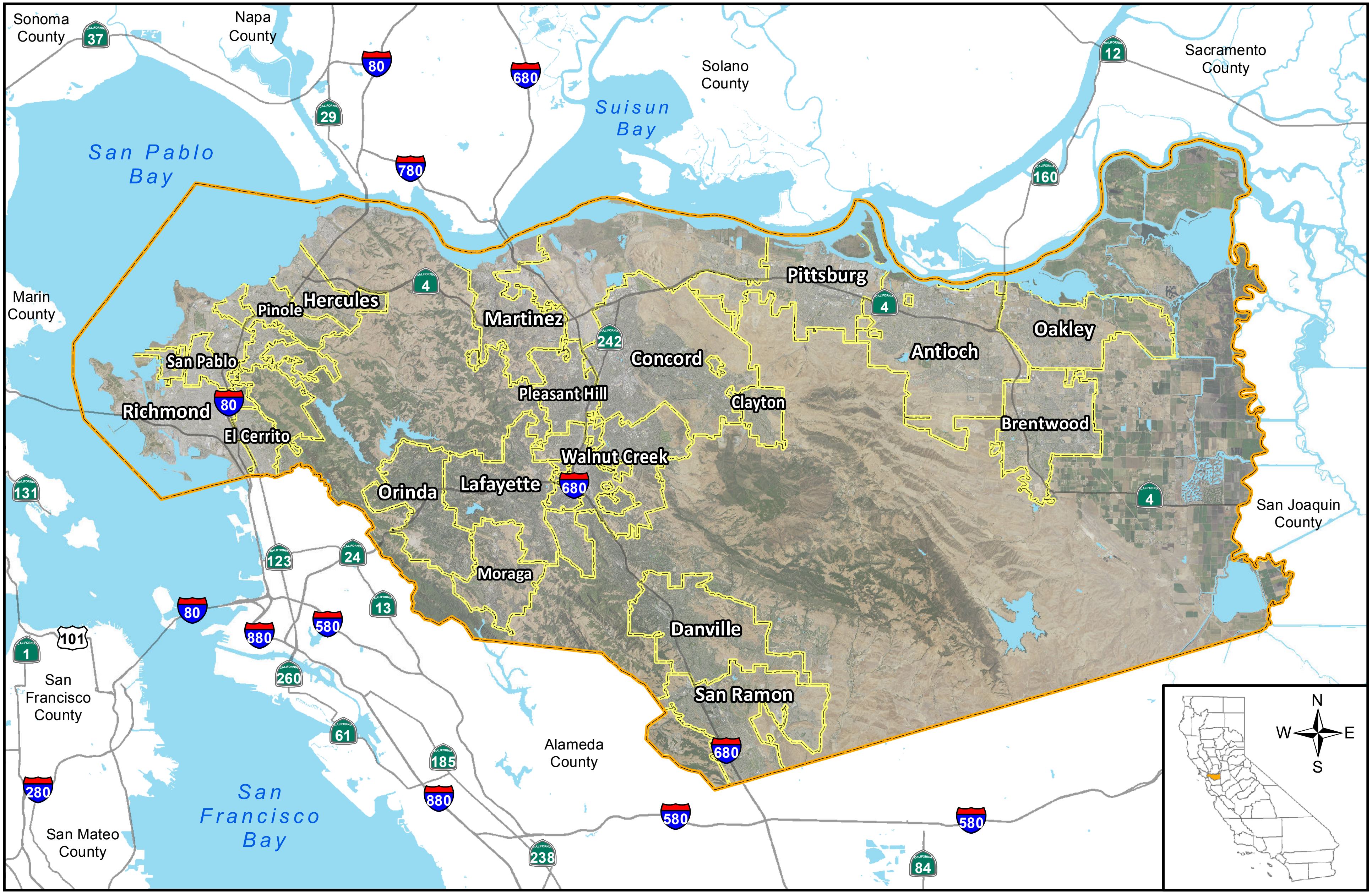
Although there is considerable development in Contra Costa County, much of the land is rural, providing access to natural resource attractions. Many areas offer recreation opportunities. The county is bounded to the north and west by water features, such as the bays of San Francisco, San Pablo and Suisun, and to the east by the San Joaquin River. Bayside alluvial plains, wildlife refuges, dunes, regional park districts and the trails of the Diablo range attract tourists and residents.

Contra Costa County is bounded on the north by Solano and Sacramento Counties (San Pablo Bay and Suisun Bay), on the east by San Joaquin County, on the south by Alameda County, and to the west by the San Francisco Bay and the counties of Marin and San Francisco. The county covers 804 square miles, of which about 10 percent is water.

The western part of Contra Costa County includes the cities of El Cerrito, Hercules, Pinole, Richmond, and San Pablo and is home to the Richmond Inner Harbor at San Francisco Bay. Communities in the central area include Clayton, Concord, Danville, Lafayette, Martinez, Moraga, Orinda, Pleasant Hill, San Ramon and Walnut Creek. Numerous special-purpose districts operate in the county as well, as shown on Figure 4-2 through Figure 4-5.

Central Contra Costa County also hosts the Port Chicago National Memorial and the Concord Naval Weapons Station, along with California State University-East Bay, Mount Diablo State Park, the John Muir National Historic Site and the Eugene O'Neill National Historic Site. Eastern incorporated communities of the County include Antioch, Brentwood, Pittsburg and Oakley. Several reservoirs, the Antioch Dunes National Wildlife Refuge and the San Joaquin River system also occupy the eastern areas of Contra Costa County.

Contra Costa County features abundant open space. The county's physical geography is punctuated by the bayside alluvial plain, the Oakland-Berkeley Hills and the Diablo Range of hills. The San Joaquin-Sacramento River Delta area provides boating, fishing and other water recreation activities. At 3,849 feet, Mount Diablo is an isolated upthrust peak within the Diablo Range that offers trails, picnic areas and other recreational opportunities for area residents and visitors. The East Bay Regional Park District is one of the largest regional park districts in the United States, with over 96,000 acres in 65 area parks.



Contra Costa County

Figure 4-1. Planning Area

Contra Costa County Boundary
City Boundaries
Water Bodies & Channels

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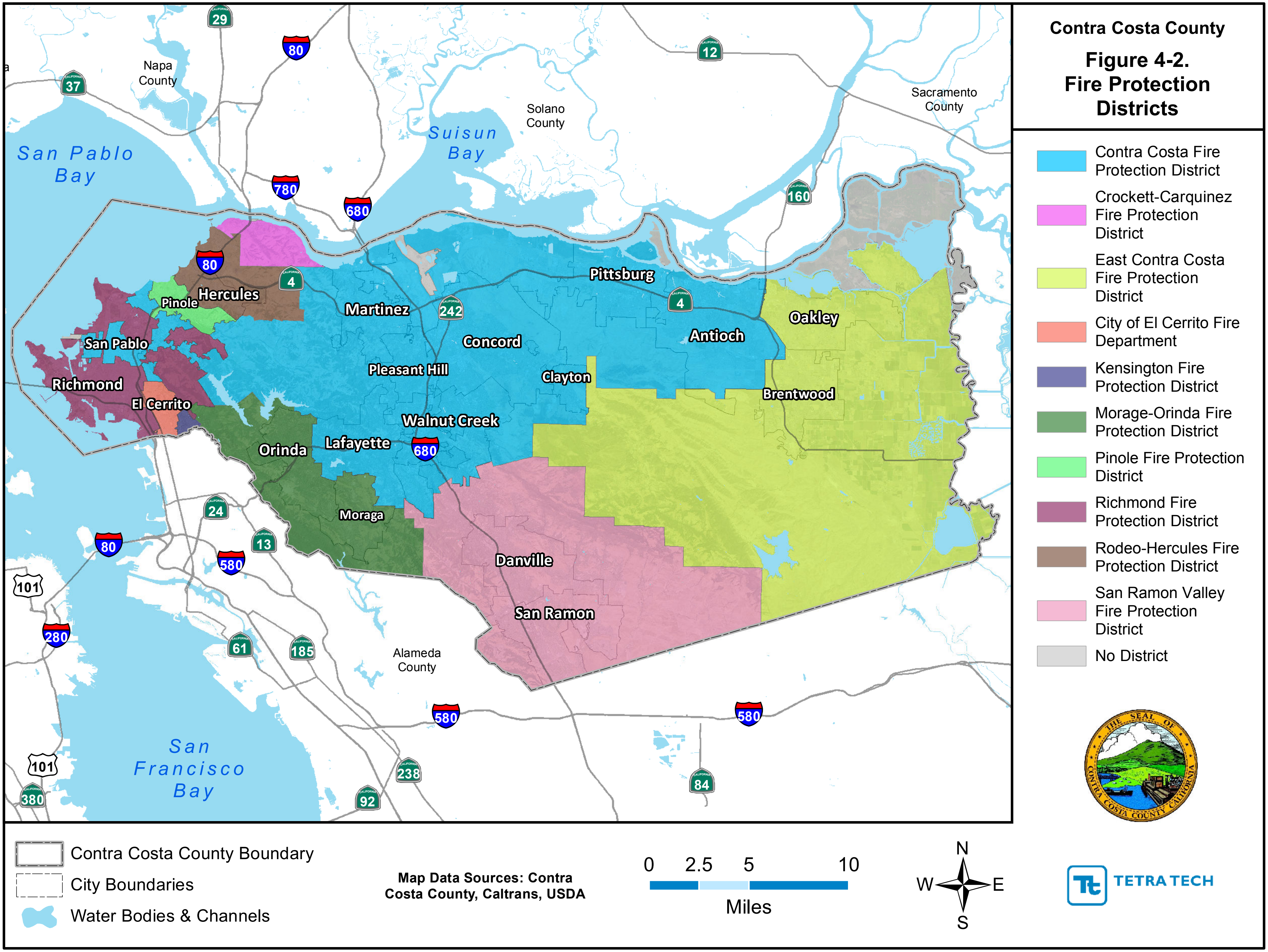
Miles

Map Data Sources: Contra Costa County, CalTrans, USDA

TETRA TECH


Contra Costa County
Figure 4-2.
Fire Protection Districts
Contra Costa Fire Protection District
Crockett-Carquinez Fire Protection District
East Contra Costa Fire Protection District
City of El Cerrito Fire Department
Kensington Fire Protection District
Morage-Orinda Fire Protection District
Pinole Fire Protection District
Richmond Fire Protection District
Rodeo-Hercules Fire Protection District
San Ramon Valley Fire Protection District
No District
San Pablo Bay
Suisun Bay
San Francisco Bay
Napa County
Solano County
Sacramento County
Alameda County
Pittsburg
Martinez
Concord
Antioch
Oakley
Brentwood
Clayton
Pleasant Hill
Walnut Creek
Lafayette
Orinda
Moraga
Danville
San Ramon
Hercules
Pinole
San Pablo
Richmond
El Cerrito
29
80
12
37
780
680
160
4
242
24
13
580
101
280
61
185
238
84
92
380
Contra Costa County Boundary
City Boundaries
Water Bodies & Channels
Map Data Sources: Contra Costa County, Caltrans, USDA
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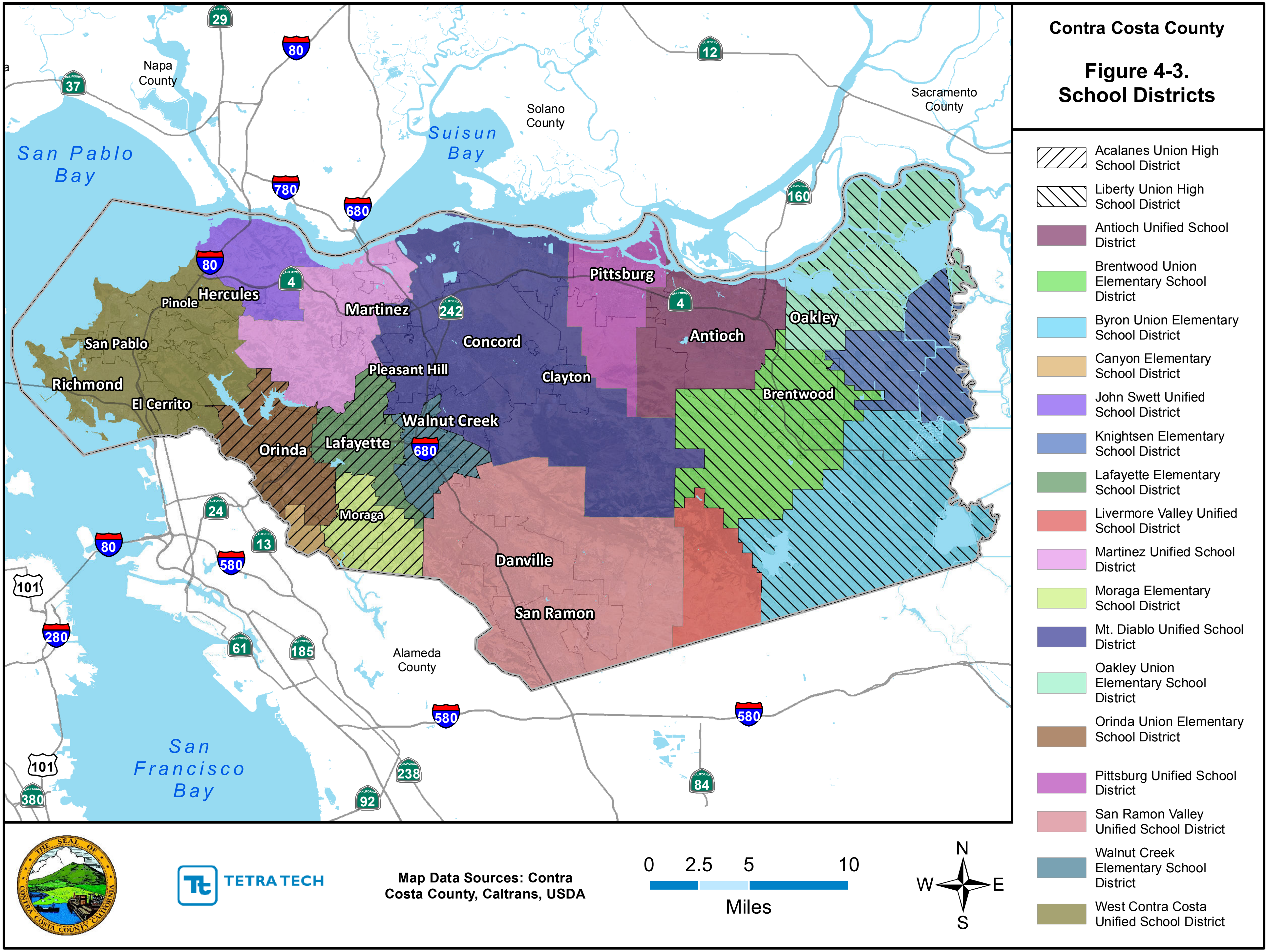
Contra Costa County

Figure 4-3. School Districts

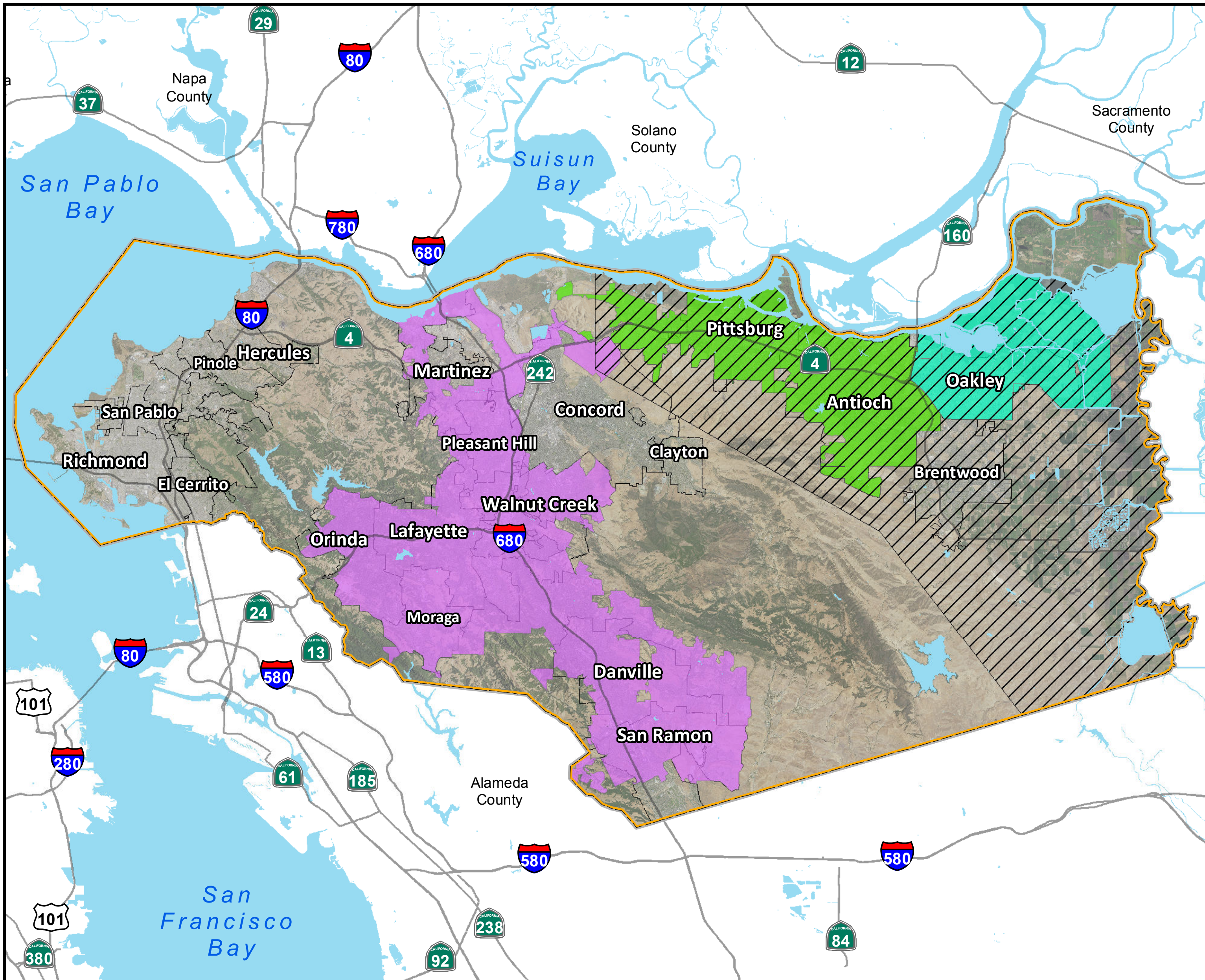


TETRA TECH

Map Data Sources: Contra Costa County, Caltrans, USDA

Contra Costa County

Figure 4-4. Education, Sanitation & Transit Districts



Contra Costa County Office of Education

TriDelta Transit Service Area

Central Contra Costa Sanitary District

Delta Diablo Sanitation District

Ironhouse Sanitary District

Contra Costa County Boundary

City Boundaries

Water Bodies & Channels

Map Data Sources: Contra Costa County, Caltrans, USDA

0 2.5 5 10

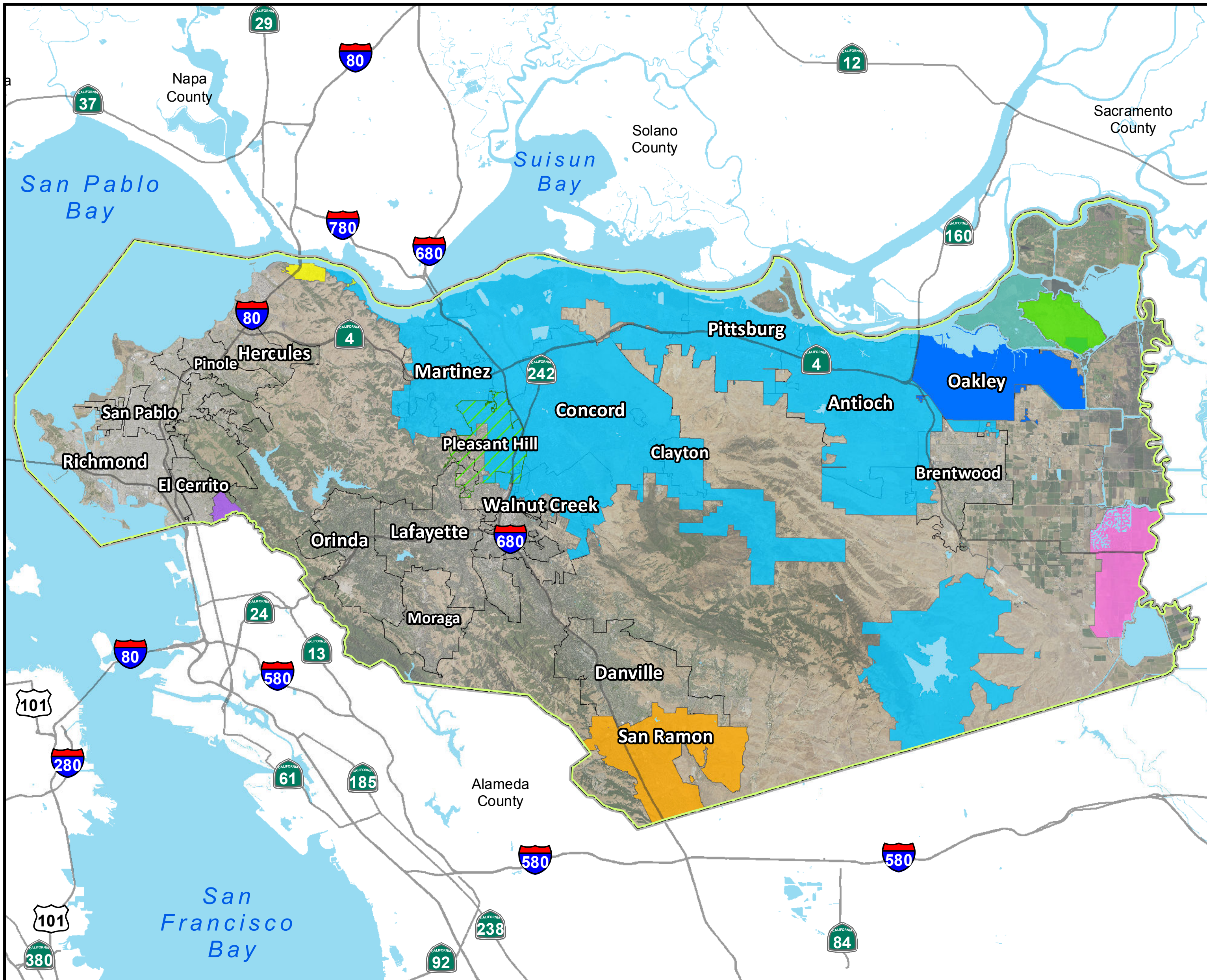
Miles

N W E S

TETRA TECH

Contra Costa County

Figure 4-5. Special Districts



Contra Costa County Flood Control & Conservation District

Bethel Island Municipal Improvement District

Pleasant Hill Parks & Recreation District

San Ramon Geologic Hazards Abatement District

Community Services Districts

Crockett Community Services District

Kensington Community Services District

Water Districts

Diablo Water District

Contra Costa Water District

Reclamation Districts

No. 800 (Byron Tract)

No. 830 (Jersey Island)

Contra Costa County Boundary

City Boundaries

Water Bodies & Channels

Map Data Sources: Contra Costa County, Caltrans, USDA

0 2.5 5 10

Miles

N W E S

TETRA TECH

4.2 HISTORICAL OVERVIEW

In the past, a number of Native American tribes populated the region now recognized as Contra Costa County. Although the indigenous people's recorded history is limited, the known settled populations were hunter-gatherer societies that fashioned embellished utilitarian crafts for everyday use, particularly woven reed baskets. Tribes traded local materials like obsidian for arrowheads across the region. These tribes did not incorporate warfare into their culture, generally cooperating with one another. Since early settlers did not record much about the culture of the natives, most of what is known comes from artifacts and from inter-generational knowledge passed down by outlying northern tribes of the larger region.

Spaniards and Portuguese first visited the region in the eighteenth century and settled there in the early nineteenth century. The immigrants settled in areas inhabited by natives whom they called Costanoans, or Coast People. The typical Portuguese immigrants were from the Azores and often began life in Contra Costa as simple farm laborers. Many of the new arrivals were illiterate, but through hard labor the immigrants were able to lease and eventually purchase farms with crop earnings. These immigrants eventually became important in the northern California dairy industry. Spanish colonization and influence throughout this region was heavy, with the King of Spain awarding extensive land grants to his army of veterans and favored settlers. Spanish missions and military establishments were also developed throughout the region, though no missions were established in what is now Contra Costa County.

As Mexico gained independence from Spain in 1821, the reorganization of held lands soon followed. The Mexican War of Independence resulted in secularization of the area missions with the reallocation of their boundaries and established a new system of land grants under the Mexican Federal Law of 1824. Eighteen substantial land grants, known as Ranchos, were made in what would become Contra Costa County. Ranchos retained their given Hispanic names and were occupied by thousands of heads of cattle managed by Hispanic families. Mission lands were extended throughout the Bay Area and included portions of Contra Costa County.

Exclusive Hispanic land ownership ended with the discovery of gold in the foothills of the Sierra Nevada in 1848. People of various ethnicities came to mine the gold, though most were unsuccessful. Many stayed in the East Bay area and founded new cities and towns bearing their European names. Hispanic land-grantee names, such as Pacheco, Martinez and Moraga, are also reflected in community names and in business parks, streets and subdivisions.

One of the original counties of California, Contra Costa County was created in 1850 at the time of statehood. The East Bay area was originally referred to as Contra Costa, meaning the "opposite coast." The county was initially to be named Mt. Diablo County, after the prominent peak in the central region of the county, but the name was changed prior to incorporation. A few southern sections of the county's original territory, including all of the bayside portions opposite San Francisco and northern portions of Santa Clara County, were given up to form Alameda County in March 25, 1853.

Contra Costa County was historically divided into three regions. Agriculture dominated the south, where plentiful farms provided food for the larger northern and western cities. The urban central area became home to the University of California. Shipping and international industry occupied the northern economy, where oil refining is still a stronghold. The northern area of the county was also home to Port Chicago, a naval weapons depot and munitions ship loading facility. During World War II, Port Chicago was the site of a deadly explosion that occurred as munitions were being loaded onto ship. The site is now a national memorial dedicated to the hundreds of sailors and civilians who lost their lives in the explosion.

The post-war era brought the expansion of suburban living in Contra Costa County. Large rural cattle ranches and farms were converted to inexpensive quarter-acre lots with tract housing. Suburbia continued to proliferate as a result of the decaying of larger urban areas in San Francisco and Alameda County.

4.3 MAJOR PAST HAZARD EVENTS

Presidential disaster declarations are typically issued for hazard events that cause more damage than state and local governments can handle without assistance from the federal government, although no specific dollar loss threshold has been established for these declarations. A presidential disaster declaration puts federal recovery programs into motion to help disaster victims, businesses and public entities. Some of the programs are matched by state programs. The planning area has experienced 14 events since the first was issued in 1969 for Contra Costa County. These events are listed in Table 4-1.

Table 4-1. Presidential Disaster Declarations

Type of Event	FEMA Disaster # [a]	Declaration Date
Severe Winter Storms, Flooding, Mudslides	DR-4308	4/1/2017
Severe Winter Storms, Flooding, and Mudslides	DR-4305	3/16/2017
Severe Storms, Flooding, and Mudslides	DR-4301	2/14/2017
Severe Storms, Flooding, Mudslides, and Landslides	DR-1628	2/3/2006
Severe Winter Storms and Flooding	DR-1203	2/9/1998
Severe Storms, Flooding, Mud and Landslides	DR-1155	1/4/1997
Severe Winter Storms, Flooding Landslides, Mud Flow	DR-1046	3/12/1995
Severe Winter Storms, Flooding, Landslides, Mud Flows	DR-1044	1/10/1995
Severe Winter Storm, Mud and Land Slides, and Flooding	DR-979	2/3/1993
Loma Prieta Earthquake	DR-845	10/18/1989
Severe Storms and Flooding	DR-758	2/21/1986
Coastal Storms, Floods, Slides, and Tornadoes	DR-677	2/9/1983
Severe Storms, Flood, Mudslides, and High Tide	DR-651	1/7/1982
Torrential Rain, High Tide, and Winds	EM- 3078	2/01/1980
Drought	EM-3023	1/20/1977
Severe Storms and Flooding	DR-253	1/26/1969

a. EM = Emergency Declaration; DR = Disaster Declaration

Source: FEMA, 2017

Review of these events helps identify targets for risk reduction and ways to increase a community's capability to avoid large-scale events in the future. Still, many natural hazard events do not trigger federal disaster declaration protocol but have significant impacts on their communities. These events are also important to consider in establishing recurrence intervals for hazards of concern.

4.4 PHYSICAL SETTING

4.4.1 Geology

The bay region of California is characterized by a series of northwest trending mountains and valleys formed by tectonic plate movement. The region has a complex geologic history of folding, faulting, uplift, sedimentation, volcanism and erosion.

The primary bedrock in Contra Costa County includes sedimentary rocks, volcanic rock intrusions and alluvial deposits. Regional basement rocks consist of the highly deformed Great Valley Sequence, which include massive beds of marine sandstone intermixed with siltstone and shale, and marine sandstone and shale overlain by soft non-marine units**.** Unconsolidated alluvial deposits, artificial fill and estuarine deposits underlie the marginal areas along the San Pablo Bay, Carquinez Straight and Suisun Bay. Landslides in the region typically occur in weak, easily weathered bedrock on relatively steep slopes. Bedrock geology for the area is not entirely mapped. Lack of detailed mapping in most cases precludes determining specific site stability without a site investigation. However, it may be valid to conclude varying degrees of relative risk based on general mapping of rock units when averaged over time.

Two distinct depositional environments exist in Contra Costa County. Since much of the county is mountainous with steep, rugged topography, a sequence of alluvial fan and fan-delta deposits have developed in most of the western part of the county. The second environment is a combination of eolian dune and river delta deposits in the San Joaquin Valley in eastern Contra Costa County.

4.4.2 Soils

Contra Costa County is in California's Central Coast Range, with northwest trending mountain ranges and valleys. Alluvium, terrace deposits and bay mud, primarily composed of sand, silt, clay and gravel, are prevalent in the lowlands. The intermountain valleys and foothills contain alluvial soils and terrace deposits. In the east, north and northwest parts of the county, the soils generally consist of bay muds. Mapping units and maps presented in the Natural Resources Conservation Service's soil survey for this region describe the prevailing soils and include information about parent rock materials, soil depth, erosion, and slope. Contra Costa County's soils may be classified into three general categories:

- **Lowland Soil Associations**—Six characteristic Lowland Soil associations range from nearly level to strongly sloping landscapes. They also range from somewhat excessively drained to poorly drained soils typically found in valley fill, low terraces, basins, floodplains and on alluvial fans. Lowland soils are also slowly permeable, highly expansive and corrosive, with slight erosion hazards. They make up 25 percent of the soils in Contra Costa County.
- **Tidal Flat-Delta-Marsh Lowland Associations**—Three Tidal Flat-Delta-Marsh Lowland soil associations are described as being poorly drained on level land within deltas, floodplains, saltwater marshes and tidal flats. Formed in mineral alluvium and from the remains of hydrophytic plants, these soils are clay loam, muck, silty clay and clay. Tidal Flat-Delta-Marsh Lowland soils make up 10 percent of the county's soils. Soils of these associations are highly expansive due to the clay content and are highly corrosive.
- **Upland Soil Associations**—Five Upland Soil groups make up 64 percent of Contra Costa County's soils. Upland soils are located on level terraces or steep mountain uplands and range from being moderately well drained to excessively drained. These soils range from loams to clays and form in weakly consolidated alluvial sediments, weathered sedimentary rock interbeds and some igneous rock. Upland soils are typically highly expansive and corrosive, with slow to moderate permeability.

Soils have varying levels of susceptibility to erosion, but each soil type benefits from conservation management techniques to prevent erosion. Soil erosion in Contra Costa County occurs as a result of intensive land use, wind and water erosion. Erosion may be most severe where urbanization, development, recreational activities, logging and agricultural practices take place. Extreme rainfall events, lack of vegetative cover, fragile soils and steep slopes combine to accelerate erosion. Wind erosion is the primary factor for soil losses in the river delta areas. Agricultural crops are subject to the erosive forces of water and hillside grazing pastures have been strained by reduced root structure due to years of drought conditions. The conversion of agricultural lands to housing and other development may cause exposed soils to become susceptible to erosion. With proper drainage and landscaping techniques, these altered soils may return to pre-construction stability.

4.4.3 Hydrology

The hydrology of Contra Costa County is dominated by its proximity to San Francisco Bay and the San Joaquin-Sacramento River Delta. San Francisco Bay directly or indirectly receives runoff from approximately 40 percent of California, including all of Contra Costa County. Surface waters in the western, urbanized portion of the county discharge into San Pablo Bay or San Francisco Bay. The south-central portion of the County is within the Alameda Creek watershed, and drains south into Alameda County, where runoff discharges into San Francisco Bay at Fremont. The Sacramento and San Joaquin Rivers, which flow along the northern county boundary, provide a substantial portion of freshwater inflow to the bay through the San Joaquin-Sacramento Delta. Surface waters from the northern and eastern portion of the County drain into Suisun Bay and the delta river channels. More than 90 percent of the annual runoff through the delta occurs during the winter and spring, when creeks and rivers swell and are prone to flooding.

4.4.4 Climate

Contra Costa County is an area of relatively mild temperatures and moderate precipitation. The county's climate is strongly influenced by its location and topography; the San Joaquin Valley to the east has hot, dry summers and cool winters, while western Contra Costa adjacent to San Francisco Bay and San Pablo Bay has cool summers and mild winters. In summer, a steady marine wind blows through the Golden Gate and up the Carquinez Strait.

Average temperatures near San Pablo Bay vary only about 15ºF from summer to winter, although a greater temperature range is found over inland areas. Coastal temperatures near Richmond average 58ºF and range from a minimum temperature of 43ºF during winter to the low 70s in summer. Annual average temperatures near Antioch are about 60ºF, with average summer temperatures in the low 70s, although the mean daily maximum temperature in July reaches near 90ºF. Higher inland elevations near Mount Diablo average 58ºF. Temperatures typically range from 39ºF in January to 85ºF in July. Table 4-2 presents temperature summaries for the Antioch and Richmond weather stations.

Table 4-2. Temperature Summaries for Planning Area

	Antioch Pump Plant 3 Station	Richmond Station
Period of record	1955 - 2012	1950 – 2012
Winter[a] Average Minimum Temperature	38.5°F	43.8°F
Winter[a] Average Maximum Temperature	56.4°F	59.0°F
Winter[a] Mean Temperature	47.5°F	51.4°F
Spring[a] Average Minimum Temperature	47.1°F	49.1°F
Spring[a] Average Maximum Temperature	71.9°F	66.4°F
Spring[a] Mean Temperature	59.5°F	57.7°F
Summer[a] Average Minimum Temperature	56.9°F	55.3°F
Summer[a] Average Maximum Temperature	89.1°F	70.8°F
Summer[a] Mean Temperature	73.0°F	63.0°F
Fall[a] Average Minimum Temperature	49.6°F	52.5°F
Fall[a] Average Maximum Temperature	76.0°F	70.3°F
Fall[a] Mean Temperature	62.8°F	61.4°F
Maximum Temperature	117°F, June 17, 1961	107°F, September 14, 1971
Minimum Temperature	18, °F December 11, 1972	24°F, December 9, 1972
Average Annual # Days >90°F	61.3	4.3
Average Annual # Days <32°F	19.7	1.4

a. Winter: December, January, and February; Spring: March, April, and May; Summer: June, July, and August; Fall: September, October, and November.

Source: Western Regional Climate Center, 2017

Rainfall is experienced during each month of the year in Contra Costa County, with the majority of precipitation occurring during the winter. Most of this is associated with storm fronts that move in from the Pacific Ocean. A few thunder showers develop in the mountains during the summer, but they are infrequent. Annual precipitation near Richmond exceeds 23 inches, while Antioch experiences drier conditions, with rainfall totals around 13 inches. Mount Diablo's slopes and foothills experience about 24 inches of precipitation, most of it in the form of winter snowfall. Average precipitation is generally lower in the eastern portion of the county and higher in the west. Table 4-3 presents precipitation summaries for the Antioch and Richmond weather stations.

Table 4-3. Precipitation Summaries for Planning Area

	Antioch Pump Plant 3 Station	Richmond Station
Period of record	1955 - 2012	1950 – 2012
Winter[a] Mean Precipitation	7.42 inches	12.96 inches
Spring[a] Mean Precipitation	3.26 inches	5.50 inches
Summer[a] Mean Precipitation	0.15 inches	0.31 inches
Fall[a] Mean Precipitation	2.39 inches	4.37 inches
One Date Maximum Precipitation	3.03 inches, October 13, 1962	6.83 inches, January 4, 1982
Annual Precipitation	13.22 inches	23.14 inches

a. Winter: December, January, and February; Spring: March, April, and May; Summer: June, July, and August; Fall: September, October, and November.

Source: Western Regional Climate Center, 2017a

The average relative humidity near the coastal communities is higher due to the moist air influence of the Pacific Ocean and San Pablo Bay. The adjoining coastal area has a moderate, stable temperature regime. With increasing distance from the ocean, the marine influence is less pronounced, so inland areas experience wider variations of temperature and lower humidity.

The heat produced by inland temperatures, combined with the cool waters of the Bay and Pacific Ocean and the winds coming in from the water, provide suitable conditions for East Bay area fog. Fog tends to creep into lowlands at night to cool down hot summer temperatures. Farther east from the coast, less fog is present. Inland areas like Walnut Creek receive very little cool down from what some Bay Area weathermen call the "fair weather maker" of fog.

4.5 DEVELOPMENT PROFILE

4.5.1 Land Use

According to U.S. Census data, the County has a total area of 804 square miles, of which 81 square miles is water. In 1990, a 65/35 Land Preservation Standard was designated that required at least 65 percent of all land in the County shall be preserved for agriculture, open space, wetlands, parks and other non-urban uses. Table 4-4 shows current land use in the planning area. Land use information is analyzed in this plan for each identified hazard that has a defined spatial extent and location. For hazards that lack this spatial reference, the following information serves as a baseline estimate of land use and exposure for the planning area. The distribution of land uses within the planning area will change over time.

Table 4-4. Present Land Use in Planning Area

Present Use Classification	Area (acres)	% of total
Residential	85,356	18.9%
Commercial	25,395	5.6%
Industrial	10,659	2.4%
Agriculture	28,469	6.3%
Religion	1,219	0.3%
Government	15,555	3.5%
Education	4,711	1.0%
Vacant, Rights-of-way, Open water, Open Space	279,404	62.0%
Total	450,767	100.0%

4.5.2 Critical Facilities and Infrastructure

Critical facilities and infrastructure are assets, systems and networks, whether physical or virtual, whose incapacity or destruction would have a debilitating impact on security, economic security, public health or safety, or any combination. Risk assessment of hazards considers the potential impact of a hazard on the function of critical facilities and infrastructure. All critical facilities and infrastructure were analyzed in FEMA's Hazus model to help rank risk and identify mitigation actions. The risk assessment for each hazard discusses critical facilities with regard to that hazard.

The Hazus model used for risk assessment in this plan defines specific types of critical facilities and infrastructure as well as broader categories that include multiple types. For example, fire stations and police stations are specific types of facilities, both of which fall under the broader category of "protective function" facilities. Figure 4-6 and Figure 4-7 show the location of critical facilities and infrastructure in the planning area, with symbols showing each specific type of facility. The figure legend identifies the broader category that encompasses each type. Table 4-5 and Table 4-6 summarize the number of critical facilities and infrastructure within each broad category. Due to the sensitivity of this information, a detailed list of facilities is not provided. The list is on file with Contra Costa County OES.

The Steering Committee opted to also look at critical infrastructure sectors defined by the U.S. Department of Homeland Security (DHS). The Hazus model is not adaptable to use the DHS sectors; Table 4-7 lists the sectors and shows how they correspond to the Hazus output categories evaluated in this plan.

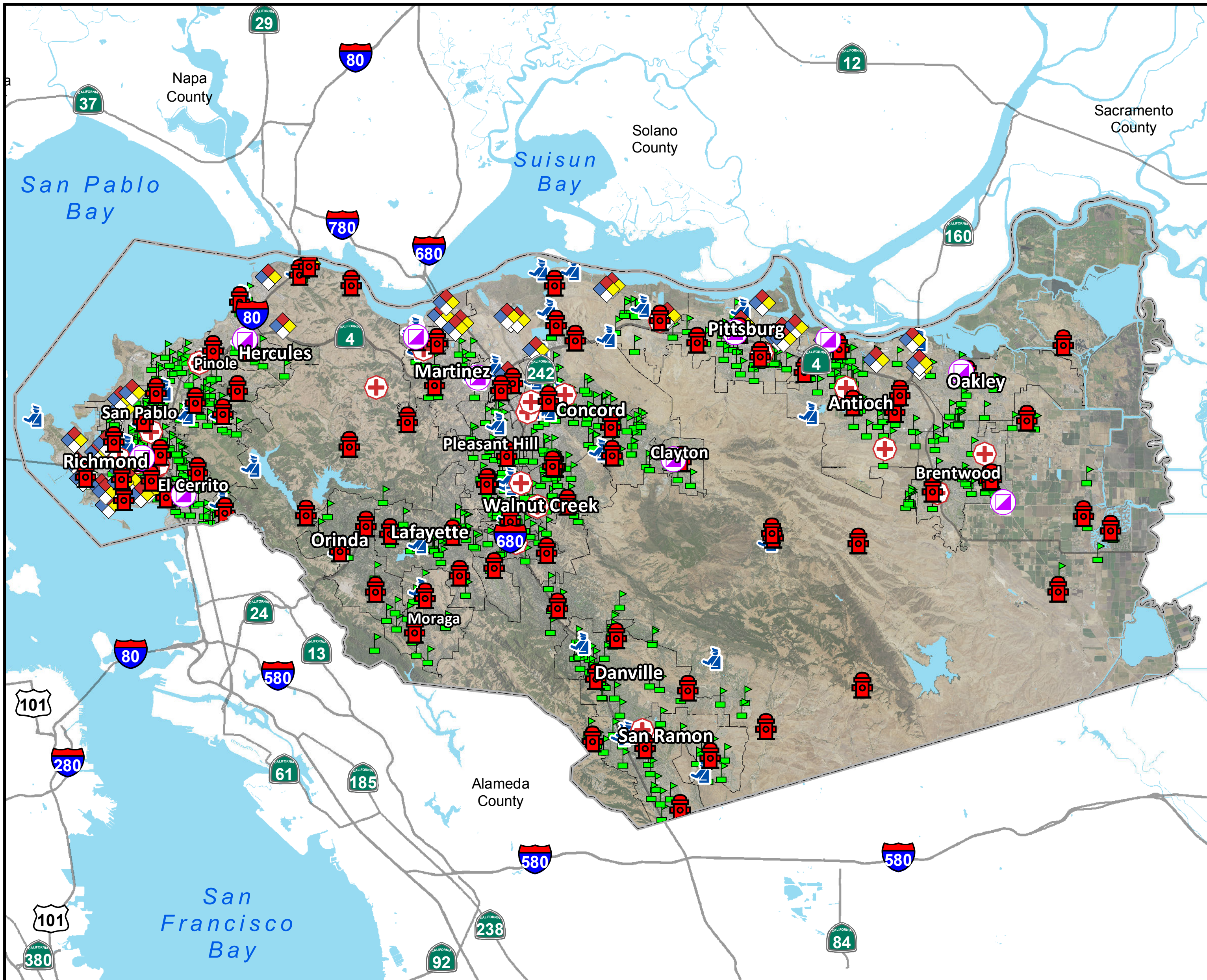
4.5.3 Future Trends in Development

The municipal planning partners have adopted general plans that govern land use decision and policy making for their jurisdictions. Decisions on land use will be governed by these plans. This hazard mitigation plan will work together with the general plans to support wise land use in the future by providing vital information on the risk associated with natural hazards in the planning area.

All municipal planning partners will incorporate this hazard mitigation plan in their general plans by reference. This will ensure that future development trends can be established with the benefits of the information on risk and vulnerability to natural hazards identified in this plan.

Contra Costa County

Figure 4-6. Critical Facilities



Emergency Operations Centers (Government)

Fire Stations (Protective Functions)

Hazardous Materials

Medical Facilities

Police Stations (Protective Functions)

Schools & Educational Facilities

Contra Costa County Boundary

City Boundaries

Water Bodies & Channels

Map Data Sources: Contra Costa County, Caltrans, Hazus 3.2, EPA, USDA

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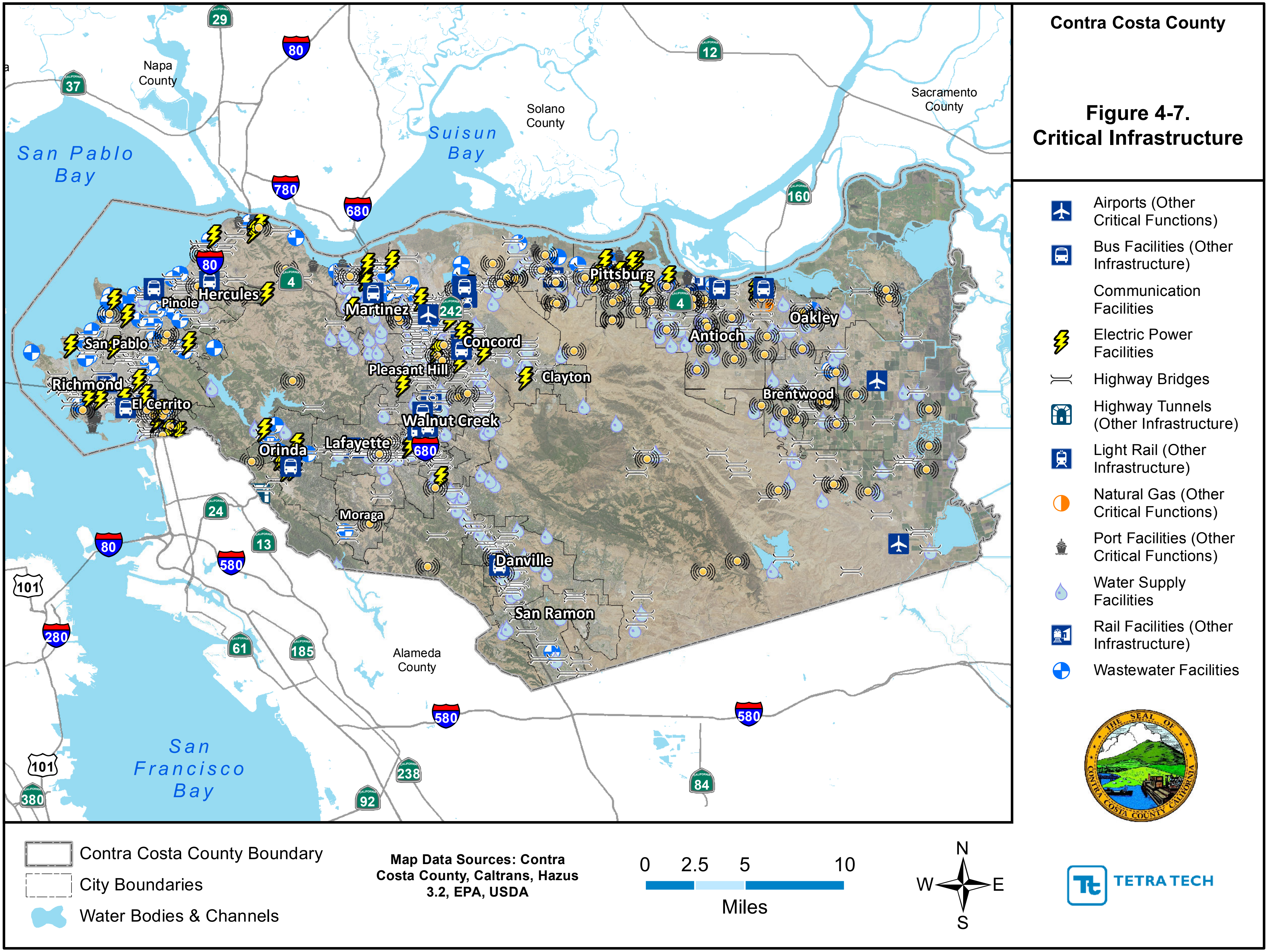


Figure 4-7. Critical Infrastructure

Table 4-5. Planning Area Critical Facilities

	Number of Facilities					
	Medical and Health	Government Functions	Protective Functions	Schools and Educational Facilities	Hazmat	Total
Antioch	3	1	6	40	2	52
Brentwood	3	1	4	32	0	40
Clayton	0	1	1	4	0	6
Concord	4	0	15	59	1	79
Danville	0	0	3	24	0	27
El Cerrito	0	1	3	15	0	19
Hercules	0	1	2	6	0	9
Lafayette	0	0	4	19	0	23
Martinez	1	2	13	15	2	33
Moraga	0	0	3	9	0	12
Oakley	0	1	3	15	2	21
Orinda	0	0	4	11	0	15
Pinole	1	0	3	8	0	12
Pittsburg	1	1	4	32	6	44
Pleasant Hill	0	0	5	18	0	23
Richmond	5	1	20	53	15	94
San Pablo	1	0	2	10	1	14
San Ramon	3	0	8	23	0	34
Walnut Creek	2	0	7	29	0	38
Unincorporated	3	0	42	71	16	132
Total	27	9	152	493	45	727

Table 4-6. Planning Area Critical Infrastructure

	Number of Facilities							
	Bridges	Water Supply	Wastewater	Power	Communications	Other Critical Functions	Other Critical Infrastructure	Total
Antioch	21	31	4	2	19	2	4	83
Brentwood	8	1	1	0	9	0	4	23
Clayton	0	1	0	0	0	0	0	1
Concord	47	16	1	8	7	0	16	95
Danville	22	3	0	0	2	0	14	41
El Cerrito	3	0	1	4	6	2	2	18
Hercules	6	1	1	1	2	0	1	12
Lafayette	22	2	0	0	2	0	5	31
Martinez	16	21	4	3	3	1	6	54
Moraga	3	0	1	0	1	0	0	5
Oakley	10	10	1	0	5	0	1	27
Orinda	8	2	8	4	2	0	3	27
Pinole	10	0	3	0	0	0	2	15
Pittsburg	13	6	2	6	15	2	2	46
Pleasant Hill	18	2	0	1	0	0	6	27
Richmond	33	1	11	7	2	5	2	61
San Pablo	8	0	0	1	0	0	0	9
San Ramon	11	0	1	0	0	0	3	15
Walnut Creek	37	14	1	2	0	0	8	62
Unincorporated	111	46	26	13	34	7	38	275
Total	407	157	66	52	109	17	117	927

Table 4-7. Comparison of Critical Facilities and Infrastructure Categories

U.S. Department of Homeland Security Sector	Hazus Category
Chemical	Hazardous Materials Facilities
Commercial Facilities	Not Available
Communications	Communication
Critical Manufacturing	Not Available
Dams	Not Available
Defense Industrial Base	Not Available
Emergency Services	Protective Function
Energy	Power
Financial Services	Not Available
Food and Agriculture	Not Available
Government Facilities	Government
Healthcare and Public Health	Medical
Information Technology	Communication
Nuclear Reactors, Materials, and Waste	Other Critical Facilities
Transportation Systems	Other Critical Infrastructure
Water and Wastewater Systems	Water Supply and Wastewater

4.6 DEMOGRAPHICS

Some populations are at greater risk from hazard events because of decreased resources or physical abilities. Elderly people, for example, may be more likely to require additional assistance. Research has shown that people living near or below the poverty line, the elderly, women, children, ethnic minorities, renters, individuals with disabilities, and others with access and functional needs, all experience more severe effects from disasters than the general population. These vulnerable populations may vary from the general population in risk perception, living conditions, access to information before, during and after a hazard event, capabilities during an event, and access to resources for post-disaster recovery. Indicators of vulnerability—such as disability, age, poverty, and minority race and ethnicity—often overlap spatially and often in the geographically most vulnerable locations. Detailed spatial analysis to locate areas where there are higher concentrations of vulnerable community members would help to extend focused public outreach and education to these most vulnerable citizens.

4.6.1 Population Characteristics

Resident Population

Knowledge of the composition of the population and how it has changed in the past and how it may change in the future is needed for making informed decisions about the future. Information about population is a critical part of planning because it directly relates to land needs such as housing, industry, stores, public facilities and services, and transportation. The California Department of Finance estimated the planning area's population at 1,123,429 as of January 1, 2016.

Population changes are useful socio-economic indicators. A growing population can indicate a growing economy, and a decreasing population may signify economic decline. Figure 4-8 shows the planning area population percentage change from 2000 to 2015 compared to that of the State of California. In that period, the state's population grew by 14.8 percent (about 0.93 percent per year) while the planning area's population increased by 17.11 percent (1.1 percent per year). Table 4-8 shows the population in the planning area from 2000 to 2016.

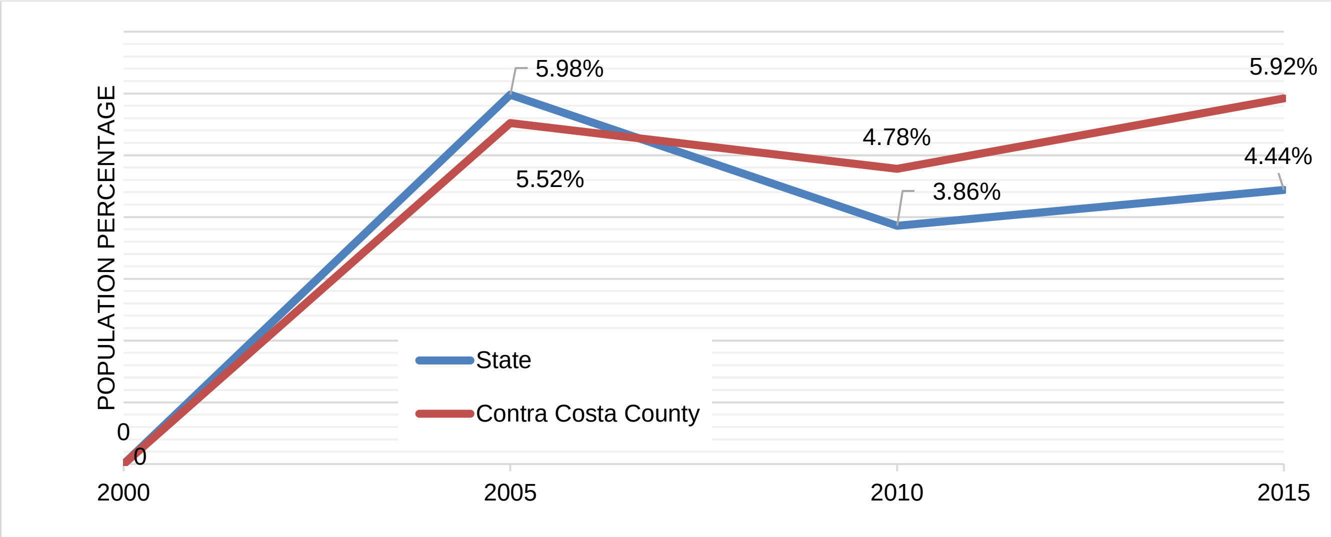


Figure 4-8. California and Contra Costa County Population Growth [2000-2015]

Table 4-8. Recent Population Data

	Population				
	2000	2005	2010	2015	2016
City of Antioch	90,532	99,713	102,372	111,973	112,968
City of Brentwood	23,302	41,343	51,481	57,072	58,784
City of Clayton	10,762	10,843	10,897	11,159	11,209
City of Concord	121,872	122,373	122,067	128,063	129,707
Town of Danville	41,715	42,113	42,039	42,491	42,865
City of El Cerrito	23,171	23,120	23,549	24,132	24,378
City of Hercules	19,488	22,832	24,060	24,578	24,791
City of Lafayette	23,908	23,857	23,893	24,732	24,924
City of Martinez	35,866	36,061	35,824	36,931	37,057
Town of Moraga	16,290	16,133	16,016	16,434	16,513
City of Oakley	25,619	28,747	35,432	39,609	40,141
City of Orinda	17,599	17,514	17,643	18,578	18,749
City of Pinole	19,039	18,837	18,390	18,660	18,739
City of Pittsburg	56,769	61,120	63,264	67,119	67,817
City of Pleasant Hill	32,837	32,982	33,152	33,918	34,077
City of Richmond	99,216	101,098	103,701	109,568	110,378
City of San Pablo	30,256	29,632	29,139	30,498	30,829
City of San Ramon	44,722	53,923	72,148	77,470	78,363
City of Walnut Creek	64,296	64,705	64,173	68,652	70,018
Balance of County	151,557	154,270	159,785	169,506	171,122
Total	948,816	1,001,216	1,049,025	1,111,143	1,123,429

Source: California Department of Finance, Demographic Research Unit, 2017

Daily Commuting Population

According to the California Employment Development Department, approximately 89,000 daily commuters in 2013 worked in Contra Costa County and lived elsewhere. The majority of commuters came from Alameda County, followed by Solano County and San Joaquin County. Some commuters travel to Contra Costa County from as far as El Dorado and Fresno Counties. Conversely, approximately 188,000 Contra Costa County residents commute daily to jobs outside the county.

This large commuter contingent has impacts on the planning area's infrastructure and service needs, as well as on planning for hazard mitigation and emergency management. Commuters may be familiar with the area immediately surrounding their place of business or regular route to work, but may be less familiar with the services and resources provided to the population during a disaster event. Figure 4-9 shows county-to-county commuting estimates for the planning area.

Source: California Employment Development Department, 2017

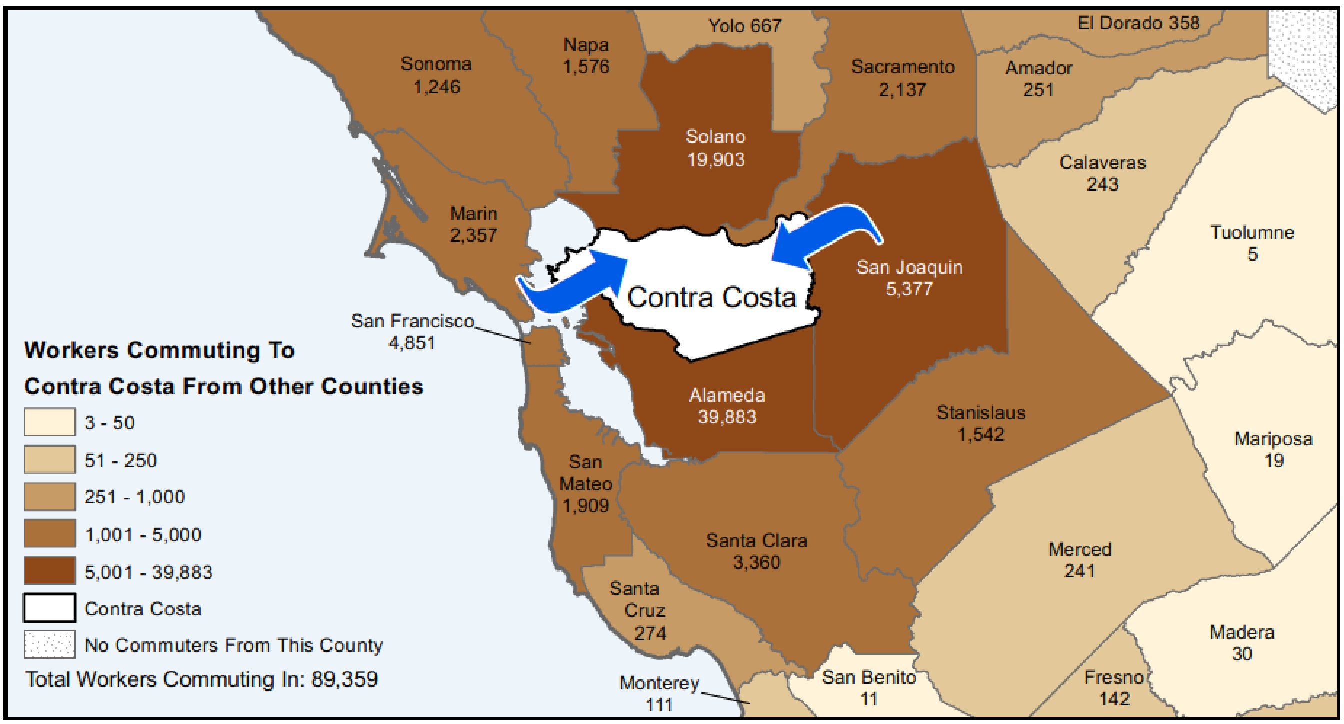


Figure 4-9. 2013 Commuting Estimates To Contra Costa County

4.6.2 Age Distribution

As a group, the elderly are more apt to lack the physical and economic resources necessary for response to hazard events and are more likely to suffer health-related consequences making recovery slower. They are more likely to be vision, hearing, and/or mobility impaired, and more likely to experience mental impairment or dementia. Additionally, the elderly are more likely to live in assisted-living facilities where emergency preparedness occurs at the discretion of facility operators. These facilities are typically identified as "critical facilities" by emergency managers because they require extra notice to implement evacuation. Elderly residents living in their own homes may have more difficulty evacuating their homes and could be stranded in dangerous situations. This population group is more likely to need special medical attention, which may not be readily available during natural disasters due to isolation caused by the event. Specific planning attention for the elderly is an important consideration given the current aging of the American population.

Children under 14 are particularly vulnerable to disaster events because of their young age and dependence on others for basic necessities. Very young children may additionally be vulnerable to injury or sickness; this vulnerability can be worsened during a natural disaster because they may not understand the measures that need to be taken to protect themselves from hazards.

The overall age distribution for the planning area is illustrated in Figure 4-10. Based on U.S. Census data, 13.8 percent of the planning area's population is 65 or older, compared to the state average of 13.3 percent. According to U.S. Census data, 33.9 percent of the over-65 population has disabilities of some kind, and 6.6 percent have incomes below the poverty line. Children under 18 account for nearly 14.0 percent of individuals who are below the poverty line. It is also estimated that 23.2 percent of the population is 18 or younger, compared to the state average of 23.3 percent.

Source: American Fact Finder, 2011-2015 American Community Survey 5-Year Estimates, 2017

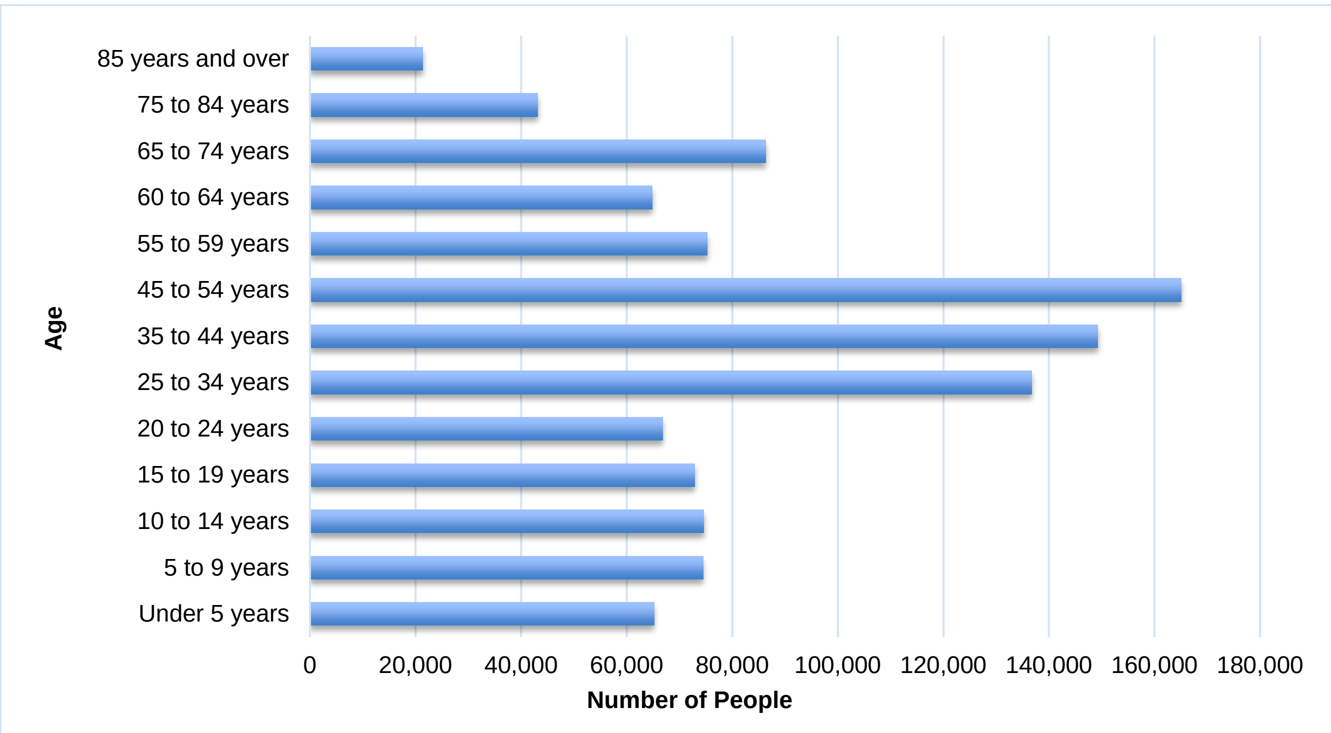


Figure 4-10. Planning Area Age Distribution

4.6.3 Race, Ethnicity and Language

Research shows that minorities are less likely to be involved in pre-disaster planning and experience higher mortality rates during a disaster event. Post-disaster recovery can be ineffective and is often characterized by cultural insensitivity. Since higher proportions of ethnic minorities live below the poverty line than the majority white population, poverty can compound vulnerability. According to the U.S. Census, the racial composition of the planning area is predominantly white, at about 60.5 percent. The largest minority populations are Asian at 15.3 percent and African American at 8.9 percent. While not considered a separate race, the planning area has 24.9 percent Hispanic or Latino population. Figure 4-11 shows the racial distribution in the planning area.

The planning area has a 23.9-percent foreign-born population. Other than English, the most commonly spoken language in the planning area is Spanish. The census estimates 14.0 percent of the residents speak English "less than very well."

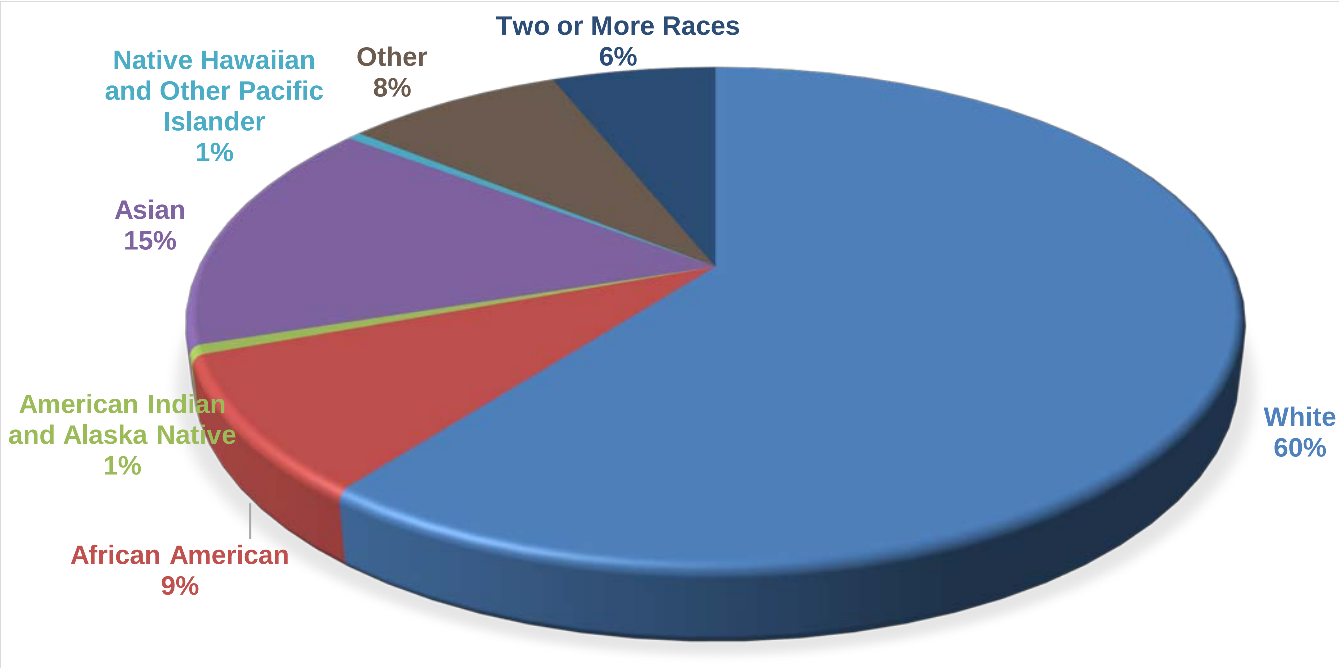


Figure 4-11. Planning Area Race Distribution

4.6.4 Individuals with Disabilities or with Access and Functional Needs

The 2010 U.S. Census estimates that 54 million non-institutionalized Americans with disabilities live in the U.S. This equates to about one-in-five persons. Individuals with disabilities are more likely to have difficulty responding to a hazard event than the general population. Local government is the first level of response to assist these individuals, and coordination of efforts to meet their access and functional needs is paramount to life safety efforts. It is important for emergency managers to distinguish between functional and medical needs in order to plan for incidents that require evacuation and sheltering. Knowing the percentage of population with a disability will allow emergency management personnel and first responders to have personnel available who can provide services needed by those with access and functional needs. According to the 2011-2015 American Community Survey, there are 7.3 percent under the age of 65 living with some form of disability within the planning area.

4.7 ECONOMY

4.7.1 Income

In the United States, individual households are expected to use private resources to prepare for, respond to and recover from disasters to some extent. This means that households living in poverty are automatically disadvantaged when confronting hazards. Additionally, the poor typically occupy more poorly built and inadequately maintained housing. Mobile or modular homes, for example, are more susceptible to damage in earthquakes and floods than other types of housing. In urban areas, the poor often live in older houses and apartment complexes, which are more likely to be made of un-reinforced masonry, a building type that is particularly susceptible to damage during earthquakes. Furthermore, residents below the poverty level are less likely to have insurance to compensate for losses incurred from natural disasters. This means that residents below the poverty level have a great deal to lose during an event and are the least prepared to deal with potential losses. The events following Hurricane Katrina in 2005 illustrated that personal household economics significantly impact people’s decisions on evacuation. Individuals who cannot afford gas for their cars will likely decide not to evacuate.

Based on U.S. Census Bureau estimates, per capita income in the planning area in 2015 was $39,313, and the median household income was $80,185. It is estimated that about 18.3 percent of households receive an income between $100,000 and $149,999 per year and over 22.3 percent of household incomes are above $150,000 annually. About 14.8 percent of the households in the planning area make less than $25,000 per year and are therefore below the poverty level. The weighted average poverty threshold for a family of four in 2015 was $24,257; for a family of three, $18,871; for a family of two, $15,391; and for unrelated individuals, $12,082.

4.7.2 Industry, Businesses and Institutions

The planning area's economy is strongly based in the educational services, health care and social assistance industry (21.9 percent), followed by professional, scientific, management, administrative and waste management services; finance, insurance, real estate, rental and leasing; and art, entertainment, recreation, accommodation and food services. Agriculture, wholesale trade, and information make up the smallest source of the local economy. Figure 4-12 shows the breakdown of industry types in the planning area.

The planning area benefits from a variety of business activity. Major businesses include Kaiser Permanente, John Muir Medical Center, San Ramon Regional Medical Center, Chevron Oil, Sutter Delta Medical Center, Contra Costa Regional Medical Center, and Shell Oil Products.

Major educational and research institutions in the planning area include Contra Costa Community College, Diablo Valley College, St. Mary's College of California, and Los Medanos College.

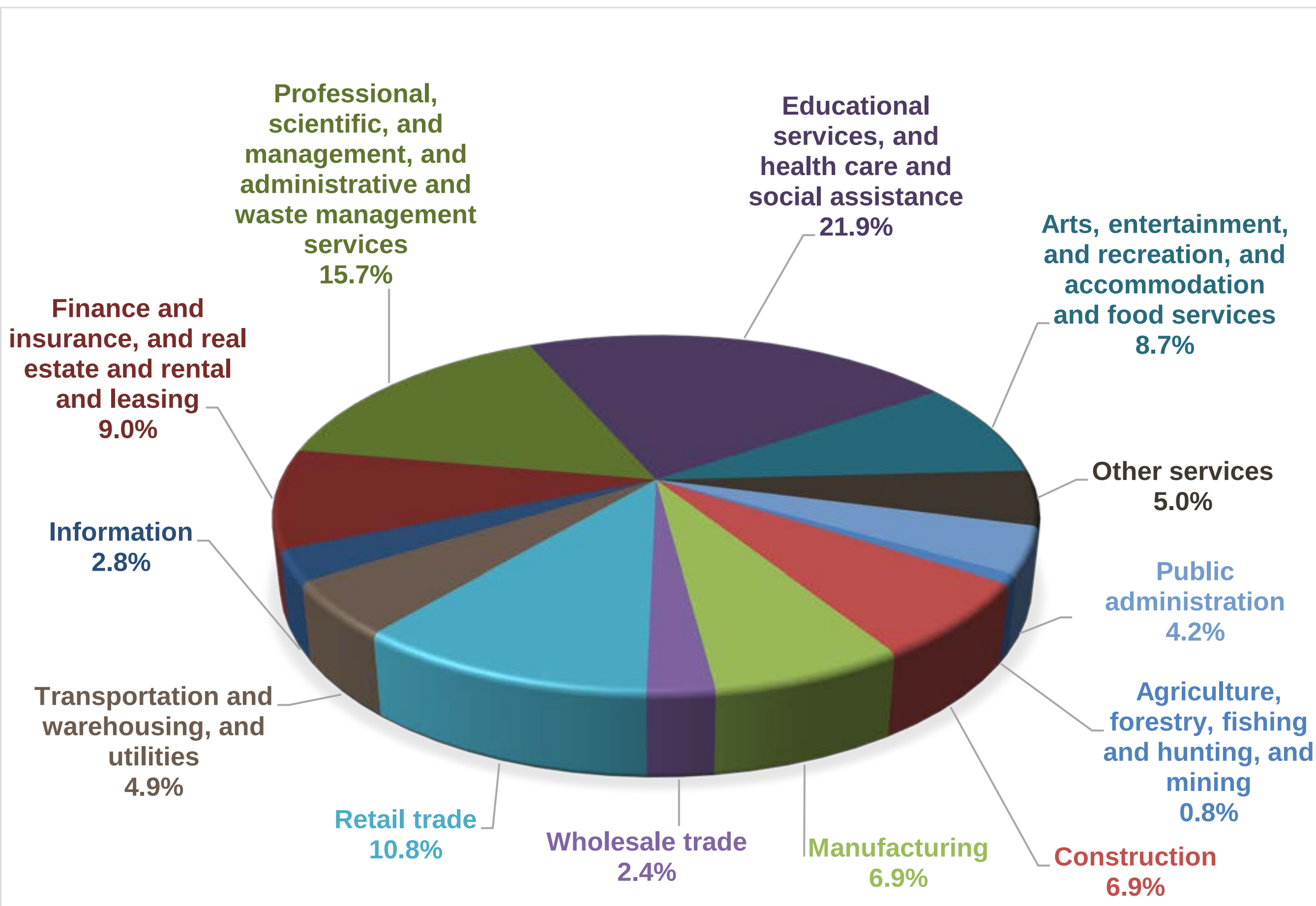


Figure 4-12. Industry in the Planning Area

4.7.3 Employment Trends and Occupations

According to the American Community Survey, about 64.6 percent of the planning area's population is in the labor force. Of the working-age population group (ages 16 and over), 41.7 percent of men and 58.3 percent of women are in the labor force.

Figure 4-13 compares California's and Contra Costa County's unemployment trends from 2007 to January 1, 2016 Contra Costa County's unemployment rate was lowest in 2016, at 4.4 percent. Unemployment rates were 4.7 percent in 2007, peaked in 2010 and been on a downward trend since 2010.

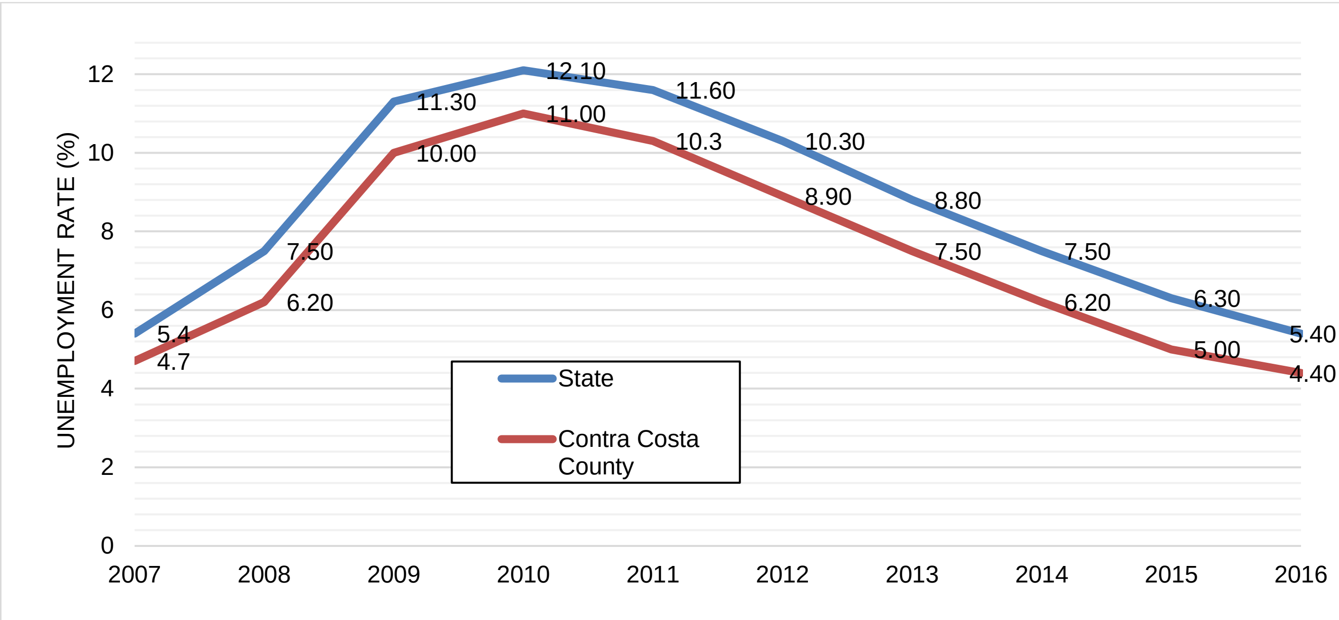


Figure 4-13. California and Contra Costa County Unemployment Rate

Management, business, science, and arts and sales and office occupations make up 66.5 percent of the jobs in the planning area. Other major occupations are sales and office (22 percent), service (17.5 percent) and natural resources, construction, and maintenance (8.2 percent). Only about 7.7 percent of the employment in the planning area is in production, transportation, and material moving (see Figure 4-14).

Available online data sources identify the following large employers in Contra Costa County (California Employment Development Department, 2017):

- Large oil refinery manufacturing companies—Chevron Corporation and Chevron Richmond Refinery
- Oil and gas producer—Shell Oil Products
- Pipeline company—Santa Fe Pacific Pipe Lines
- Personnel consultant—Job Connections
- Employment agency—Robert Half International.
- University—St. Mary's College.
- Large health-care providers—John Muir Medical Center, Kaiser Permanente Antioch Medical, Walnut Creek Medical, and Martinez Medical, Department of Veteran Affairs Clinics and Sutter Delta Medical Center.
- Grocer retail—La Raza Market.
- Automobile club—AAA Northern California, Nevada, and Utah
- Transit line—Bay Area Rapid Transit.

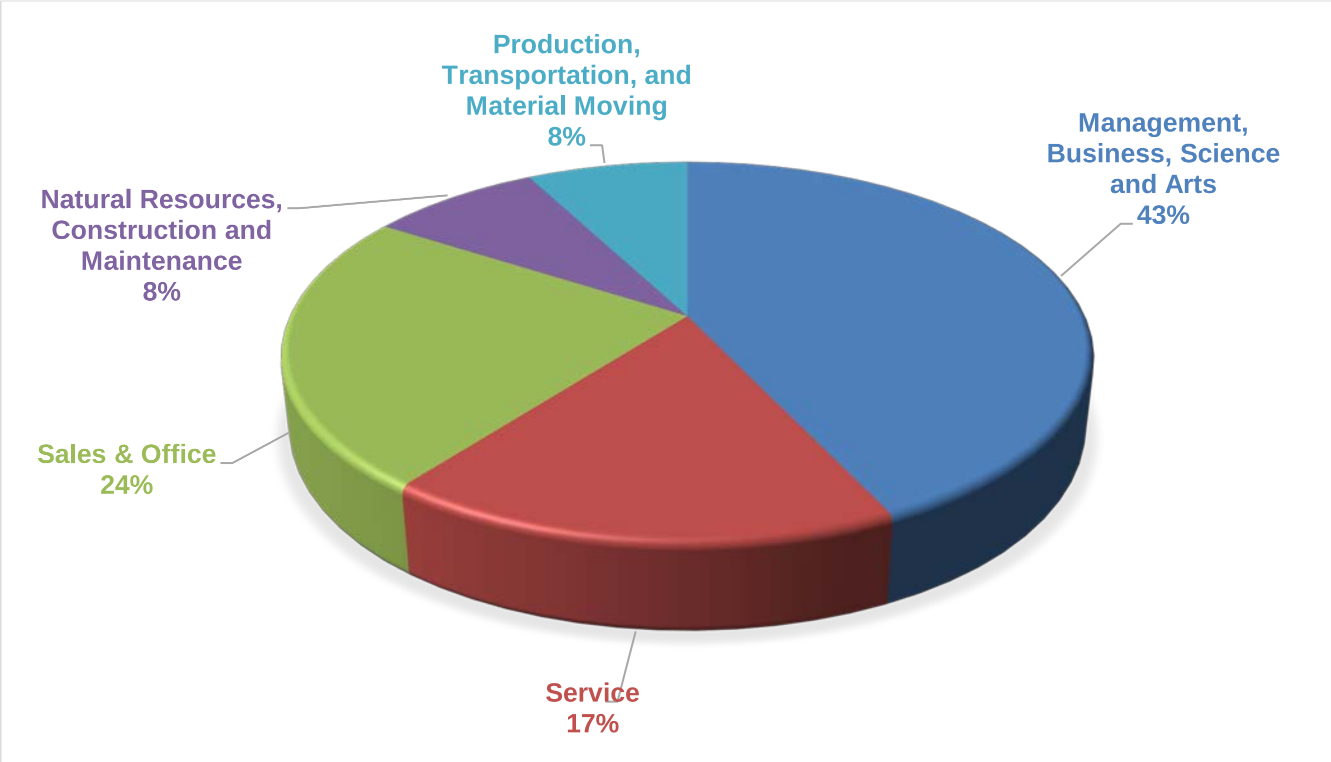


Figure 4-14. Occupations in the Planning Area

The U.S. Census estimates that over 68.9 percent of workers in the planning area commute alone (by car, truck or van) to work, and mean travel time to work is 35.3 minutes (the state average is 28 minutes).

4.8 LAWS, ORDINANCES AND PROGRAMS

Existing laws, ordinances, plans and programs at the federal, state and local level can support or impact hazard mitigation actions identified in this plan. Hazard mitigation plans are required to include a review and incorporation, if appropriate, of existing plans, studies, reports, and technical information as part of the planning process (44 CFR, Section 201.6(b)(3)). The following federal and state programs have been identified as programs that may interface with the actions identified in this plan. Each program enhances capabilities to implement mitigation actions or has a nexus with a mitigation action in this plan. Information presented in this section can be used in review local capabilities to implement the actions found in the jurisdictional annexes of Volume 2. Each planning partner has individually reviewed existing local plans, studies, reports, and technical information in its jurisdictional annex, presented in Volume 2.

4.8.1 Federal

Disaster Mitigation Act

The DMA is the current federal legislation addressing hazard mitigation planning. It emphasizes planning for disasters before they occur. It specifically addresses planning at the local level, requiring plans to be in place before Hazard Mitigation Assistance grant funds are available to communities. This plan is designed to meet the requirements of DMA, improving eligibility for future hazard mitigation funds.

National Incident Management System

The National Incident Management System (NIMS) is a systematic approach for government, nongovernmental organizations, and the private sector to work together to manage incidents involving hazards. The NIMS provides a flexible but standardized set of incident management practices. Incidents typically begin and end locally, and they are managed at the lowest possible geographical, organizational, and jurisdictional level. In some cases, success depends on the involvement of multiple jurisdictions, levels of government, functional agencies, and emergency responder disciplines. These cases necessitate coordination across a spectrum of organizations. Communities using NIMS follow a comprehensive national approach that improves the effectiveness of emergency management and response personnel across the full spectrum of potential hazards (including natural hazards, terrorist activities, and other human-caused disasters) regardless of size or complexity. Although participation is voluntary, Federal departments and agencies are required to make adoption of NIMS by local and state jurisdictions a condition to receive Federal Preparedness grants and awards.

Community Development Block Grant Disaster Resilience Program

In response to disasters, Congress may appropriate additional funding for the U.S. Department of Housing and Urban Development Community Development Block Grant programs to be distributed as Disaster Recovery grants (CDBG-DR). These grants can be used to rebuild affected areas and provide seed money to start the recovery process. CDBG-DR assistance may fund a broad range of recovery activities, helping communities and neighborhoods that otherwise might not recover due to limited resources. CDBG-DR grants often supplement disaster programs of the Federal Emergency Management Agency, the Small Business Administration, and the U.S. Army Corps of Engineers. Housing and Urban Development generally awards noncompetitive, nonrecurring CDBG-DR grants by a formula that considers disaster recovery needs unmet by other federal disaster assistance programs. To be eligible for CDBG-DR funds, projects must meet the following criteria:

- Address a disaster-related impact (direct or indirect) in a presidentially declared county for the covered disaster
- Be a CDBG-eligible activity (according to regulations and waivers)
- Meet a national objective.

Incorporating preparedness and mitigation into these actions is encouraged, as the goal is to rebuild in ways that are safer and stronger. CDGB-DR funding is a potential alternative source of funding for actions identified in this plan.

Emergency Watershed Program

The USDA Natural Resources Conservation Service (NRCS) administers the Emergency Watershed Protection (EWP) Program, which responds to emergencies created by natural disasters. Eligibility for assistance is not dependent on a national emergency declaration. The program is designed to help people and conserve natural resources by relieving imminent hazards to life and property caused by floods, fires, windstorms, and other natural occurrences. EWP is an emergency recovery program. Financial and technical assistance are available for the following activities (Natural Resources Conservation Service, 2016):

- Remove debris from stream channels, road culverts, and bridges
- Reshape and protect eroded banks
- Correct damaged drainage facilities
- Establish cover on critically eroding lands
- Repair levees and structures
- Repair conservation practices.

This federal program could be a possible funding source for actions identified in this plan.

Emergency Relief for Federally Owned Roads Program

The U.S. Forest Service's Emergency Relief for Federally Owned Roads Program was established to assist federal agencies with repair or reconstruction of tribal transportation facilities, federal lands transportation facilities, and other federally owned roads that are open to public travel and have suffered serious damage by a natural disaster over a wide area or by a catastrophic failure. The program funds both emergency and permanent repairs (Office of Federal Lands Highway, 2016). Eligible activities under this program meet some of the goals and objectives for this plan and the program is a possible funding source for actions identified in this plan.

National Flood Insurance Program

The National Flood Insurance Program (NFIP) provides federally backed flood insurance in exchange for communities enacting floodplain regulations. Participation and good standing under NFIP are prerequisites to grant funding eligibility under the Robert T. Stafford Act. Contra Costa County and all of the planning partner cities participate in the NFIP and have adopted regulations that meet the NFIP requirements. At the time of the preparation of this plan, all participating jurisdictions were in good standing with NFIP requirements. Full compliance and good standing under the NFIP are application prerequisites for all FEMA grant programs for which participating jurisdictions are eligible under this plan.

Presidential Executive Orders 11988 and 13690

Executive Order 11988 requires federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. It requires federal agencies to provide leadership and take action to reduce the risk of flood loss, minimize the impact of floods on human safety, health, and welfare, and restore and preserve the natural and beneficial values of floodplains. The requirements apply to the following activities (FEMA, 2015a):

- Acquiring, managing, and disposing of federal lands and facilities
- Providing federally undertaken, financed, or assisted construction and improvements
- Conducting federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulation, and licensing.

Executive Order 13690 expands Executive Order 11988 and acknowledges that the impacts of flooding are anticipated to increase over time due to the effects of climate change and other threats. It mandates a federal flood risk management standard to increase resilience against flooding and help preserve the natural values of floodplains. This standard expands management of flood issues from the current base flood level to a higher vertical elevation and corresponding horizontal floodplain. The goal is to address current and future flood risk and ensure that projects funded with taxpayer dollars last as long as intended (Office of the Press Secretary, 2015). All actions identified in this plan will seek full compliance with all applicable presidential executive orders.

The Clean Water Act

The federal Clean Water Act (CWA) employs regulatory and non-regulatory tools to reduce direct pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage polluted runoff. These tools are employed to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's surface waters so that they can support "the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water."

Evolution of CWA programs over the last decade has included a shift from a program-by-program, source-by-source, and pollutant-by-pollutant approach to more holistic watershed-based strategies. Under the watershed approach, equal emphasis is placed on protecting healthy waters and restoring impaired ones. A full array of issues are addressed, not just those subject to CWA regulatory authority. Involvement of stakeholder groups in the development and implementation of strategies for achieving and maintaining water quality and other environmental goals is a hallmark of this approach.

The CWA is important to hazard mitigation in several ways. There are often permitting requirements for any construction within 200 feet of water of the United States, which may have implications for mitigation projects identified by a local jurisdiction. Additionally, CWA requirements apply to wetlands, which serve important functions related to preserving and protecting the natural and beneficial functions of floodplains and are linked with a community's floodplain management program. Finally, the National Pollutant Discharge Elimination System is part of the CWA and addresses local stormwater management programs. Stormwater management plays a critical role in hazard mitigation by addressing urban drainage or localized flooding issues within jurisdictions.

FEMA hazard mitigation project grant applications require full compliance with applicable federal acts. Any action identified in this plan that falls within the scope of this act will need to meet its requirements.

Presidential Executive Order 11990

Executive Order 11990 requires federal agencies to provide leadership and take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands. The requirements apply to the following activities (National Archives, 2016):

- Acquiring, managing, and disposing of federal lands and facilities
- Providing federally undertaken, financed, or assisted construction and improvements
- Conducting federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulation, and licensing.

All actions identified in this plan will seek full compliance with all applicable presidential executive orders.

Endangered Species Act

The federal Endangered Species Act (ESA) was enacted in 1973 to conserve species facing depletion or extinction and the ecosystems that support them. The act sets forth a process for determining which species are threatened and endangered and requires the conservation of the critical habitat in which those species live. The ESA provides broad protection for species of fish, wildlife and plants that are listed as threatened or endangered. Provisions are made for listing species, as well as for recovery plans and the designation of critical habitat for listed species. The ESA outlines procedures for federal agencies to follow when taking actions that may jeopardize listed species and contains exceptions and exemptions. It is the enabling legislation for the Convention on International Trade in Endangered Species of Wild Fauna and Flora. Criminal and civil penalties are provided for violations of the ESA and the Convention.

Federal agencies must seek to conserve endangered and threatened species and use their authorities in furtherance of the ESA's purposes. The ESA defines three fundamental terms:

- **Endangered** means that a species of fish, animal or plant is "in danger of extinction throughout all or a significant portion of its range." (For salmon and other vertebrate species, this may include subspecies and distinct population segments.)
- **Threatened** means that a species "is likely to become endangered within the foreseeable future." Regulations may be less restrictive for threatened species than for endangered species.
- **Critical habitat** means "specific geographical areas that are…essential for the conservation and management of a listed species, whether occupied by the species or not."

Five sections of the ESA are of critical importance to understanding it:

- **Section 4: Listing of a Species**—The National Oceanic and Atmospheric Administration Fisheries Service (NOAA Fisheries) is responsible for listing marine species; the U.S. Fish and Wildlife Service is responsible for listing terrestrial and freshwater aquatic species. The agencies may initiate reviews for listings, or citizens may petition for them. A listing must be made "solely on the basis of the best scientific and commercial data available." After a listing has been proposed, agencies receive comment and conduct further scientific reviews for 12 to 18 months, after which they must decide if the listing is warranted. Economic impacts cannot be considered in this decision, but it may include an evaluation of the adequacy of local and state protections. Critical habitat for the species may be designated at the time of listing.
- **Section 7: Consultation**—Federal agencies must ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed or proposed species or adversely modify its critical habitat. This includes private and public actions that require a federal permit. Once a final listing is made, non-federal actions are subject to the same review, termed a "consultation." If the listing agency finds that an action will "take" a species, it must propose mitigations or "reasonable and prudent" alternatives to the action; if the proponent rejects these, the action cannot proceed.
- **Section 9: Prohibition of Take—**It is unlawful to "take" an endangered species, including killing or injuring it or modifying its habitat in a way that interferes with essential behavioral patterns, including breeding, feeding or sheltering.
- **Section 10: Permitted Take**—Through voluntary agreements with the federal government that provide protections to an endangered species, a non-federal applicant may commit a take that would otherwise be prohibited as long as it is incidental to an otherwise lawful activity (such as developing land or building a road). These agreements often take the form of a "Habitat Conservation Plan."
- **Section 11: Citizen Lawsuits**—Civil actions initiated by any citizen can require the listing agency to enforce the ESA's prohibition of taking or to meet the requirements of the consultation process.

FEMA hazard mitigation project grant applications require full compliance with applicable federal acts. Any action identified in this plan that falls within the scope of this act will need to meet its requirements.

National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires federal agencies to consider the environmental impacts of proposed actions and reasonable alternatives to those actions, alongside technical and economic considerations. NEPA established the Council on Environmental Quality (CEQ), whose regulations (40 CFR Parts 1500-1508) set standards for NEPA compliance. Consideration and decision-making regarding environmental impacts must be documented in an environmental impact statement or environmental assessment. Environmental impact assessment requires the evaluation of reasonable alternatives to a proposed action, solicitation of input from organizations and individuals that could be affected, and an unbiased presentation of direct, indirect, and cumulative environmental impacts. FEMA hazard mitigation project grant applications require full compliance with applicable federal acts. Any action identified in this plan that falls within the scope of this act will need to meet its requirements.

National Incident Management System

The National Incident Management System (NIMS) is a systematic approach for government, nongovernmental organizations, and the private sector to work together to manage incidents involving hazards. The NIMS provides a flexible but standardized set of incident management practices. Incidents typically begin and end locally, and they are managed at the lowest possible geographical, organizational, and jurisdictional level. In some cases, success depends on the involvement of multiple jurisdictions, levels of government, functional agencies, and emergency responder disciplines. These cases necessitate coordination across a spectrum of organizations. Communities using NIMS follow a comprehensive national approach that improves the effectiveness of emergency management and response personnel across the full spectrum of potential hazards (including natural hazards, technological hazards, and human-caused hazards) regardless of size or complexity.

Although participation is voluntary, federal departments and agencies are required to make adoption of NIMS by local and state jurisdictions a condition to receive federal preparedness grants and awards. The content of this plan is considered to be a viable support tool for any phase of emergency management. The NIMS program is considered as a response function, and information in this hazard mitigation plan can support the implementation and update of all NIMS-compliant plans within the planning area.

Americans with Disabilities Act

The Americans with Disabilities Act (ADA) seeks to prevent discrimination against people with disabilities in employment, transportation, public accommodation, communications, and government activities. Title II of the ADA deals with compliance with the Act in emergency management and disaster-related programs, services, and activities. It applies to state and local governments as well as third parties, including religious entities and private nonprofit organizations.

The ADA has implications for sheltering requirements and public notifications. During an emergency alert, officials must use a combination of warning methods to ensure that all residents have all necessary information. Those with hearing impairments may not hear radio, television, sirens, or other audible alerts, while those with visual impairments may not see flashing lights or other visual alerts. Two technical documents for shelter operators address physical accessibility needs of people with disabilities, as well as medical needs and service animals.

The ADA intersects with disaster preparedness programs in regards to transportation, social services, temporary housing, and rebuilding. Persons with disabilities may require additional assistance in evacuation and transit (e.g., vehicles with wheelchair lifts or paratransit buses). Evacuation and other response plans should address the unique needs of residents. Local governments may be interested in implementing a special-needs registry to identify the home addresses, contact information, and needs for residents who may require more assistance.

FEMA hazard mitigation project grant applications require full compliance with applicable federal acts. Any action identified in this plan that falls within the scope of this act will need to meet its requirements.

Civil Rights Act of 1964

The Civil Rights Act of 1964 prohibits discrimination based on race, color, religion, sex or nation origin and requires equal access to public places and employment. The Act is relevant to emergency management and hazard mitigation in that it prohibits local governments from favoring the needs of one population group over another. Local government and emergency response must ensure the continued safety and well-being of all residents equally, to the extent possible. FEMA hazard mitigation project grant applications require full compliance with applicable federal acts. Any action identified in this plan that falls within the scope of this act will need to meet its requirements.

Army Corps of Engineers Programs

The U.S. Army Corps of Engineers has several civil works authorities and programs related to flood risk and flood hazard management:

- The Floodplain Management Services program offers 100-percent federally funded technical services such as development and interpretation of site-specific data related to the extent, duration and frequency of flooding. Special studies may be conducted to help a community understand and respond to flood risk. These may include flood hazard evaluation, flood warning and preparedness, or flood modeling.

- For more extensive studies, the Corps of Engineers offers a cost-shared program called Planning Assistance to States and Tribes. Studies under this program generally range from $25,000 to $100,000 with the local jurisdiction providing 50 percent of the cost.
- The Corps of Engineers has several cost-shared programs (typically 65 percent federal and 35 percent non-federal) aimed at developing, evaluating and implementing structural and non-structural capital projects to address flood risks at specific locations or within a specific watershed:

  - The Continuing Authorities Program for smaller-scale projects includes Section 205 for Flood Control, with a $7 million federal limit and Section 14 for Emergency Streambank Protection with a $1.5 million federal limit. These can be implemented without specific authorization from Congress.
  - Larger scale studies, referred to as General Investigations, and projects for flood risk management, for ecosystem restoration or to address other water resource issues, can be pursued through a specific authorization from Congress and are cost-shared, typically at 65 percent federal and 35 percent non-federal.
  - Watershed management planning studies can be specifically authorized and are cost-shared at 50 percent federal and 50 percent non-federal.

- The Corps of Engineers provides emergency response assistance during and following natural disasters. Public Law 84-99 enables the Corps to assist state and local authorities in flood fight activities and cost share in the repair of flood protective structures. Assistance is provided in the flowing categories:

  - **Preparedness—**The Flood Control and Coastal Emergency Act establishes an emergency fund for preparedness for emergency response to natural disasters; for flood fighting and rescue operations; for rehabilitation of flood control and hurricane protection structures. Funding for Corps of Engineers emergency response under this authority is provided by Congress through the annual Energy and Water Development Appropriation Act. Disaster preparedness activities include coordination, planning, training and conduct of response exercises with local, state and federal agencies.
  - **Response Activities—**PL 84-99 allows the Corps of Engineers to supplement state and local entities in flood fighting urban and other non-agricultural areas under certain conditions (Engineering Regulation 500-1-1 provides specific details). All flood fight efforts require a project cooperation agreement signed by the public sponsor and the sponsor must remove all flood fight material after the flood has receded. PL 84-99 also authorizes emergency water support and drought assistance in certain situations and allows for “advance measures” assistance to prevent or reduce flood damage conditions of imminent threat of unusual flooding.
  - **Rehabilitation—**Under PL 84-99, an eligible flood protection system can be rehabilitated if damaged by a flood event. The flood system would be restored to its pre-disaster status at no cost to the federal system owner, and at 20-percent cost to the eligible non-federal system owner. All systems considered eligible for PL 84-99 rehabilitation assistance have to be in the Rehabilitation and Inspection Program prior to the flood event. Acceptable operation and maintenance by the public levee sponsor are verified by levee inspections conducted by the Corps on a regular basis. The Corps has the responsibility to coordinate levee repair issues with interested federal, state, and local agencies following natural disaster events where flood control works are damaged.

All of these authorities and programs are available to the planning partners to support any intersecting mitigation actions.

4.8.2 State

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act was enacted in 1972 to mitigate the hazard of surface faulting to structures for human occupancy. The Alquist-Priolo Earthquake Fault Zoning Act's main purpose is to prevent construction of buildings used for human occupancy on the surface trace of active faults. Before a new project is permitted, cities and counties require a geologic investigation to demonstrate that proposed buildings will not be constructed on active faults. The act addresses only the hazard of surface fault rupture and is not directed toward other earthquake hazards, such as liquefaction or seismically induced landslides. The law requires the State of California Geologist to establish regulatory zones around the surface traces of active faults and to issue appropriate maps. The maps are distributed to all affected cities, counties, and state agencies for their use in planning and controlling new or renewed construction. Local agencies must regulate most development projects within the zones. Projects include all land divisions and most structures for human occupancy. All seismic hazard mitigation actions identified in this plan will seek full compliance with the Alquist-Priolo Earthquake Fault Zoning Act.

California General Planning Law

California state law requires that every county and city prepare and adopt a comprehensive long-range plan to serve as a guide for community development. The general plan expresses the community's goals, visions, and policies relative to future land uses, both public and private. The general plan is mandated and prescribed by state law (Cal. Gov. Code §65300 et seq.), and forms the basis for most local government land use decision-making.

The plan must consist of an integrated and internally consistent set of goals, policies, and implementation measures. In addition, the plan must focus on issues of the greatest concern to the community and be written in a clear and concise manner. City and county actions, such as those relating to land use allocations, annexations, zoning, subdivision and design review, redevelopment, and capital improvements, must be consistent with the plan.

All municipal planning partners to this plan have general plans that are currently compliant with this law and have committed to integrating this mitigation plan with their general plans through provisions referenced below (AB-2140 and SB-379)

California Environmental Quality Act

The California Environmental Quality Act (CEQA) was passed in 1970, shortly after the federal government enacted the National Environmental Policy Act, to institute a statewide policy of environmental protection. CEQA requires state and local agencies in California to follow a protocol of analysis and public disclosure of the potential environmental impacts of development projects. CEQA makes environmental protection a mandatory part of every California state and local agency's decision making process.

CEQA establishes a statewide environmental policy and mandates actions all state and local agencies must take to advance the policy. Jurisdictions conduct analysis of the project to determine if there are potentially significant environmental impacts, identify mitigation measures, and possible project alternatives by preparing environmental reports for projects that requires CEQA review. This environmental review is required before an agency takes action on any policy, program, or project.

Contra Costa County has determined that this plan update is categorically exempt from the formal CEQA protocol. The County will initiate the formal CEQA protocol on any project recommended in this plan that requires adherence to this protocol at the initiation of the project. Any project action identified in this plan will seek full CEQA compliance upon implementation.

AB 162: Flood Planning

This California State Assembly Bill passed in 2007 requires cities and counties to address flood-related matters in the land use, conservation, and safety and housing elements of their general plans. The land use element must identify and annually review the areas covered by the general plan that are subject to flooding as identified in floodplain mapping by either FEMA or the state Department of Water Resources (DWR). During the next revision of the housing element on or after January 1, 2009, the conservation element of the general plan must identify rivers, creeks, streams, flood corridors, riparian habitat, and land that may accommodate floodwater for the purpose of groundwater recharge and stormwater management. The safety element must identify information regarding flood hazards, including:

- Flood hazard zones
- Maps published by FEMA, DWR, the U.S. Army Corps of Engineers, the Central Valley Flood Protection Board, and the Governor's Office of Emergency Services (Cal OES)
- Historical data on flooding
- Existing and planned development in flood hazard zones.

The general plan must establish goals, policies and objectives to protect from unreasonable flooding risks, including:

- Avoiding or minimizing the risks of flooding new development
- Evaluating whether new development should be located in flood hazard zones
- Identifying construction methods to minimize damage.

AB 162 establishes goals, policies and objectives to protect from unreasonable flooding risks. It establishes procedures for the determination of available land suitable for urban development, which may exclude lands where FEMA or DWR has concluded that the flood management infrastructure is not adequate to avoid the risk of flooding.

AB 2140: General Plans—Safety Element

This bill provides that the state may allow for more than 75 percent of public assistance funding under the California Disaster Assistance Act only if the local agency is in a jurisdiction that has adopted a local hazard mitigation plan as part of the safety element of its general plan. The local hazard mitigation plan needs to include elements specified in this legislation. In addition, this bill requires Cal OES to give preference for federal mitigation funding to cities and counties that have adopted local hazard mitigation plans. The intent of the bill is to encourage cities and counties to create and adopt hazard mitigation plans.

AB 70: Flood Liability

This bill provides that a city or county may be required to contribute a fair and reasonable share to compensate for property damage caused by a flood to the extent that it has increased the state's exposure to liability for property damage by unreasonably approving new development in a previously undeveloped area that is protected by a state flood control project, unless the city or county meets specified requirements.

AB 32: The California Global Warming Solutions Act

This bill identifies the following potential adverse impacts of global warming:

> "… the exacerbation of air quality problems, a reduction in the quality and supply of water to the state from the Sierra snowpack, a rise in sea levels resulting in the displacement of thousands of coastal businesses and residences, damage to marine ecosystems and the natural environment, and an increase in the incidences of infectious diseases, asthma, and other human health-related problems."

AB 32 establishes a state goal of reducing greenhouse gas emissions to 1990 levels by 2020 (a reduction of approximately 25 percent from forecast emission levels), with further reductions to follow. The law requires the state Air Resources Board to do the following:

- Establish a program to track and report greenhouse gas emissions.
- Approve a scoping plan for achieving the maximum technologically feasible and cost-effective reductions from sources of greenhouse gas emissions.
- Adopt early reduction measures to begin moving forward.
- Adopt, implement and enforce regulations—including market mechanisms such as “cap and-trade” programs—to ensure that the required reductions occur.

The Air Resources Board has adopted a statewide greenhouse gas emissions limit and an emissions inventory, along with requirements to measure, track, and report greenhouse gas emissions by the industries it determined to be significant sources of greenhouse gas emissions.

AB 2800: Climate Change—Infrastructure Planning

This California State Assembly bill passed in 2016 and until July 1, 2020, requires state agencies to take into account the current and future impacts of climate change when planning, designing, building, operating, maintaining, and investing in state infrastructure. The bill, by July 1, 2017, and until July 1, 2020, requires an agency to establish a Climate-Safe Infrastructure Working Group for the purpose of examining how to integrate scientific data concerning projected climate change impacts into state infrastructure engineering, as prescribed.

Senate Bill 97: Guidelines for Greenhouse Gas Emissions

Senate Bill 97, enacted in 2007, amends CEQA to clearly establish that greenhouse gas emissions and the effects of greenhouse gas emissions are appropriate subjects for CEQA analysis. It directs the Governor’s Office of Planning and Research to develop draft CEQA guidelines for the mitigation of greenhouse gas emissions or their effects by July 1, 2009 and directs the California Natural Resources Agency to certify and adopt the CEQA Guidelines by January 1, 2010.

Senate Bill 1241: General Plans: Safety Element—Fire Hazard Impacts

In 2012, Senate Bill 1241 was enacted, requiring that all future General Plans address fire risk in state responsibility areas and very high fire hazard severity zones in their safety element. In addition, the bill requires cities and counties to make certain findings regarding available fire protection and suppression services before approving a tentative map or parcel map.

Senate Bill 1000: General Plan Amendments—Safety and Environmental Justice Elements

In 2016, Senate Bill 1000 amended California’s Planning and Zoning Law in two ways:

- The original law established requirements for initial revisions of general plan safety elements to address flooding, fire, and climate adaptation and resilience. It also required subsequent review and revision as necessary based on new information. Senate Bill 1000 specifies that the subsequent reviews and revision based on new information are required to address only flooding and fires (not climate adaptation and resilience).
- Senate Bill 1000 adds a requirement that, upon adoption or revision of any two other general plan elements on or after January 1, 2018, an environmental justice element be adopted for the general plan or environmental justice goals, policies and objectives be incorporated into other elements of the plan.

Senate Bill 1241: General Plans: Safety Element—Fire Hazard Impacts

In 2012, Senate Bill 1241 passed requiring that the safety elements of all future general plans address fire risk in state responsibility areas and very high fire hazard severity zones. The bill requires cities and counties to make findings regarding available fire protection and suppression services before approving a tentative map or parcel map.

Senate Bill 379: General Plans: Safety Element—Climate Adaptation

Senate Bill 379 builds upon the flood planning inclusions into the safety and housing elements and the hazard mitigation planning safety element inclusions in general plans outlined in AB 162 and AB 2140, respectively. SB 379 focuses on a new requirement that cities and counties include climate adaptation and resiliency strategies in the safety element of their general plans beginning January 1, 2017. In addition, this bill requires general plans to include a set of goals, policies and objectives, and specified implementation measures based on the conclusions drawn from climate adaptation research and recommendations.

This update process for this hazard mitigation plan was conducted with the intention of full compliance with this bill. However, at the time of the update, there was no clear guidance from the state on what constitutes full compliance or what protocol is to be used to determine compliance. When such guidance has been established, the planning partners will submit this plan or its subsequent updates to the state for review and approval.

California State Building Code

California Code of Regulations Title 24 (CCR Title 24), also known as the California Building Standards Code, is a compilation of building standards from three sources:

- Building standards that have been adopted by state agencies without change from building standards contained in national model codes
- Building standards that have been adopted and adapted from the national model code standards to meet California conditions
- Building standards authorized by the California legislature that constitute extensive additions not covered by the model codes adopted to address particular California concerns.

The state Building Standards Commission is authorized by California Building Standards Law (Health and Safety Code Sections 18901 through 18949.6) to administer the processes related to the adoption, approval, publication, and implementation of California's building codes. These building codes serve as the basis for the design and construction of buildings in California. The national model code standards adopted into Title 24 apply to all occupancies in California, except for modifications adopted by state agencies and local governing bodies. Since 1989, the Building Standards Commission has published new editions of Title 24 every three years.

On January 1, 2014, California Building Code Accessibility Standards found in Chapter 11B incorporated the 2010 Americans with Disabilities Act (ADA) Standards as the model accessibility code for California. The purpose was to ensure consistency with federal guidelines. As a result of this incorporation, the California standards will fully implement and include 2010 ADA Standards within the California Building Code while maintaining enhanced levels of accessibility already provided by existing California accessibility regulations. All planning partners that have building code and permit authority have adopted building codes that are in full compliance with the California State Building Code.

Standardized Emergency Management System

CCR Title 19 establishes the Standardized Emergency Management System (SEMS) to standardize the response to emergencies involving multiple jurisdictions. SEMS is intended to be flexible and adaptable to the needs of all emergency responders in California. It requires emergency response agencies to use basic principles and components of emergency management. Local governments must use SEMS by December 1, 1996, to be eligible for state funding of response-related personnel costs under CCR Title 19 (Sections 2920, 2925 and 2930).The roles and responsibilities of Individual agencies contained in existing laws or the state emergency plan are not superseded by these regulations. This hazard mitigation plan is considered to be a support document for all phases of emergency management, including those associated with SEMS.

State of California Multi-Hazard Mitigation Plan

Under the DMA, California must adopt a federally approved state multi-hazard mitigation plan to be eligible for certain disaster assistance and mitigation funding. The intent of the *State of California Multi-Hazard Mitigation Plan* is to reduce or prevent injury and damage from hazards in the state through the following:

- Documenting statewide hazard mitigation planning in California
- Describing strategies and priorities for future mitigation activities
- Facilitating the integration of local and tribal hazard mitigation planning activities into statewide efforts
- Meeting state and federal statutory and regulatory requirements.

The plan is an annex to the *State Emergency Plan*, and it identifies past and present mitigation activities, current policies and programs, and mitigation strategies for the future. It also establishes hazard mitigation goals and objectives. The plan will be reviewed and updated annually to reflect changing conditions and new information, especially information on local planning activities.

Under 44 CFR Section 201.6, local hazard mitigation plans must be consistent with their state's hazard mitigation plan. In updating this plan, the Steering Committee reviewed the California State Hazard Mitigation Plan to identify key relevant state plan elements (see Section 3.7).

California Coastal Management Program

The California Coastal Management Program under the California Coastal Act requires each city or county lying wholly or partly within the coastal zone to prepare a local coastal plan. The specific contents of such plans are not specified by state law, but they must be certified by the Coastal Commission as consistent with policies of the Coastal Act (Public Resources Code, Division 20). The Coastal Act has provisions relating to geologic hazards, but does not mention tsunamis specifically. Section 30253(1) of the Coastal Act states that new development shall minimize risks to life and property in areas of high geologic, flood, and fire hazard. Development should be prevented or limited in high hazard areas whenever possible. However, where development cannot be prevented or limited, land use density, building value, and occupancy should be kept at a minimum.

There are identified coastal zones in Contra Costa County, and affected planning partners have developed local coastal plans to address them. Any mitigation project identified in this plan that intersects the mapped coastal zone will be consistent with the recommendations of the local coastal plan.

Governor's Executive Order S-13-08

Governor's Executive Order S-13-08 enhances the state's management of climate impacts from sea level rise, increased temperatures, shifting precipitation and extreme weather events. There are four key actions in the executive order:

- Initiate California's first statewide climate change adaptation strategy to assess expected climate change impacts, identify where California is most vulnerable, and recommend adaptation policies. This effort will improve coordination within state government so that better planning can more effectively address climate impacts on human health, the environment, the state's water supply and the economy.

- Request that the National Academy of Science establish an expert panel to report on sea level rise impacts in California, to inform state planning and development efforts.
- Issue interim guidance to state agencies for how to plan for sea level rise in designated coastal and floodplain areas for new projects.
- Initiate a report on critical infrastructure projects vulnerable to sea level rise.

California Fire Alliance

The California Fire Alliance (CFA) was established in response to directives from the National Fire Plan that was developed in 2001. The National Fire Plan presented a comprehensive strategy in five key initiatives:

- **Firefighting**—Be adequately prepared to fight fires each fire season.
- **Rehabilitation and Restoration**—Restore landscapes and rebuild communities damaged by wildfires.
- **Hazardous Fuel Reduction**—Invest in projects to reduce fire risk.
- **Community Assistance**—Work directly with communities to ensure adequate protection.
- **Accountability—**Be accountable and establish adequate oversight, coordination, program development, and monitoring for performance.

The CFA pursues four strategies to deal with the National Fire Plan’s community assistance initiative:

- Work with communities at risk from wildfires to develop community-based planning leadership and facilitate the development of community fire loss mitigation plans, which transcend jurisdiction and ownership boundaries.
- Assist communities in development of fire loss mitigation planning, education and projects to reduce the threat of wildfire losses on public and private lands.
- Develop an information and education outreach plan to increase awareness of wildland fire protection program opportunities available to communities at risk.
- Work collaboratively to develop, modify and maintain a comprehensive list of communities at risk.

Adapting to Rising Tides

In 2010, the San Francisco Bay Conservation and Development Commission and NOAA’s Office for Coastal Management brought together local, regional, state and federal agencies and organizations, as well as non-profit and private associations, for a collaborative planning project along the Alameda County shoreline—the ART (Adapting to Rising Tides) Sub-Regional Project—to identify how flooding affects communities, infrastructure, ecosystems and the economy.

The ART program leads and supports projects that build local and regional capacity in the San Francisco Bay area to plan for and implement adaptation. The program tests adaptation planning methods that integrate sustainability and transparent decision-making from start to finish and foster collaboration on adaptation. The ART Program integrates adaptation into local and regional planning and decision-making in multiple ways:

- Leading planning projects that build a comprehensive understanding of climate vulnerability and risk, develop effective and equitable adaptation responses, and find paths forward for implementing these responses.
- Assisting adaptation planning efforts with staff support that includes help with process and meeting design and review of work products.
- Providing the ART Portfolio, which combines online resources—including how-to guides, tools and findings—with support from experienced staff to help planners use the resources to assess and plan for climate impacts.

- Building regional capacity for adaptation by working with local, regional, state and federal agencies to find funding and develop capacity and support at all scales.
- Advocating for adaptation by communicating findings, issues, processes and needs to state and federal agencies to ensure that grant and other assistance programs are responsive to conditions in the Bay Area.

California Residential Mitigation Program

The California Residential Mitigation Program was established in 2011 to help Californians strengthen their homes against damage from earthquakes. The program is a joint powers authority created by Cal OES and the California Earthquake Authority, which is a not-for-profit, publicly managed, privately funded provider of home earthquake insurance to California homeowners and renters.

Earthquake Brace + Bolt was developed to help homeowners lessen the potential for damage to their houses during an earthquake. A residential seismic retrofit strengthens an existing older house, making it more resistant to earthquake activity such as ground shaking and soil failure. The seismic retrofitting involves bolting the house to its foundation and adding bracing around the perimeter of the crawl space. Most homeowners hire a contractor to do the retrofit work, and owners of houses in ZIP Codes with house characteristics suitable for this type of retrofit are eligible for up to $3,000 toward the cost. A typical retrofit by a contractor may cost between $3,000 and $7,000, depending on the location and size of the house, contractor fees, and the amount of materials and work involved. If the homeowner is an experienced do-it-yourselfer, a retrofit can cost less than $3,000.

4.8.3 Local

Plans, Reports and Codes

Plans, reports and other technical information were identified and provided directly by participating jurisdictions and stakeholders or were identified through independent research by the planning consultant. These documents were reviewed to identify the following:

- Existing jurisdictional capabilities.
- Needs and opportunities to develop or enhance capabilities, which may be identified within the local mitigation strategies.
- Mitigation-related goals or objectives, considered during the development of the overall goals and objectives.
- Proposed, in-progress, or potential mitigation projects, actions and initiatives to be incorporated into the updated jurisdictional mitigation strategies.

The following local regulations, codes, ordinances and plans were reviewed in order to develop complementary and mutually supportive goals, objectives, and mitigation strategies that are consistent across local and regional planning and regulatory mechanisms:

- General plans (housing elements, safety elements)
- Building codes
- Zoning and subdivision ordinances
- NFIP flood damage prevention ordinances
- Stormwater management plans
- Emergency management and response plans
- Land use and open space plans
- Climate action plans.

Capability Assessment

All participating jurisdictions compiled an inventory and analysis of existing authorities and capabilities called a "capability assessment." A capability assessment creates an inventory of a jurisdiction's mission, programs and policies, and evaluates its capacity to carry them out. This assessment identifies potential gaps in the jurisdiction's capabilities.

The Planning Partnership views all core jurisdictional capabilities as fully adaptable to meet a jurisdiction's needs. Every code can be amended, and every plan can be updated. Such adaptability is itself considered to be an overarching capability. If the capability assessment identified an opportunity to add a missing core capability or expand an existing one, then doing so has been selected as an action in the jurisdiction's action plan, which is included in the individual annexes presented in Volume 2 of this plan.

Capability assessments for each planning partner are presented in the jurisdictional annexes in Volume 2. The sections below describe the specific capabilities evaluated under the assessment.

Legal and Regulatory Capabilities

Jurisdictions have the ability to develop policies and programs and to implement rules and regulations to protect and serve residents. Local policies are typically identified in a variety of community plans, implemented via a local ordinance, and enforced through a governmental body.

Jurisdictions regulate land use through the adoption and enforcement of zoning, subdivision and land development ordinances, building codes, building permit ordinances, floodplain, and stormwater management ordinances. When effectively prepared and administered, these regulations can lead to hazard mitigation.

Fiscal Capabilities

Assessing a jurisdiction's fiscal capability provides an understanding of the ability to fulfill the financial needs associated with hazard mitigation projects. This assessment identifies both outside resources, such as grant-funding eligibility, and local jurisdictional authority to generate internal financial capability, such as through impact fees.

Administrative and Technical Capabilities

Legal, regulatory, and fiscal capabilities provide the backbone for successfully developing a mitigation strategy; however, without appropriate personnel, the strategy may not be implemented. Administrative and technical capabilities focus on the availability of personnel resources responsible for implementing all the facets of hazard mitigation. These resources include technical experts, such as engineers and scientists, as well as personnel with capabilities that may be found in multiple departments, such as grant writers.

NFIP Compliance

Flooding is the costliest natural hazard in the United States and, with the promulgation of recent federal regulation, homeowners throughout the country are experiencing increasingly high flood insurance premiums. Community participation in the NFIP opens up opportunity for additional grant funding associated specifically with flooding issues. Assessment of the jurisdiction's current NFIP status and compliance provides planners with a greater understanding of the local flood management program, opportunities for improvement, and available grant funding opportunities.

Public Outreach Capability

Regular engagement with the public on issues regarding hazard mitigation provides an opportunity to directly interface with community members. Assessing this outreach and education capability illustrates the connection between the government and community members, which opens a two-way dialogue that can result in a more resilient community based on education and public engagement.

Participation in Other Programs

Other programs, such as the Community Rating System, StormReady, and Firewise, enhance a jurisdiction's ability to mitigate, prepare for, and respond to natural hazards. These programs indicate a jurisdiction's desire to go beyond minimum requirements set forth by local, state and federal regulations in order to create a more resilient community. These programs complement each other by focusing on communication, mitigation, and community preparedness to save lives and minimize the impact of natural hazards on a community.

Development and Permitting Capability

Identifying previous and future development trends is achieved through a comprehensive review of permitting since completion of the previous plan and in anticipation of future development. Tracking previous and future growth in potential hazard areas provides an overview of increased exposure to a hazard within a community.

Adaptive Capacity

An adaptive capacity assessment evaluates a jurisdiction's ability to anticipate impacts from future conditions. By looking at public support, technical adaptive capacity, and other factors, jurisdictions identify their core capability for resilience against issues such as sea level rise. The adaptive capacity assessment provides jurisdictions with an opportunity to identify areas for improvement by ranking their capacity high, medium or low.

Integration Opportunity

The assessment looked for opportunities to integrate this mitigation plan with the legal/regulatory capabilities identified. Capabilities were identified as integration opportunities if they can support or enhance the actions identified in this plan or be supported or enhanced by components of this plan. Planning partners considered actions to implement this integration as described in their jurisdictional annexes.

Contra Costa County Hazard Mitigation Plan

PART 2—RISK ASSESSMENT

5. IDENTIFIED HAZARDS OF CONCERN AND RISK ASSESSMENT METHODOLOGY

Risk assessment is the process of measuring the potential loss of life, personal injury, economic injury, and property damage resulting from identified hazards. It allows emergency management personnel to establish early response priorities by identifying potential hazards and vulnerable assets. The process focuses on the following elements:

- **Hazard identification**—Use all available information to determine what types of hazards may affect a jurisdiction, how often they can occur, and their potential severity.
- **Exposure identification—**Estimate the total number of people and properties in the jurisdiction that are likely to experience a hazard event if it occurs.
- **Vulnerability identification and loss estimation**—Assess the impact of hazard events on the people, property, environment, economy and lands of the region, including estimates of the cost of potential damage or cost that can be avoided by mitigation.

The risk assessment for this hazard mitigation plan update evaluates the risk of natural hazards prevalent in the planning area and meets requirements of the Disaster Mitigation Act (44 CFR, Section 201.6(c)(2)).

To protect individual privacy and the security of critical facilities, information on properties assessed is presented in aggregate, without details about specific individual personal or public properties.

5.1 IDENTIFIED HAZARDS OF CONCERN

The Steering Committee considered the full range of natural hazards that could affect the planning area and then listed hazards that present the greatest concern. The process incorporated a review of state and local hazard planning documents as well as information on the frequency of, magnitude of, and costs associated with hazards that have struck the planning area or could do so. Anecdotal information regarding natural hazards and the perceived vulnerability of the planning area's assets to them was also used. Based on the review, this plan addresses the following hazards of concern (presented in alphabetical order; the order of listing does not indicate the hazards' relative severity):

- Dam and levee failure
- Drought
- Earthquake
- Flood
- Landslide
- Severe weather
- Tsunami
- Wildfire
- Other hazards of interest.

5.2 RISK ASSESSMENT TOOLS

5.2.1 Mapping

National, state, and county databases were reviewed to locate available spatially based data relevant to this planning effort. Maps were produced using geographic information system (GIS) software to show the spatial extent and location of hazards when such datasets were available. These maps are included in the hazard profile chapters of this document. Mapping methodology is further described in Appendix B.

5.2.2 Hazus

Overview

In 1997, FEMA developed the standardized Hazards U.S. (Hazus) model to estimate losses caused by earthquakes and identify areas that face the highest risk and potential for loss. Hazus was later expanded into a multi-hazard methodology with new models for estimating potential losses from hurricanes and floods.

Hazus is a GIS-based software program used to support risk assessments, mitigation planning, and emergency planning and response. It provides a wide range of inventory data, such as demographics, building stock, critical facility, transportation and utility lifeline, and multiple models to estimate potential losses from natural disasters. The program maps and displays hazard data and the results of damage and economic loss estimates for buildings and infrastructure. Its advantages include the following:

- Provides a consistent methodology for assessing risk across geographic and political entities.
- Provides a way to save data so that they can readily be updated as population, inventory, and other factors change and as mitigation planning efforts evolve.
- Facilitates review of mitigation plans because it helps to ensure that FEMA methodologies are incorporated.
- Supports grant applications by calculating benefits using FEMA definitions and terminology.
- Produces hazard data and loss estimates that can be used in communication with local stakeholders.
- Is administered by the local government and can be used to manage and update a hazard mitigation plan throughout its implementation.

Levels of Detail for Evaluation

Hazus provides default data for inventory, vulnerability, and hazards; these default data can be supplemented with local data to provide a more refined analysis. The model can carry out three levels of analysis, depending on the format and level of detail of information about the planning area:

- **Level 1**—All of the information needed to produce an estimate of losses is included in the software’s default data. These data are derived from national databases and describe in general terms the characteristic parameters of the planning area.
- **Level 2**—More accurate estimates of losses require more detailed information about the planning area. To produce Level 2 estimates of losses, detailed information is required about local geology, hydrology, hydraulics, and building inventory, as well as data about utilities and critical facilities. This information is needed in a GIS format.
- **Level 3**—This level of analysis generates the most accurate estimate of losses. It requires detailed engineering and geotechnical information to customize it for the planning area.

5.3 RISK ASSESSMENT APPROACH

The risk assessments in this plan describe the risks associated with each hazard of concern identified. The following steps were used to define the risk of each hazard:

- **Identify and profile each hazard**—The following information is given for each hazard:
  - Geographic areas most affected by the hazard
  - Event frequency estimates
  - Severity estimates
  - Warning time likely to be available for response.
- **Determine exposure to each hazard**—Exposure was assessed by overlaying hazard maps with an inventory of structures, facilities, and systems to decide which of them would be exposed to each hazard.
- **Assess the vulnerability of exposed facilities**—Vulnerability of exposed structures and infrastructure was evaluated by interpreting the probability of occurrence of each event and assessing structures, facilities, and systems that are exposed to each hazard. Tools such as GIS and FEMA's hazard-modeling program Hazus were used for this assessment for the dam failure, earthquake, and flood hazards. Outputs similar to those from Hazus were generated for other hazards, using data generated through GIS.

5.3.1 Earthquake, Dam Failure, and Flood

The following hazards were evaluated using Hazus:

- **Flood**—A Level 2 user-defined analysis was performed for general building stock in flood zones and for critical facilities and infrastructure. Current flood mapping for the planning area was used to delineate flood hazard areas and estimate potential losses from the 1-percent-annual-chance, 0.2-percent-annual-chance, and 10-percent-annual-chance flood events. To estimate damage that would result from a flood, Hazus uses pre-defined relationships between flood depth at a structure and resulting damage, with damage given as a percent of total replacement value. Curves defining these relationships have been developed for damage to structures and for damage to typical contents within a structure. By inputting flood depth data and known property replacement cost values, dollar-value estimates of damage were generated.
- **Dam Failure**—A Level 2 analysis was run using the flood methodology described above.
- **Earthquake**—A Level 2 analysis was performed to assess earthquake exposure and vulnerability for five scenario events:
  - A Magnitude-7.0 event on the Calaveras (North Central) Fault with an epicenter 0.7 miles south southwest of the Roundhouse Market & Conference Center in the City of San Ramon.
  - A Magnitude-6.8 event on the Concord-Green Valley Fault with an epicenter 20 miles north of the City of Martinez.
  - A Magnitude-7.0 event on the Greenville Fault with an epicenter 29 miles southeast of the City of San Ramon.
  - A Magnitude-7.05 event on the Hayward Fault (Haywired scenario) with an epicenter 3.5 miles southwest of the Town of Moraga.
  - A Magnitude-6.7 event on the Mount Diablo Fault with an epicenter 10.5 miles east of the Town of Danville.

5.3.2 Drought

The risk assessment methodologies used for this plan focus on damage to structures. The risk assessment for drought was more limited and qualitative than the assessment for the other hazards of concern because drought does not affect structures.

5.3.3 Landslide, Severe Weather, Wildfire

Historical datasets were not adequate to model future losses for most of the hazards of concern. However, areas and inventory susceptible to some of the hazards of concern were mapped by other means and exposure was evaluated. A qualitative analysis was conducted for other hazards using the best available data and professional judgment.

5.4 SOURCES OF DATA USED IN HAZUS MODELING

5.4.1 Building, Land Use and Cost Data

Replacement cost values and detailed structure information derived from parcel and tax assessor data provided by Contra Costa County were loaded into Hazus. When available, an updated inventory was used in place of the Hazus defaults for critical facilities and infrastructure. Land use areas were calculated using the County's parcel data and Hazus general occupancy classes.

Replacement cost is the cost to replace the entire structure with one of equal quality and utility. Replacement cost is based on industry-standard cost-estimation models published in *RS Means Square Foot Costs* (RS Means, 2017). It is calculated using the RS Means square foot cost for a structure, which is based on the Hazus occupancy class (i.e., multi-family residential or commercial retail trade), multiplied by the square footage of the structure from the tax assessor data. The construction class and number of stories for single-family residential structures also factor into determining the square foot costs.

5.4.2 Hazus Data Inputs

The following hazard datasets were used for the Hazus Level 2 analysis conducted for the risk assessment:

- **Flood**—The effective Digital Flood Insurance Rate Map (DFIRM) for the planning area was used to delineate flood hazard areas and estimate potential losses from the 1-percent-annual-chance, 0.2-percent-annual-chance, and 10-percent-annual-chance flood events. Using the DFIRM floodplain boundaries and base flood elevation information, and the U.S. Geological Survey's (USGS) 3-meter digital elevation model data, flood depth grids were generated and integrated into the Hazus model.
- **Dam Failure**—Dam inundation area data provided by the County and the USGS 3-meter digital elevation model were used to develop depth grids that were integrated into the Hazus model.
- **Earthquake**—Earthquake shake maps prepared by the USGS were used for the analysis of this hazard. A National Earthquake Hazard Reduction Program (NEHRP) soils map from the California Department of Conservation, the Association of Bay Area Governments' (ABAG) liquefaction susceptibility data, and the California Geological Survey's landslide susceptibility data were also integrated into the Hazus model.

5.4.3 Other Local Hazard Data

Locally relevant information on hazards was gathered from a variety of sources. Frequency and severity indicators include past events and the expert opinions of geologists, emergency management specialists, and others. Data sources for specific hazards were as follows:

- **Landslide**—Susceptibility to deep-seated landslide data were provided by the California Geological Survey. Areas categorized as moderate (susceptibility classes V and VI), high (classes VII, VIII, and IX), and very high (class X) were used in the exposure analysis.
- **Sea Level Rise**—Sea level rise data were provided by the San Francisco Bay Conservation and Development Commission (*Adapting to Rising Tides*). Sea level rise intervals of 12 inches, 52 inches (equivalent to 12 inches of sea level rise plus 100-year extreme tide), 66 inches, and 108 inches (equivalent to 66 inches of sea level rise plus 100-year extreme tide) were used for the exposure analysis.
- **Severe Storm**—No GIS format severe storm area datasets were identified for Contra Costa County.
- **Tsunami—**Tsunami inundation zones data were acquired from the California Department of Conservation.
- **Wildfire—**Fire severity data were acquired from the California Department of Forestry and Fire Protection (CAL FIRE).
- **Climate Change**—Climate change related projections, data and visualization tools were provided by Cal-Adapt, an online resource that provides information on how climate change might affect local communities in California, unless otherwise indicated. The data available on Cal-Adapt is from a variety of organizations in the scientific community and represents peer-reviewed science.

5.4.4 Data Source Summary

Table 5-1 summarizes the data sources used for the risk assessment for this plan.

5.5 LIMITATIONS

Loss estimates, exposure assessments, and hazard-specific vulnerability evaluations rely on the best available data and methodologies. Uncertainties are inherent in any loss estimation methodology and arise in part from incomplete scientific knowledge concerning natural hazards and their effects on the built environment. Uncertainties also result from the following:

- Approximations and simplifications necessary to conduct a study
- Incomplete or outdated inventory, demographic or economic parameter data
- The unique nature, geographic extent, and severity of each hazard
- Mitigation measures already employed
- The amount of advance notice residents have to prepare for a specific hazard event
- The uncertain spatial accuracy of the dam inundation area data.
- Lack of a standardized model for assessing sea level rise impacts. Multiple models provide multiple results. Not all models were run in the development of the sea level rise analysis.

These factors can affect loss estimates by a factor of two or more. Therefore, potential exposure and loss estimates are approximate and should be used only to understand relative risk. Over the long term, Contra Costa County will collect additional data to assist in estimating potential losses associated with other hazards.

Table 5-1. Risk Assessment Data Sources

Data	Source	Date	Format
Property parcel data including use code, year built, number of stories, and area	Contra Costa County	2017	Digital (GIS) format
Building replacement cost	RS Means	2017	Paper format
Demographic data	FEMA Hazus version 3.2 (U.S. Census)	2010	Digital (GIS and tabular) format
Flood hazard data	FEMA	2016	Digital (GIS) format
Earthquake shake maps	USGS Earthquake Hazards Program website	2012-2014	Digital (GIS) format
Liquefaction susceptibility	ABAG (from USGS)	2006	Digital (GIS) format
Susceptibility to deep-seated landslides	CA Geological Survey	2011	Digital (GIS) format
NEHRP soils	California Department of Conservation	2008	Digital (GIS) format
Dam inundation areas	Contra Costa County (from CA Office of Emergency Services)	Unknown	
Levee data	U.S. Army Corps of Engineers National Levee Database extract	2017	Digital (GIS) format
Sea-level rise data	San Francisco Bay Conservation and Development Commission (*Adapting to Rising Tides*)	2016	Digital (GIS) format
Tsunami inundation zones	California Department of Conservation	2009	Digital (GIS) format
Fire hazard severity zones	CAL FIRE	2008	Digital (GIS) format
National elevation data 3m	USGS	Unknown	Digital (GIS) format
Developable lands	Contra Costa County Department of Conservation & Development (Urban Limit Line Review: Preliminary Land Use Designations)	2016	Digital (GIS) format
Critical Facilities and Assets			
Emergency operation centers; fire stations; medical care facilities; police stations; schools; dams; hazardous material facilities; airports; bus facilities; highway bridges and tunnels; port facilities; railway bridges; communications facilities; electric power facilities; natural gas facilities; potable water facilities; wastewater facilities	2011 Contra Costa County Local Hazard Mitigation Plan data reviewed and updated by County OES	2011	Digital (GIS) format
Railway tunnels	FEMA Hazus version 3.2 Default Critical Facilities Data	2016	Digital (GIS) format
Fire stations	Contra Costa County	2017	Digital (GIS) format
Schools	Contra Costa County	2017	Digital (GIS) format
Rail stations	CA Department of Transportation	2013	Digital (GIS) format
Reclamation district levees	Contra Costa County	Unknown	Digital (GIS) format

6. DAM AND LEVEE FAILURE

6.1 GENERAL BACKGROUND

6.1.1 Dams

A dam is an artificial barrier that has the ability to store water, wastewater, or liquid-borne materials for many reasons—flood control, human water supply, irrigation, livestock water supply, energy generation, containment of mine tailings, recreation, or pollution control. Many dams fulfill a combination of these functions. They are an important resource in the United States (Association of State Dam Safety Officials, 2013).

Dams can be classified according to their purpose, the construction material or methods used, their slope or cross-section, the way they resist the force of the water pressure, or the means used for controlling seepage. Materials used to construct dams include earth, rock, tailings from mining or milling, concrete, masonry, steel, timber, plastic, rubber, and combinations of these.

More than a third of the country's dams are 50 or more years old. Approximately 14,000 of those dams pose a significant hazard to life and property if failure occurs. There are about 2,000 unsafe dams in the United States, located in almost every state.

Dam failures typically occur when spillway capacity is inadequate and excess flow overtops the dam, or when internal erosion (piping) through the dam or foundation occurs. Complete failure occurs if internal erosion or overtopping results in a complete structural breach, releasing a high-velocity wall of debris-filled water that rushes downstream, damaging anything in its path.

6.1.2 Levees

Levees are man-made structures, usually earthen embankments, designed and constructed to contain, control, or divert a flow of water in order to protect land from peak flood levels or to protect land that is below sea level.

DEFINITIONS

Dam—Any artificial barrier, together with appurtenant works, that does or may impound or divert water, and that either (a) is 25 feet or more in height from the natural bed of the stream or watercourse at the downstream toe of the barrier (or from the lowest elevation of the outside limit of the barrier if it is not across a stream channel or watercourse) to the maximum possible water storage elevation; or (b) has an impounding capacity of 50 acre-feet or more. (CA Water Code, Division 3.)

Dam Failure—An uncontrolled release of impounded water due to structural deficiencies in dam.

Levee—A man-made structure, usually an earthen embankment or concrete floodwall, designed and constructed to contain, control, or divert the flow of water.

Levee Failure (Breach)—When part of a levee breaks away, leaving a large opening for water to flood the land protected by the levee.

Emergency Action Plan—A formal document that identifies potential emergency conditions at a dam and specifies actions to be followed to minimize property damage and loss of life. The plan specifies actions the dam owner should take to alleviate problems at a dam. It contains procedures and information to assist the dam owner in issuing early warning and notification messages to responsible downstream emergency management authorities of the emergency situation. It also contains inundation maps to show emergency management authorities the critical areas for action in case of an emergency.

High Hazard Dam—Dams where failure or improper operation will probably cause loss of human life.

Significant Hazard Dam—Dams where failure or improper operation will result in no probable loss of human life but can cause economic loss, environmental damage or disruption of lifeline facilities, or can impact other concerns. Significant hazard dams are often located in rural or agricultural areas but could be located in areas with population and significant infrastructure.

The U.S. Army Corps of Engineers operates, maintains, and evaluates flood protection levees to determine if they meet accreditation requirements. Most levees are owned by local communities and flood control districts that must ensure proper operation and maintenance of the levee system as well (FEMA, 2013). Two types of levees are present in the San Joaquin-Sacramento River Delta area of Contra Costa County (2015-2016 Contra Costa County Grand Jury, 2016):

- Levees that are part of an authorized federal flood control project on the Sacramento-San Joaquin River Delta systems that deliver irrigation and drinking water are designated as “project” levees. The 385 miles of project levees are built to the highest level of flood protection standards, are maintained mainly by the County, and are inspected by the U.S. Army Corps of Engineers.
- All other levees in the Delta are “non-project” or “local” levees. These levees, totaling 730 miles in length, are maintained by local reclamation districts.

The non-project levees incorporate modern techniques and materials as the reclamation districts work to bring the old agricultural levees up to current standards. As land has subsided and sea levels have risen, a lot of the land behind these levees is now 10 to 15 feet below sea level, making the efforts of continual improvements essential to avoid overtopping and consequent flooding.

6.1.3 Causes of Dam Failure

Dam failures in the United States typically occur in one of four ways:

- Overtopping of the primary dam structure, which accounts for 34 percent of all dam failures, can occur due to inadequate spillway design, settlement of the dam crest, blockage of spillways, and other factors.
- Foundation defects due to differential settlement, slides, slope instability, uplift pressures, and foundation seepage can also cause dam failure. These account for 30 percent of all dam failures.
- Failure due to piping and seepage accounts for 20 percent of all failures. These are caused by internal erosion due to piping and seepage, erosion along hydraulic structures such as spillways, erosion due to animal burrows, and cracks in the dam structure.
- Failure due to problems with conduits and valves, typically caused by the piping of embankment material into conduits through joints or cracks, constitutes 10 percent of all failures.

The remaining 6 percent of U.S. dam failures are due to miscellaneous causes. Many dam failures in the United States have been secondary results of other disasters. The prominent causes are earthquakes, landslides, extreme storms, massive snowmelt, equipment malfunction, structural damage, foundation failures, and sabotage. The most likely disaster-related causes of dam failure in Contra Costa County are earthquakes, excessive rainfall, and landslides.

Poor construction, lack of maintenance and repair, and deficient operational procedures are preventable or correctable by a program of regular inspections. Terrorism and vandalism are serious concerns that all operators of public facilities must plan for; these threats are under continuous review by public safety agencies.

6.1.4 Causes of Levee Failure

A levee breach occurs when part of a levee gives way, creating an opening through which floodwaters may pass. A breach may occur gradually or suddenly. The most dangerous breaches happen quickly during periods of high water. The resulting torrent can quickly swamp a large area behind the failed levee with little or no warning. When a levee system fails or is overtopped, severe flood damage can occur due to increased water surface elevation associated with levees and the resulting increase in water velocity.

Earthen levees can be damaged in several ways. For instance, strong river currents and waves can erode the surface. Trees growing on a levee can blow over, leaving a hole where the root wad and soil used to be. Burrowing animals, such as the California ground squirrel, the salt marsh harvest mouse, or the western burrowing owl can create holes that enable water to pass through a levee. If severe enough, any of these situations can lead to a zone of weakness that could cause a levee breach. In seismically active areas, earthquakes and ground shaking can cause a loss of soil strength, weakening a levee and possibly resulting in failure. Seismic activity can also cause levees to slide or slump, both of which can lead to failure.

No levee provides protection from events for which it was not designed, and levees require maintenance to continue to provide the level of protection they were designed and built to offer. Maintenance responsibility belongs to a variety of entities including local, state, and federal government and private landowners. Well-maintained levees may obtain certification through independent inspections. Levees may not be certified for maintaining flood protection when the levee owner does not maintain the levee or pay for an independent inspection. The impacts of an un-certified levee include higher risk of levee failure. In addition, insurance rates may increase because FEMA identifies on Flood Insurance Rate Maps that the structures are not certified to protect from a 1-percent annual chance flood event (FEMA, 2004).

6.1.5 Regulatory Oversight

National Dam Safety Act

Potential for catastrophic flooding due to dam failures led to passage of the National Dam Safety Act (Public Law 92-367). The National Dam Safety Program requires a periodic engineering analysis of the majority of dams in the country; exceptions include the following:

- Dams under jurisdiction of the Bureau of Reclamation, Tennessee Valley Authority, or International Boundary and Water Commission
- Dams constructed pursuant to licenses issued under the Federal Power Act
- Dams that the Secretary of the Army determines do not pose any threat to human life or property.

The goal of this FEMA-monitored effort is to identify and mitigate the risk of dam failure so as to protect lives and property of the public. The National Dam Safety Program is a partnership among the states, federal agencies, and other stakeholders that encourages individual and community responsibility for dam safety. Under FEMA’s leadership, state assistance funds have allowed all participating states to improve their programs through increased inspections, emergency action planning, and purchases of needed equipment. FEMA has also expanded existing and initiated new training programs. Grant assistance from FEMA provides support for improvement of dam safety programs that regulate most of the dams in the United States.

California Division of Safety of Dams

California’s Division of Safety of Dams (a division of the DWR) monitors the dam safety program at the state level and maintains a working list of dams in the state. When a new dam is proposed, Division engineers and geologists inspect the site and the subsurface. Upon submittal of an application, the Division reviews the plans and specifications prepared by the owner to ensure that the dam is designed to meet minimum requirements and that the design is appropriate for the known geologic conditions. After approval of the application, the Division inspects all aspects of the construction to ensure that the work is done in accordance with the approved plans and specifications. After construction, the Division inspects each dam to ensure that it is performing as intended and is not developing problems. The Division periodically reviews the stability of dams and their major appurtenances in light of improved design approaches and requirements, as well as new findings regarding earthquake hazards and hydrologic estimates in California. Over 1,200 dams are inspected by Division engineers on a yearly schedule to ensure performance and maintenance of dams (California Division of Safety of Dams, 2017).

U.S. Army Corps of Engineers Dam Safety Program

The U.S. Army Corps of Engineers operates and maintains approximately 700 dams nationwide. It is also responsible for safety inspections of some federal and non-federal dams in the United States that meet the size and storage limitations specified in the National Dam Safety Act. The Corps has inventoried dams; surveyed each state and federal agency's capabilities, practices and regulations regarding design, construction, operation and maintenance of the dams; and developed guidelines for inspection and evaluation of dam safety. The Corps maintains the National Inventory of Dams, which contains information about a dam's location, size, purpose, type, last inspection and regulatory status (U.S. Army Corps of Engineers, 2017). Table 6-1 provides the most recent inspection dates for the dams in Contra Costa County.

Table 6-1. Contra Costa County Dam Inspection Dates

Dam Name	Inspection Date	Dam Name	Inspection Date
Antioch Red	05/04/2015	Mallard	12/17/2014
Argyle No.2	09/11/2014	Maloney	09/11/2014
Briones	10/16/2014	Marsh Creek	02/09/2015
CL Tilden Park	09/03/2014	Moraga	09/18/2014
Clearwell #2	07/21/2014	North	09/11/2014
Clifton Court Forebay	11/04/2014	Orinda Lake	06/04/2015
Contra Loma	10/10/2014	Pine Creek	02/09/2015
Danville	09/18/2014	Pine Creek Detention	02/09/2015
Deer Creek	02/09/2015	San Pablo	10/16/2014
Dry Creek	02/09/2015	San Pablo Clearwell	09/11/2014
Lafayette	10/16/2014	Sobrante Clearwell	09/11/2014
Leland	09/18/2014	Upper Sand Creek Det. Basin	02/09/2015
Los Vaqueros	12/17/2014	Vista Del Mar Detention Basin	05/26/2015

Source: U.S. Army Corps of Engineers, 2017

Federal Energy Regulatory Commission Dam Safety Program

The Federal Energy Regulatory Commission (FERC) cooperates with a large number of federal and state agencies to ensure and promote dam safety. More than 3,000 dams are part of regulated hydroelectric projects in the FERC program. Two-thirds of these are more than 50 years old. As dams age, concern about their safety and integrity grows, so oversight and regular inspection are important. FERC inspects hydroelectric projects on an unscheduled basis to investigate the following:

- Potential dam safety problems
- Complaints about constructing and operating a project
- Safety concerns related to natural disasters
- Issues concerning compliance with the terms and conditions of a license.

Every five years, an independent engineer approved by the FERC must inspect and evaluate projects with dams higher than 32.8 feet (10 meters), or with a total storage capacity of more than 2,000 acre-feet.

FERC monitors seismic research and applies it in performing structural analyses of hydroelectric projects. FERC also evaluates the effects of potential and actual large floods on the safety of dams. During and following floods, FERC visits dams and licensed projects, determines the extent of damage, if any, and directs any necessary studies or remedial measures the licensee must undertake. The FERC publication *Engineering Guidelines for the Evaluation of Hydropower Projects* guides the FERC engineering staff and licensees in evaluating dam safety. The publication is frequently revised to reflect current information and methodologies.

FERC requires licensees to prepare emergency action plans and conducts training sessions on how to develop and test these plans. The plans outline an early warning system if there is an actual or potential sudden release of water from a dam due to failure. The plans include operational procedures that may be used, such as reducing reservoir levels and reducing downstream flows, as well as procedures for notifying affected residents and agencies responsible for emergency management. These plans are frequently updated and tested to ensure that everyone knows what to do in emergency situations.

Corps of Engineers and FEMA Levee Oversight

The Corps and FEMA have differing roles and responsibilities related to levees. The Corps addresses operation and maintenance, risk communication, risk management, and risk reduction issues as part of its responsibilities under the Levee Safety Program. FEMA addresses mapping and floodplain management issues related to levees, and it accredits levees as meeting requirements set forth by the National Flood Insurance Program.

Depending on the levee system, the Corps and FEMA may be involved with a levee sponsor and community independently or jointly. The two agencies' long-term goals are similar: to reduce risk and lessen the devastating consequences of flooding. Corps and FEMA partnering activities related to levees include the following:

- Joint meetings with levee sponsors and other stakeholders
- Integration of levee information into the National Levee Database
- State Silver Jackets teams
- Sharing of levee information
- Targeted task forces to improve program alignment.

Coordination between the Corps and FEMA on levees is now standard within many of each agency's policies and practices. Over the past several years, both agencies coordinated policies where appropriate; jointly participated in meetings with stakeholders; and participated in many multiagency efforts, such as the National Committee on Levee Safety, the Federal Interagency Floodplain Management Task Force, and the Silver Jackets Program, which brings together state, federal, tribal, and local agencies to learn from each other and apply their knowledge to reduce risk from hazards.

National Committee on Levee Safety

Congress created the National Committee on Levee Safety—made up of representatives from state, regional, and local agencies; the private sector; the Corps; and FEMA—to develop a national levee safety program. The Committee has been working toward this goal since October 2008 (National Committee on Levee Safety, 2010).

California DWR Levee Repair Program

California initiated the levee repair program in 2006 after a state of emergency was declared for heavy rainfall and runoff and California's levee system was compromised. The emergency declaration allowed for $500 million of state funds to repair and evaluate state and federal levees. The project evaluated the stability of the levee system and implemented critically needed repairs (California DWR, 2017).

Contra Costa County Grand Jury Report 1607, 2015-2016

The 2015-2016 Contra Costa County Grand Jury conducted an investigation into the Delta levees in the County. The Grand Jury's report (*Delta Levees in Contra Costa Country; How Well Do We Protect This Vital Safety System?*) recommends focusing on three major areas: sharing of resources and knowledge among reclamation districts, education of district residents about the reasons for levee rules and regulations, and increased involvement and participation by entities that benefit from the protection afforded by the levee system.

6.2 HAZARD PROFILE

6.2.1 Past Events

Dams

According to the 2013 *State of California Multi-Hazard Mitigation Plan*, there have been nine failures of federally regulated dams in the state since 1950, none of them in the planning area. Overtopping caused two of the nine dam failures in the state, and the others were caused by seepage or leaks. The most catastrophic event was the failure of the St. Francis Dam in Los Angeles County, which failed in 1928 and killed an estimated 450 people. San Francisquito Canyon, which was flooded in the event, was home to hundreds of transients who were not accounted for in the death estimate. a more recent failure, the 1963 Baldwin Hills Dam Failure (Los Angeles County), resulted in three deaths when a leak turned into a washout.

The state's most recent dam emergency occurred in February 2017 when the Oroville Dam in Butte County was on the verge of overflow. The dam's concrete spillway was damaged by erosion and a massive hole developed. The auxiliary spillway was used to prevent overtopping of the dam, and it experienced erosion problems also. Evacuation orders were issued in advance of a potential large uncontrolled release of water from Lake Oroville, but such a release did not occur.

California has had about 45 failures of non-federal dams. The failures occurred for a variety of reasons, the most common being overtopping. Other reasons include shortcomings in the dams or an inadequate assessment of surrounding geomorphologic characteristics.

Levees

Two recent notable levee failures have been recorded in the San Joaquin-Sacramento River Delta:

- August 2009 Levee Breach at Bradford Island—A bulk carrier ship was outbound from the Port of Stockton when it grounded, lost steering, and hit the levee at Bradford Island. The collision damaged approximately 150 feet of levee, causing a serious breach. It was quickly repaired, avoiding a much larger problem of jeopardized drinking water quality for 23 million people.
- June 2004 Levee Breach on Jones Tract—The Jones Tract is located in the San Joaquin County portion of the Delta, adjacent to Contra Costa County.

6.2.2 Location

According to the Corps' National Inventory of Dams, there are 27 dams in Contra Costa County (see Table 6-2), and another six dams outside the County that have inundation areas within the County (see Table 6-3). Six of these dams are operated by federal agencies, and the remainder are under the jurisdiction of the state. The Fay Hill Reservoir Dam, another dam located within the county, is not on the Corps' inventory or on the California DWR list. The Fay Hill Reservoir Dam inundation area is included in the dam exposure combined inundation area used for this hazard mitigation plan. Inundation mapping was conducted as part of the risk assessment; however, these maps are not included in the plan for security reasons.

The U.S. Army Corps of Engineer's National Levee Database lists 17 project levees in the County, all of which are included in the Corps' levee program (Table 6-4). An additional 18 non-project levees owned by reclamation districts in the County are listed in Table 6-5. Levee locations are shown on Figure 6-1.

Table 6-2. Dams in Contra Costa County

Name	National ID #	Hazard Class[a]	Water Course	Owner	Year Built	Dam Type	Crest Length (feet)	Height (feet)	Storage Capacity (acre-feet)	Drainage area (sq. mi.)
Martinez	CA10168	H	Sacramento R. Tributary	US Bureau of Reclamation	1947	Earth	1260	44	268	72
Contra Loma	CA10143	H	San Joaquin River OS	US Bureau of Reclamation	1967	Earth	360	25	2,630	107
Antioch Res	CA00057	H	San Joaquin Tributary	City of Antioch	1935	Earth	450	30	722	1.68
Argyle #2	CA00186	H	Off-stream	EBMUD	1970	Reinforced Tank	875	27	22	0
Briones	CA00172	H	Bear Creek	EBMUD	1964	Earth	2100	273	67,520	
CL Tilden Park	CA00161	H	Wildcat Creek	EBRPD	1938	Earth	355	88	268	1.56
Clearwell #2	CA01109	S	Grayson Creek	Contra Costa Sanitation Dist.	1977	Earth	2090	30	100	0
Clifton Court Forebay	CA00050	L	Old River Tributary	CA Dept. of Water Res	1970	Earth	39000	34	29,000	6
Danville	CA00184	H	Off-stream	EBMUD	1961	Earth	765	75	45	0
Deer Creek	CA00810	S	Deer Creek	Contra Costa FCWCD	1963	Earth	900	28	233	4.86
Dry Creek	CA00811	S	Dry Creek	Contra Costa FCWCD	1963	Earth	470	30	330	2.7
Lafayette	CA00163	H	Lafayette Creek	EBMUD	1929	Earth	1200	132	4250	1.34
Leland	CA00177	S	Off-stream	EBMUD	1955	Earth	945	41	60	0
Los Vaqueros	CA01396	H	Kellogg Creek	Contra Costa Water District	1997	Earth	980	197	100,000	18.38
Mallard	CA00838	S	Off-stream	Contra Costa Water District	1930	Earth	11,000	30	3113	0
Maloney	CA00180	H	Off-stream	EBMUD	1960	Earth	620	107	68	0
Marsh Creek	CA00809	H	Marsh Creek	Contra Costa FCWCD	1963	Earth	1540	59	4425	52.5
Moraga	CA00178	H	Off-stream	EBMUD	1965	Earth	210	37	36	0
North	CA00183	H	Off-stream	EBMUD	1961	Earth	1080	82	244	0.09
Orinda Lake	CA00659	H	Cascade Creek	Orinda Country Club	1936	Earth	360	45	200	0.48
Pine Creek	CA00808	H	Pine Creek	Contra Costa FCWCD	1956	Earth	320	87	225	4.36
Pine Creek Detention	CA01252	S	Pine Creek	Contra Costa FCWCD	1981	Gravity	232	30	320	10
San Pablo	CA00166	H	San Pablo Creek	EBMUD	1920	Earth	1250	170	43,193	32.15
San Pablo Clearwell	CA00185	H	Off-stream	EBMUD	1922	Earth	627	42	17	0
Sobrante Clearwell	CA00179	H	Off-stream	EBMUD	1964	Earth	1032	28	25	0

Name	National ID #	Hazard Class[a]	Water Course	Owner	Year Built	Dam Type	Crest Length (feet)	Height (feet)	Storage Capacity (acre-feet)	Drainage area (sq. mi.)
Upper Sand Creek Detention Basin	CA01555	U	Sand Creek	Contra Costa FCWCD	2015	Earth	1,400	40	895	9.75
Vista Del Mar Detention Basin	CA01489	U	Suisun Bay	Private Entity	2011	Earth	552	42	33	4

a. Hazard Class: H = High, S = Significant, L = Low, U = Unknown
EBMUD—East Bay Municipal Utility District
EBRPD—East Bay Regional Park District
FCWCD—Flood Control and Water Conservation District
Source: U.S. Army Corps of Engineers, 2017

Table 6-3. Dams Outside Contra Costa County with Inundation Area Extending to the County

Name	National ID #	Hazard Class[a]	Water Course	Owner	Year Built	Dam Type	Crest Length (feet)	Height (feet)	Storage Capacity (acre-feet)	Drainage area (sq. mi.)
Exchequer Main	CA00240	H	Merced River	Merced Irrigation District	1966	Rock fill	1,220	490	1,100,000	1,037
New Hogan	CA10109	H	Calaveras River	Corps of Engineers Sacramento District	1963	Rock fill	1,960	210	317,100	363
New Melones	CA10246	H	Stanislaus River	US Bureau of Reclamation	1979	Rock fill	1,560	625	2,870,000	897
Pine Flat	CA10112	H	Kings River	Corps of Engineers Sacramento District	1947	Concrete	1,840	440	1,000,000	1,542
San Luis Reservoir (B.F. Sisk)	CA10183	H	San Luis Creek and man-made aqueducts	US Bureau of Reclamation	1963	Earth	18,600	305	2,094,900	83
Summit	CA00171	H	Trail Wildcat Creek	EBMUD	1891	Rock fill	675	61	117	.03

a. Hazard Class: H = High, S = Significant, L = Low, U = Unknown
EBMUD—East Bay Municipal Utility District
Source: U.S. Army Corps of Engineers, 2017

Table 6-4. Project Levees in Contra Costa County

Levee Name	Levee Owner	Segment Length (miles)	Corps Program Levee
Wildcat Creek – right bank	Contra Costa County Public Works	.86	Yes
Wildcat Creek – left bank	Contra Costa County Public Works	.29	Yes
Walnut Creek and Pacheco Creek – right bank	Contra Costa County FCWCD	1.74	Yes
Walnut Creek and Pacheco Creek – left bank	Contra Costa County FCWCD	1.86	Yes
Walnut Creek and Grayson Creek – right bank	Contra Costa County FCWCD	2.88	Yes
Walnut Creek and Grayson Creek – left bank	Contra Costa County FCWCD	1.49	Yes
Walnut Creek and Clayton Valley Drain – right bank	Contra Costa County FCWCD	.56	Yes
Walnut Creek and Clayton Valley Drain – left bank	Contra Costa County FCWCD	1.68	Yes
San Pablo Creek – right bank	Contra Costa County Public Works	1	Yes
San Pablo Creek – left bank	Contra Costa County Public Works	.92	Yes
Rodeo Creek – right bank	Contra Costa County Public Works	.19	Yes
Rodeo Creek – left bank	Contra Costa County Public Works	.25	Yes
Rheem Creek – right bank	Contra Costa County Public Works	.46	Yes
Rheem Creek – left bank	Contra Costa County Public Works	.47	Yes
RD 0800 – Byron Tract	RD 0800 – Byron Tract	8.9	Yes
Pinole Creek – right bank	Contra Costa County Public Works	.35	Yes
Pinole Creek – left bank	Contra Costa County Public Works	.41	Yes

Source: U.S. Army Corps of Engineers, 2017a

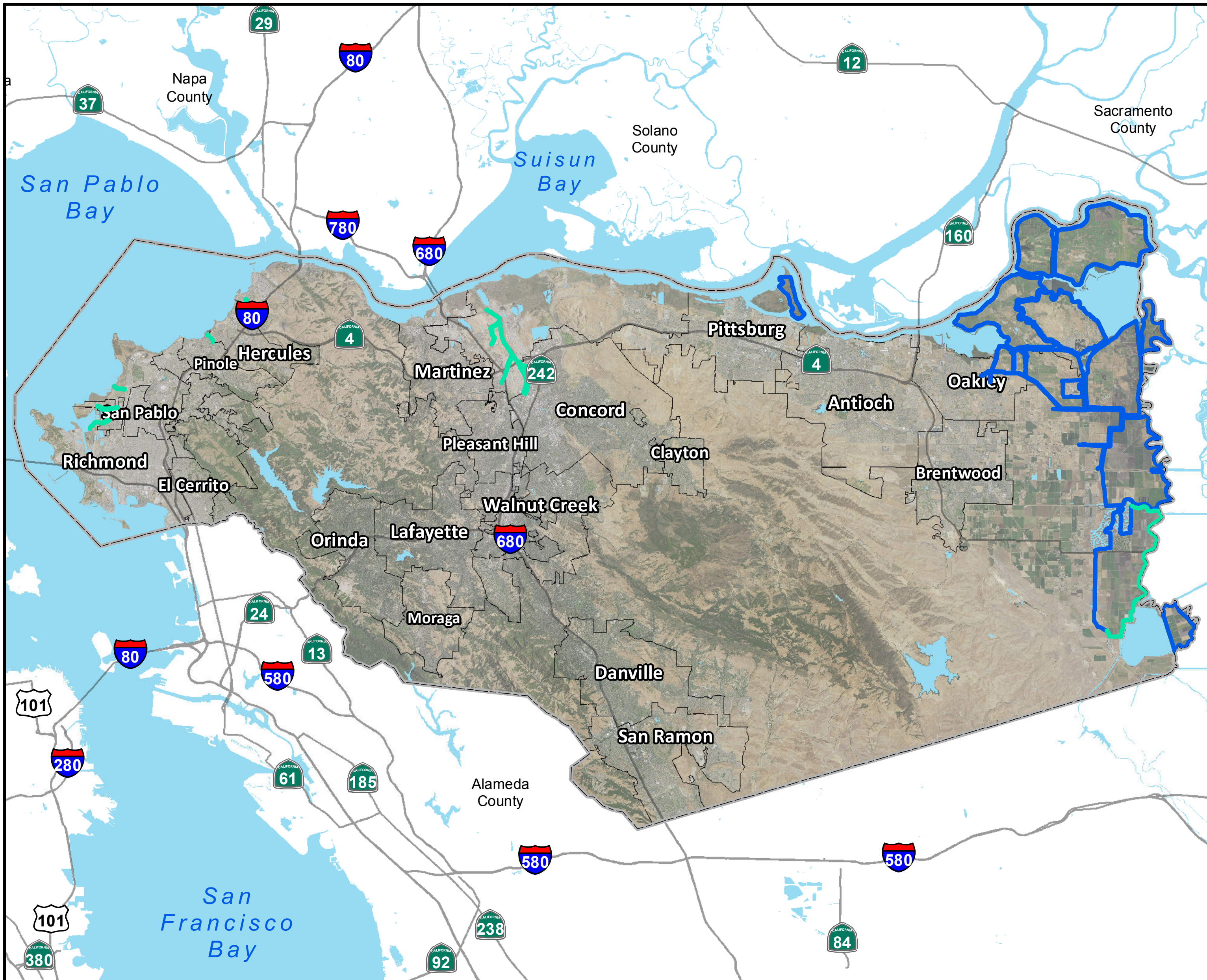
Table 6-5. Non-Project Reclamation District Levees in Contra Costa County

Levee Name	Segment Length (miles)
2121	2.04
Bethel Island	11.62
Bradford Island	7.41
Byron Tract / Disco Bay	9.40
Coney Island	5.49
Contra Costa Canal	8.15
Cypress Corridor	3.82
Cypress Flood Control	1.32
Cypress Flood Control	1.88
Holland Tract	10.97
Hotchkiss Tract	6.91
Jersey Island	15.52
Palm Tract / Orwood Tract	14.42
Quimby Island	7.02
Summer Lake	3.10
Veale Tract	6.01
Webb Tract	12.96
Winter Island	4.77

Source: Contra Costa County Department of Conservation & Development draft levee shapefile

Contra Costa County

Figure 6-1. Levees in the Planning Area



Project Levees (Corps of Engineers)

Non-Project Levees (Reclamation Districts)

Contra Costa County Boundary

City Boundaries

Water Bodies & Channels

Map Data Sources: Contra Costa County, Caltrans, US Army Corps of Engineers, USDA

0 2.5 5 10

Miles

N W E S

TETRA TECH

6.2.3 Frequency

Dam failure events are infrequent and usually coincide with events that cause them, such as earthquakes, landslides and excessive rainfall and snowmelt. There is a “residual risk” associated with dams that remains after safeguards have been implemented. The residual risk is associated with events beyond those that the facility was designed to withstand. However, the probability of dam failure is low in today’s regulatory environment.

Levee failure probabilities are considered to be higher than dam failure probabilities because levees are often exposed to more adverse conditions associated with high velocity flood flows, such as erosion and scour. Many levees are designed to overtop in high flow conditions; such overtopping is referred to as design failure.

6.2.4 Severity

Dam failure can be catastrophic to all life and property downstream. The U.S. Army Corps of Engineers developed the classification system shown in Table 6-6 for the hazard potential of dam failures.

Table 6-6. Corps of Engineers Hazard Potential Classification

Hazard Category[a]	Direct Loss of Life[b]	Lifeline Losses[c]	Property Losses[d]	Environmental Losses[e]
Low	None (rural location, no permanent structures for human habitation)	No disruption of services (cosmetic or rapidly repairable damage)	Private agricultural lands, equipment, and isolated buildings	Minimal incremental damage
Significant	Rural location, only transient or day-use facilities	Disruption of essential facilities and access	Major public and private facilities	Major mitigation required
High	Certain (one or more) extensive residential, commercial, or industrial development	Disruption of essential facilities and access	Extensive public and private facilities	Extensive mitigation cost or impossible to mitigate

a. Categories are assigned to overall projects, not individual structures at a project.
b. Loss of life potential based on inundation mapping of area downstream of the project. Analyses of loss of life potential should take into account the population at risk, time of flood wave travel, and warning time.
c. Indirect threats to life caused by the interruption of lifeline services due to project failure or operational disruption; for example, loss of critical medical facilities or access to them.
d. Damage to project facilities and downstream property and indirect impact due to loss of project services, such as impact due to loss of a dam and navigation pool, or impact due to loss of water or power supply.
e. Environmental impact downstream caused by the incremental flood wave produced by the project failure, beyond what would normally be expected for the magnitude flood event under which the failure occurs.

Source: U.S. Army Corps of Engineers, 1995

In the event of a levee failure, floodwaters may ultimately inundate the protected area landward of the levee. The extent of inundation is dependent on the flooding intensity. Failure of a levee during a 1-percent annual chance flood will inundate the 100-year floodplain previously protected by the levee. Residential and commercial buildings nearest the levee overtopping or breach location will suffer the most damage from the initial embankment failure flood wave. Landward buildings will be damaged by inundation.

6.2.5 Warning Time

Warning time for dam failure varies depending on the cause of the failure. In events of extreme precipitation or massive snowmelt, evacuations can be planned with sufficient time. In the event of a structural failure due to earthquake, there may be no warning time. A dam’s structural type also affects warning time. Earthen dams do not tend to fail completely or instantaneously. Once a breach is initiated, discharging water erodes the breach until either the reservoir water is depleted or the breach resists further erosion. Concrete gravity dams also tend to have a partial breach as one or more monolith sections are forced apart by escaping water. The time of breach formation ranges from a few minutes to a few hours.

Contra Costa County and its planning partners have established protocols for flood warning and response to imminent dam failure in the flood warning portion of its adopted emergency operations plan. These protocols are tied to the emergency action plans created by the dam owners.

Warning time for levee failures depends on the cause of the failure. A levee failure caused by structural failure can be sudden and occur with little to no warning. If heavy rains are impacting a levee system, communities located in the immediate danger zone can be evacuated before a failure occurs. If the levee failure is caused by overtopping, the community may or may not be able to recognize the impending failure and evacuate. If a levee failure occurs suddenly, evacuation may not be possible.

6.3 SECONDARY HAZARDS

Dam and levee failure can cause severe downstream flooding, depending on the magnitude of the failure. Other potential secondary hazards are landslides, bank erosion, and destruction of downstream habitat. Levee failures can also cause environmental incidents due to hazardous materials releases when floodwaters infiltrate facilities that store these types of materials.

6.4 EXPOSURE

Exposure to dam failure hazard was assessed by use of spatial analysis. The inundation areas for the following dams, for which inundation mapping was available, were combined into a single inundation area:

- Antioch Municipal Reservoir
- Anza Lake (CL Tilden)
- Argyle #2 Reservoir
- Bethany Reservoir
- Briones Reservoir
- Clifton Court Forebay
- Contra Loma Reservoir
- Danville Reservoir
- Deer Creek Detention Basin
- Dry Creek Detention Basin
- EBMUD San Pablo Water Treatment Plant Clearwell
- EBMUD Sobrante Water Treatment Plant Clearwell
- EBMUD Walnut Creek Water Treatment Plant Clearwell
- Fay Hill Reservoir
- Lafayette Reservoir
- Lake Cascade (Lake Orinda Dam)
- Lake McClure (New Exchequer)
- Leland Reservoir
- Los Vaqueros Reservoir
- Maloney Reservoir
- Marsh Creek Reservoir
- Martinez Reservoir
- Moraga Reservoir
- New Hogan Reservoir
- New Melones Lake
- North Reservoir
- Pine Creek Reservoir Dam
- Pine Flat Reservoir
- San Luis Reservoir
- San Pablo Reservoir
- Schapiro Reservoir
- Summit Reservoir.

This combined inundation area was overlaid with planning area general building stock and critical facility databases. The Hazus flood module was used to assess dam failure. Hazus uses census data at the block level, which has a level of accuracy acceptable for planning purposes. Where possible, the Hazus default data was enhanced using GIS data from local, state and federal sources.

6.4.1 Population

All residents in a dam failure inundation zone would be exposed to the risk of a dam failure. The potential for loss of life is affected by the capacity and number of evacuation routes available to those living in potential inundation areas. The estimated population living in the mapped inundation areas within the planning area is 173,776 or 15.5 percent of the total planning-area population. Table 6-7 summarizes the at-risk population in the planning area.

Table 6-7. Population Living in the Combined Dam Failure Inundation Area

Jurisdiction	Affected Population	% of City Population
Antioch	6,698	5.9%
Brentwood	5,548	9.4%
Clayton	0	0.0%
Concord	18,241	14.1%
Danville	888	2.1%
El Cerrito	1,074	4.4%
Hercules	75	0.3%
Lafayette	2,808	11.3%
Martinez	363	1.0%
Moraga	473	2.9%
Oakley	5,046	12.6%
Orinda	11	0.1%
Pinole	2,300	12.3%
Pittsburg	2,545	3.8%
Pleasant Hill	1,641	4.8%
Richmond	41,192	37.3%
San Pablo	27,179	88.2%
San Ramon	0	0.0%
Walnut Creek	13,342	19.1%
Unincorporated	44,352	25.9%
Total	173,776	15.5%

6.4.2 Property

Buildings in the Combined Dam Inundation Areas

Based on assessor parcel data, the Hazus model estimated that there are 51,760 structures within the combined dam failure inundation area. The value of exposed buildings in the planning area was generated using Hazus as summarized in Table 6-8. This methodology estimated $44 billion worth of building-and-contents exposure to dam failure inundation, representing 18 percent of the total replacement value of the planning area.

Land Use in the Combined Dam Inundation Areas

Table 6-9 shows the general land use of parcels in the combined dam failure inundation area. The predominant use is the combined category of vacant, rights-of-way, open water and open space.

6.4.3 Critical Facilities

GIS analysis identified 367 critical facilities and infrastructure—22 percent of the planning area total—in the mapped inundation areas, as summarized in Table 6-10 and Table 6-11.

6.4.4 Environment

The environment would be exposed to a number of risks in the event of dam failure. The inundation could introduce many foreign elements into local waterways. This could result in destruction of downstream habitat and could have detrimental effects on many species of animals, especially endangered species such as salmon.

Table 6-8. Exposure and Value of Structures in Combined Dam Failure Inundation Areas

Jurisdiction	Number of Buildings Exposed	Value Exposed			Exposed Value as % of Total Replacement Value
		Structure	Contents	Total	
Antioch	1,897	$713,124,281	$497,604,358	$1,210,728,639	5.9%
Brentwood	1,721	$526,105,150	$303,943,373	$830,048,523	6.8%
Clayton	0	$0	$0	$0	0.0%
Concord	5,357	$3,046,124,316	$2,437,304,588	$5,483,428,904	21.0%
Danville	426	$271,367,475	$223,686,564	$495,054,039	4.8%
El Cerrito	397	$273,969,582	$209,475,086	$483,444,668	8.8%
Hercules	25	$6,739,481	$3,369,740	$10,109,221	0.2%
Lafayette	1,035	$633,588,432	$469,434,746	$1,103,023,178	16.9%
Martinez	278	$292,826,385	$274,562,383	$567,388,768	6.4%
Moraga	181	$256,244,857	$222,641,528	$478,886,386	12.2%
Oakley	1,434	$508,132,738	$288,109,893	$796,242,631	13.1%
Orinda	7	$62,602,425	$62,161,996	$124,764,420	2.6%
Pinole	787	$215,511,371	$129,099,150	$344,610,521	8.9%
Pittsburg	694	$313,635,802	$292,303,907	$605,939,709	5.0%
Pleasant Hill	572	$429,423,455	$357,807,668	$787,231,123	9.9%
Richmond	11,348	$5,340,007,489	$4,841,138,246	$10,181,145,735	38.3%
San Pablo	5,817	$2,315,949,730	$1,704,149,111	$4,020,098,840	89.0%
San Ramon	0	$0	$0	$0	0.0%
Walnut Creek	5,365	$2,522,395,760	$1,874,084,467	$4,396,480,227	22.8%
Unincorporated	14,419	$6,996,323,378	$5,433,649,205	$12,429,972,583	30.4%
Total	51,760	$24,724,072,106	$19,624,526,007	$44,348,598,113	18.0%

Table 6-9. Land Use Within the Combined Dam Inundation Areas

Type of Land Use	Area (acres)	% of total
Residential	9,193	9.6%
Commercial	3,193	3.3%
Industrial	3,819	4.0%
Agriculture	10,163	10.7%
Religion	159	0.2%
Government	4,698	4.9%
Education	543	0.6%
Vacant, Rights-of-way, Open water, Open space	63,601	66.7%
Total	95,369	100%

Table 6-10. Critical Facilities in Dam Failure Inundation Areas

Jurisdiction	Number of Facilities in Dam Failure Inundation Areas					
	Medical and Health	Government Functions	Protective Functions	Schools	Hazmat	**Total**
Antioch	0	1	0	1	1	3
Brentwood	0	1	1	2	0	4
Clayton	0	0	0	0	0	0
Concord	3	0	6	7	0	16
Danville	0	0	0	0	0	0
El Cerrito	0	0	0	0	0	0
Hercules	0	0	0	0	0	0
Lafayette	0	0	0	4	0	4
Martinez	0	0	4	2	1	7
Moraga	0	0	0	1	0	1
Oakley	0	0	1	1	0	2
Orinda	0	0	0	1	0	1
Pinole	0	0	0	0	0	0
Pittsburg	0	0	0	0	2	2
Pleasant Hill	0	0	2	2	0	4
Richmond	2	0	7	23	8	40
San Pablo	1	0	2	10	1	14
San Ramon	0	0	0	0	0	0
Walnut Creek	0	0	3	5	0	8
Unincorporated	1	0	9	19	7	36
Total	7	2	35	78	20	142

Table 6-11. Critical Infrastructure in Dam Failure Inundation Areas

Jurisdiction	Number of Facilities in Dam Failure Inundation Areas							
	Bridges	Water Supply	Wastewater	Power	Communications	Other Critical Functions	Other Critical Infrastructure	Total
Antioch	4	2	1	0	2	2	1	12
Brentwood	5	0	0	0	2	0	0	7
Clayton	0	0	0	0	0	0	0	0
Concord	15	4	0	2	5	0	5	31
Danville	0	0	0	0	1	0	1	2
El Cerrito	0	0	0	0	0	0	0	0
Hercules	0	0	0	0	0	0	0	0
Lafayette	6	2	0	0	1	0	2	11
Martinez	5	1	2	1	1	1	5	16
Moraga	0	0	0	0	0	0	0	0
Oakley	2	1	0	0	0	0	0	3
Orinda	1	1	3	1	0	0	0	6
Pinole	0	0	1	0	0	0	0	1
Pittsburg	0	0	1	3	0	2	0	6
Pleasant Hill	0	0	0	0	0	0	0	0
Richmond	8	0	3	3	0	2	1	17
San Pablo	7	0	0	1	0	0	0	8
San Ramon	0	0	0	0	0	0	0	0
Walnut Creek	17	2	0	2	0	0	3	24
Unincorporated	36	13	10	1	9	2	10	81
Total	106	26	21	14	21	9	28	225

6.5 VULNERABILITY

6.5.1 Population

Vulnerable populations are all populations downstream from dam failures that are incapable of escaping the area within the allowable time frame. This population includes the elderly and young who may be unable to get themselves out of the inundation area. The vulnerable population also includes those who would not have adequate warning from a television or radio emergency warning system.

6.5.2 Property

Vulnerable properties are those closest to the dam inundation area. These properties would experience the largest, most destructive surge of water. Low-lying areas are also vulnerable since they are where the dam waters would collect. Transportation routes are vulnerable to dam inundation and have the potential to be wiped out, creating isolation issues. This includes all roads, railroads and bridges in the path of the dam inundation. Those that are most vulnerable are those that are already in poor condition and would not be able to withstand a large water surge. Utilities such as overhead power lines, cable and phone lines could also be vulnerable. Loss of these utilities could create additional isolation issues for the inundation areas.

The estimated total loss due to property damage in the combined dam failure inundation area is $11 billion. This represents 18 percent of the total structure exposure in the inundation area, and 4.8 percent of the estimated replacement value of the entire planning area. Table 6-12 summarizes the loss estimates for dam failure.

Table 6-12. Loss Estimates for Dam Failure

Jurisdiction	Estimated Loss Associated with Dam Failure			Estimated Loss as % of Total Replacement Value
	Structure	Contents	Total	
Antioch	$112,242,906	$95,825,009	$208,067,915	1.0%
Brentwood	$12,432,080	$30,800,492	$43,232,572	0.4%
Clayton	$0	$0	$0	0.0%
Concord	$110,891,208	$144,694,578	$255,585,786	1.0%
Danville	$21,588,700	$25,399,605	$46,988,305	0.5%
El Cerrito	$31,370,989	$25,296,147	$56,667,136	1.0%
Hercules	$284,647	$164,374	$449,021	0.0%
Lafayette	$208,538,341	$247,919,207	$456,457,547	7.0%
Martinez	$110,789,529	$168,562,925	$279,352,453	3.1%
Moraga	$50,769,558	$92,248,002	$143,017,560	3.6%
Oakley	$156,061,974	$91,566,217	$247,628,191	4.1%
Orinda	$15,438,850	$29,806,399	$45,245,249	1.0%
Pinole	$92,394,486	$63,476,793	$155,871,280	4.0%
Pittsburg	$33,225,923	$44,095,402	$77,321,325	0.6%
Pleasant Hill	$8,874,626	$13,797,322	$22,671,948	0.3%
Richmond	$1,239,446,088	$1,621,161,809	$2,860,607,896	10.8%
San Pablo	$1,447,129,932	$1,277,359,673	$2,724,489,605	60.3%
San Ramon	$0	$0	$0	0.0%
Walnut Creek	$285,351,857	$421,884,614	$707,236,471	3.7%
Unincorporated	$1,940,090,602	$1,494,673,842	$3,434,764,444	8.4%
Total	$5,876,922,293	$5,888,732,410	$11,765,654,704	4.8%

6.5.3 Critical Facilities

Hazus was used to estimate the loss potential to critical facilities exposed to the dam failure risk. Using depth/damage function curves, it estimated the percent of damage to the building and contents of critical facilities. The results are shown in Table 6-13. On average, critical facilities would receive 45 percent damage to the structure and 80 percent damage to the contents during the modeled dam failure event.

Table 6-13. Estimated Damage to Critical Facilities and Infrastructure from the Modeled Dam Failure

Types of Critical Facilities and Infrastructure	Number of Facilities Affected	Average % of Total Value Damaged	
		Structure	Content
Protective Functions	26	50.72	87.76
Government	1	42.66	100.00
Schools & Educational Facilities	57	56.23	82.88
Medical Facilities	6	31.17	70.06
Power	6	54.61	75.89
Communication	7	66.50	96.00
Hazardous Materials	8	50.26	68.51
Water Supply	16	35.64	N/A
Wastewater	17	39.54	N/A
Bridges	80	0.94	N/A
Other Critical Functions	5	72.41	57.69
Other Critical Infrastructure	16	37.57	N/A
Total/Average	245	44.85	79.85

6.5.4 Environment

The environment would be vulnerable to a number of risks in the event of dam failure. The inundation could introduce foreign elements into local waterways, resulting in destruction of downstream habitat and detrimental effects on many species of animals, especially endangered species such as coho salmon. The extent of the vulnerability of the environment is the same as the exposure of the environment.

6.6 FUTURE TRENDS IN DEVELOPMENT

Land use in the planning area will be directed by general plans adopted under state law. The safety elements of the general plans establish standards and plans for the protection of the community from hazards. Dam failure is currently not addressed as a standalone hazard in the safety elements, but flooding is. Municipalities participating in this plan have established comprehensive policies regarding sound land use in identified flood hazard areas. Most of the areas vulnerable to the more severe impacts from dam failure intersect the mapped flood hazard areas. Flood-related policies in the general plans will help to reduce the risk associated with the dam failure hazard for all future development in the planning area. Table 6-14 summarizes developable land by land use in the dam failure inundation zone.

Table 6-14. Developable Land in the Dam Failure Inundation Zone

	Area of Developable Land in the Dam Failure Inundation Zone (acres)	% of Total Developable Land in the Dam Failure Inundation Zone
Residential	1,730.7	65.5%
Commercial-Industrial	798.5	30.2%
Mixed Use	113.3	4.3%
Total	2,642.5	100.0%

Source: Contra Costa County, 2016.

6.7 SCENARIO

An earthquake in the region could lead to liquefaction of soils around a dam. This could occur without warning during any time of the day. A human-caused failure such as a terrorist attack also could trigger a catastrophic failure of a dam that impacts the planning area. While the probability of dam failure is very low, the probability of flooding associated with changes to dam operational parameters in response to climate change is higher. Dam designs and operations are developed based on hydrographs with historical record. If these hydrographs experience significant changes over time due to the impacts of climate change, the design and operations may no longer be valid for the changed condition. This could have significant impacts on dams that provide flood control. Specified release rates and impound thresholds may have to be changed. This would result in increased discharges downstream of these facilities, thus increasing the probability and severity of flooding.

6.8 ISSUES

The most significant issue associated with dam and levee failure involves the properties and populations in the inundation zones. Flooding as a result of a dam or levee failure would significantly impact these areas. There is often limited warning time for dam or levee failures. These events are frequently associated with other natural hazard events such as earthquakes, landslides or severe weather, which limits their predictability and compounds the hazard. Important issues associated with dam and levee failure hazards include the following:

- Dam and levee infrastructure may require repair and improvement to withstand climate change impacts.
- Federally regulated dams have an adequate level of oversight and sophistication in the development of emergency action plans for public notification in the unlikely event of failure. However, the protocol for notification of downstream citizens of imminent failure needs to be tied to local emergency response planning.
- Mapping for federally regulated dams is already required and available; however, mapping for non-federal-regulated dams that estimates inundation depths is needed to better assess the risk associated with dam failure from these facilities.
- Most dam failure mapping required at federal levels requires determination of the probable maximum flood. While the probable maximum flood represents a worst-case scenario, it is generally the event with the lowest probability of occurrence. For non-federal-regulated dams, mapping of dam failure scenarios that are less extreme than the probable maximum flood but have a higher probability of occurrence can be valuable to emergency managers and community officials downstream of these facilities. This type of mapping can illustrate areas potentially impacted by more frequent events to support emergency response and preparedness.
- The concept of residual risk associated with structural flood control projects should be considered in the design of capital projects and the application of land use regulations.
- Addressing security concerns and the need to inform the public of the risk associated with dam failure is a challenge for public officials.

7. DROUGHT

7.1 GENERAL BACKGROUND

Drought is a significant decrease in water supply relative to what is typical in a given location. It is a normal phase in the climate cycle of most regions, originating from a deficiency of precipitation over an extended period of time, usually a season or more. This leads to a water shortage for some activity, group or environmental sector.

Determination of when drought begins is based on impacts on water users and assessments of available water supply, including water stored in reservoirs or groundwater basins. Different water agencies have different criteria for defining drought. Some issue drought watch or drought warning announcements. The California water code does not include a statutory definition of drought; however, references to drought in state code generally relate to issues of water shortage. (California Code of Regulations (CCR) 2017).

DEFINITIONS

Drought—The cumulative impacts of several dry years on water users. It can include deficiencies in surface and subsurface water supplies and generally impacts health, wellbeing, and quality of life.

Meteorological drought—Precipitation's departure from normal over some period of time. Meteorological measurements are the first indicators of drought and are usually region-specific.

Agricultural Drought—Inadequate soil moisture for a particular crop at a particular time.

Hydrological Drought—Deficiencies in surface and subsurface water supplies. It is measured as stream flow and as lake, reservoir, and groundwater levels.

Socioeconomic Drought—Drought impacts on health, wellbeing, and quality of life.

7.1.1 Monitoring Drought

The National Oceanic and Atmospheric Administration (NOAA) has developed several indices to measure drought impacts and severity and to map their extent and locations:

- The ***Palmer Crop Moisture Index*** measures short-term drought on a weekly scale to quantify drought's impacts on agriculture. Figure 7-1 shows this index for the week ending March 11, 2017.
- The ***Palmer Z Index*** measures short-term drought on a monthly scale. Figure 7-2 shows this index for February 2017.
- The ***Palmer Drought Severity Index*** measures the duration and intensity of long-term weather patterns. The intensity of drought in a given month is dependent on current weather plus the cumulative patterns of previous months. Weather patterns can change quickly, and the Palmer Drought Severity Index can respond fairly rapidly. Figure 7-3 shows this index for March 11, 2017.
- The ***Palmer Hydrological Drought Index***, quantifies hydrological effects (reservoir levels, groundwater levels, etc.), which take longer to develop and last longer. This index responds more slowly to changing conditions than the Palmer Drought Index. Figure 7-4 shows this index for February 2017.
- While the Palmer indices consider precipitation, evapotranspiration and runoff, the ***Standardized Precipitation Index*** considers only precipitation. In the Standardized Precipitation Index, an index of zero indicates the median precipitation amount; the index is negative for drought and positive for wet conditions. The Standardized Precipitation Index is computed for time scales ranging from one month to 24 months. Figure 7-5 shows the 24-month Standardized Precipitation Index map for March 2015 – February 2017.

Source: NOAA, NWS. 2017

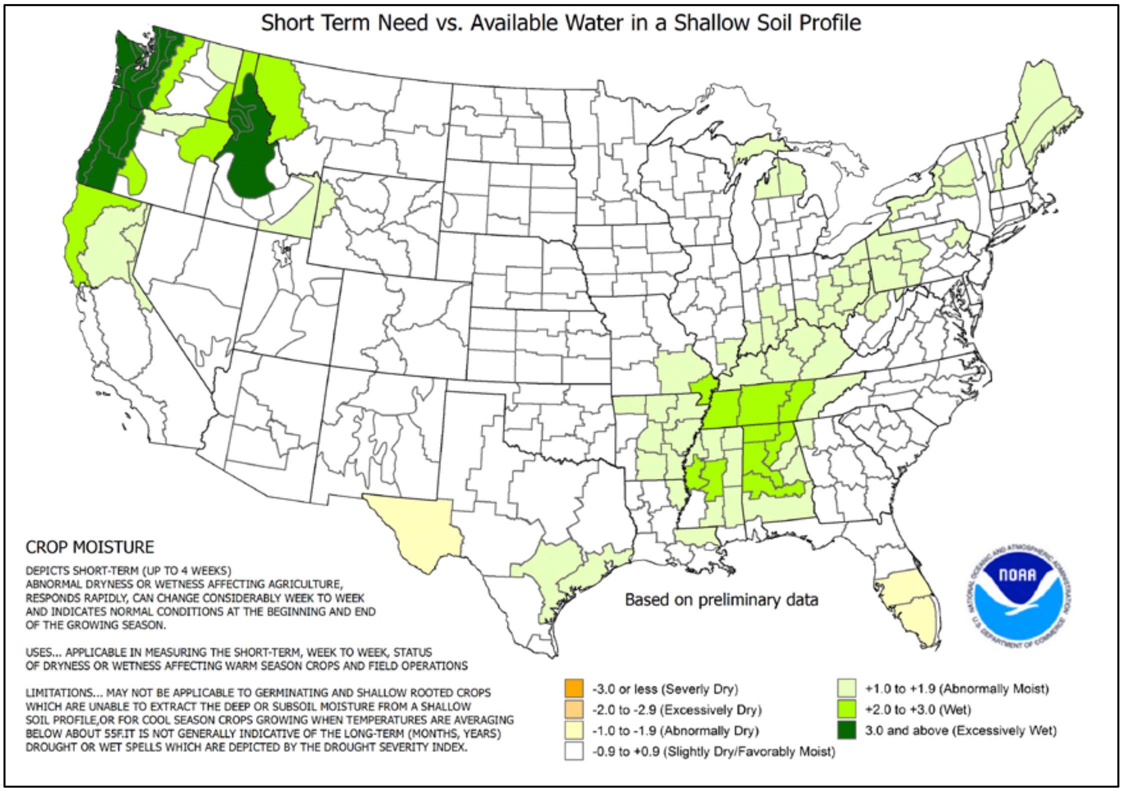


Figure 7-1. Palmer Crop Moisture Index for Week Ending March 11, 2017

Source: NOAA, NWS. 2017a

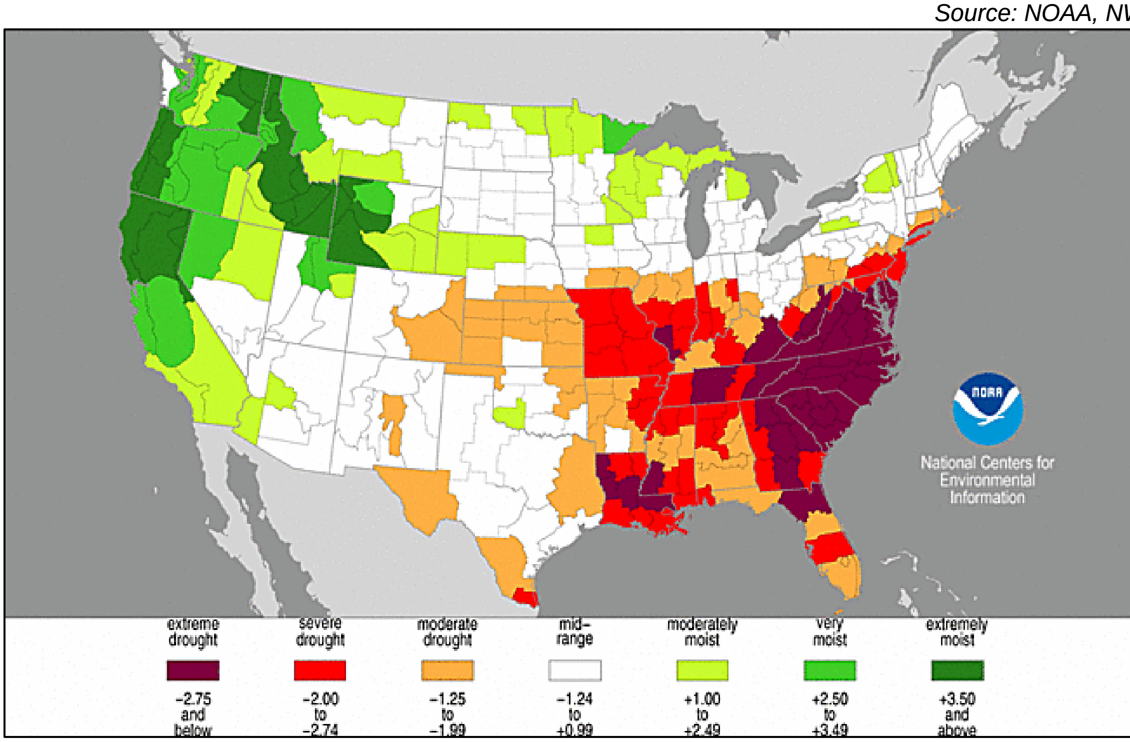


Figure 7-2. Palmer Z Index Short-Term Drought Conditions (February 2017)

Source: NOAA, NWS. 2017b

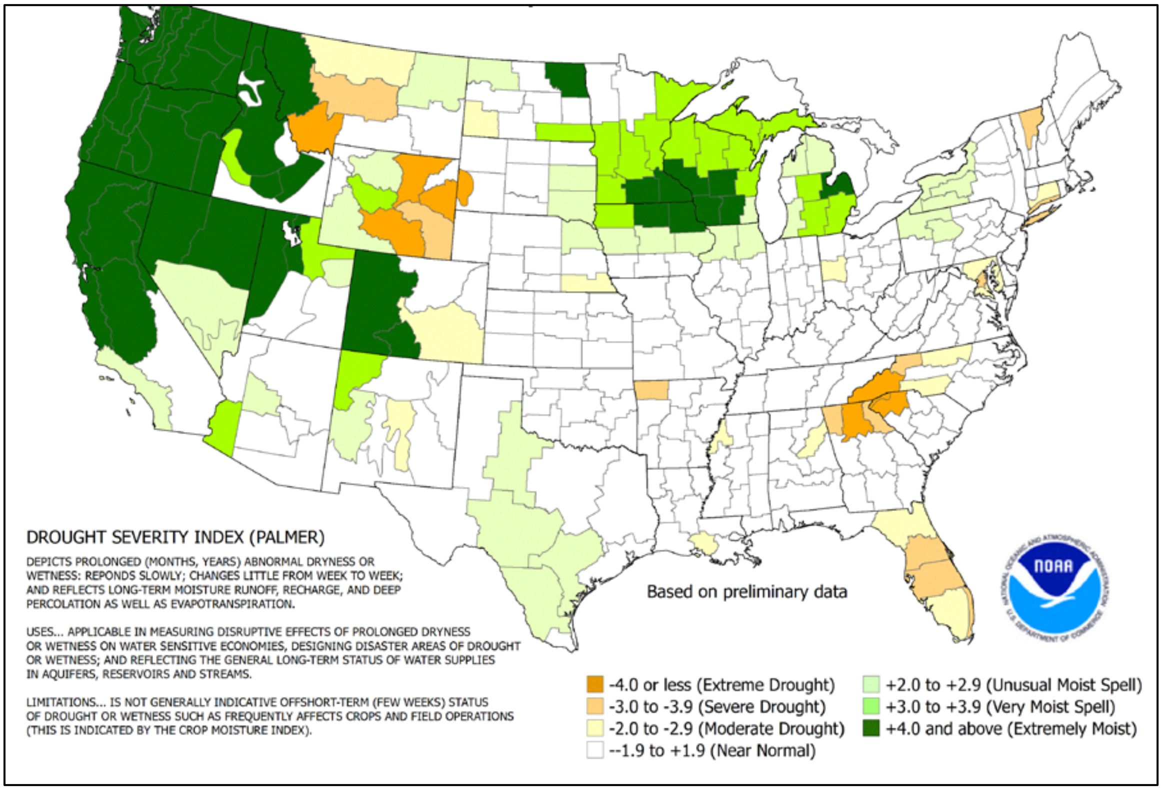


Figure 7-3. Palmer Drought Severity Index (March 11, 2017)

Source: NOAA, NWS. 2017c

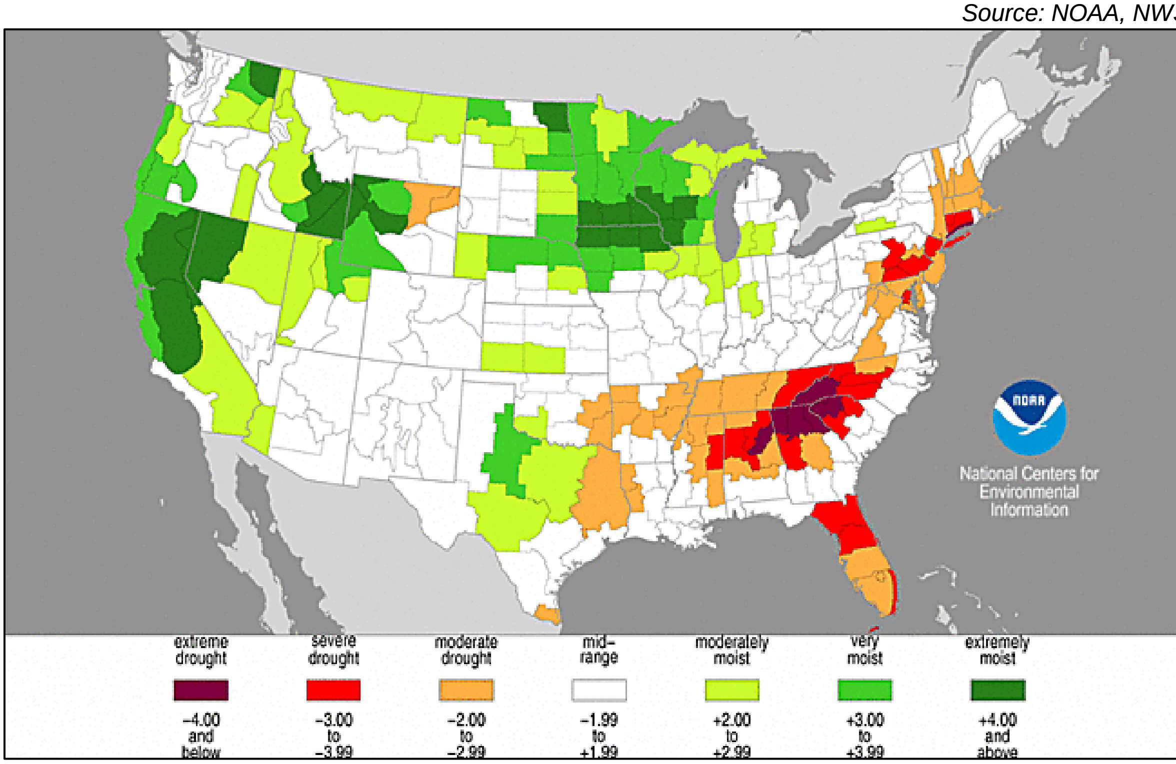


Figure 7-4. Palmer Hydrological Drought Index (February 2017)

Source: NOAA, NWS. 2017d

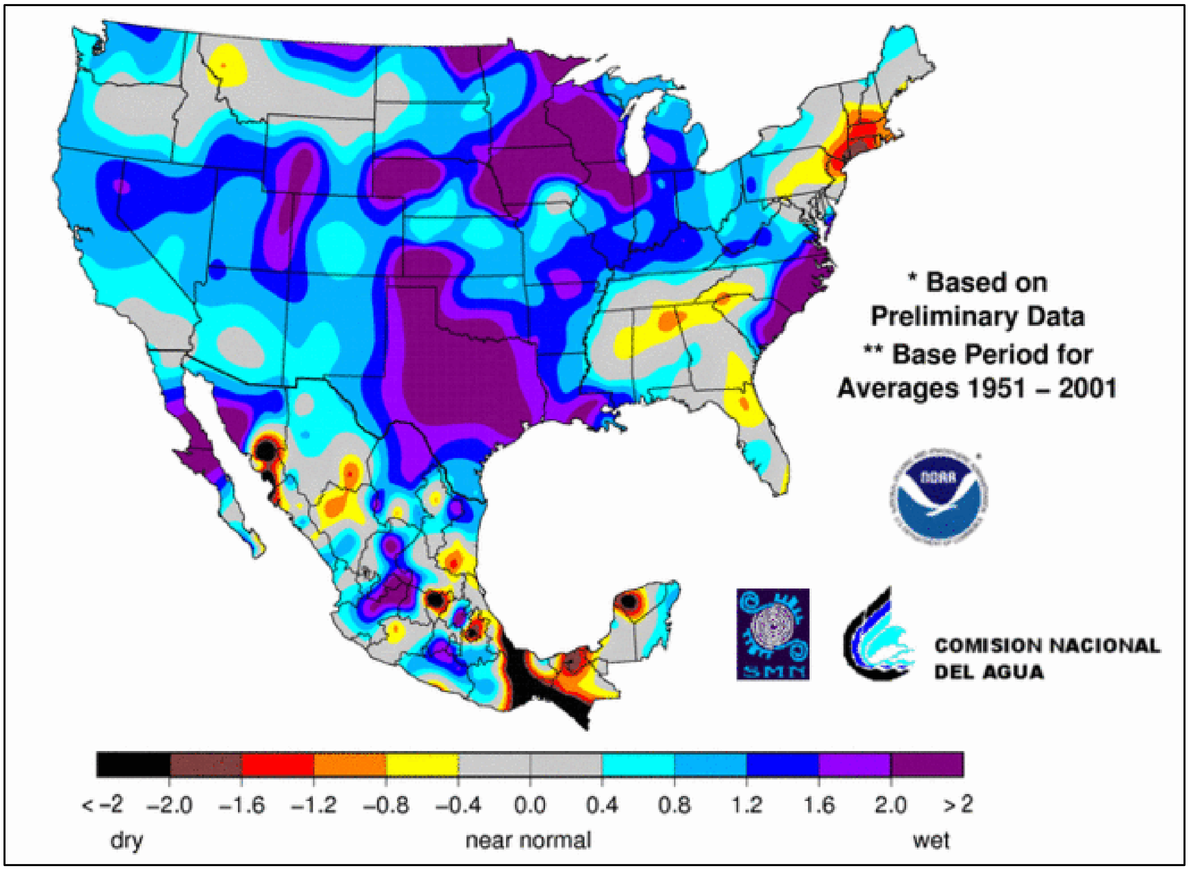


Figure 7-5. 24-Month Standardized Precipitation Index (March 2015 – February 2017)

7.1.2 Drought in California

Most of California's precipitation comes from storms moving across the Pacific Ocean. The path followed by the storms is determined by the position of an atmospheric high pressure belt that normally shifts southward during the winter, allowing low pressure systems to move into the State. On average, 75 percent of California's annual precipitation occurs between November and March, with 50 percent occurring between December and February. A persistent Pacific high pressure zone over California in mid-winter signals a tendency for a dry water year.

A typical water year produces about 100 inches of rainfall over the North Coast, 50 inches of precipitation (combination of rain and snow) over the Northern Sierra, 18 inches in the Sacramento area, and 13 inches to 23 inches in the planning area. In extremely dry years, these annual totals can fall to as little as one half, or even one third of these amounts.

The Sierra Nevada snowpack serves as the primary agent for replenishing water in the San Francisco Bay area, including Contra Costa County, and for much of the State of California. A reduction in spring snowpack runoff, whether due to drier winters or to increasing temperatures leading to more rain than snow, can increase risk of summer or fall water shortages throughout the region.

7.1.3 Local Water Supply

Water supply is one component of the safety element of the Contra Costa County General Plan. The County has a diverse set of water supply options, including surface water and groundwater wells, to ensure that the community has adequate water, even after a period of dry years, through a combination of water supplies and water conservation measures. The Contra Costa County General Plan presents four goals related to water supply (Contra Costa County, 2017):

- To ensure a continuous supply of safe water to county residents.
- To protect the quality, quantity, and productivity of water resources as vital resources for maintaining the public, ecological and economic health of the region.
- The safety of valuable underground water supplies for present and future users shall be ensured by preventing contamination.
- All wells and other entrances to aquifers shall be identified and protected

The County is serviced by 11 purveyors of domestic and industrial water. These providers supply water to the entire planning area. The County receives most of its water supply through surface water supplies from the East Bay Municipal Utility District (EBMUD) and the Contra Costa Water District (CCWD). The EBMUD provides drinking water for 1.4 million customers in Contra Costa and Alameda counties over a 331-square-mile area (EBMUD, 2017). The EBMUD service area for drinking water in Contra Costa County extends from Crockett on the north, eastward to Walnut Creek, and south through the San Ramon Valley. CCWD provides treated and untreated water to a population of 500,000 in central and east Contra Costa County (CCWD, 2017).

The City of Antioch receives untreated water from CCWD and provides treated water to residential, commercial, and irrigation customers within the city. Some small public and private water companies use deeper groundwater supplies, mostly in eastern county communities such as Bethel Island, Knightsen, Byron and Discovery Bay. The City of Martinez Water System provides potable water for Martinez residents and businesses and is a part of the CCWD.

Diablo Water District obtains, treats, and supplies water for about residential, commercial, and parks throughout a 21-squiare mile area consisting of Oakley, Cypress Corridor and Hotchkis Tract, as well as Summer Lakes, and portions of Bethel Island and Knightsen. Golden State Water Company serves about 4,900 customers in Bay Point, eastern Contra Costa County.

7.1.4 Defined Drought Stages

During critically dry years, the California State Water Resources Control Board can mandate water conservation by water users and agencies to address statewide water shortages. Table 7-1 lists State Drought Management Program stages mandated to water right holders.

Table 7-1. State Drought Management Program

Drought Stage	State Mandated Customer Demand Reduction	Rate Impacts
Stage 0 or 1	<10%	Normal rates
Stage 2	10 to 15%	Normal rates; Drought surcharge
Stage 3	15 to 20%	Normal rates; Drought surcharge
Stage 4	>20%	Normal rates, Drought surcharge

EBMUD defined drought stages in its *2015 Urban Water Management Plan* (Chapter 3, Water Shortage Contingency Plan) for a variety of situations that could affect water supply. It enacts the state's mandates as listed above, activates a drought communication plan to promote water use reductions and improve efficiencies, implements drought rates and penalties, and applies water use restrictions.

CCWD's *2015 Urban Water Management Plan* (Chapter 8, Water Shortage Contingency Planning) addresses water management practices required during a drought or other interruption of water supplies. Four demand reduction stages are defined; reductions increase from Stage I to Stage IV, beginning less than 10 percent of normal demand and growing to 50 percent. Stages I and II involve voluntary customer demand reduction measures and Stages III and IV impose mandatory measures, including allotments and temporary drought charges.

The City of Antioch Water Department's *2015 Urban Water Management Plan* (Chapter 5, Water Supply Reliability and Water Shortage Contingency Planning) has adopted water shortage contingencies in Stages I through IV. It ranges from a 5 percent voluntary reduction in water usage to 50 percent mandatory water rationing.

Diablo Water District's *2015 Urban Water Management Plan* (Chapter 5, Water Supply Reliability and Shortage Contingency Plan) adopts water shortage contingency in three stages, A through C. It ranges from a 15 percent voluntary reduction in water usage to 50 percent water rationing and imposing extra charges or penalties for exceeding allotments.

7.2 HAZARD PROFILE

Droughts originate from a deficiency of precipitation resulting from an unusual weather pattern. If the weather pattern lasts a short time (a few weeks or a couple months), the drought is considered short-term. If the weather pattern becomes entrenched and the precipitation deficits last for several months or years, the drought is considered to be long-term. It is possible for a region to experience a long-term circulation pattern that produces drought, and to have short-term changes in this long-term pattern that result in short-term wet spells. Likewise, it is possible for a long-term wet circulation pattern to be interrupted by short-term weather spells that result in short-term drought.

7.2.1 Past Events

The California Department of Water Resources has state hydrologic data back to the early 1900s (CA DWR 2017). The hydrologic data show multi-year droughts from 1912 to 1913, 1918 to 1920, 1922 to 1924, and 1928 to 1934. Since then, prolonged periods of drought occurred in California, all of which impacted Contra Costa County to some degree:

- **2012 to 2016 Drought**—California's last drought set several records for the state. The period from 2012 to 2014 ranked as the driest three consecutive years for statewide precipitation. Calendar year 2014 set new climate records for statewide average temperatures and for record-low water allocations from State Water Project and federal Central Valley Project contractors. Calendar year 2013 set minimum annual precipitation records for many communities. The state has detailed executive orders and regulations concerning water conservation and management. Total impacts of the drought have not yet been determined.
- **2007 to 2009 Drought**—The governor issued an executive order that proclaimed a statewide drought emergency on June 4, 2008 after spring 2008 was the driest spring on record, with low snowmelt runoff. On February 27, 2009, the governor proclaimed a state of emergency for the entire state as severe drought conditions continued. The largest court-ordered water restriction in state history (at the time) was imposed.
- **1987 to 1992 Drought** —California received precipitation well below average levels for four consecutive years. While the Central Coast was most affected, the Sierra Nevadas in Northern California and the Central Valley counties were also affected. During this drought, only 56 percent of average runoff for the Sacramento Valley was received, totaling just 10 million acre-feet. In 1991, the State Water Project sharply decreased deliveries to water suppliers, including the San Francisco Bay area. By February 1991, all 58 counties in California were experiencing drought conditions. Urban areas as well as agricultural areas were impacted.

- **1976 to 1977 Drought**—California had one of its most severe droughts due to lack of rainfall during the winters of 1976 and 1977. 1977 was the driest period on record in California, with the previous winter recorded as the fourth driest in California's hydrological history. The cumulative impact led to widespread water shortages and severe water conservation measures throughout the state. Only 37 percent of the average Sacramento Valley runoff was received, with just 6.6 million acre-feet recorded. Over $2.6 billion in crop damage was recorded in 31 counties. FEMA declared a drought emergency (Declaration 3023-EM) on January 20, 1977 for 58 California counties, including Contra Costa County.

The National Drought Mitigation Center developed the Drought Impact Reporter in response to the need for a national drought impact database for the United States. Information comes from a variety of sources: on-line, drought-related news stories and scientific publications, members of the public who visit the website and submit a drought-related impact for their region, members of the media, and staff of government agencies. The database is being populated beginning with the most recent impacts and working backward in time. The Drought Impact Reporter contains information on 146 impacts from droughts that specifically affected Contra Costa County from 2006 through January 2017 (DIR, 2017). The following are the categories and reported number of impacts. Note that some impacts have been assigned to more than one category.

- Agriculture—24
- Business and Industry—9
- Energy—2
- Fire—13
- Plants and Wildlife—32
- Relief, Response, and Restrictions—83
- Society and Public Health—61
- Tourism and Recreation—7
- Water Supply and Quality—95

Summaries of notable incidents that impacted Contra Costa County are described below from the Drought Impact Reporter (DIR, 2017):

- August 16, 2016—More than 3,800 fires burned more than 112,900 acres in California since the start of 2016.
- April 2016—Many oak and pine trees at Mount Diablo State Park toppled during winter storms after drought and bark beetles damaged and weakened the trees.
- April 2016—State bond fund became available to enlarge the capacity of the Los Vaqueros Reservoir in eastern Contra Costa County from 160,000 acre-feet to 275,000 acre-feet.
- January 2016—The January 2016 trawl survey for delta smelt found just six fish, the fewest fish ever recorded.
- August 25, 2015—A large microcystis bloom developed in the Sacramento-San Joaquin Delta. Microcystis is a type of blue-green algae that can produce lethal toxins in high concentrations to fish and people. The bloom was observed in the central and north parts of the Delta. Scientists from the University of California-Davis, state water agencies and federal research groups monitoring the bloom were unsure of the exact cause, but thought that it was produced through a combination of factors related to the warmer, slower water flow due to the drought.
- June to October 2015—The State Water Resources Control Board ordered senior water rights holders in the Sacramento, San Joaquin and Delta watersheds to stop pumping from those waterways amid California's fourth year of drought.
- June 2015—EBMUD customers had to pay a temporary 25 percent drought surcharge that covered the purchase of water from four sellers.

- June 2015—After the state of California installed a salinity barrier on the False River as a drought measure to protect Delta drinking water from saltwater intrusion, currents shifted dramatically, causing problems for boaters and ferries.
- April 2015—The CCWD board voted for a conservation program to help its 500,000 customers cut water use by 25 percent by increasing water rates to encourage lower water use.
- April 14, 2015—The EBMUD board declared a Stage IV critical drought and mandated a district-wide 20 percent reduction in water use. Customers responded by curbing their water use by 24 percent.
- March 13, 2015—Dublin San Ramon Services District planned to buy 1,500 acre-feet of water from Yuba County Water Agency and EBMUD to prevent water shortages.
- November 7, 2014—Water thefts became more common, as some people filled up at water hydrants. The CCWD planned to address the topic with fines of $25 to $250 to discourage theft. The agency considered installing security cameras to monitor certain hydrants.
- April 22, 2014—The EBMUD board voted to divert water from the Freeport Regional Water Program on the Sacramento River for its customers.
- February 2014—EBMUD asked customers to voluntarily trim water use by 10 percent.
- April 2009—EBMUD and CCWD both asked customers to voluntarily trim water use by 10 percent.
- January to September 2009—The U.S. Fish and Wildlife Service declared roughly half of California, which has been stricken by drought, to be critical habitat for the California red-legged frog.
- May 13, 2008— EBMUD required customers to ration water use by 15 percent.

Agriculture-related disasters and disaster declarations are common in the United States, and the U.S. Department of Agriculture (USDA) Farm Service Agency provides assistance for losses resulting from drought, flood, fire, freeze, tornadoes, pest infestation, and other natural disasters. Many counties have been designated disaster areas in the past several years of record crop production. The U.S. Secretary of Agriculture is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to them. Between 2012 and 2016, the period for which data was available, California was included in 61 USDA disaster declarations. Contra Costa County was included in 12 of these (in relation to drought): S3248 and S3379 in 2012; S3558 and S3569 in 2013; S3626, S3637, S3743, and S3797 in 2014; S3784 in 2015; and S3952 in 2016 (USDA, 2017).

7.2.2 Location

Drought is a regional phenomenon. A drought affects all aspects of the environment and the community simultaneously and has the potential to directly or indirectly impact every person in the county as well as adversely affect the local economy.

7.2.3 Frequency

Historical drought data for the planning area indicate there have been four significant multi-year droughts in the last 40 years (1976 to 2016). The county has been included in various levels of drought stages during 12 of the last 40 years. This equates to a 30-percent chance of a drought in any given year. As temperatures increase, the probability of future droughts will likely increase. Therefore, droughts likely will occur in California and Contra Costa County at varied severities in the future.

7.2.4 Severity

Drought can have a widespread impact on the environment and the economy, although it typically does not result in loss of life or damage to property, as do other natural disasters. Nationwide, the impacts of drought occur in the following categories: agriculture; business and industry; energy; fire; plants and wildfire; relief, response and restrictions; tourism and recreation; and water supply and quality sectors. The National Drought Mitigation Center uses three categories to describe likely drought impacts:

- Economic Impacts—These impacts of drought cost people (or businesses) money—farmers' crops are destroyed; low water supply necessitates spending on irrigation or to drill new wells; businesses that sell boats and fishing equipment may not be able to sell their goods.
- Environmental Impacts—Plants and animals depend on water. When a drought occurs, their food supply can shrink and their habitat can be damaged.
- Social Impacts—These impacts affect people's health and safety. Social impacts include public safety, health, conflicts between people when there is not enough water to go around, and changes in lifestyle.

The severity of a drought depends on the degree of moisture deficiency, the duration, and the size and location of the affected area. The longer the duration of the drought and the larger the area impacted, the more severe the potential impacts.

Drought generally does not affect groundwater sources as quickly as surface water supplies, but groundwater supplies generally take longer to recover. Reduced precipitation during a drought means that groundwater supplies are not replenished at a normal rate. This can lead to a reduction in groundwater levels and problems such as reduced pumping capacity or wells going dry. Shallow wells are more susceptible than deep wells. Reduced replenishment of groundwater affects streams. Much of the flow in streams comes from groundwater, especially during the summer when there is less precipitation and after snowmelt ends. Reduced groundwater levels mean that even less water will enter streams when steam flows are lowest.

7.2.5 Warning Time

Droughts are climatic patterns that occur over long periods of time. Only generalized warning can take place due to the numerous variables that scientists have not pieced together well enough to make accurate and precise predictions.

Empirical studies conducted over the past century have shown that meteorological drought is never the result of a single cause. It is the result of many causes, often synergistic in nature; these include global weather patterns that produce persistent, upper-level high-pressure systems along the West Coast with warm, dry air resulting in less precipitation.

Scientists at this time do not know how to predict drought more than a month in advance for most locations. Predicting drought depends on the ability to forecast precipitation and temperature. Anomalies of precipitation and temperature may last from several months to several decades. California is currently finishing a several-year-long drought, while other areas in the United States may undergo droughts as short as 1 or 2 months. How long they last depends on interactions between the atmosphere and the oceans, soil moisture and land surface processes, topography, internal dynamics, and the accumulated influence of weather systems on the global scale.

7.3 SECONDARY HAZARDS

The secondary hazard most commonly associated with drought is wildfire. A prolonged lack of precipitation dries out vegetation, which becomes increasingly susceptible to ignition as the duration of the drought extends. Millions of board feet of timber have been lost, and in many cases erosion occurred, which caused serious damage to aquatic life, irrigation, and power production by heavy silting of streams, reservoirs, and rivers.

Drought also is often accompanied by extreme heat, exposing people to the risk of sunstroke, heat cramps and heat exhaustion. Pets and livestock are also vulnerable to heat-related injuries. Crops can be vulnerable as well.

Environmental losses are the result of damage to plants, animals, wildlife habitat, and air and water quality; forest and range fires; degradation of landscape quality; loss of biodiversity; and soil erosion. Some of the effects are short-term and conditions quickly return to normal following the end of the drought. Other environmental effects linger for some time or may even become permanent. Wildlife habitat, for example, may be degraded through the loss of wetlands, lakes, and vegetation. However, many species will eventually recover from this temporary aberration. The degradation of landscape quality, including increased soil erosion, may lead to a more permanent loss of biological productivity. Although environmental losses are difficult to quantify, growing public awareness and concern for environmental quality has forced public officials to focus greater attention and resources on these effects.

7.4 EXPOSURE

Drought can affect a wide range of economic, environmental, and social activities. Its impacts can span many sectors of the economy because water is integral to the ability to produce goods and provide services. The impacts can reach well beyond the area undergoing physical drought. Vulnerability of an activity to drought depends on its water demand and the water supplies available to meet the demand.

California's 2005 Water Plan and subsequent updates indicate that water demand in the state will increase through 2030. The Department of Water Resources predicts a modest decrease in agricultural water use, but an urban water use increase of 1.5 to 5.8 million acre-feet per year (DWR, 2005). The 2013 update to the Water Plan explores measures, benchmarks, and successes in increasing agricultural and urban water use efficiency.

7.5 VULNERABILITY

7.5.1 Population

The entire population of Contra Costa County is vulnerable to drought events. Drought can affect people's health and safety, including health problems related to low water flows, poor water quality, or dust. Droughts can also lead to loss of human life (National Drought Mitigation Center, 2017). Other possible impacts include recreational risks; effects on air quality; diminished living conditions related to energy, air quality, and hygiene; compromised food and nutrition; and increased incidence of illness and disease (Centers for Disease Control and Prevention 2012). Droughts can also lead to reduced local firefighting capabilities.

EBMUD, CCWD, regional water purveyors, and other regional stakeholders have devoted considerable time and effort to protect life, safety, and health during consecutive dry years. Provisions and measures have been taken to analyze and account for anticipated water shortages. Through coordination with residents in the planning area, EBMUD and CCWD have the ability to minimize and reduce impacts on residents and water consumers in Contra Costa County.

7.5.2 Property

No structures will be directly affected by drought conditions, though some structures may become vulnerable to wildfires, which are more likely following years of drought. Droughts can also have significant impacts on landscapes, which could cause a financial burden to property owners. However, these impacts are not considered critical in planning for impacts from the drought hazard.

7.5.3 Critical Facilities

Critical facilities as defined for this plan will continue to be operational during a drought. Critical facility elements such as landscaping may not be maintained due to limited resources, but the risk to the planning area's critical facilities inventory will be largely aesthetic. For example, when water conservation measures are in place, landscaped areas will not be watered and may die. These aesthetic impacts are not considered significant.

7.5.4 Environment

Environmental losses from drought are associated with damage to plants, animals, wildlife habitat, and air and water quality; forest and range fires; degradation of landscape quality; loss of biodiversity; and soil erosion. Some of the effects are short-term and conditions quickly return to normal following the end of the drought. Other environmental effects linger for some time or may even become permanent. Wildlife habitat, for example, may be degraded through the loss of wetlands, lakes and vegetation. However, many species will eventually recover from this temporary aberration. The degradation of landscape quality, including increased soil erosion, may lead to a more permanent loss of biological productivity. Although environmental losses are difficult to quantify, growing public awareness and concern for environmental quality has forced public officials to focus greater attention and resources on these effects.

7.5.5 Economic Impact

Drought causes the most significant economic impacts on industries that use water or depend on water for their business, most notably, agriculture and related sectors (forestry, fisheries, and waterborne activities), power plants and oil refineries. In addition to losses in yields in crop and livestock production, drought is associated with increased insect infestations, plant diseases, and wind erosion. Drought can lead to other losses because so many sectors are affected—losses that include reduced income for farmers and reduced business for retailers and others who provide goods and services to farmers. This leads to unemployment, increased credit risk for financial institutions, capital shortfalls, and loss of tax revenue. Prices for food, energy, and other products may also increase as supplies decrease.

A prolonged drought can affect a community’s economy significantly. Increased demand for water and electricity may result in shortages and higher costs of these resources. Industries that rely on water for business may be impacted the most (e.g., landscaping businesses). Although most businesses will still be operational, they may be affected aesthetically—especially the recreation and tourism industry. Moreover, droughts within another area could affect food supply/price of food for residents within the County.

7.6 FUTURE TRENDS IN DEVELOPMENT

Land use planning is directed by general plans adopted under California’s General Planning Law. Municipal planning partners are encouraged to establish general plans with policies to deal with issues of water supply and protection of water resources. These plans increase capability at the local municipal level to protect future development from impacts of drought. All planning partners reviewed their general plans under the capability assessments undertaken for this hazard mitigation plan. Deficiencies revealed by these reviews are identified as mitigation actions to increase capability to deal with future trends in development.

7.7 SCENARIO

Continuation or exacerbation of the current situation across the State of California (i.e., an extreme, multiyear drought associated with record-breaking rates of low precipitation and high temperatures) is the worst-case scenario for Contra Costa County. Low precipitation and high temperatures increase possibility of wildfires throughout the County, increasing need for water when water is already in limited supply. Surrounding counties, also under drought conditions, could increase their demand for the water supplies on which Contra Costa County also relies, triggering social and political conflicts. The higher density population of the Bay Area increases likelihood of such conflicts. Additionally, the longer drought conditions last in or near the county, the greater the effect on the local economy; water-dependent industries especially will undergo setbacks.

7.8 ISSUES

The planning team has identified the following drought-related issues:

- Identification of the availability and reliability of new water supplies
- Using water transfers obtained through purchased water rights or land and short term contracts for drought reliability
- The probability of increased drought frequencies and durations due to climate change
- The promotion of active water conservation even during non-drought periods
- Application of alternative techniques (groundwater recharge, water recycle, local capture and reuse, desalination, and transfer) to stabilize and offset Sierra Nevada snowpack water supply shortfalls
- Regular occurrence of drought or multiyear droughts that may limit the planning area's ability to successfully recover from or prepare for more occurrences—particularly considering the longevity of the 2012 to 2016 drought.

8. EARTHQUAKE

8.1 GENERAL BACKGROUND

An earthquake is the vibration of the earth's surface following a release of energy in the earth's crust. This energy can be generated by a sudden dislocation of the crust or by a volcanic eruption. Most destructive quakes are caused by dislocations of the crust. The crust may first bend and then, when the stress exceeds the strength of the rocks, break and snap to a new position. In the process of breaking, vibrations called "seismic waves" are generated. These waves travel outward from the source of the earthquake at varying speeds.

Geologists have found that earthquakes tend to reoccur along faults, which are zones of weakness in the earth's crust. Even if a fault zone has recently experienced an earthquake, there is no guarantee that all the stress has been relieved. Another earthquake could still occur. In fact, relieving stress along one part of a fault may increase it in another part.

DEFINITIONS

Earthquake—The shaking of the ground caused by an abrupt shift of rock along a fracture in the earth or a contact zone between tectonic plates.

Epicenter—The point on the earth's surface directly above the hypocenter of an earthquake. The location of an earthquake is commonly described by the geographic position of its epicenter and by its focal depth.

Fault—A fracture in the earth's crust along which two blocks of the crust have slipped with respect to each other.

Hypocenter—The region underground where an earthquake's energy originates

Liquefaction—Loosely packed, water-logged sediments losing their strength in response to strong shaking, causing major damage during earthquakes.

California is seismically active because of movement of the North American Plate, east of the San Andreas Fault, and the Pacific Plate to the west, which includes the state's coastal communities. Movement of the tectonic plates against one another creates stress, which is released as energy that moves through the earth as seismic waves.

Active faults have experienced displacement in historical time. However, inactive faults, where no such displacements have been recorded, also have the potential to reactivate or experience displacement along a branch sometime in the future. An example of a fault zone that has been reactivated is the Foothills Fault Zone. The zone was considered inactive until evidence of an earthquake (approximately 1.6 million years ago) was found near Spenceville, California. Then, in 1975, an earthquake occurred on another branch of the zone near Oroville, California (now known as the Cleveland Hills Fault). The State Division of Mines and Geology indicates that increased earthquake activity throughout California may cause tectonic movement along currently inactive fault systems.

8.1.1 Earthquake Classifications

Earthquakes are typically classified in one of two ways: By the amount of energy released, measured as magnitude; or by the impact on people and structures, measured as intensity.

Magnitude

An earthquake's magnitude is a measure of the energy released at the source of the earthquake. It is commonly expressed by ratings on either of two scales (USGS, 2017a):

- The **Richter scale** measures magnitude of earthquakes based on the amplitude of the largest energy wave released by the earthquake. Richter scale readings are suitable for smaller earthquakes; however, because it is a logarithmic scale, the scale does not distinguish clearly the magnitude of large earthquakes above a certain level. Richter scale magnitudes and corresponding earthquake effects are as follows:
  - 2.5 or less—Usually not felt, but can be recorded by seismograph
  - 2.5 to 5.4—Often felt, but causes only minor damage
  - 5.5 to 6.0—Slight damage to buildings and other structures
  - 6.1 to 6.—May cause a lot of damage in very populated areas
  - 7.0 to 7.9—Major earthquake; serious damage
  - 8.0 or greater—Great earthquake; can totally destroy communities near the epicenter
- A more commonly used magnitude scale today is the **moment magnitude (M_W) scale**. The moment magnitude scale is based on the total moment release of the earthquake (the product of the distance a fault moved and the force required to move it). Moment magnitude roughly matches the Richter scale but provides more accuracy for larger magnitude earthquakes. The scale is as follows:
  - Great—$M_W \geq 8$
  - Major—$M_W = 7.0 - 7.9$
  - Strong—$M_W = 6.0 - 6.9$
  - Moderate—$M_W = 5.0 - 5.9$
  - Light—$M_W = 4.0 - 4.9$
  - Minor—$M_W = 3.0 - 3.9$
  - Micro—$M_W < 3$

Intensity

Currently the most commonly used intensity scale is the modified Mercalli intensity scale, with ratings defined as follows (USGS, 1989):

- I. Not felt except by a very few under especially favorable conditions
- II. Felt only by a few persons at rest, especially on upper floors of buildings.
- III. Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it is an earthquake. Standing cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
- IV. Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like a heavy truck striking building. Standing cars rocked noticeably.
- V. Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
- VI. Felt by all; many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
- VII. Damage negligible in buildings of good design and construction; slight in well-built ordinary structures; considerable in poorly built or badly designed structures. Some chimneys broken.
- VIII. Damage slight in specially designed structures; considerable damage in ordinary buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
- IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.

- X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
- XI. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
- XII. Damage total. Lines of sight and level are distorted. Objects thrown into the air.

8.1.2 Ground Motion

Earthquake hazard assessment is also based on expected ground motion. The ground experiences acceleration as it shakes during an earthquake. The peak ground acceleration (PGA) is the largest acceleration recorded by a monitoring station during an earthquake. PGA is a measure of how hard the earth shakes in a given geographic area. It is expressed as a percentage of the acceleration due to gravity (%g). Horizontal and vertical PGA varies with soil or rock type. Instruments called accelerographs record levels of ground motion due to earthquakes at stations throughout a region. These readings are recorded by state and federal agencies that monitor and predict seismic activity. Earthquake hazard assessment involves estimating the annual probability that certain ground motion accelerations will be exceeded, and then summing the annual probabilities over a time period of interest.

National maps of earthquake shaking hazards, which have been produced since 1948, provide information for creating and updating seismic design requirements for building codes, insurance rate structures, earthquake loss studies, retrofit priorities and land use planning. After thorough review of the studies, professional organizations of engineers update the seismic-risk maps and seismic design requirements contained in building codes (Brown et al., 2001). The USGS updated the National Seismic Hazard Maps in 2014. New seismic, geologic, and geodetic information on earthquake rates and associated ground shaking were incorporated into these revised maps. The 2014 map, shown in Figure 8-1, represents the best available data as determined by the USGS.

Building codes that include seismic provisions specify the horizontal force due to lateral acceleration that a building should be able to withstand during an earthquake. Buildings, bridges, highways and utilities built to meet modern seismic design requirements are typically able to withstand earthquakes better, with less damage and disruption. PGA values are directly related to these lateral forces that could damage “short period structures” (e.g. single-family dwellings). Longer-period response components determine the lateral forces that damage larger structures with longer natural periods (apartment buildings, factories, high-rises, bridges). Table 8-1 lists damage potential and perceived shaking by PGA factors, compared to the Mercalli scale.

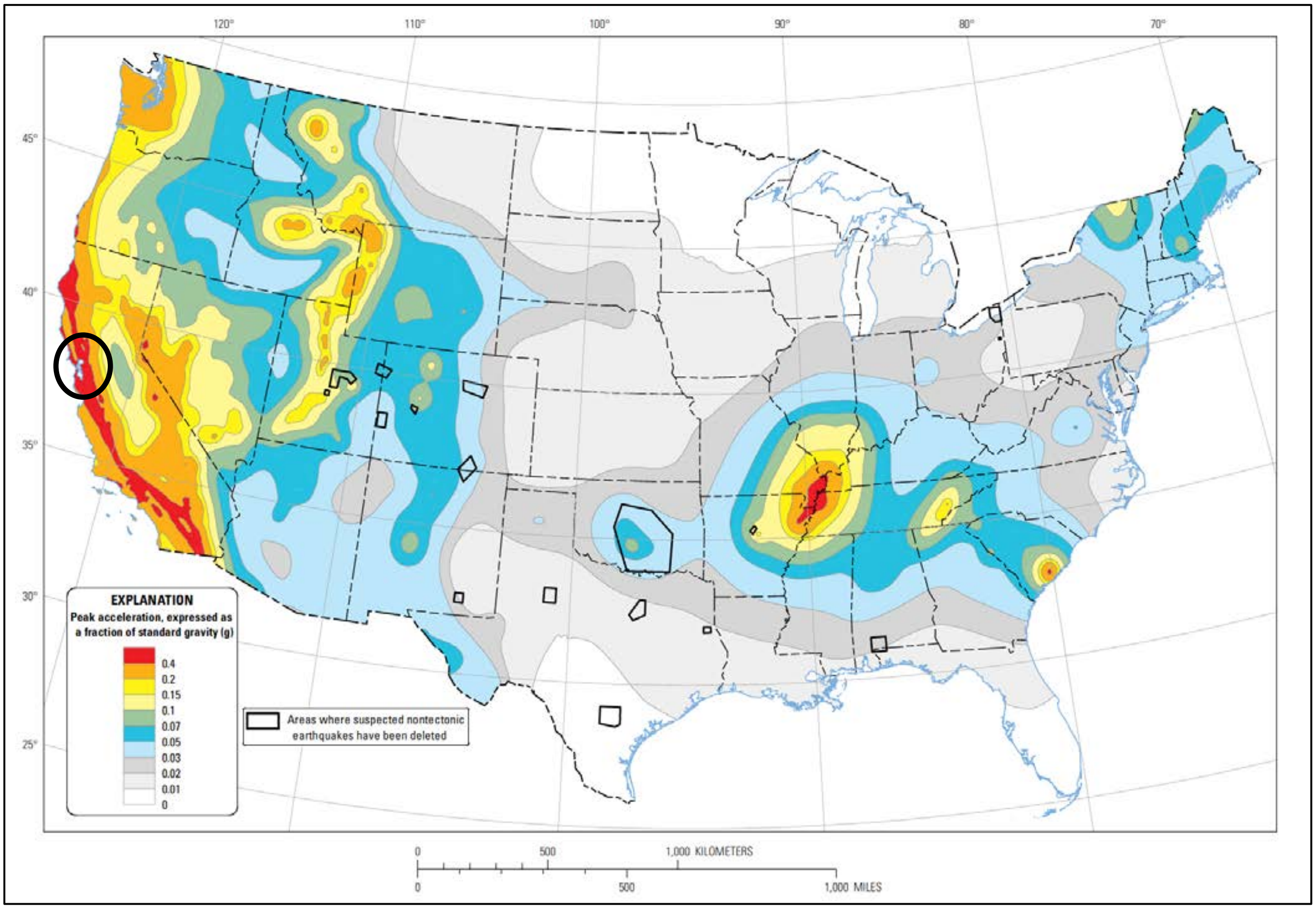
8.1.3 Effect of Soil Types

The impact of an earthquake on structures is a function of ground shaking, distance from the source of the quake, and liquefaction, a secondary effect of an earthquake in which soils lose their shear strength and behave as liquid, damaging structures that derive their support from the soil. Liquefaction involves loose sandy soil with a high water content that undermines the ground’s ability to solidly support building structures during an earthquake.

A program called the National Earthquake Hazard Reduction Program (NEHRP) creates maps based on soil characteristics to help identify locations subject to liquefaction. Table 8-2 summarizes NEHRP soil classifications. NEHRP Soils B and C typically can sustain ground shaking without much effect, dependent on the earthquake magnitude. The areas that are commonly most affected by ground shaking have NEHRP Soils D, E and F. In general, these areas are also most susceptible to liquefaction.

The USGS has created a soil type map for the San Francisco Bay area that provides rough estimates of site effects based on surface geology. NEHRP soil types were assigned to a geologic unit based on the average velocity of that unit. The USGS notes that this approach can lead to some inaccuracy. For instance, a widespread unit consisting of Quaternary sand, gravel, silt, and mud has been assigned as Class C soil types; however, some of the slower soil types in this unit fall under Class D. USGS does not have any way of differentiating units for slower-velocity soils in its digital geologic dataset (USGS, 2017b).

Source: USGS, 2014



Note: The black circle indicates the approximate location of Contra Costa County

Figure 8-1. Peak Acceleration (%g) with 10% Probability of Exceedance in 50 Years

Table 8-1. Mercalli Scale and Peak Ground Acceleration Comparison

Modified Mercalli Scale	Perceived Shaking	Potential Structure Damage		Estimated PGA[a] (%g)
		Resistant Buildings	Vulnerable Buildings	
I	Not Felt	None	None	<0.17%
II-III	Weak	None	None	0.17% - 1.4%
IV	Light	None	None	1.4% - 3.9%
V	Moderate	Very Light	Light	3.9% - 9.2%
VI	Strong	Light	Moderate	9.2% - 18%
VII	Very Strong	Moderate	Moderate/Heavy	18% - 34%
VIII	Severe	Moderate/Heavy	Heavy	34% - 65%
IX	Violent	Heavy	Very Heavy	65% - 124%
X - XII	Extreme	Very Heavy	Very Heavy	>124%

a. PGA measured in percent of g, where g is the acceleration of gravity

Sources: USGS, 2008; USGS, 2010

Table 8-2. NEHRP Soil Classification System

NEHRP Soil Type	Description	Mean Shear Velocity to 30 m (m/s)
A	Hard Rock	1,500
B	Firm to Hard Rock	760-1,500
C	Dense Soil/Soft Rock	360-760
D	Stiff Soil	180-360
E	Soft Clays	< 180
F	Special Study Soils (liquefiable soils, sensitive clays, organic soils, soft clays >36 m thick)	

8.2 HAZARD PROFILE

The Bay region lies within the active boundary between the Pacific and the North American tectonic plates. The Pacific Plate is constantly moving northwest past the North American Plate at a rate of about 2 inches per year (Cal OES, 2013). Earthquakes in the San Francisco Bay region result from strain energy constantly accumulating across the region because of the motion of the Pacific Plate relative to the North American Plate. The San Andreas Fault, on which earthquakes of magnitude 7.8 and 7.9 have occurred in the past, including the 1906 San Francisco earthquake, is the fastest slipping fault along the plate boundary.

8.2.1 Past Events

California has been included in 12 FEMA major disaster (DR) or emergency (EM) declarations for earthquakes. Contra Costa County was included in only one declaration: DR-845 for the Loma Prieta Earthquake, which occurred in October 1989. The declaration for this event also covered Alameda, Marin, Monterey, Sacramento, San Benito, San Francisco, San Joaquin, San Mateo, Santa Clara, Santa Cruz, and Solano Counties. Figure 8-2 and Table 8-3 summarize recent earthquakes of magnitude of 5.0 or greater impacting the Bay Area.

8.2.2 Location

Fault Locations

Contra Costa County is located in a region of high seismicity with numerous local faults, as shown on Figure 8-3. The primary seismic hazard for the county is potential ground shaking from these faults, especially the Hayward, Calaveras North, Concord-Green Valley, Mount Diablo, and Greenville faults, which are further described below.

Calaveras (North Central)

The Calaveras (North Central) Fault is a major branch of the San Andreas Fault, located east of the Hayward Fault. It extends 76 miles from the San Andreas Fault near Hollister to Danville at its northern end. The Calaveras Fault is one of the most geologically active and complex faults in the Bay Area (USGS, 2003). The probability of experiencing a Magnitude 6.7 or greater earthquake along the Calaveras Fault in the next 30 years is 26 percent.

Concord-Green Valley

The Concord-Green Valley Fault, named for being located under the City of Concord, is connected to the main Green Valley Fault. The fault extends approximately 11 miles east of West Napa Fault, from Mount Diablo to the Carquinez Strait. It is considered to be under high stress and has a 16 percent probability of experiencing a Magnitude 6.7 or greater earthquake in the next 30 years.

Source: USGS, 2016

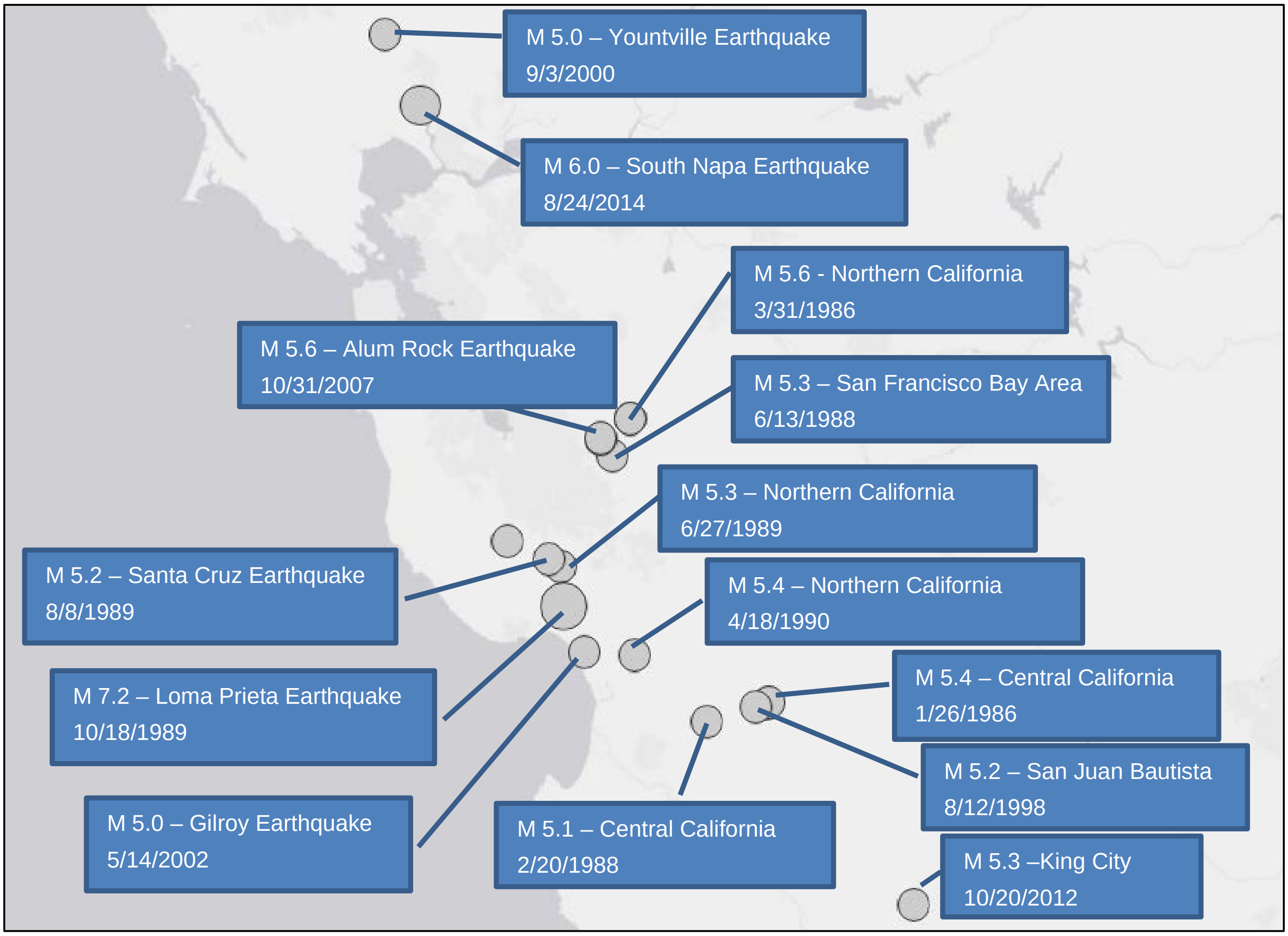
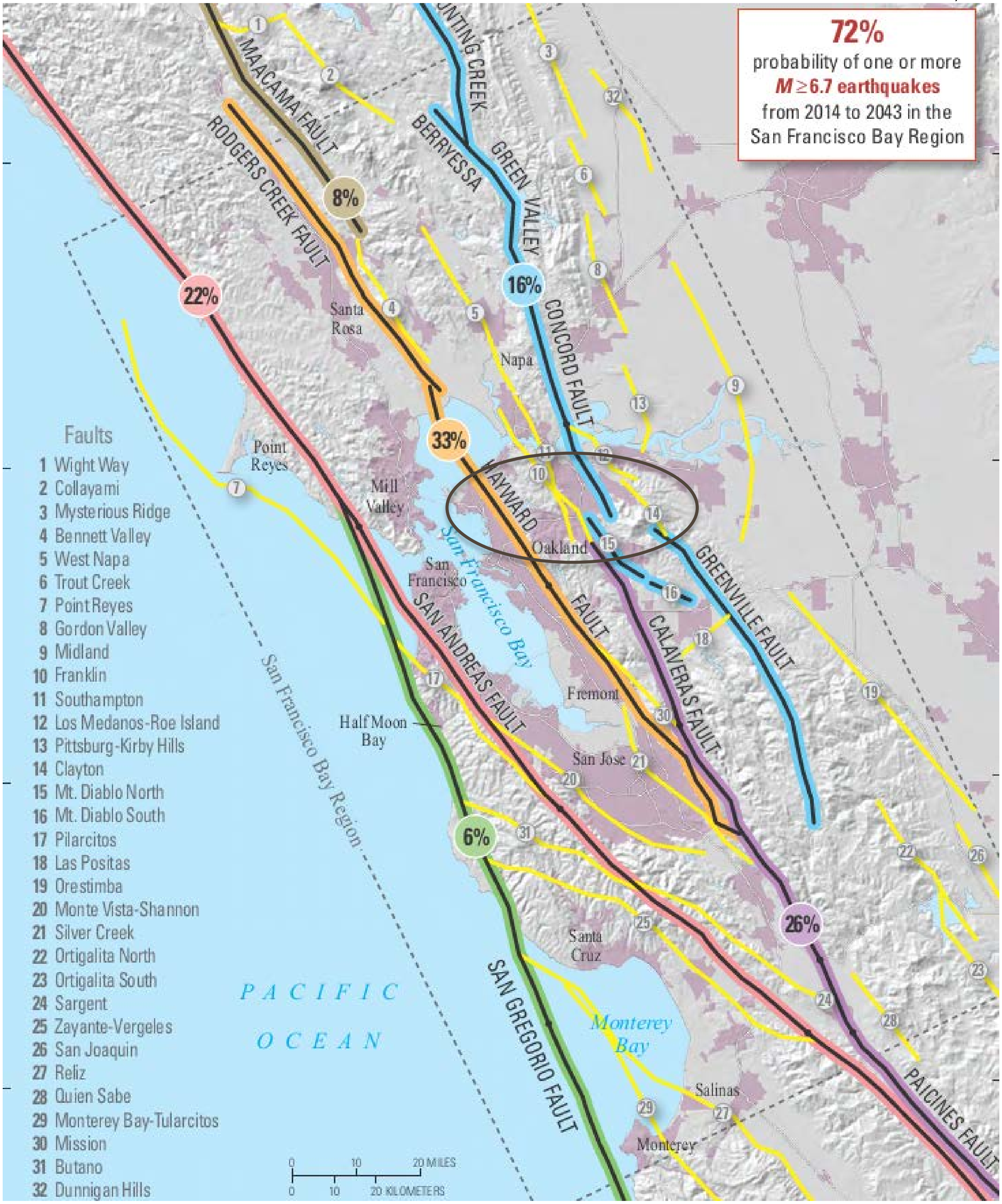


Figure 8-2. Recent Earthquakes in California

Table 8-3. Recent Earthquakes Magnitude 5.0 or Larger Near Planning Area

Date	Magnitude	Epicenter Location
8/24/2014 – South Napa Earthquake	6.0	South Napa
10/20/2012 – King City Earthquake	5.3	28 km east-northeast of King City, CA
10/31/2007 – Alum Rock Earthquake	5.6	San Francisco Bay area, California
5/14/2002 – Gilroy Earthquake	5	Northern California
9/3/2000 – Yountville Earthquake	5	Northern California
8/12/1998 – San Juan Bautista Earthquake	5.2	Central California
4/18/1990 – Northern California	5.4	Near Aromas, Northern California
10/18/1989 – Loma Prieta Earthquake	7.2	Northern California
8/8/1989 – Santa Cruz County Earthquake	5.2	Central California
6/27/1989	5.3	Northern California
6/13/1988	5.3	San Francisco Bay area, California
2/20/1988	5.1	Central California
3/31/1986	5.6	Northern California
1/26/1986	5.4	Central California

Source: USGS, 2016a



Note: Oval shows the approximate location of Contra Costa County.

Figure 8-3. Significant Known Faults in the Bay Area

Greenville

The Greenville Fault is in the eastern Bay Area in Contra Costa and Alameda Counties. This dextral strike-slip fault zone borders the eastern side of Livermore Valley and is considered to be part of the larger San Andreas fault system in the central Coast Ranges. The fault zone extends from northwest of Livermore Valley along the Marsh Creek and Clayton faults toward Clayton Valley.

Hayward Fault

The Hayward Fault is an approximately 45-mile-long fault that runs through densely populated areas on the East Bay, parallel to the San Andreas Fault. The Hayward Fault extends through some of the Bay Area's most populated areas, including San Jose, Oakland, and Berkeley. The Hayward Fault is a right-lateral slip fault.

The Hayward Fault is increasingly becoming a hazard priority throughout the Bay Area because of its increased chance for activity and its intersection with highly populated areas and critical infrastructure. The probability of experiencing a Magnitude 6.7 or greater earthquake along the Hayward Fault in the next 30 years is 33 percent. An earthquake of this magnitude has regional implications for the entire Bay Area, as the Hayward Fault crosses transportation and resource infrastructure, such as multiple highways and the Hetch-Hetchy Aqueduct.

Mount Diablo

The Mount Diablo thrust fault is in the vicinity of Mount Diablo in Contra Costa County. The fault lies between the Calaveras Fault, the Greenville Fault, and the Concord Fault, all right-lateral strike slip faults, and appears to transfer movement from the Calaveras and Greenville Faults to the Concord Fault, while continuing to uplift Mount Diablo.

Mapping of Earthquake Impact

Identifying the extent and location of an earthquake is not as simple as it is for other hazards such as flood, landslide or wild fire. The impact of an earthquake is largely a function of the following components:

- Ground shaking (ground motion accelerations)
- Liquefaction (soil instability)
- Distance from the source (both horizontally and vertically).

Mapping that shows the impacts of these components was used to assess the risk of earthquakes within the planning area. While the impacts from each of these components can build upon each other during an earthquake event, the mapping looks at each component individually. The mapping used in this assessment is described below.

Shake Maps

A shake map is a representation of ground shaking produced by an earthquake. The information it presents is different from the earthquake magnitude and epicenter that are released after an earthquake because shake maps focus on the ground shaking resulting from the earthquake, rather than the parameters describing the earthquake source. An earthquake has only one magnitude and one epicenter, but it produces a range of ground shaking at sites throughout the region, depending on the distance from the earthquake, the rock and soil conditions at sites, and variations in the propagation of seismic waves from the earthquake due to complexities in the structure of the earth's crust. A shake map shows the extent and variation of ground shaking in a region immediately following significant earthquakes.

Ground motion and intensity maps are derived from peak ground motion amplitudes recorded on seismic sensors (accelerometers), with interpolation based on estimated amplitudes where data are lacking, and site amplification corrections. Color-coded instrumental intensity maps are derived from empirical relations between peak ground motions and Modified Mercalli intensity. Earthquake scenario maps describe the expected ground motions and effects of hypothetical large earthquakes for a region. The following scenarios were chosen for this plan:

- Calaveras (North Central) Fault Scenario—A Magnitude-7.0 event with a depth of 7 km and epicenter 0.7 miles south southwest of the Roundhouse Market & Conference Center in the City of San Ramon. (See Figure 8-4)
- Concord-Green Valley Fault Scenario—A Magnitude-6.8 event with a depth of 9 km and epicenter 20 miles north of the City of Martinez. (See Figure 8-5)
- Greenville Fault Scenario—A Magnitude-7.0 event with a depth of 12 km and epicenter 29 miles southeast of the City of San Ramon. (See Figure 8-6)
- Haywired Fault Scenario—A Magnitude-7.05 event with a depth of 8 km and epicenter 3.5 miles southwest of the Town of Moraga. (See Figure 8-7)
- Mount Diablo Fault Scenario—A Magnitude-6.7 event with a depth of 14 km and epicenter 10.5 miles east of the City of Danville. (See Figure 8-8).

NEHRP Soil Maps

NEHRP soil types define the locations that will be significantly impacted by an earthquake. NEHRP Soils B and C typically can sustain low-magnitude ground shaking without much effect. The areas that are most commonly affected by ground shaking have NEHRP Soils D, E and F. Figure 8-9 shows NEHRP soil classifications in the planning area.

Liquefaction Maps

Soil liquefaction maps are useful tools to assess potential damage from earthquakes. When the ground liquefies, sandy or silty materials saturated with water behave like a liquid, causing pipes to leak, roads and airport runways to buckle, and building foundations to be damaged. In general, areas with NEHRP Soils D, E and F are also susceptible to liquefaction. If there is a dry soil crust, excess water will sometimes come to the surface through cracks in the confining layer, bringing liquefied sand with it, creating sand boils. Figure 8-10 shows the liquefaction susceptibility in the planning area.

Alquist-Priolo Zone Maps

The sliding movement of earth on either side of a fault is called a fault rupture. Fault rupture begins below the ground surface at the earthquake hypocenter, typically between 3 and 10 miles below the ground surface in California. If an earthquake is large enough, the fault rupture will travel to the ground surface, potentially destroying structures built across its path (Cal OES, 2013).

California's Alquist-Priolo Zone maps define regulatory zones for potential surface fault rupture where fault lines intersect with future development and populated areas. The purpose of these maps is to assist in a geologic investigation before construction begins to ensure that structures will not be located on an active fault. Contra Costa County is located in a designated Alquist-Priolo Zone for active faults (California Department of Conservation, 2010).

Alquist-Priolo maps were referenced, but not specifically used, in the assessment of risk for this plan. This plan assumes that the studies conducted and information provided by the State of California are the best available data for surface rupture risk and could not be improved through a separate assessment for this plan. Alquist-Priolo maps are available to the public on the California Department of Conservation website.

Contra Costa County

Figure 8-4. Calaveras M7.0 Earthquake Scenario Peak Ground Acceleration

Modified Mercalli Scale, Potential Shaking

- I (Not Felt)
- II-III (Weak)
- IV (Light)
- V (Moderate)
- VI (Strong)
- VII (Very Strong)
- VIII (Severe)
- IX (Violent)
- X+ (Extreme)

Range of Model Results Inside Planning Area

Contra Costa County Boundary

City Boundaries

Water Bodies & Channels

Map Data Sources: Contra Costa County, Caltrans, USGS, USDA

0 2.5 5 10

Miles

N W E S

TETRA TECH

Contra Costa County

Figure 8-5. Concord Green Valley M6.8 Earthquake Scenario Peak Ground Acceleration

Modified Mercalli Scale, Potential Shaking

- I (Not Felt)
- II-III (Weak)
- IV (Light)
- V (Moderate)
- VI (Strong)
- VII (Very Strong)
- VIII (Severe)
- IX (Violent)
- X+ (Extreme)

Range of Model Results Inside Planning Area

Contra Costa County Boundary

City Boundaries

Water Bodies & Channels

Map Data Sources: Contra Costa County, Caltrans, USGS, USDA

0 2.5 5 10

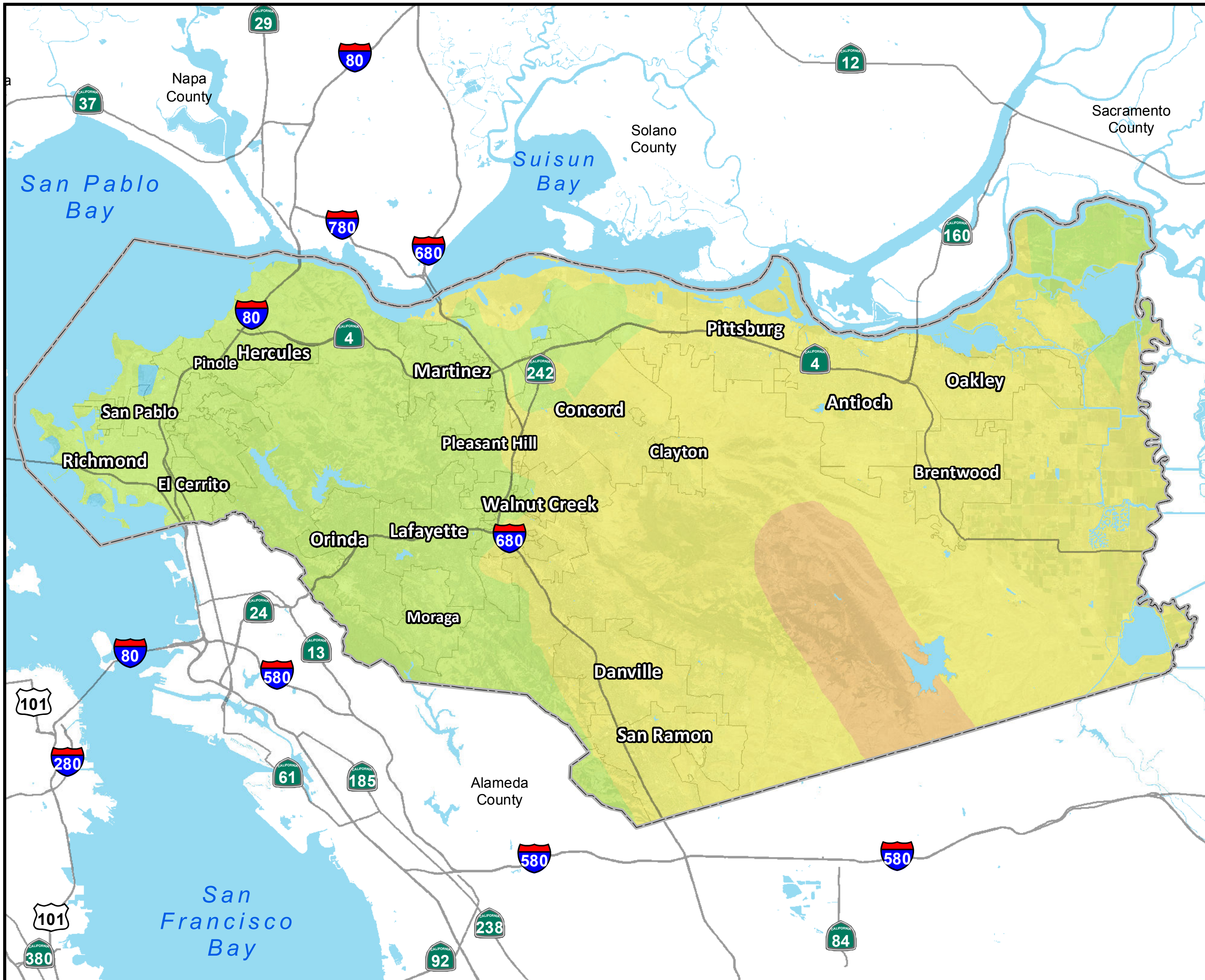
Miles

N W E S

TETRA TECH

Contra Costa County

Figure 8-6. Greenville M7.0 Earthquake Scenario Peak Ground Acceleration



Modified Mercalli Scale, Potential Shaking

- I (Not Felt)
- II-III (Weak)
- IV (Light)
- V (Moderate)
- VI (Strong)
- VII (Very Strong)
- VIII (Severe)
- IX (Violent)
- X+ (Extreme)

Range of Model Results Inside Planning Area

Contra Costa County Boundary

City Boundaries

Water Bodies & Channels

Map Data Sources: Contra Costa County, Caltrans, USGS, USDA

0 2.5 5 10

Miles

N W E S

TETRA TECH

Contra Costa County

Figure 8-7. Haywired M7.05 Earthquake Scenario Peak Ground Acceleration

Modified Mercalli Scale, Potential Shaking

- I (Not Felt)
- II-III (Weak)
- IV (Light)
- V (Moderate)
- VI (Strong)
- VII (Very Strong)
- VIII (Severe)
- IX (Violent)
- X+ (Extreme)

Range of Model Results Inside Planning Area

- Contra Costa County Boundary
- City Boundaries
- Water Bodies & Channels

Map Data Sources: Contra Costa County, Caltrans, USGS, USDA

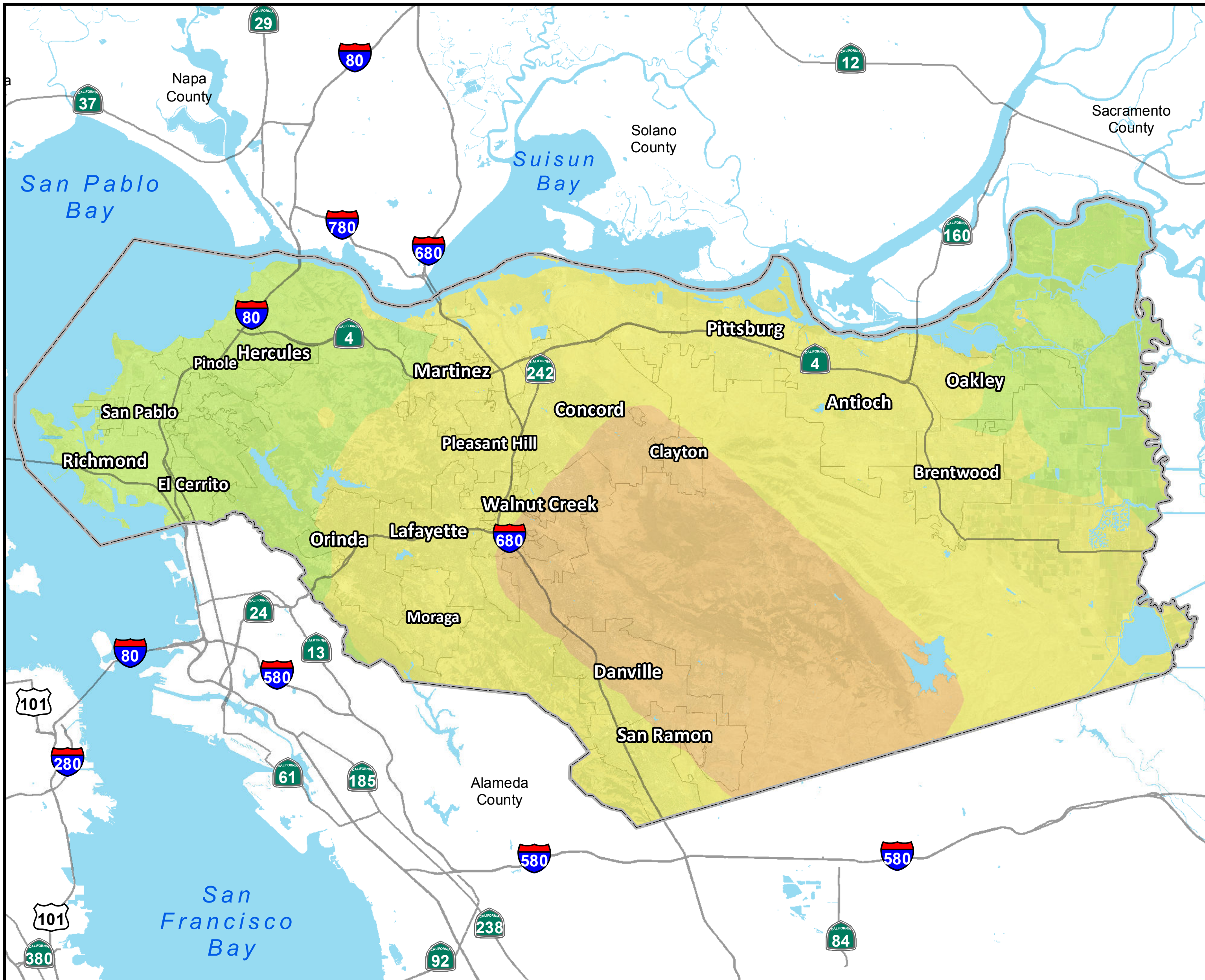
0 2.5 5 10
Miles

N
W E
S

TETRA TECH

Contra Costa County

Figure 8-8. Mt. Diablo M6.7 Earthquake Scenario Peak Ground Acceleration



Modified Mercalli Scale, Potential Shaking

- I (Not Felt)
- II-III (Weak)
- IV (Light)
- V (Moderate)
- VI (Strong)
- VII (Very Strong)
- VIII (Severe)
- IX (Violent)
- X+ (Extreme)

Range of Model Results Inside Planning Area

- Contra Costa County Boundary
- City Boundaries
- Water Bodies & Channels

Map Data Sources: Contra Costa County, Caltrans, USGS, USDA

0 2.5 5 10
Miles

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W E
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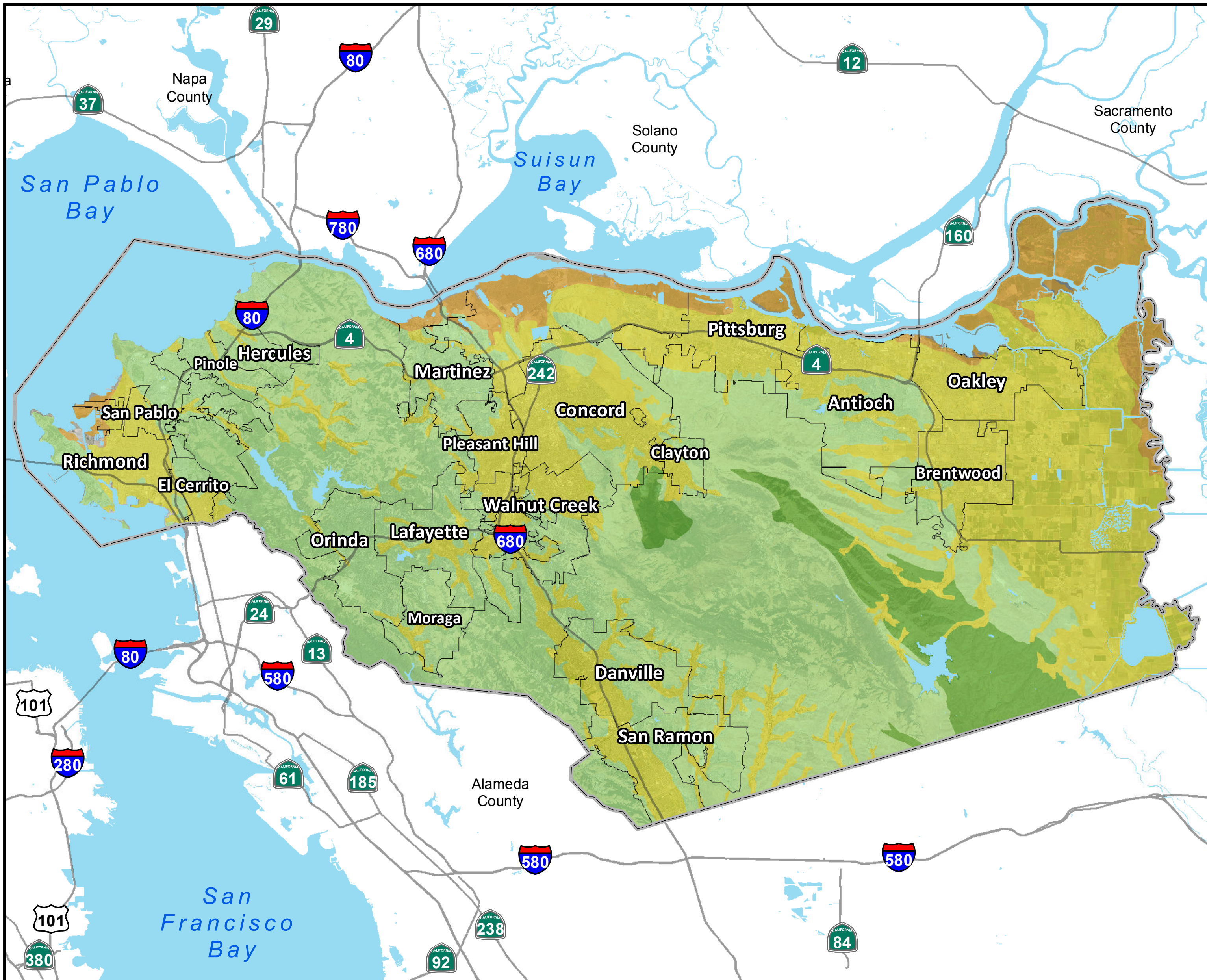
TETRA TECH

Contra Costa County

Figure 8-9. National Earthquake Hazard Reduction Program (NEHRP) Soil Class



NEHRP Site Class / Soil Profile

- B / Rock
- C / Very Dense Soil - Soft Rock
- D / Stiff Soil
- E / Soft Soil

- Contra Costa County Boundary
- City Boundaries
- Water Bodies & Channels

Map Data Sources: Contra Costa County, Caltrans, California Department of Conservation, USDA

0 2.5 5 10

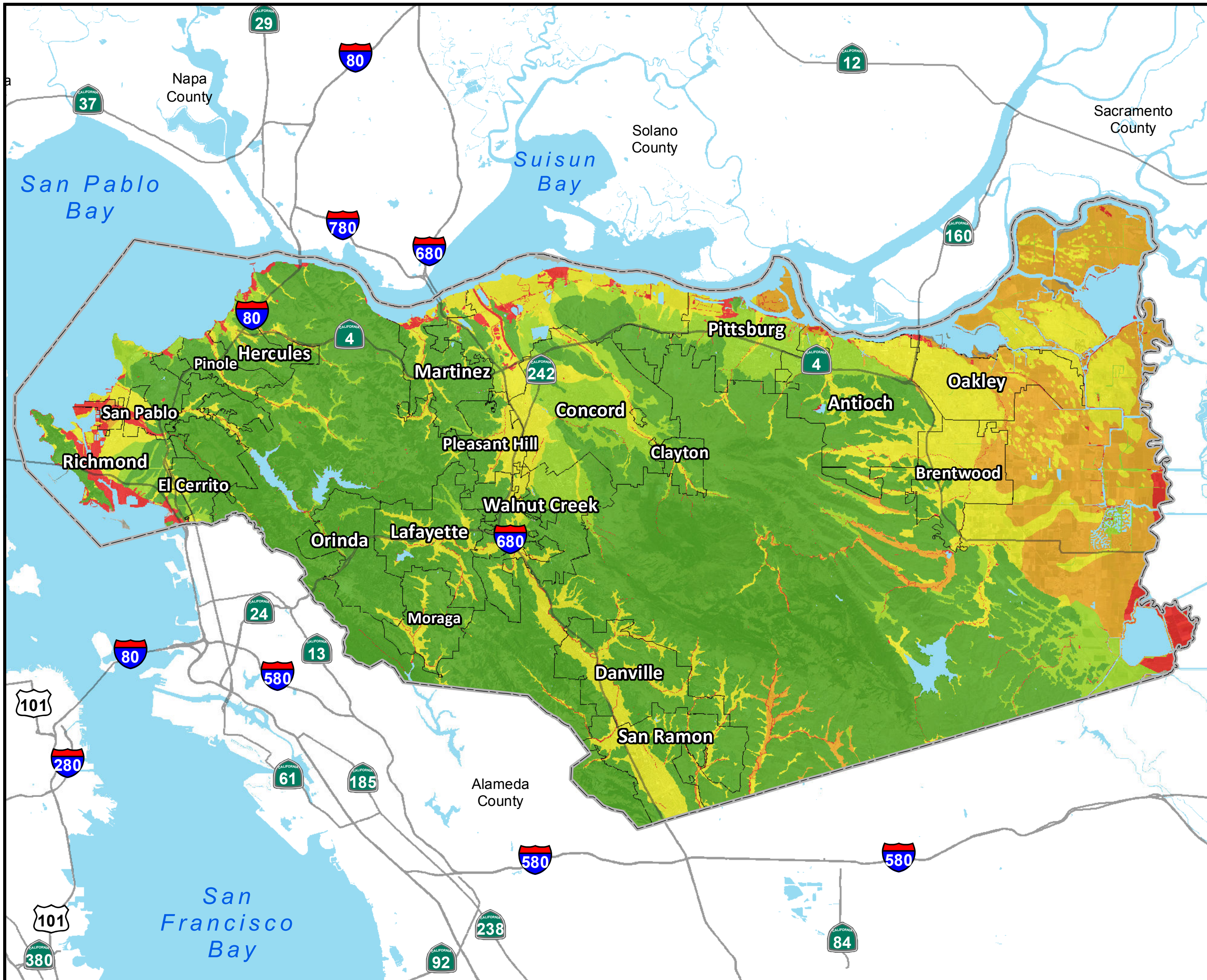
Miles

N W E S

TETRA TECH

Contra Costa County

Figure 8-10. Liquefaction Susceptibility



No Liquefaction Data Available

Susceptibility to Liquefaction

- Very Low
- Low
- Medium
- High
- Very High

Contra Costa County Boundary

City Boundaries

Water Bodies & Channels

Map Data Sources: Contra Costa County, Caltrans, California Geological Survey, USDA, USGS

0 2.5 5 10

Miles

N W E S

TETRA TECH

8.2.3 Frequency

California experiences hundreds of earthquakes each year, most with minimal damage and magnitudes below 3.0 on the Richter Scale. Earthquakes that cause moderate damage to structures occur several times a year. According to the USGS, a strong earthquake measuring greater than 5.0 on the Richter Scale occurs every 2 to 3 years and major earthquakes of more than 7.0 on the Richter Scale occur once a decade.

The USGS estimated in 2016 that there is a 72-percent probability of at least one earthquake before 2043 with a magnitude of 6.7 or greater that could cause widespread damage in the San Francisco Bay area (USGS, 2016). The 2013 *State of California Multi-Hazard Mitigation Plan* cites projections that in the next 30 years there is more than a 99-percent probability of a Magnitude 6.7 earthquake in California and a 94-percent probability of a Magnitude 7.0 earthquake. Probabilities for earthquakes on major fault lines in the San Francisco Bay Area have been estimated by the USGS in a 2016 report (see Table 8-4). The Hayward and Rodgers Creek Faults have high potential for experiencing major to great events.

Table 8-4. Earthquake Probabilities for the San Francisco Bay Area Region, 2014-2043

Fault	Probability of One or More M≥6.7 Quake 2014-2043
Hunting Creek	16%
Green Valley	16%
Concord	16%
Greenville	16%
Berryessa	16%
Calaveras	26%
Maacama	8%
Rodgers Creek Fault	33%
Hayward	33%
San Andreas	22%
San Gregorio	6%

Source: USGS, 2016

8.2.4 Severity

The severity of an earthquake can be expressed in terms of intensity or magnitude:

- Intensity represents the observed effects of ground shaking at any specified location. The intensity of earthquake shaking lessens with distance from the earthquake epicenter. Tabulated peak ground accelerations for a listed “maximum credible earthquakes” are a measure of how a site will be affected by seismic events on distant faults.
- Magnitude represents the amount of seismic energy released at the hypocenter of the earthquake. It is based on the amplitude of the earthquake waves recorded on instruments. Magnitude is thus represented by a single, instrumentally determined value.

USGS ground motion maps, based on current information about fault zones, show the PGA that has a certain probability of being exceeded in a 50-year period. The maps, last updated in 2014 with the best currently available data, show that the PGA with a 10-percent probability of exceedance in 50 years for Contra Costa County is 0.4g (see Figure 8-11). ABAG estimates a potential loss of 159,000 housing units in Bay Area communities after a large earthquake. This loss would have disastrous effects on local and regional economies. Recovery, repair, and rebuilding time for each household would be lengthy.

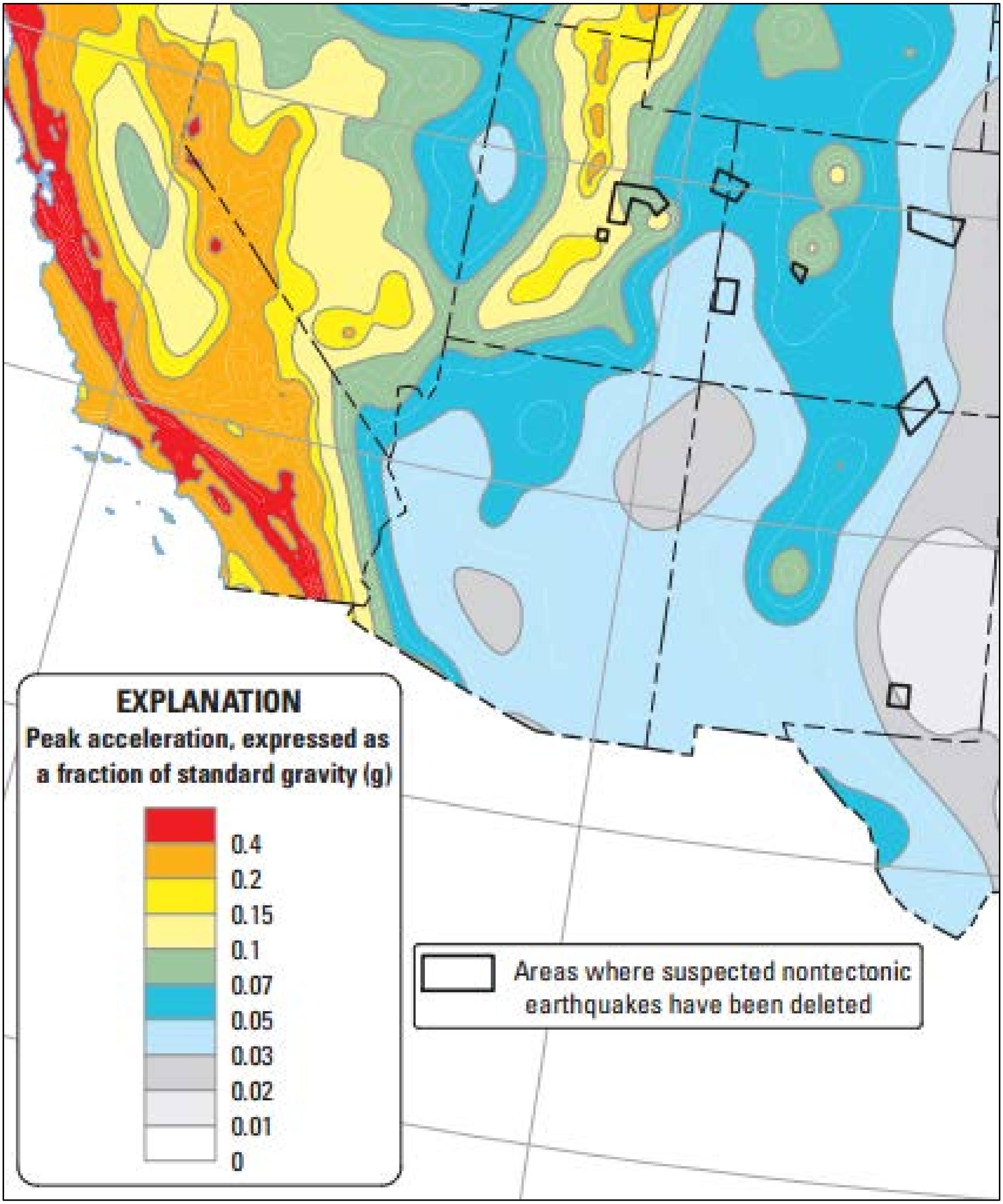


Figure 8-11. Peak Ground Acceleration with 10-percent Probability of Exceedance in 50 Years

8.2.5 Warning Time

There is no current reliable way to predict the day or month that an earthquake will occur at any given location. Research is being done with warning systems that use the low energy waves that precede major earthquakes. These potential warning systems give approximately 40 seconds notice that a major earthquake is about to occur. The warning time is very short but it could allow for someone to get under a desk, step away from a hazardous material they are working with, or shut down a computer system.

8.3 SECONDARY HAZARDS

Earthquakes can cause disastrous landslides. River valleys are vulnerable to slope failure, often as a result of loss of cohesion in clay-rich soils. Soil liquefaction occurs when water-saturated sands, silts or gravelly soils are shaken so violently that the individual grains lose contact with one another and float freely in the water, turning the ground into a pudding-like liquid. Building and road foundations lose load-bearing strength and may sink into what was previously solid ground. Unless properly secured, hazardous materials can be released, causing significant damage to the environment and people. Earthen dams and levees are highly susceptible to seismic events and the impacts of their eventual failures can be considered secondary risks for earthquakes.

Earthen dams and levees are highly susceptible to seismic events, and the impacts of their eventual failures can be considered secondary risk exposure to earthquakes. Depending on the location, earthquakes can also trigger tsunamis. Tsunamis significantly damage many locations beyond what the earthquake struck; however, coastal communities near the earthquake epicenter that are also vulnerable to tsunamis could experience devastating impacts. Additionally, fires can result from gas lines or power lines that are broken or downed during the earthquake. It may be difficult to control a fire, particularly if the water lines feeding fire hydrants are also broken.

8.4 EXPOSURE

8.4.1 Population

The entire population of the planning area is potentially exposed to direct and indirect impacts from earthquakes. Whether directly impacted or indirectly impact, the entire population will have to deal with the consequences of earthquakes to some degree. Business interruption could keep people from working, road closures could isolate populations, and loss of functions of utilities could impact populations that suffered no direct damage from an event itself.

8.4.2 Property

According to Contra Costa County Assessor records, there are 346,901 buildings in the planning area, with a total replacement value of $246.3 billion. Since all structures in the planning area are susceptible to earthquake impacts to varying degrees, this represents the property exposure to seismic events. Most of the buildings (97 percent) are residential. Table 8-5 shows the exposure value breakdown by municipality.

8.4.3 Critical Facilities and Infrastructure

All critical facilities in the planning area (see Table 4-5 and Table 4-6) are exposed to the earthquake hazard. Hazardous materials releases can occur during an earthquake from fixed facilities or transportation-related incidents. Transportation corridors can be disrupted during an earthquake, leading to the release of materials to the surrounding environment. Facilities holding hazardous materials are of particular concern because of possible isolation of neighborhoods surrounding them. During an earthquake, structures storing these materials could rupture and leak into the surrounding area or an adjacent waterway, having a disastrous effect on the environment.

Table 8-5. Earthquake Exposure by Municipality

Jurisdiction	Total # of Buildings	Total Building Value—Structure and Contents
Antioch	31,467	$20,634,649,519
Brentwood	18,500	$12,128,473,460
Clayton	4,080	$2,252,467,641
Concord	37,003	$26,123,025,057
Danville	15,570	$10,282,590,156
El Cerrito	8,409	$5,468,962,350
Hercules	8,284	$4,178,980,493
Lafayette	8,397	$6,524,080,333
Martinez	12,683	$8,879,794,159
Moraga	5,549	$3,931,573,175
Oakley	11,448	$6,069,903,473
Orinda	6,855	$4,739,583,178
Pinole	6,279	$3,861,258,311
Pittsburg	18,142	$12,127,672,643
Pleasant Hill	11,311	$7,982,365,182
Richmond	30,016	$26,588,690,622
San Pablo	6,579	$4,518,650,567
San Ramon	23,493	$19,832,689,351
Walnut Creek	27,594	$19,307,555,958
Unincorporated	55,242	$40,853,385,267
Total	346,901	$246,286,350,895

The following major roads in the planning area intersect moderate to very high liquefiable soils and thus are exposed to earthquakes:

- Interstate 680
- Interstate 80
- State Hwy 160
- State Hwy 242
- State Hwy 4
- State Hwy 4 Bypass
- Road 20
- Eastshore Freeway
- Grove Shafter Freeway
- John T Knox Freeway
- Byron Highway
- Pittsburg Antioch Highway
- Port Chicago Highway
- Branch Parkway
- Chilpancingo Parkway
- Garin Parkway
- John Muir Parkway
- Marina Bay Parkway
- Mountaire Parkway
- Richmond Parkway
- Rossmoor Parkway
- Village Parkway
- Vineyards Parkway
- Vintage Parkway
- Waterworld Parkway
- Windemere Parkway

8.4.4 Environment

Environmental problems as a result of an earthquake can be numerous. Secondary hazards will likely have some of the most damaging effects on the environment. Earthquake-induced landslides can significantly damage surrounding habitat. It is also possible for streams to be rerouted after an earthquake. Rerouting can change the water quality, possibly damaging habitat and feeding areas. Streams fed by groundwater wells can dry up because of changes in underlying geology.

8.5 VULNERABILITY

Earthquake vulnerability data was generated using a Hazus analysis. Once the location and size of a hypothetical earthquake are identified, Hazus estimates the intensity of the ground shaking, the number of buildings damaged, the number of casualties, the damage to transportation systems and utilities, the number of people displaced from their homes, and the estimated cost of repair and clean up.

8.5.1 Population

Residents of High Risk Areas

The degree of vulnerability is dependent on many factors, including the age and construction type of the structures people live in, the soil type their homes are constructed on, their proximity to fault location, etc. There are estimated to be 369,779 people living on soils with moderate to very high liquefaction potential in the planning area. This is about 32 percent of the total population. This includes 24,921 households on soils with high or very high liquefaction potential.

Susceptible Population Groups

Two groups are particularly vulnerable to earthquake hazards:

- **Population Below Poverty Level**—An estimated 43,465 households in areas with moderate to very high liquefaction potential soils have household incomes less than $50,000 per year. This is about 33 percent of all households in those areas. These households may lack the financial resources to improve their homes to prevent or mitigate earthquake damage. Economically disadvantaged residents are also less likely to have insurance to compensate for losses in earthquakes.
- **Population Over 65 Years Old**—An estimated 39,331 residents in areas with moderate to very high liquefaction potential soils are over 65 years old. This is about 11 percent of all residents in those areas. This population group is vulnerable because they are more likely to need special medical attention, which may not be available due to isolation caused by earthquakes. Elderly residents also have more difficulty leaving their homes during earthquake events and could be stranded in dangerous situations.

Estimated Impacts on Persons and Households

Impacts on persons and households in the planning area were estimated for the five selected earthquake scenarios through the Hazus analysis. Table 8-6 summarizes the results.

Table 8-6. Estimated Earthquake Impact on Persons

Scenario	Number of Displaced Households	Number of Persons Requiring Short-Term Shelter
Calaveras North Central	3,034	1,593
Concord-Green Valley	5,131	2,974
Greenville	1,838	1,237
Haywired	9,867	5,962
Mount Diablo	5,051	2,744

8.5.2 Property

Liquefaction Potential

Table 8-7 shows the estimated number of buildings on moderate to very high liquefiable soils. There are estimated to be 118,430 buildings, or 34 percent of the total building stock, on these soils.

Table 8-7. Number of Buildings on Moderate to Very High Liquefiable Soils

Jurisdiction	Number of Buildings
Antioch	6,866
Brentwood	14,913
Clayton	589
Concord	8,858
Danville	7,769
El Cerrito	1,557
Hercules	1,555
Lafayette	3,150
Martinez	2,180
Moraga	1,940
Oakley	11,448
Orinda	161
Pinole	931
Pittsburg	823
Pleasant Hill	5,449
Richmond	7,841
San Pablo	5,204
San Ramon	10,858
Walnut Creek	6,241
Unincorporated	20,097
Total	118,430

Building Age

Table 8-8 identifies significant milestones in building and seismic code requirements that directly affect the structural integrity of development. Using these time periods, the planning team used Hazus to identify the number of structures in the planning area by date of construction. The number of structures does not reflect the number of total housing units, as many multi-family units and attached housing units are reported as one structure.

Table 8-8. Age of Structures in Planning Area

Time Period	Number of Current Planning Area Structures Built in Period	Significance of Time Frame
Pre-1933	7,938	Before 1933, there were no explicit earthquake requirements in building codes. State law did not require local governments to have building officials or issue building permits.
1933-1940	5,350	In 1940, the first strong motion recording was made.
1941-1960	63,291	In 1960, the Structural Engineers Association of California published guidelines on recommended earthquake provisions.
1961-1975	72,228	In 1975, significant improvements were made to lateral force requirements.
1976-1994	116,492	In 1994, the Uniform Building Code was amended to include provisions for seismic safety.
1994 - present	81,602	Seismic code is currently enforced.
Total	346,901	

Approximately 24 percent of the planning area’s structures were constructed after the Uniform Building Code was amended in 1994 to include seismic safety provisions. Approximately 2 percent were built before 1933 when there were no building permits, inspections, or seismic standards.

Soft-Story Buildings

A soft-story building is a multi-story building with one or more floors that are “soft” due to structural design. If a building has a floor that is 70-percent less stiff than the floor above it, it is considered a soft-story building. This soft story creates a major weak point in an earthquake. Since soft stories are typically associated with retail spaces and parking garages, they are often on the lower stories of a building. When they collapse, they can take the whole building down with them, causing serious structural damage that may render the structure totally unusable (see Figure 8-12).

Figure 8-12. Soft-Story Damage from 1989 Loma Prieta Earthquake

These floors can be especially dangerous in earthquakes, because they cannot cope with the lateral forces caused by the swaying of the building during a quake. As a result, the soft story may fail, causing what is known as a soft story collapse. Soft-story collapse is one of the leading causes of earthquake damage to private residences.

Exposure and vulnerability of soft-story construction in the planning area are not currently known. ABAG and other agencies in the Bay Area have programs generating this type of data, but it is not known when such data will be available for the Contra Costa County planning area. This type of data will need to be generated to support future risk assessments of the earthquake hazard.

Unreinforced Masonry Buildings

Unreinforced masonry buildings are constructed from materials such as adobe, brick, hollow clay tiles, or other masonry materials and do not contain an internal reinforcing structure, such as rebar in concrete or steel bracing for brick. Unreinforced masonry poses a significant danger during an earthquake because the mortar holding masonry together is typically not strong enough to withstand significant earthquakes. The brittle composition of these buildings can break apart and fall away or buckle, potentially causing a complete collapse of the building.

In Contra Costa County, unreinforced masonry buildings are generally brick buildings that were constructed before modern earthquake building codes and designs were enacted. The State of California enacted a law in 1986 that required all local governments in Seismic Zone 4 (nearest to active earthquake faults) to inventory unreinforced masonry buildings. The law encourages local governments to adopt local mandatory strengthening programs, delineate seismic retrofit standards, and put into place measures to reduce the number of people in unreinforced masonry buildings.

According to ABAG, housing units in unreinforced masonry buildings account for only 1 percent of the total Bay Area housing stock and 2.9 percent of the total Bay Area multi-family stock.

Loss Potential

Property losses were estimated through the Hazus analysis for the five scenario events. Results for two types of property loss are shown on Table 8-9 through Table 8-13:

- Structural loss, representing damage to building structures
- Contents loss, representing the value of lost contents and inventory, relocation, income loss, rental loss, and wage loss.

Table 8-9. Loss Estimates for Calaveras (North Central) Fault Scenario Earthquake

	Estimated Loss Associated with Earthquake			% of Total Replacement Value
	Structure	Contents	**Total**	
Antioch	$167,633,378	$56,856,584	$224,489,962	1.1%
Brentwood	$52,137,319	$18,178,306	$70,315,626	0.6%
Clayton	$33,623,127	$9,466,778	$43,089,905	1.9%
Concord	$305,109,098	$104,561,253	$409,670,351	1.6%
Danville	$619,694,363	$163,128,425	$782,822,788	7.6%
El Cerrito	$15,359,041	$6,751,569	$22,110,610	0.4%
Hercules	$20,554,472	$7,342,326	$27,896,798	0.7%
Lafayette	$188,995,316	$56,009,721	$245,005,037	3.8%
Martinez	$58,420,508	$22,289,852	$80,710,360	0.9%
Moraga	$108,740,476	$32,380,036	$141,120,512	3.6%
Oakley	$16,655,384	$6,539,941	$23,195,325	0.4%
Orinda	$40,230,312	$14,132,031	$54,362,342	1.1%
Pinole	$10,116,522	$4,427,137	$14,543,660	0.4%
Pittsburg	$177,553,729	$59,890,594	$237,444,323	2.0%
Pleasant Hill	$153,315,426	$45,978,741	$199,294,166	2.5%
Richmond	$84,489,325	$40,865,336	$125,354,662	0.5%
San Pablo	$12,286,290	$5,454,918	$17,741,207	0.4%
San Ramon	$1,355,882,243	$409,290,234	$1,765,172,476	8.9%
Walnut Creek	$396,950,009	$123,756,798	$520,706,807	2.7%
Unincorporated	$540,058,723	$175,325,328	$715,384,051	1.8%
Total	$4,357,805,060	$1,362,625,909	$5,720,430,969	2.3%

Table 8-10. Loss Estimates for Concord-Green Valley Fault Scenario Earthquake

	Estimated Loss Associated with Earthquake			% of Total Replacement Value
	Structure	Contents	Total	
Antioch	$174,455,002	$61,298,359	$235,753,360	1.1%
Brentwood	$35,440,819	$14,663,580	$50,104,399	0.4%
Clayton	$73,877,219	$19,863,405	$93,740,624	4.2%
Concord	$1,542,523,038	$487,903,347	$2,030,426,385	7.8%
Danville	$129,734,161	$42,694,841	$172,429,002	1.7%
El Cerrito	$16,542,848	$8,146,686	$24,689,534	0.5%
Hercules	$58,279,030	$20,629,448	$78,908,478	1.9%
Lafayette	$150,898,921	$47,484,149	$198,383,070	3.0%
Martinez	$342,950,977	$113,368,761	$456,319,738	5.1%
Moraga	$47,865,153	$16,986,980	$64,852,133	1.6%
Oakley	$14,865,010	$6,541,725	$21,406,734	0.4%
Orinda	$19,734,071	$8,994,906	$28,728,978	0.6%
Pinole	$17,853,942	$7,527,843	$25,381,785	0.7%
Pittsburg	$272,968,523	$92,284,802	$365,253,324	3.0%
Pleasant Hill	$494,510,917	$137,775,869	$632,286,786	7.9%
Richmond	$122,110,898	$64,347,405	$186,458,303	0.7%
San Pablo	$20,934,144	$9,538,316	$30,472,460	0.7%
San Ramon	$153,933,806	$61,142,458	$215,076,264	1.1%
Walnut Creek	$663,013,019	$204,330,669	$867,343,688	4.5%
Unincorporated	$711,133,973	$253,556,842	$964,690,814	2.4%
Total	$5,063,625,472	$1,679,080,391	$6,742,705,863	2.7%

Table 8-11. Loss Estimates for Greenville Fault Scenario Earthquake

	Estimated Loss Associated with Earthquake			% of Total Replacement Value
	Structure	Contents	Total	
Antioch	$403,425,765	$130,135,114	$533,560,879	2.6%
Brentwood	$139,692,285	$46,317,741	$186,010,026	1.5%
Clayton	$50,082,379	$13,834,636	$63,917,015	2.8%
Concord	$151,525,452	$66,556,095	$218,081,547	0.8%
Danville	$74,908,838	$26,991,738	$101,900,576	1.0%
El Cerrito	$6,131,267	$3,680,192	$9,811,459	0.2%
Hercules	$15,117,244	$5,854,570	$20,971,814	0.5%
Lafayette	$31,772,881	$12,632,943	$44,405,824	0.7%
Martinez	$31,280,889	$14,825,077	$46,105,966	0.5%
Moraga	$13,371,884	$6,159,680	$19,531,564	0.5%
Oakley	$45,105,907	$17,441,418	$62,547,325	1.0%
Orinda	$6,706,314	$3,414,422	$10,120,736	0.2%
Pinole	$4,327,025	$2,588,433	$6,915,458	0.2%
Pittsburg	$270,515,892	$91,598,683	$362,114,575	3.0%
Pleasant Hill	$59,501,948	$22,725,045	$82,226,992	1.0%
Richmond	$43,339,577	$26,833,192	$70,172,769	0.3%
San Pablo	$6,076,624	$3,548,490	$9,625,114	0.2%
San Ramon	$171,203,574	$66,557,486	$237,761,059	1.2%
Walnut Creek	$92,693,975	$41,398,903	$134,092,878	0.7%
Unincorporated	$253,028,933	$103,882,284	$356,911,218	0.9%
Total	$1,869,808,654	$706,976,141	$2,576,784,795	1.0%

Table 8-12. Loss Estimates for Haywired Fault Scenario Earthquake

	Estimated Loss Associated with Earthquake			% of Total Replacement Value
	Structure	Contents	Total	
Antioch	$309,016,689	$94,261,385	$403,278,074	2.0%
Brentwood	$128,374,678	$37,472,569	$165,847,246	1.4%
Clayton	$47,273,047	$13,218,372	$60,491,419	2.7%
Concord	$422,239,844	$138,533,546	$560,773,390	2.1%
Danville	$853,583,623	$234,777,918	$1,088,361,541	10.6%
El Cerrito	$354,307,468	$105,944,154	$460,251,622	8.4%
Hercules	$310,159,915	$88,843,782	$399,003,696	9.5%
Lafayette	$472,810,358	$129,861,459	$602,671,817	9.2%
Martinez	$177,820,976	$57,100,395	$234,921,371	2.6%
Moraga	$315,707,575	$90,198,522	$405,906,098	10.3%
Oakley	$49,908,680	$15,467,891	$65,376,571	1.1%
Orinda	$254,610,593	$78,234,733	$332,845,326	7.0%
Pinole	$309,266,624	$92,090,153	$401,356,777	10.4%
Pittsburg	$274,014,820	$87,211,794	$361,226,614	3.0%
Pleasant Hill	$232,965,479	$65,754,785	$298,720,264	3.7%
Richmond	$2,323,076,152	$845,392,266	$3,168,468,418	11.9%
San Pablo	$502,723,229	$158,190,334	$660,913,563	14.6%
San Ramon	$1,674,141,701	$515,170,649	$2,189,312,350	11.0%
Walnut Creek	$526,041,900	$167,786,118	$693,828,018	3.6%
Unincorporated	$1,722,945,372	$569,743,858	$2,292,689,230	5.6%
Total	$11,260,988,722	$3,585,254,683	$14,846,243,405	6.0%

Table 8-13. Loss Estimates for Mount Diablo Fault Scenario Earthquake

	Estimated Loss Associated with Earthquake			% of Total Replacement Value
	Structure	Contents	Total	
Antioch	$313,399,993	$101,240,063	$414,640,056	2.0%
Brentwood	$98,755,085	$33,741,927	$132,497,012	1.1%
Clayton	$190,406,014	$49,301,302	$239,707,317	10.6%
Concord	$766,343,253	$233,499,443	$999,842,696	3.8%
Danville	$614,208,865	$166,713,807	$780,922,672	7.6%
El Cerrito	$13,006,105	$6,034,677	$19,040,781	0.3%
Hercules	$18,447,602	$6,990,786	$25,438,389	0.6%
Lafayette	$217,207,487	$65,464,312	$282,671,799	4.3%
Martinez	$81,873,874	$31,894,006	$113,767,880	1.3%
Moraga	$82,471,301	$26,720,366	$109,191,667	2.8%
Oakley	$27,655,316	$11,156,038	$38,811,354	0.6%
Orinda	$29,549,610	$11,906,595	$41,456,205	0.9%
Pinole	$9,628,257	$4,473,724	$14,101,981	0.4%
Pittsburg	$355,713,509	$114,526,305	$470,239,814	3.9%
Pleasant Hill	$214,500,805	$63,285,530	$277,786,335	3.5%
Richmond	$72,188,701	$39,189,643	$111,378,343	0.4%
San Pablo	$8,993,188	$4,530,423	$13,523,612	0.3%
San Ramon	$790,679,464	$249,458,466	$1,040,137,930	5.2%
Walnut Creek	$804,849,062	$243,694,598	$1,048,543,661	5.4%
Unincorporated	$1,017,991,790	$336,255,656	$1,354,247,446	3.3%
Total	$5,727,869,282	$1,800,077,667	$7,527,946,949	3.1%

Debris Estimates

The Hazus analysis also estimated the amount of earthquake-caused debris in the planning area for the five scenario events, as summarized in Table 8-14.

Table 8-14. Estimated Earthquake-Caused Debris

	Debris to Be Removed (tons)
Calaveras (North Central)	1,267,680
Concord-Green Valley	1,624,080
Greenville	396,530
Haywired	3,593,550
Mount Diablo	1,561,660

8.5.3 Critical Facilities and Infrastructure

Level of Damage

Hazus classifies the vulnerability of critical facilities to earthquake damage in five categories: no damage, slight damage, moderate damage, extensive damage, or complete damage. The model was used to assign a probability of each damage state to every critical facility in the planning area, which was then averaged across the facility category. The results for the five fault scenario events are summarized in Table 8-15 through Table 8-19.

Time to Return to Functionality

Hazus estimates the time to restore critical facilities to fully functional use. Results are presented as probability of being functional at specified time increments: 1, 3, 7, 14, 30 and 90 days after the event. For example, Hazus may estimate that a facility has 5 percent chance of being fully functional at Day 3, and a 95-percent chance of being fully functional at Day 90. The analysis of critical facilities in the planning area was performed for the five fault scenarios. Results are summarized in Table 8-20 through Table 8-24.

8.5.4 Environment

The environment vulnerable to earthquake hazard is the same as the environment exposed to the hazard.

Table 8-15. Estimated Damage to Critical Facilities from Calaveras (North Central) Fault Scenario

	Probability of Experiencing Damage Level (Average for All Facilities in Category)				
Category	No Damage	Slight Damage	Moderate Damage	Extensive Damage	Complete Damage
Medical and Health	88.94%	8.89%	0.23%	0.10%	1.82%
Government Functions	87.80%	11.40%	0.39%	0.07%	0.33%
Protective Functions	77.29%	18.77%	1.55%	0.13%	2.24%
Schools	76.88%	19.53%	1.70%	0.12%	1.75%
Hazardous Materials	76.52%	14.60%	6.51%	0.28%	2.06%
Bridges	75.41%	14.54%	2.90%	4.76%	2.36%
Water supply	74.99%	16.19%	6.37%	0.81%	1.62%
Wastewater	81.47%	11.93%	3.95%	0.70%	1.93%
Power	84.05%	11.69%	3.11%	0.09%	1.04%
Communications	84.87%	9.90%	3.45%	0.42%	1.34%
Other Critical Functions	87.98%	7.19%	0.46%	0.16%	4.19%
Other Critical Infrastructure	54.10%	18.69%	15.30%	2.41%	9.49%
Total/Average	79.2%	13.6%	3.8%	0.8%	2.5%

Table 8-16. Estimated Damage to Critical Facilities from Concord-Green Valley Fault Scenario

Category	Probability of Experiencing Damage Level (Average for All Facilities in Category)				
	No Damage	Slight Damage	Moderate Damage	Extensive Damage	Complete Damage
Medical and Health	85.46%	10.74%	0.58%	0.23%	2.97%
Government Functions	79.76%	16.33%	1.60%	0.42%	1.87%
Protective Functions	74.20%	19.84%	2.38%	0.29%	3.26%
Schools	77.31%	18.10%	2.04%	0.22%	2.31%
Hazardous Materials	57.52%	13.71%	14.99%	6.90%	6.86%
Bridges	64.55%	18.60%	4.41%	8.12%	4.29%
Water supply	59.48%	19.75%	15.91%	1.68%	3.16%
Wastewater	66.47%	13.72%	12.75%	2.10%	4.95%
Power	68.98%	15.36%	11.72%	1.00%	2.91%
Communications	80.76%	10.83%	5.66%	0.67%	2.06%
Other Critical Functions	75.24%	8.36%	3.22%	0.68%	12.48%
Other Critical Infrastructure	54.55%	20.10%	13.38%	1.61%	10.34%
Total/Average	67.9%	15.8%	8.6%	2.3%	5.3%

Table 8-17. Estimated Damage to Critical Facilities from Greenville Fault Scenario

Category	Probability of Experiencing Damage Level (Average for All Facilities in Category)				
	No Damage	Slight Damage	Moderate Damage	Extensive Damage	Complete Damage
Medical and Health	95.68%	2.29%	0.19%	0.12%	1.70%
Government Functions	90.42%	7.56%	0.22%	0.07%	1.70%
Protective Functions	91.01%	6.60%	0.42%	0.15%	1.79%
Schools	91.46%	6.90%	0.21%	0.12%	1.29%
Hazardous Materials	81.14%	11.22%	4.43%	0.23%	2.95%
Bridges	84.32%	11.02%	1.60%	2.47%	0.56%
Water supply	83.96%	10.75%	2.83%	0.51%	1.93%
Wastewater	92.94%	4.30%	0.62%	0.18%	1.95%
Power	95.18%	3.46%	0.38%	0.05%	0.90%
Communications	86.82%	8.21%	2.20%	0.28%	2.47%
Other Critical Functions	85.74%	5.42%	0.94%	0.60%	7.28%
Other Critical Infrastructure	79.78%	8.94%	2.69%	0.41%	8.15%
Total/Average	87.5%	7.7%	1.5%	0.5%	2.8%

Table 8-18. Estimated Damage to Critical Facilities from Haywired Fault Scenario

Category	Probability of Experiencing Damage Level (Average for All Facilities in Category)				
	No Damage	Slight Damage	Moderate Damage	Extensive Damage	Complete Damage
Medical and Health	73.84%	21.29%	0.59%	0.17%	4.08%
Government Functions	61.39%	33.41%	3.56%	0.10%	1.52%
Protective Functions	52.55%	36.32%	5.43%	0.30%	5.38%
Schools	52.32%	36.95%	5.62%	0.27%	4.82%
Hazardous Materials	36.07%	20.75%	26.16%	8.06%	8.94%
Bridges	54.26%	22.84%	5.67%	9.62%	7.58%
Water supply	57.84%	22.86%	14.00%	1.74%	3.54%
Wastewater	31.98%	19.27%	24.30%	9.58%	14.84%
Power	47.62%	24.13%	18.58%	3.76%	5.88%
Communications	64.51%	18.68%	10.27%	1.68%	4.83%
Other Critical Functions	59.37%	23.62%	3.20%	0.52%	13.26%
Other Critical Infrastructure	42.30%	26.60%	16.17%	2.39%	12.53%
Total/Average	49.9%	25.2%	12.9%	3.8%	8.2%

Table 8-19. Estimated Damage to Critical Facilities from Mount Diablo Fault Scenario

Category	Probability of Experiencing Damage Level (Average for All Facilities in Category)				
	No Damage	Slight Damage	Moderate Damage	Extensive Damage	Complete Damage
Medical and Health	87.01%	9.67%	0.16%	0.13%	3.02%
Government Functions	81.30%	13.89%	1.50%	0.13%	3.16%
Protective Functions	73.70%	20.28%	2.38%	0.16%	3.46%
Schools	72.34%	22.08%	2.63%	0.17%	2.75%
Hazardous Materials	66.43%	17.70%	10.86%	0.66%	4.33%
Bridges	66.18%	19.11%	4.19%	7.30%	3.19%
Water supply	62.05%	20.90%	12.32%	1.30%	3.41%
Wastewater	81.19%	12.01%	3.47%	0.26%	3.05%
Power	78.74%	13.00%	6.06%	0.32%	1.85%
Communications	75.76%	14.82%	5.88%	0.52%	3.00%
Other Critical Functions	79.57%	9.44%	1.18%	0.35%	9.43%
Other Critical Infrastructure	45.43%	20.51%	19.57%	2.61%	11.86%
Total/Average	70.1%	17.0%	6.9%	1.4%	4.6%

Table 8-20. Functionality of Critical Facilities for Calaveras (North Central) Fault Scenario

Planning Unit	# of Critical Facilities	Probability of Being Fully Functional (%)					
		at Day 1	at Day 3	at Day 7	at Day 14	at Day 30	at Day 90
Medical and Health	27	88.9	89.1	97.6	97.8	98.0	98.1
Government Functions	9	87.8	88.0	98.9	99.2	99.5	99.6
Protective Functions	152	77.3	77.7	95.6	96.0	97.5	97.6
Schools	493	76.9	77.3	95.9	96.4	98.0	98.1
Hazardous Materials	157	76.5	77.2	91.0	91.1	97.6	97.8
Bridges	45	87.3	91.8	93.0	93.2	93.6	96.1
Water supply	66	85.5	95.3	97.5	98.0	98.6	99.5
Wastewater	407	85.8	95.1	97.3	97.5	97.9	99.3
Power	52	90.6	97.3	98.9	99.0	99.4	99.9
Communications	109	96.7	98.4	98.6	98.8	99.1	99.8
Other Critical Facilities	17	95.8	96.0	96.1	96.1	96.3	97.0
Other Critical Infrastructure	117	72.2	86.5	89.4	89.7	90.7	94.7
Total/Average	1,624	84.7	89.1	95.7	95.9	97.1	98.1

Table 8-21. Functionality of Critical Facilities for Concord-Green Valley Fault Scenario

Planning Unit	# of Critical Facilities	Probability of Being Fully Functional (%)					
		at Day 1	at Day 3	at Day 7	at Day 14	at Day 30	at Day 90
Medical and Health	27	85.4	85.6	95.9	96.1	96.7	96.8
Government Functions	9	79.7	80.1	95.7	96.0	97.6	97.8
Protective Functions	152	74.2	74.6	93.6	94.0	96.4	96.5
Schools	493	77.3	77.7	95.0	95.4	97.4	97.5
Hazardous Materials	157	57.5	58.1	71.2	71.2	86.2	93.1
Bridges	45	80.1	86.1	87.8	88.2	88.8	93.2
Water supply	66	74.4	90.5	95.2	95.9	96.6	98.5
Wastewater	407	72.4	86.0	92.8	93.4	94.4	98.3
Power	52	78.6	90.3	96.6	97.4	98.4	99.9
Communications	109	94.8	97.6	97.9	98.3	98.7	99.7
Other Critical Facilities	17	86.2	87.7	88.4	88.5	89.0	91.1
Other Critical Infrastructure	117	73.9	86.7	89.2	89.5	90.4	94.3
Total/Average	1,615	76.9	83.5	90.8	91.2	93.6	96.2

Table 8-22. Functionality of Critical Facilities for Greenville Fault Scenario

Planning Unit	# of Critical Facilities	Probability of Being Fully Functional (%)					
		at Day 1	at Day 3	at Day 7	at Day 14	at Day 30	at Day 90
Medical and Health	27	95.6	95.7	97.9	97.9	98.1	98.1
Government Functions	9	90.4	90.5	97.8	97.9	98.1	98.2
Protective Functions	152	91.0	91.1	97.4	97.6	98.0	98.0
Schools	493	91.4	91.6	98.2	98.3	98.5	98.6
Hazardous Materials	157	81.1	81.6	92.3	92.3	96.7	97.0
Bridges	45	93.1	96.4	97.0	97.1	97.3	98.5
Water supply	66	90.7	96.7	97.6	97.9	98.2	99.0
Wastewater	407	94.4	97.4	97.8	97.9	98.0	99.2
Power	52	97.3	98.8	99.0	99.1	99.4	99.9
Communications	109	96.5	97.6	97.8	98.0	98.4	99.7
Other Critical Facilities	17	92.3	92.8	93.0	93.1	93.4	94.8
Other Critical Infrastructure	117	87.1	91.6	92.2	92.4	92.9	95.5
Total/Average	1,615	91.5	93.6	96.2	96.4	97.1	98.0

Table 8-23. Functionality of Critical Facilities for Haywired Fault Scenario

Planning Unit	# of Critical Facilities	Probability of Being Fully Functional (%)					
		at Day 1	at Day 3	at Day 7	at Day 14	at Day 30	at Day 90
Medical and Health	27	73.8	74.3	94.6	95.1	95.7	95.7
Government Functions	9	61.3	62.1	94.0	94.8	98.3	98.3
Protective Functions	152	52.5	53.3	88.0	88.8	94.2	94.4
Schools	493	52.3	53.1	88.4	89.2	94.8	95.0
Hazardous Materials	157	36.0	37.0	56.7	56.8	82.9	91.0
Bridges	45	73.4	80.9	83.1	83.6	84.3	89.6
Water supply	66	74.0	90.4	94.8	95.6	96.4	98.4
Wastewater	407	41.2	63.0	76.2	78.3	83.4	96.0
Power	52	63.4	81.6	92.2	94.7	96.9	99.9
Communications	109	89.3	94.5	95.2	96.1	97.0	99.4
Other Critical Facilities	17	85.6	87.2	87.8	88.0	88.4	90.6
Other Critical Infrastructure	117	68.3	83.8	86.8	87.2	88.3	93.2
Total/Average	1,615	63.6	72.5	84.9	85.8	90.7	94.7

Table 8-24. Functionality of Critical Facilities for Mount Diablo Fault Scenario

Planning Unit	# of Critical Facilities	Probability of Being Fully Functional (%)					
		at Day 1	at Day 3	at Day 7	at Day 14	at Day 30	at Day 90
Medical and Health	27	86.9	87.2	96.4	96.6	96.8	96.8
Government Functions	9	81.3	81.6	94.8	95.1	96.6	96.7
Protective Functions	152	73.7	74.1	93.5	93.9	96.3	96.4
Schools	493	72.3	72.8	93.9	94.4	97.0	97.1
Hazardous Materials	157	66.4	67.2	84.0	84.1	94.9	95.6
Bridges	45	82.0	88.0	89.7	90.1	90.6	94.4
Water supply	66	76.9	91.4	95.3	96.1	96.8	98.5
Wastewater	407	85.5	94.6	96.6	96.7	97.0	99.0
Power	52	86.4	94.8	98.0	98.3	98.9	99.9
Communications	109	94.0	97.0	97.3	97.6	98.1	99.6
Other Critical Facilities	17	90.5	91.1	91.3	91.5	91.8	93.3
Other Critical Infrastructure	117	66.1	83.4	87.1	87.5	88.6	93.5
Total/Average	1,615	79.4	85.4	92.7	93.0	95.0	96.7

8.6 FUTURE TRENDS IN DEVELOPMENT

Land use in the planning area will be directed by general plans adopted under California's General Planning Law. The safety elements of the general plans establish standards and plans for the protection of the community from hazards. The information in this plan provides a tool to ensure that there is no increase in exposure in areas of high seismic risk. Development in the planning area will be regulated through building standards and performance measures so that the degree of risk will be reduced. The geologic hazard portions of the planning area are heavily regulated under California's General Planning Law. The International Building Code establishes provisions to address seismic risk. Table 8-25 summarizes developable land by land use in areas with high or very high susceptibility to liquefaction.

Table 8-25. Developable Land in High and Very High Liquefaction Susceptibility Areas

	Area of Developable Land in High and Very High Liquefaction Susceptibility Areas (acres)	% of Total Developable Land in High and Very High Liquefaction Susceptibility Areas
Residential	1,349.3	72.9%
Commercial-Industrial	377.7	20.4%
Mixed Use	124.6	6.7%
Total	1,851.6	100.0%

Source: Contra Costa County, 2016.

8.7 SCENARIO

With the abundance of fault exposure in the Bay Area, the potential scenarios for earthquake activity are many. An earthquake does not have to occur within the planning area to have a significant impact on the people, property and economy of the planning area.

Any seismic activity of 6.0 or greater on faults within the planning area would have significant impacts throughout the planning area. Potential warning systems could give approximately 40 seconds notice that a major earthquake is about to occur. This would not provide adequate time for preparation. Earthquakes of this magnitude or higher would lead to massive structural failure of property on NEHRP C, D, E, and F soils. Levees and revetments built on these poor soils would likely fail, representing a loss of critical infrastructure. These events could cause secondary hazards, including landslides and mudslides that would further damage structures. River valley hydraulic-fill sediment areas are also vulnerable to slope failure, often as a result of loss of cohesion in clay-rich soils. Soil liquefaction would occur in water-saturated sands, silts or gravelly soils.

8.8 ISSUES

Important issues associated with an earthquake include the following:

- More information is needed on the exposure and performance of soft-story construction within the planning area.
- 43 percent of the planning area’s building stock was built prior to 1975, when seismic provisions became uniformly applied through building code applications.
- Based on the modeling of critical facility performance performed for this plan, a moderate number of facilities in the planning area are expected to have complete or extensive damage from scenario events. These facilities are prime targets for structural retrofits.
- Critical facility owner should be encouraged to create or enhance continuity of operations plans using the information on risk and vulnerability contained in this plan.
- Geotechnical standards should be established that take into account the probable impacts from earthquakes in the design and construction of new or enhanced facilities.
- The planning area has 1,115 miles of earthen levees and revetments on soft, unstable soil. These soils are prone to liquefaction, which would severely undermine the integrity of these facilities.
- There are a large number of earthen dams within the planning area. Dam failure warning and evacuation plans and procedures should be reviewed and updated to reflect the dams’ risk potential associated with earthquake activity in the region.
- Earthquakes could trigger other natural hazard events such as dam failures and landslides, which could severely impact the planning area.
- A worst-case scenario would be the occurrence of a large seismic event during a flood or high-water event. Levee failures would happen at multiple locations, increasing the impacts of the individual events.
- Citizens are expected to be self-sufficient up to 3 days after a major earthquake without government response agencies, utilities, private-sector services, and infrastructure components. Education programs are currently in place to facilitate development of individual, family, neighborhood, and business earthquake preparedness. Government alone can never make this region fully prepared. It takes individuals, families, and communities working in concert with one another to truly be prepared for disaster.
- After a major seismic event, Contra Costa County is likely to experience disruptions in the flow of goods and services resulting from the destruction of major transportation infrastructure across the broader region.

9. FLOOD

9.1 GENERAL BACKGROUND

A floodplain is the area adjacent to a river, creek or lake that becomes inundated during a flood. Floodplains may be broad, as when a river crosses an extensive flat landscape, or narrow, as when a river is confined in a canyon.

When floodwaters recede after a flood event, they leave behind layers of rock and mud. These gradually build up to create a new floor of the floodplain. Floodplains generally contain unconsolidated sediments (accumulations of sand, gravel, loam, silt, and/or clay), often extending below the bed of the stream. These sediments provide a natural filtering system, with water percolating back into the ground and replenishing groundwater. These are often important aquifers, the water drawn from them being filtered compared to the water in the stream. Fertile, flat reclaimed floodplain lands are commonly used for agriculture, commerce and residential development.

Connections between a river and its floodplain are most apparent during and after major flood events. These areas form a complex physical and biological system that not only supports a variety of natural resources but also provides natural flood and erosion control. When a river is separated from its floodplain with levees and other flood control facilities, natural, built-in benefits can be lost, altered, or significantly reduced.

DEFINITIONS

Flood—The inundation of normally dry land resulting **from** the rising and overflowing of a body of water.

Floodplain—The land area along the sides of a river that becomes inundated with water during a flood.

1-Percent-Annual-Chance (100-Year) Floodplain—The area flooded by the flood that has a 1-percent chance of being equaled or exceeded in a given year. The 1-percent-annual-chance flood is the standard used by most federal and state agencies.

0.2-Percent-Annual-Chance (500-Year) Floodplain—The area flooded by the flood that has a 0.2-percent chance of being equaled or exceeded in a given year.

Regulatory Floodway—Channel of a river or other water course and adjacent land areas that must be reserved for discharge of the base flood without cumulatively increasing water surface elevation more than a designated height. Communities must regulate development in these floodways to ensure no increases in upstream flood elevations.

Return Period—The average number of years between occurrences of a hazard (equal to the inverse of the annual likelihood of occurrence).

Riparian Zone—The area along the banks of a natural watercourse.

9.1.1 Measuring Floods and Floodplains

The frequency and severity of flooding are measured using a discharge probability, which is the probability that a certain river discharge (flow) level will be equaled or exceeded in a given year. Flood studies use historical records to determine the probability of occurrence for the different discharge levels. The flood frequency equals 100 divided by the discharge probability. For example, the 100-year discharge has a 1-percent chance of being equaled or exceeded in any given year. The "annual flood" is the greatest flood event expected to occur in a typical year. These measurements reflect statistical averages only; it is possible for two or more floods with a 100-year or higher recurrence interval to occur in a short time period. The same flood can have different recurrence intervals at different points on a river.

The extent of flooding associated with a 1-percent annual probability of occurrence (the base flood or 100-year flood) is used as the regulatory boundary by many agencies. Also referred to as the special flood hazard area (SFHA), this boundary is a convenient tool for assessing vulnerability and risk in flood-prone communities. Many communities have maps that show the extent and likely depth of flooding for the base flood. Corresponding water-surface elevations describe the elevation of water that will result from a given discharge level, which is one of the most important factors used in estimating flood damage.

9.1.2 Floodplain Ecosystems

Floodplains can support ecosystems that are rich in plant and animal species. A floodplain can contain 100 or even 1,000 times as many species as a river. Wetting of the floodplain soil releases an immediate surge of nutrients: those left over from the last flood, and those that result from the rapid decomposition of organic matter that has accumulated since then. Microscopic organisms thrive and larger species enter a rapid breeding cycle. Opportunistic feeders (particularly birds) move in to take advantage. The production of nutrients peaks and falls away quickly, but the surge of new growth endures for some time. This makes floodplains valuable for agriculture. Species growing in floodplains are markedly different from those that grow outside floodplains. For instance, riparian trees (trees that grow in floodplains) tend to be very tolerant of root disturbance and very quick-growing compared to non-riparian trees.

9.1.3 Effects of Human Activities

Because they border water bodies, floodplains have historically been popular sites to establish settlements. Human activities tend to concentrate in floodplains for a number of reasons: water is readily available; land is fertile and suitable for farming; transportation by water is easily accessible; and land is flatter and easier to develop. But human activity in floodplains frequently interferes with the natural function of floodplains. It can affect the distribution and timing of drainage, thereby increasing flood problems. Human development can create local flooding problems by altering or confining drainage channels. This increases flood potential in two ways: it reduces the stream’s capacity to contain flows, and it increases flow rates or velocities downstream during all stages of a flood event. Human activities can interface effectively with a floodplain as long as steps are taken to mitigate the activities’ adverse impacts on floodplain functions.

9.1.4 Federal Flood Programs

National Flood Insurance Program

The NFIP makes federally backed flood insurance available to homeowners, renters, and business owners in participating communities. For most participating communities, FEMA has prepared a detailed Flood Insurance Study. The study presents water surface elevations for floods of various magnitudes, including the 1-percent annual chance flood (100-year flood) and the 0.2-percent annual chance flood (500-year flood). Base flood elevations and the boundaries of the 100- and 500-year floodplains are shown on Flood Insurance Rate Maps (FIRMs), which are the principle tool for identifying the extent and location of the flood hazard. FIRMs are the most detailed and consistent data source available, and for many communities they represent the minimum area of oversight under the local floodplain management program. In recent years, FIRMs have been digitized as Digital Flood Insurance Rate Maps (DFIRMs), which are more accessible to residents, local governments and stakeholders.

Participants in the NFIP must, at a minimum, regulate development in floodplain areas in accordance with NFIP criteria. Before issuing a permit to build in a floodplain, participating jurisdictions must ensure that three criteria are met:

- New buildings and those undergoing substantial improvements must, at a minimum, be elevated to protect against damage by the 100-year flood.
- New floodplain development must not aggravate existing flood problems or increase damage to other properties.

- New floodplain development must exercise a reasonable and prudent effort to reduce its adverse impacts on threatened salmonid species.

Contra Costa County and all incorporated cities in the county participate in the NFIP. The county and cities are currently in good standing with the provisions of the NFIP. Compliance is monitored by FEMA regional staff and by the California Department of Water Resources (DWR) under a contract with FEMA. Maintaining compliance under the NFIP is an important component of flood risk reduction. All planning partners that participate in the NFIP have identified initiatives to maintain their compliance and good standing.

Table 9-1 lists each municipal jurisdiction's date of entrance into the NFIP and the effective date of its current FIRM. Contra Costa County entered the NFIP on July 16, 1987. Structures permitted or built in the County before then are called "pre-FIRM" structures, and structures built afterwards are called "post-FIRM." The insurance rate is different for the two types of structures. The effective date for the current countywide FIRM is September 30, 2015. This map is a DFIRM (digital flood insurance rate map). Details about participation in the NFIP are further described the individual annexes in Volume 2 of this plan.

Table 9-1. NFIP Status in the Planning Area

Community	NFIP Community #	NFIP Entry Date	Current Effective FIRM
City of Antioch	060026B	12/02/80	09/30/15
City of Brentwood	060439	04/15/79	06/16/09
City of Clayton	060027	12/04/79	06/16/09
City of Concord	065022B	07/05/84	09/30/15
Town of Danville	060707	09/27/85	06/16/09
City of El Cerrito	065027B	06/01/77	09/30/15
City of Hercules	060434B	09/30/82	09/30/15
City of Lafayette	065037	03/16/81	06/16/09
City of Martinez	065044B	03/15/78	09/30/15
Town of Moraga	060637	05/19/81	06/16/09
City of Oakley	060766B	10/30/00	09/30/15
City of Orinda	060722	02/10/88	06/16/09
City of Pinole	060032B	08/15/80	09/30/15
City of Pittsburg	060033B	08/15/80	09/30/15
City of Pleasant Hill	060034	09/30/83	06/16/09
City of Richmond	060035B	03/01/79	09/30/15
City of San Pablo	060036B	08/01/77	09/30/15
City of San Ramon	060710	09/27/85	06/16/09
City of Walnut Creek	065070	05/01/85	06/16/09
Unincorporated County	060025B	07/16/87	09/30/15

Source: FEMA, 2017

FEMA Regulatory Flood Zones

FEMA defines flood hazard areas as areas expected to be inundated by a flood of a given magnitude. These areas are determined via statistical analyses of records of river flow, storm tides, and rainfall; information obtained through consultation with the community; floodplain topographic surveys; and hydrologic and hydraulic analyses. Flood hazard areas are delineated on DFIRMs, which provide the following information:

- Locations of specific properties in relation to SFHAs

- Base flood elevations (1-percent annual chance) at specific sites
- Magnitudes of flood in specific areas
- Undeveloped coastal barriers where flood insurance is not available
- Regulatory floodways and floodplain boundaries (1-percent and 0.2-percent annual chance floodplain boundaries).

Land area covered by floodwaters of the base flood is the SFHA on a DFIRM—an area where NFIP floodplain management regulations must be enforced, and where mandatory purchase of flood insurance applies. This regulatory boundary is a convenient tool for assessing vulnerability and risk in flood-prone communities, because many communities have maps showing the extent of the base flood and likely depths that will occur.

The base flood elevation (the water elevation of a flood that has a 1-percent chance of occurring in any given year) is one of the most important factors in estimating potential damage from flooding. A structure within a 1-percent annual chance floodplain has a 26-percent chance of undergoing flood damage during the term of a 30-year mortgage. The 1-percent annual chance flood is used by the NFIP as the basis for insurance requirements nationwide. DFIRMs also depict 0.2-percent annual chance flood designations (500-year events).

DFIRM, FIRMs, and other flood hazard information can be used to identify the expected extent of flooding from a 1-percent and 0.2-percent annual chance event. DFIRMS and FIRMS depict SFHAs, defined as follows:

- **Zones A1-30 and AE:** SFHAs that are subject to inundation by the base flood, determined using detailed hydraulic analysis. Base flood elevations are shown within these zones.
- **Zone A (Also known as Unnumbered A-zones**): SFHAs where no base flood elevations or depths are shown because detailed hydraulic analyses have not been performed.
- **Zone AO:** SFHAs subject to inundation by types of shallow flooding where average depths are between 1 and 3 feet. These are normally areas prone to shallow sheet flow flooding on sloping terrain.
- **Zone VE, V1-30:** SFHAs along coasts that are subject to inundation by the base flood with additional hazards due to waves with heights of 3 feet or greater. Base flood elevations derived from detailed hydraulic analysis are shown within these zones.
- **Zone B and X (shaded):** Zones where the land elevation as been determined to be above the base flood elevation, but below the 500-year flood elevation. These zones are not SFHAs.
- **Zones C and X (unshaded):** Zones where the land elevation has been determined to be above both the base flood elevation and the 500-year flood elevation. These zones are not SFHAs.

Bay-adjacent SFHAs are of concern to Contra Costa County, particularly where land is at or slightly above sea level.

In California, the DWR is the coordinating agency for floodplain management. The DWR works with FEMA and local governments by providing grants and technical assistance, evaluating community floodplain management programs, reviewing local floodplain ordinances, participating in statewide flood hazard mitigation planning, and facilitating annual statewide workshops. Compliance is monitored by FEMA regional staff and by the DWR.

The Community Rating System

The CRS is a voluntary program within the NFIP that encourages floodplain management activities that exceed the minimum NFIP requirements. Flood insurance premiums are discounted to reflect the reduced flood risk resulting from community actions meeting the following three goals of the CRS:

- Reduce flood losses.
- Facilitate accurate insurance rating.
- Promote awareness of flood insurance.

For participating communities, flood insurance premium rates are discounted in increments of 5 percent. For example, a Class 1 community would receive a 45 percent premium discount, and a Class 9 community would receive a 5 percent discount. (Class 10 communities are those that do not participate in the CRS; they receive no discount.) The discount partially depends on location of the property. Properties outside the SFHA receive smaller discounts: a 10-percent discount if the community is at Class 1 to 6 and a 5-percent discount if the community is at Class 7 to 9. The CRS classes for local communities are based on 18 creditable activities in the following categories:

- Public information
- Mapping and regulations
- Flood damage reduction
- Flood preparedness.

Figure 9-1 shows the nationwide number of CRS communities by class as of October 2016, when there were 1,391 communities receiving flood insurance premium discounts under the CRS program.

Source: FEMA, 2016

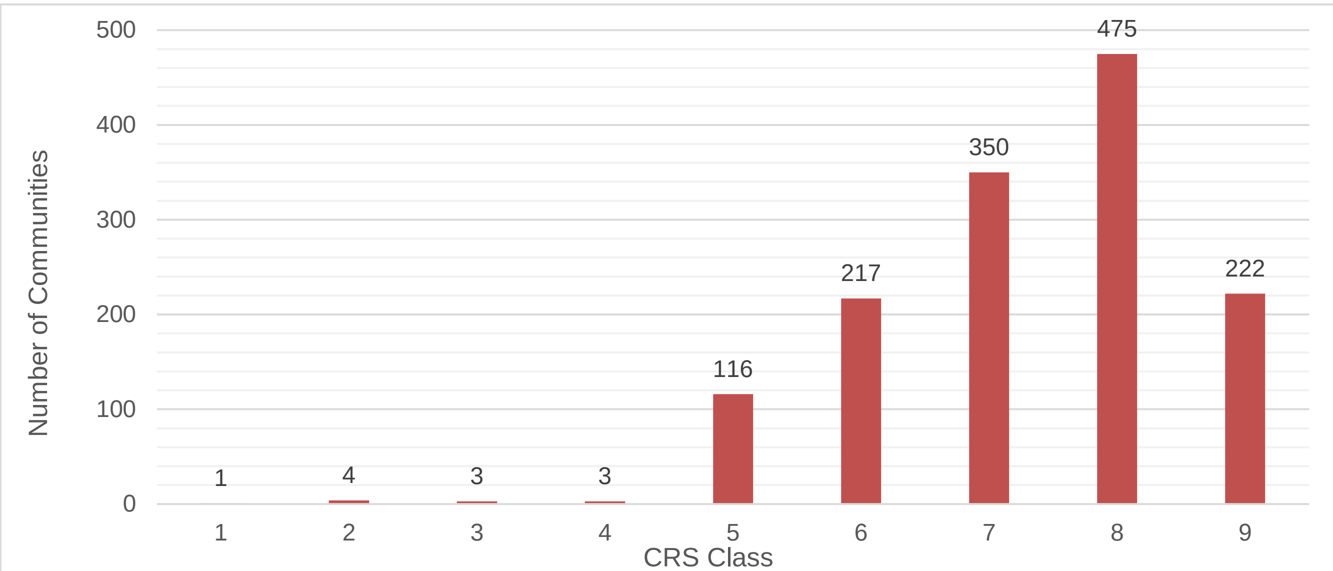


Figure 9-1. CRS Communities by Class Nationwide as of October 2016

CRS activities can help to save lives and reduce property damage. Communities participating in the CRS represent a significant portion of the nation's flood risk; over 66 percent of the NFIP's policy base is located in these communities. Communities receiving premium discounts through the CRS range from small to large and represent a broad mixture of flood risks, including both coastal and riverine flood risks.

Contra Costa County and the cities of Concord, Pleasant Hill, San Ramon and Walnut Creek are currently participating in the CRS program. Their CRS status is summarized in Table 9-2. The total annual savings on flood insurance premiums within the planning area is nearly $600,000. Many of the mitigation actions identified in Volume 2 of this plan are creditable activities under the CRS program. Therefore successful implementation of this plan offers the potential for these communities to enhance their CRS classifications and for currently non-participating communities to join the program.

Table 9-2. CRS Community Status in the Planning Area

Community	NFIP Community #	CRS Entry Date	Current CRS Classification	% Premium Discount, SFHA/non-SFHA	Total Premium Savings
Concord	065022	10/01/2008	7	15/5	$64,768
Pleasant Hill	060034	05/01/2003	8	10/5	$50,112
Richmond	060035	10/01/1995	10[a]	0	$0
San Pablo	060036	10/01/2013	8	10/5	$45,826
San Ramon	060710	10/01/1991	6	20/10	$11,598
Walnut Creek	065070	10/01/1991	8	10/5	$30,829
Contra Costa County	060025	10/01/1991	6	20/10	$394,935
Total					$598,068

Source: FEMA, 2016

a. City of Richmond retrograded to a Class 10 on 5/01/2015

9.2 HAZARD PROFILE

Flooding in the planning area is typically caused by high-intensity, short-duration (1 to 3 hours) storms concentrated on a stream reach with already saturated soil. Two types of flooding are typical:

- Flash floods that occur suddenly after a brief but intense downpour. They move rapidly, end suddenly, and can occur in areas not generally associated with flooding (such as subdivisions not adjacent to a water body and areas serviced by underground drainage systems). Although the duration of these events is usually brief, the damage they cause can be severe. Flash floods cannot be predicted accurately and happen whenever there are heavy storms.
- Riverine floods described in terms of their extent (including the horizontal area affected and the vertical depth of floodwater) and the related probability of occurrence (expressed as the percentage chance that a flood of a specific extent will occur in any given year).

Flooding is predominantly confined within traditional riverine valleys. Locally, some natural or manmade levees separate channels from floodplains and cause independent overland flow paths. Occasionally, railroad, highway or canal embankments form barriers, resulting in ponding or diversion of the flow. Some localized flooding not associated with stream overflow can occur where there are no drainage facilities to control flows or when runoff volumes exceed the design capacity of drainage facilities.

9.2.1 Types of Flooding

Flooding in Contra Costa County typically occurs during the rainy winter season. Four types of flooding primarily affect the County: stormwater runoff, riverine, flash floods, and tidal floods.

Stormwater Runoff Floods

Urban drainage systems are designed to remove surface water from developed areas as quickly as possible to prevent flooding on streets and in other urban areas. These closed conveyance systems channel water away from an urban area to surrounding streams, bypassing natural processes of water filtration through the ground, containment, and evaporation of excess water. Urban drainage systems can play a role in flooding in two ways:

- Because drainage systems reduce the amount of time surface water takes to reach surrounding streams, flooding in those streams can occur more quickly and reach greater depths than prior to development in the area (FEMA, 2008).

- If stormwater runoff exceeds the capacity of the drainage system, then stormwater runoff flooding can result throughout the system's service area. This is especially likely when groundwater levels are high and during high tides.

Stormwater runoff flooding can occur in areas other than delineated floodplains or along recognizable channels. It generally occurs in flat areas, and generally increases with urbanization, which speeds accumulation of floodwaters because of impervious areas. Shallow street flooding can occur unless channels have been improved to account for increased flows (FEMA, 1997). Numerous areas in the County undergo stormwater flooding that contributes to street and structure inundation.

Riverine Floods

Riverine flooding is overbank flooding of rivers and streams. Flooding in large river systems typically results from large-scale weather systems that generate prolonged rainfall over a wide geographic area, causing flooding in hundreds of smaller streams, which then drain into the major rivers. Two types of flood hazards are generally associated with riverine flooding:

- **Inundation**—Inundation occurs when floodwaters and debris flow through an area not normally covered by water. These events cause minor to severe damage, depending on velocity and depth of flows, duration of the flood event, quantity of debris carried by the flow, and amount and type of development and personal property along the floodwater's path.
- **Channel Migration**—Erosion of banks and soils worn away by flowing water, combined with sediment deposition, can cause migration or lateral movement of a river channel across a floodplain. A channel can also abruptly change location (termed "avulsion"); a shift in channel location over a large distance can occur within as short a time as one flood event.

Shallow area flooding is a special type of riverine flooding. FEMA defines shallow flood hazards as areas inundated by the 100-year flood with flood depths of only 1 to 3 feet. These areas are generally flooded by low-velocity sheet flows of water.

Natural stream channels in rural parts of Contra Costa County typically can accommodate average rainfall amounts and mild storm systems; however, severe floods occur in years of abnormally high rainfall or unusually severe storms. During those periods of severe floods, high-velocity floodwaters carry debris over long distances, block stream channels, and create severe localized flooding.

Flash Floods

The National Weather Service defines a flash flood as a rapid and extreme flow of high water into a normally dry area, or a rapid water level rise in a stream or creek above a predetermined flood level. Such floods generally begin within 6 hours of the rain event that causes them. Ongoing flooding can intensify to flash flooding in cases where intense rainfall results in a rapid surge of rising floodwaters (NWS, 2009).

Flash floods can tear out trees, undermine buildings and bridges, and scour new channels. In urban areas, flash flooding is an increasingly serious problem due to removal of vegetation and replacement of ground cover with impermeable surfaces such as roads, driveways, and parking lots. The greatest risk from flash floods is occurrence with little to no warning. Major factors in predicting potential damage are intensity and duration of rainfall, and steepness of watershed and streams.

Tidal Floods

Tidal floods are characterized by inundation of normally dry lands by bay waters, often caused by extreme high tide events that result in shallow flooding of low-lying coastal areas. Colloquially known as "king tides," extreme high level tide events are the highest predicted high tide events of the year at a coastal location. These tides exceed the highest water level reached at high tide on an average day and normally occur once or twice per year. King tide events are the leading cause of flooding by bay waters.

Tidal flooding is exacerbated by sea level rise resulting from climate change or tectonic activity (NOAA, no date). Average daily water levels are rising along with the oceans. As a result, high tides are reaching higher and extending further inland than in the past. Additional information regarding the impacts and exposure of the planning area to sea level rise is presented in Chapter 14.

9.2.2 Principal Flooding Sources

FEMA’s Flood Insurance Study for Contra Costa County assessed over 50 creeks, channels, and water bodies, including the following principal flooding sources (FEMA, 2015b):

- Along Giant Road from Standard Oil to Rheem Creek
- Appian Creek
- Arroyo Del Hambre Creek
- Brookside Road Tributary
- Carquinez Straight
- Cascade Creek
- Cerrito Creek
- Clayton Valley Drain
- Corliss Drive Tributary
- Deer Creek
- Ditch No. 2
- Donner Creek
- Dutch Slough
- East Antioch Creek
- Each Branch Green Valley Creek
- East Branch Homestead Creek
- East Branch Refugio Creek
- East Fork Grayson Creek
- Eccleston Avenue Tributary
- Farm Bureau Road Drain
- Galindo Creek
- Garrity Creek
- Grayson Creek
- Green Valley Creek
- Grizzly Creek
- Happy Valley Creek
- Hidden Valley Creek
- Hillcrest Branch East Antioch Creek
- Homestead Creek
- Ivy Drive Tributary
- Jonas Hill Creek
- Kirker Creek
- Lafayette Creek
- Laguna Creek
- Larch Creek
- Las Trampas Creek
- Lauterwasser Creek
- Lawlor Creek
- Line A, DA-40
- Los Medanos Wasteway
- Mangini Creek
- Markley Creek
- Marsh Creek
- Middle Branch West Antioch Creek
- Miranda Creek
- Mitchell Creek
- Moraga Creek
- Mount Diablo Creek
- Mount Diablo Split Flow
- Murderers Creek
- North Branch Reliez Creek
- North Branch Stone Valley Creek
- Orinda Village Overflow
- Overhill Creek
- Overland Cross Section
- Pacheco Creek
- Payton Slough
- Pine Creek
- Pinole Creek
- Refugio Creek
- Reliez Creek
- Rheem Creek Radeo Creek
- Sand Creek
- San Francisco Bay
- San Pablo Bay
- San Pablo Creek
- San Ramon Creek
- San Ramon Creek Overflow
- Sans Crainte Creek
- Sans Crainte Creek Tributary A
- Shore Acres Creek
- South Branch Moraga Creek
- South San Ramon Creek (overbank flooding)
- South San Ramon Creek
- St. Marys Road Tributary
- Stone Valley Creek
- Suisun Bay
- Sycamore Creek
- Tice Creek
- Tice Creek Overflow
- Walnut Creek
- West Antioch Creek
- West Branch Alamo Creek
- West Branch East Antioch Creek
- West Branch Refugio Creek
- Wildcat Creek
- Willow Creek

San Joaquin-Sacramento River Delta Region

Water that falls in the Central Valley of California and in most of the Sierra Nevada Mountains ultimately flows to the Pacific Ocean through the San Joaquin-Sacramento River Delta and along the shorelines of Contra Costa County.

Much of the delta is tidally influenced, and significant land in it has been reclaimed by about 1,100 miles of levees along natural and manmade waterways that divide it into about 120 tracts that are locally known as islands. The entire region of approximately 700,000 acres is under the influence of the tides, and much of the land is lower than the water on the opposite side of the levees. Many of the islands are 15 to 25 feet below sea level due to the subsidence of the peat land structure. Flooding of the delta islands has usually resulted from structural failure of the levees prior to overtopping. Major levee breaks have created new water bodies such as Franks Tract and Big Break. However, since the construction of many upstream dams, the flood factor has been reduced and now the major cause of flooding is levee instability.

Naturally occurring rich soil deposited in the lowlands by repeated flooding from the delta have attracted agricultural to this region. Flood control infrastructure was constructed to protect farmland, and irrigation canals crisscross the land to channel water through the region. Water for much of the county and the rest of the state is pumped from the delta. Clifton Court Forebay in the Brushy Creek watershed is the primary diversion point.

Baxter, Cerrito and West Richmond Watersheds

This 11,832-acre area is a series of subbasins containing two historically important East Bay waterways:

- Baxter Creek and its tributaries (14.44 miles) originate in underground springs beneath El Cerrito’s Mira Vista Golf Course and flow down from the hills in three branches. After running through a series of neighborhood parks, the creeks join near the Gateway Property at San Pablo and Macdonald Avenues. The creek then flows through Richmond into Stege Marsh and San Francisco Bay.
- Cerrito Creek (5.82 miles) straddles the Contra Costa-Alameda County border, draining the hills of El Cerrito and the unincorporated Community of Kensington before emptying into the Albany Flats and San Francisco Bay, just south of Point Isabel Regional Shoreline.

The headwaters of these creeks are in the northern extent of the East Bay Hills. The Wildcat Creek watershed forms this region’s northern boundary. The Contra Costa County line follows Cerrito Creek along the watershed’s southern boundary.

Many creeks in the Baxter and Cerrito Creek watersheds were lined or culverted during the first half of the 20th century to accommodate urbanization and prevent flooding in the lower areas. This relatively level area between the Berkeley Hills and Point Richmond is now drained by an extensive municipal stormwater system. The Richmond flatlands were first drained for agricultural use. Later, following the introduction of the railroad, this area became the site of industry in the region.

Wildcat Creek Watershed

The Wildcat Creek watershed drains a 6,848-acre area. The upper watershed is contained in Wildcat Canyon. The lower watershed enters the alluvial plain at Alvarado Park in the City of Richmond. Wildcat Creek then flows through San Pablo and Richmond to the San Francisco Bay.

Complex geologic characteristics affect the 13.43-mile Wildcat Creek. Trending parallel to the Hayward Fault, the creek leaves the Berkeley Hills and enters a massive alluvial fan. Repeated drought and flood events have caused changes in the shape of the fan and the course of the creek.

Rancho San Pablo (18,000-acre land-grant, 1823), one of the East Bay's earliest agricultural areas, included most of the Wildcat Creek watershed. Rich sediments in the alluvial fan supported farming of fruits and vegetables. The middle and upper watershed provided pasture for livestock and horses. After a deep water port was established at Point Richmond, land use in the area changed dramatically. Farms gave way to industry and manufacturing. The endpoint on the Santa Fe Railroad line was established in the region, further encouraging this land use transition. Oil refining was introduced as an industry in 1900, and remains a major industry in the area today.

San Pablo Creek Watershed

The San Pablo Creek watershed is 27,640 acres in the heart of western Contra Costa County. This area also was included in the site of Rancho San Pablo.

The headwaters of San Pablo Creek are in the City of Orinda. The headwaters cross into land administered by the East Bay Municipal Utility District (EBMUD) and flow into the San Pablo Reservoir. From the headwaters, the creek flows approximately 20 miles before reaching the San Francisco Bay. Tributary headwaters to the north enter the Briones Reservoir and are regulated by EBMUD as well. As water leaves the San Pablo Reservoir, it flows through first rural and then heavily urbanized residential and commercial areas before reaching the saltwater marshes adjacent to San Francisco Bay.

San Pablo Creek's flow regime and steep banks have prevented the creek from being diverted through culverts, providing the cities of San Pablo and Richmond, and the community of El Sobrante with a natural reminder of the surrounding watershed.

Rheem and Garrity Creek Watersheds

This 1,790-acre area in western Contra Costa County includes the watersheds of Rheem Creek (3.36 miles) and Garrity Creek (3.67 miles). These watersheds include sections of the Cities of Richmond, Pinole and San Pablo, as well as a small portion of unincorporated County (El Sobrante). Point Pinole Regional Shoreline is at the westernmost tip of the area, providing 632 acres of parkland in the watershed and marking the northernmost boundary of Rancho San Pablo.

The Giant Powder Company, one of the first American Companies to produce dynamite, moved to the area in 1892, making the area a populated, industrial center. Explosives were produced at the factory until 1960. The Carquinez Golf Club leased land just east of the explosive factory in 1934, and presently the Richmond Country Club occupies 180 acres of open space in the region.

The headwaters of Rheem Creek begin just east of Interstate 80 in a residential neighborhood of Richmond. On its route to San Pablo Bay, the creek passes into the City of San Pablo for one mile before entering the City of Richmond again, continuing its course to San Francisco Bay. One third of the creek is culverted under residential areas; the other two-thirds are above ground but contained in concrete and earthen channels. Flowing through a variety of industrial and residential area, it reaches the bay a half mile south of Point Pinole Regional Shoreline.

Pinole Creek Watershed

Pinole Creek is a perennial stream that drains a 9,705-acre watershed in western Contra Costa County. The creek is an important feature of the City of Pinole, and the City government is working with organizations such as the Friends of Pinole Creek, County Flood Control, and the U.S. Army Corps of Engineers to restore the creek through the center of the city. The creek flows northwest for approximately 11 miles from headwaters in the Briones Hills to its outlet at San Pablo Bay.

The Pinole Creek watershed is lightly developed compared to other watersheds in western Contra Costa County. One reason for this is that a drinking water reservoir was at one time planned for construction in the center of the watershed. EBMUD purchased thousands of acres of land in the area to prepare for this possibility. Plans for the new reservoir were ultimately set aside, but the public watershed land remains, and it continues to be managed by EBMUD. General watershed features are as follows:

- The City of Pinole occupies the northern third of the watershed. Pinole was incorporated in 1903 after being the site of Rancho Pinole (land-grant—1823). The city was originally settled in the alluvial floodplain of Pinole Creek, close to transport provided by the railroad and shipping on the bay.
- Interstate 80 forms a man-made margin where Pinole Creek leaves the confines of the East Bay Hills. From this point to the bay, the U.S. Army Corps of Engineers carried out extensive work on the Pinole Creek channel in the 1950s to control flooding in the downtown area.
- In the middle third of the watershed owned and managed by the EBMUD, various restoration projects along the tributaries that feed Pinole Creek (such as the Pavon Creeks restoration project) have provided shade and habitat to areas previously denuded by grazing and erosion. The central reaches of Pinole Creek and its tributaries meander through a broad, open valley and have a relatively intact floodplain, an unusual feature in the western part of County.
- The upper watershed consists of private ranchlands and remains a northern California oak woodlands and grasslands landscape. The very tip of the upper watershed is part of Briones Regional Park and is owned by the East Bay Regional Park District (EBRPD).

Refugio, Rodeo and Carquinez Area Watersheds

Refugio Creek, Rodeo Creek and the drainages at the northwest tip of Contra Costa County that flow into the Carquinez Strait cover 16,348 acres. The watersheds feature diverse land uses, including pristine oak-covered hills, an interstate highway, ranches, heavy industry, towns and new residential development. The City of Hercules and the communities of Rodeo, Crockett and Port Costa are located in the watershed.

Refugio Creek (4.52 miles), Rodeo Creek (8.35 miles), Canada del Cierbo Creek (2.86 miles) and Edwards Creek (2.0 miles) trend northwest and resemble other west county drainages, with a rural upper watershed with an urbanized or industrialized lower watershed. However, these watersheds do not have flatland areas in their lower reaches like the watersheds of Pinole, San Pablo, and Wildcat Creeks.

The upper watershed of Rodeo Creek and its tributaries is on private ranchland and EBRPD property. An industrial area and the community of Rodeo are in the lower watershed. Two smaller drainages to the north of Rodeo, including Canada del Cierbo Creek and an unnamed creed, begin in undeveloped land on the east side of Interstate 80 before being diverted underground through refinery properties.

The shorter, steeper Carquinez drainages flow southeast to northwest. These drainages are mostly unnamed except for Bull Valley Creek (2 miles), which flows north through the town of Port Costa, first filling the reservoir south of the town. The upper watersheds of these drainages also begin in EBRPD land and ranchlands before reaching residential and industrial areas on the shores of the Carquinez Strait.

Alhambra Creek and Peyton Slough Watersheds

The 7.88-mile main stem of Alhambra Creek and its two large tributaries (Franklin Creek and Arroyo Del Hambre) drain a 10,753-acre watershed and flow through the City of Martinez before discharging to the Carquinez Strait. Before Martinez incorporated in 1876, it was a busy trading post and transportation hub. Prospectors rode a ferry from the Martinez waterfront to cross the delta on their way to the Sierra-Nevada foothills. Tons of sediment, loosened by hydraulic mining practices in the Sierras, washed into the delta and changed the shape of the waterfront, repeatedly forcing the mouth of Alhambra Creek to advance northward.

The upper watershed retains much of its rural character. Alhambra Creek's headwaters are located in Briones Regional Park. Other tracts of open space and agricultural lands further protect habitat in the watershed. Coastal Oak woodlands dominate the north-facing slopes of the upper and middle watershed.

The lower watershed also retains a rural feeling in higher elevations. Carquinez Strait Regional Shoreline protects the watershed north of Highway 4. Lower elevations, defined by the Alhambra Creek floodplain, were urbanized through the late 1800s. Shell opened its first U.S. refinery in Martinez in 1915.

Peyton Slough watershed (3,914 acres) is east of the Alhambra Creek watershed and has experienced almost 100 years of industrialization and urbanization. Peyton Creek (3.64 miles) is culverted underground through residential and industrial areas for over a third of its length. Over half of the watershed is urbanized, including all of the upper watershed. Early industry in the lower watershed included oil refining, chemical manufacturing and copper smelting.

Water in the predominantly residential upper watershed is controlled by storm drain systems. The lower watershed retains some of the marshland habitat central to the early history of this area. Native Americans lived in and frequented the local marshes for their abundant food sources. MacNabney Marsh, located in the Pacific Flyway, is home to many species of waterfowl and shorebirds.

Walnut Creek Watershed (Grayson-Murderers, Concord, Pine-Galindo, San Ramon and Las Trampas Subbasins)

Walnut Creek watershed encompasses 93,556 acres in central Contra Costa County. Draining the west side of Mount Diablo and the east side of the East Bay Hills, Walnut Creek's major tributaries include San Ramon Creek (18.89 miles), Bollinger Creek (6.72 miles), Las Trampas Creek (12.37 miles), Lafayette Creek (3.78 miles), Grayson Creek (8.87 miles), Murderer's Creek (4.37 miles), Pine Creek (12.65 miles) and Galindo Creek (6.5 miles). Rainfall varies throughout the area in part due to the rain shadow effect of the East Bay Hills and the western slopes of Mount Diablo.

The Cities of Walnut Creek, Lafayette, Pleasant Hill and Danville lie completely within the boundaries of the watershed, and the Cities of Concord, Martinez, and small areas of Moraga and San Ramon are partly within the watershed. Rancho Monte Del Diablo, Rancho Arroyo de las Nueces y Bolbones, Rancho San Ramon, Rancho Las Juntas and Rancho Canada de Hambre all were established in the watershed in the early 1800s when agriculture and livestock played an important role. With the introduction of irrigation technologies, fruit and nut orchards started evolving in the valley. Later housing and commercial ventures along the Walnut Creek corridor resulted in an increased need for flood control. An extensive stormwater drainage system reroutes surface waters that once meandered across the valley.

Mount Diablo Creek Watershed

Mount Diablo Creek flows northwest from the Mount Diablo for 17.24 miles before reaching Suisun Bay. Unincorporated county land accounts for 64 percent of the watershed, which also includes the cities of Clayton and Concord. The lower third of the watershed is owned and managed by the U.S. Navy. Naval Weapons Station Seal Beach (previously the Concord Naval Weapons Station) occupies approximately 13,000 acres of open, relatively unaltered floodplain.

The headwaters of Mount Diablo Creek are in Mount Diablo State Park. Major tributaries—Mitchell Creek, Back Creek and Donner Creek—also originate in the state park. The creek and its tributaries flow relatively unencumbered from the headwaters to its outlet in Suisun Bay. The creek is channeled underground through the few areas that are more developed.

Willow and Kirker Creek Watersheds

The 10,132-acre Kirker Creek watershed reaches from the foothills of Mount Diablo to the Sacramento-San Joaquin Delta. Flowing north from its headwaters, Kirker Creek (9.43 miles) runs through parkland and ranchland in the upper watershed and continues through suburban residential neighborhoods and commercial areas in the lower watershed. Though most of Kirker Creek is open channel, culverts direct the creek underground at road crossings and through some urban areas. Originally, Kirker Creek flowed directly north to the delta. In the 1940s, it was diverted to bypass the U.S. Steel property (now USS-Posco Industries). Kirker Creek now makes a 90-degree turn and flows into Los Medanos Wasteway. At high flow it also uses Dowest Slough.

The creek flows during the rainy season (November through April) and dries out in the summer. Irrigation and related urban runoff produce some urban dry-weather flow that keeps areas of the creek wet throughout the year, which is characteristic of the entire watershed. Annual rainfall here averages 16.5 inches in the upper reaches.

The Willow Creek watershed encompasses 16,063 acres. Willow Creek (6.16 miles) is located in the middle of the watershed, with approximately 10 miles of unnamed tributaries draining into it in its lower reaches. Most of the lower reaches of these tributaries, including creeks to the east of Willow Creek, are in underground culverts as they flow through the single-family residential neighborhoods of Bay Point and Pittsburg.

East and West Antioch Creek Watersheds

The watersheds of East and West Antioch Creeks are in the northeastern part of Contra Costa County, between the hills south of Antioch and the Sacramento-San Joaquin River Delta.

The main stem of West Antioch Creek flows from headwaters in land managed by EBRPD. The creek flows through a valley that was at one time proposed for a major landfill facility. After a different location was selected for the landfill, the valley was purchased by EBRPD and added to Black Diamond Mine Regional Preserve. West Antioch Creek (6.24 miles) is joined by Markley Canyon Creek (5.3 miles) and a few unnamed tributaries, before passing near the Dow Wetlands Preserve and discharging into the San Joaquin River. The headwaters of Markley Canyon Creek are in the Black Diamond Mine Preserve. The confluence of Markley Canyon Creek and West Antioch is north of Highway 4, where both creeks are channelized. Although channelized in its lower half, the main stem of West Antioch Creek remains above ground for most of its length. Large sections of tributaries, however, are routed underground to provide flood protection and drainage through more developed areas.

East Antioch Creek flows from low-elevation headwaters near Lone Tree Way in Antioch. Various detention basins and levees along the length of the creek prevent stormwater from moving into the Marsh Creek drainage area, which it has done historically during flood events.

Two reservoirs located in these watersheds—Contra Loma Reservoir and the Antioch Municipal Reservoir—provide drinking water storage.

Marsh Creek Watershed

Marsh Creek flows 34.57 miles from headwaters in the foothills and on the eastern flanks of Mount Diablo to the San Joaquin River Delta at Big Break. The second largest watershed in Contra Costa County, it encompasses 60,066 acres in the eastern county. Tributaries in the upper watershed include Curry Canyon Creek (5.8 miles), Sycamore Creek (4 miles) and Briones Creek (13 miles), which flows into the Marsh Creek Reservoir. Tributaries entering the middle portion of the main stem near and in the City of Brentwood include Dry Creek (5.8 miles), Sand Creek (18.74 miles) and Dear Creek (9 miles).

North of the Marsh Creek Reservoir, Marsh Creek runs through urban and agricultural areas in the Cities of Brentwood and Oakley. Much of the undeveloped area north of the Marsh Creek Reservoir is planned for development, as well as area along Sand Creek in the City of Antioch.

Marsh Creek goes through hydrologic, geologic and topographic changes as it leaves its steep, rocky headwaters and enters the alluvial plain north of the Marsh Creek Reservoir. Historically, Marsh Creek meandered through this alluvial area. However, since 1856 and the establishment of Rancho Los Meganos, and more dramatically after the turn of the century, farmers and flood control authorities have altered the channel and the surrounding landscape to protect agricultural resources. The building of levees, detention basins, dams and reservoirs, as well as culverting, straightening and the creation of concrete-lined channels, led to a severe reduction in riparian habitat and vegetation.

Hydrology in the eastern portion of the watershed is complex due to the number of irrigation canals and diversions. The eastern boundary of the Marsh Creek watershed was generated using Contra Costa County Flood Control drainage inventory and topographical information only.

Kellogg and Brushy Creek Watersheds

The Kellogg Creek and Brushy Creek watersheds are in southeastern Contra Costa County, bordering Alameda and San Joaquin Counties. Due to the rain shadow effect of Mount Diablo, average annual rainfall is approximately 20 inches in the upper portions of these watersheds and 10 inches or less in the lower portions. Few areas here are developed, and all land is in unincorporated Contra Costa County.

The 20,863-acre Kellogg Creek watershed includes the Contra Costa Water District’s Los Vaqueros Reservoir, which can store up to 100,000 acre-feet of water, pumped to the facility from an intake at Old River near Discovery Bay. Water from Los Vaqueros serves 450,000 customers in Contra Costa County during the summer. The protected open space at Los Vaqueros Reservoir is now home to a variety of animal and bird species. The Contra Costa Water District runs educational programs for school groups from their interpretive center at the reservoir that highlights water issues, plants, wildlife and the history of the area.

Originally known as Arroyo de los Posos, the 25.34-mile Kellogg Creek barely resembles its original course through the area. Both Kellogg and Brushy Creek were diverted and altered by farmers in the north and eastern parts of the watershed, where Marsh, Kellogg and Brushy creeks enter the alluvial plain.

Upper Alameda Creek Watershed (Cayetano, Alamo-Tassajara, and South San Ramon Subbasins)

One of the largest watersheds in the Bay Area, the 405,120-acre Alameda Creek watershed stretches from the Mount Diablo foothills in the north to Mount Hamilton in the south. The 39,142-acre portion of this watershed in southern Contra Costa County is part of the headwaters. Alameda Creek’s outlet is in Alameda County in the City of Fremont near the EBRPD’s Coyote Hill Regional Park and the San Francisco Bay National Wildlife Refuge.

Other creeks in Contra Costa County portion of this watershed are South San Ramon, Alamo, Tassajara, and Cayetano Creeks. San Ramon and a small area of Danville are in the westernmost part of the area. Most of land to the east in unincorporated. The City of San Ramon’s Environmental Affairs Advisory Committee is active on creek and watershed issues in this area.

Upper San Leandro and Moraga Creek Watersheds

The Upper San Leandro and Moraga Creek watersheds include 13,059 acres in Contra Costa County. These creeks flow into the Upper San Leandro Reservoir, managed by the EBMUD. The reservoir spans the county line, and its outlet is in Alameda County. Its discharge flows through Alameda County to the San Francisco Bay.

Creeks in this area include Moraga Creek (4.7 miles), San Leandro Creek (4.76 miles), Laguna Creek (3.2 miles), Redwood Creek (1.8 miles), Indian Creek (1.8 miles), Rimer Creek (3.14 miles), Buckhorn Creek (2.1 miles), and Callahan Creek (1.3 miles). The channels of the creeks in the area are relatively unmodified. Large flood control channels have not been built in this region. Moraga Creek has been routed underground in short reaches to accommodate urbanization and infrastructure development.

The southern extent of Orinda and a major portion of Moraga make up much of these watersheds. The remaining area is unincorporated county lands, including areas managed by EBRPD and EBMUD.

9.2.3 Past Events

Delta flooding has a long history in Contra Costa County and is a continuing problem. Since construction of levees started in the early 1860s, every island in the delta has been flooded at least once due to levee overtopping or failure. Approximately 110 levee failures have occurred since 1900, almost 45 since 1930, approximately 25 since 1950, and about 12 since 1980. Little data is available for specific flood events from 1850 to the early 1900s, but records show that 13 of the many floods that occurred were outstanding events (1850, 1852, 1861-62, 1871, 1875, 1878, 1879, 1881, 1902, 1904, 1906, 1907 and 1909), and the floods of 1878, 1881, 1904, 1907 and 1909 were the most severe.

Floods in 1950 and 1955 were outstanding in peak outflows through the delta area, and several islands were flooded. The 1955 flood flow inundated almost 38,000 acres, more than doubling the flooded acreage of 1950 (about 18,000 acres), and caused about $3.3 million in damage (compared to about $1.2 million in 1950). The delta area suffered permanent damage to a sizeable amount of agricultural land. Concurrent strong onshore winds generated high waves that threatened many islands.

Table 9-3 summarizes flood events in the planning area since 1955. Since 1969, 10 presidential-declared flood events in the planning area have caused in excess of $50 million in property damage.

The flood of December 1955 had an estimated recurrence interval of 22 years. Flood conditions created by heavy rains were aggravated by high tides. The damage in Contra Costa County was extensive, with an estimated loss to private dwellings of $1.25 million (1955 dollars). Approximately 460 families were evacuated from Byron, Brentwood, Knightsen, Tree Haven, Fair Oaks, Meadow Homes, Sherman Acres, Gregory Gardens (now part of the City of Pleasant Hill), and the City of Walnut Creek.

In December 1964 and January 1965, the coincidental occurrence of very high tides and heavy inflow resulted in unusually high stages on all delta area waterways.

In January and February 1969, high tides and adverse wave action in the delta area combined with large river inflow and rain-soaked levees to cause the flooding of several islands. Approximately 11,400 acres were inundated and flood damage amounted to $9.2 million.

In mid-January 1980, severe rainstorms over central California precipitated high river outflow through the delta area which, coinciding with gale force winds over the delta area and high tides, resulted in the levee failure and flooding of two tracts, placing approximately 9,600 acres under water. Continued high inflow to the delta area and wind-generated waves increased erosion on all delta-area levees, necessitating the temporary curtailment of boat traffic.

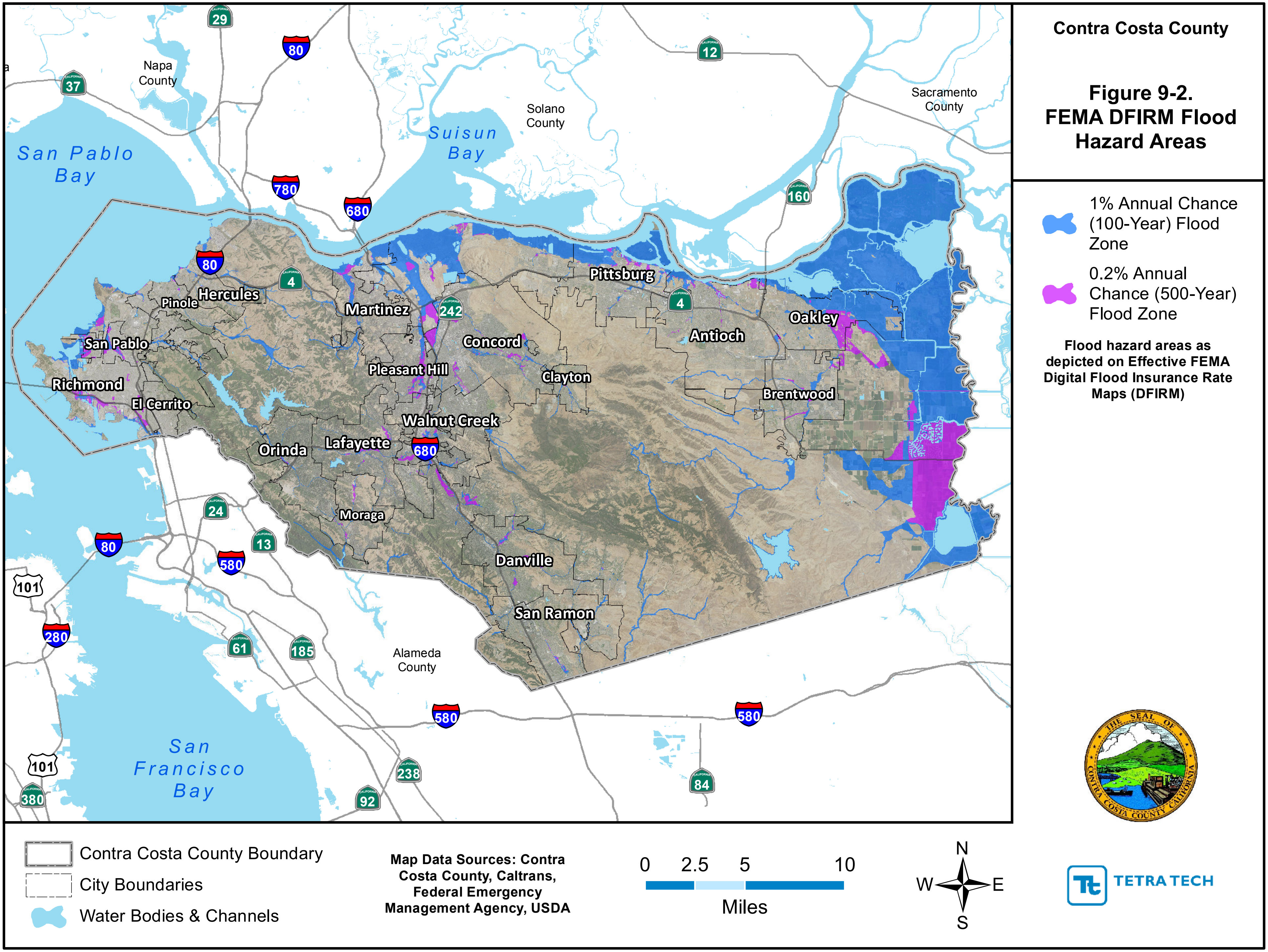
9.2.4 Location

The major floods in the planning area have resulted from intense weather rainstorms between November and March. The flooding that has occurred in portions of the planning area has been extensively documented by gage records, high water marks, damage surveys and personal accounts. This documentation was the basis for the September 30, 2015 DFIRMs generated by FEMA for Contra Costa County. The 2015 Flood Insurance Study is the sole source of data used in this risk assessment to map the extent and location of the flood hazard, as shown in Figure 9-2.

Table 9-3. History of Flood Events

Date	Declaration #	Type of event	Estimated Damage
04/01/2017	DR-4308	Severe Winter Storms, Flooding, Mudslides	N/A
03/16/2017	DR-4305	Severe Winter Storms, Flooding, Mudslides	N/A
02/14/2014	DR-4301	Severe Storms, Flooding, and Mudslides	N/A
02/09/2015	N/A	Heavy Rain	A 72 hour rainfall total of 3.93 inches from San Ramon.
03/13/2012	N/A	Heavy Rain	Periods of heavy rain caused a series of vehicle accidents.
12/02/2012	N/A	Flood	$250,000 in Orinda from a sinkhole
06/04/2011	N/A	Heavy Rain	Heavy rain caused cherry crop to absorb too much water and split fruit.
1/19/2010	N/A	Flood	Heavy rains led to flooded roads and road closures.
04/11/2010	N/A	Heavy Rain	Heavy rains led to a car crash with a vehicle upside down in the rain-swollen San Ramon Creek in Walnut Creek. There were two fatalities.
10/13/2009	N/A	Flood	Record breaking heavy rain led to flooding and debris flows.
1/1/2006	DR 1628	Severe storms, flooding, mudslides, and landslides	$22,000,000 property/$8,710,359 crop
2/14/2000	N/A	Flash flood	$100,000 property
2/9/1998	DR 1203	Severe winter storms and flooding	N/A
1/2/1997	DR 1155	Severe storms/flooding	N/A
3/12/1995	DR 1046	Flooding	$11.2 million
1/10/1995	DR 1044	Severe winter storms, flooding, landslides, mud flows	
1/13/1993	DR 979	Flooding (flash flood)	$5.5 million property/crop
12/11/1992	N/A	Flooding/severe weather	$131,579 property
2/14/1992	N/A	Flooding- severe weather	$20,718 property
5/28/1990	N/A	Flooding (flash flood)	$500,000 property
2/17/1986	DR 758	Flooding (flash flood)	$5,000,000 property
12/9/1983	N/A	Levee failure, high winds, high tides, floods, storm, wind driven water	Public: $7,240,785; Private: $2,669 million; agriculture 1 million
2/9/1983	DR 677	Flood- severe weather	$384,165 property
3/3/1982	N/A	Flooding	$166,667 property
1/3/1982	DR 651	Flood- severe weather	7,142,857 property
1/23/1980	N/A	Delta levee break Holland & Webb levee breaks	Public-11,158,700; private-1,479,500; agriculture-3,887,195; total-17,388,013
1/16/1973	N/A	Flood- severe storm/thunder	$86,206 property
1/18/1969	DR 253	Flood- severe storm/thunder	$862,068 property
1/1978	N/A		N/A
12/1955	N/A	Severe winter storms, flooding	$22 million

N/A = Information is not available
Sources: SHELDUS 2006, *FEMA, 2017; NOAA, 2017*



Contra Costa County
Figure 9-2.
FEMA DFIRM Flood Hazard Areas
1% Annual Chance (100-Year) Flood Zone
0.2% Annual Chance (500-Year) Flood Zone
Flood hazard areas as depicted on Effective FEMA Digital Flood Insurance Rate Maps (DFIRM)
Napa County
Solano County
Sacramento County
Alameda County
San Pablo Bay
Suisun Bay
San Francisco Bay
Pittsburg
Hercules
Pinole
Martinez
Oakley
Antioch
Concord
San Pablo
Pleasant Hill
Clayton
Richmond
El Cerrito
Brentwood
Walnut Creek
Orinda
Lafayette
Moraga
Danville
San Ramon
29
80
12
37
780
680
160
4
242
24
13
580
101
280
61
185
238
84
92
380
Contra Costa County Boundary
City Boundaries
Water Bodies & Channels
Map Data Sources: Contra Costa County, Caltrans, Federal Emergency Management Agency, USDA
0
2.5
5
10
Miles
N
W
E
S
TETRA TECH

9.2.5 Frequency

Recurrence intervals and average annual numbers of events in the planning area were calculated based on data from 1996 to 2016 in NOAA's Storm Events Database. Contra Costa County has experienced seven significant events since 1996 classified as flood in the database. Smaller floods may occur more frequently and be categorized as a different event type, typically "flash flood" or "heavy rain." Based on these data, floods and flash floods have a 30 percent chance of occurring in any given year and heavy rain events have a 66 percent chance. Generally, flooding will likely continue to be an annual hazard.

Additionally, 45 flood-related federally declared disasters or emergencies have occurred in California since 1954 (all 45 events were non-tsunami or hurricane-related flood events). This equates to a major, non-tsunami or hurricane-related flood event impacting the state every 1.37 years on average.

9.2.6 Severity

The principal factors affecting flood damage are flood depth and velocity. The deeper and faster flood flows become, the more damage they can cause. Shallow flooding with high velocities can cause as much damage as deep flooding with slow velocity. This is especially true when a channel migrates over a broad floodplain, redirecting high velocity flows and transporting debris and sediment.

Although jurisdictions can implement mitigation and take preventative actions to significantly reduce severity and threat of flood events, some type of residual risk will always exist (i.e., risk of a hazard event occurring despite technical and scientific measures applied to reduce/prevent it). Threats associated with residual risk include failure of a reservoir, a dam breach, or other infrastructure failure, or a severe flood event that exceeds flood design standards or drainage capacity.

Flood severity is often evaluated by examining peak discharges; Table 9-4 lists peak flows used by FEMA to map the floodplains of the planning area**.**

Table 9-4. Summary of Peak Discharges in the Planning Area

	Discharge (cubic feet/second)			
Source/Location	10-Percent Annual Chance	2--Percent Annual Chance	1-Percent Annual Chance	0.2-Percent Annual Chance
APPIAN CREEK				
Approximately 1,950 feet upstream of Appian Way	320	450	490	580
At Appian Way	430	600	660	780
At confluence with San Pablo Creek	450	640	710	840
ARROYO DEL HAMBRE CREEK AT JOSE LANE				
At John Muir Parkway	1,788[a]	2,413[a]	2,660[a]	2,903[a]
At Jose Lane	2,240	3,290	3,660	4,380
BROOKSIDE ROAD TRIBUTARY	*b*	*b*	*925*	*b*
CASCADE CREEK				
At San Pablo Creek confluence	185	325	360	470
CLAYTON VALLEY DRAIN				
1,135 feet upstream of Salvio Street	480	790	930	1,200
At confluence with Walnut Creek	1,200	1,800	2,100	2,400
CORLISS DRIVE TRIBUTARY				
At confluence with Laguna Creek	160	250	280	300

Source/Location	Discharge (cubic feet/second)			
	10-Percent Annual Chance	2--Percent Annual Chance	1-Percent Annual Chance	0.2-Percent Annual Chance
DEER CREEK				
At Marsh Creek confluence	170[c]	880	1,200	1,800
11,320 feet upstream of confluence	*b*	*b*	*571*	*b*
14,100 feet upstream of confluence	*b*	*b*	*317*	*b*
DITCH NO. 2				
At Bart Culvert	900	1,300	1,450	1,650
At confluence with Pine Creek	1,100	1,500	1,700	2,000
DONNER CREEK				
At confluence with Mount Diablo Creek	845	1,250	1,390	1,680
At Marsh Creek Road	380	740	880	1,400
DOW CHANNEL	470	1,020	1,120	1,120
EAST ANTIOCH CREEK				
At East 18th Street	340	610	760	1,900
EAST BRANCH GREEN VALLEY CREEK				
At Green Valley Road	630	1,260	1,550	2,290
EAST BRANCH REFUGIO CREEK				
At confluence with Refugio Creek	200	250	260	280
At Willow Avenue	200	240	260	260
EAST FORK GRAYSON CREEK				
At Astrid Drive	850	1,220	1,330	1,600
Just upstream of confluence with Murderers Creek	1,040	1,490	1,640	2,100
Just upstream of confluence with West Fork Grayson Creek	1,980	2,880	3,180	3,810
Just upstream of Eccleston Avenue Tributary	450	670	760	1,000
Upstream of Oak Park Boulevard	850	1,207	1,304[d]	1,394[d]
FARM BUREAU ROAD DRAIN				
At confluence with Contra Costa Canal	290	510	610	800
FLAME DRIVE CREEK				
Upstream of confluence with Grayson Creek	270[e]	430	500	620
GALINDO CREEK				
Approximately 2,500 feet downstream of Newhall Parkway	1,200	1,790	1,990	2,400
At Contra Costa Canal	1,580	2,330	2,570	3,100
At Cowell Road	1,400	2,050	2,270	2,740
At Newhall Parkway	900	1,360	1,510	1,830
At San Miguel Road	1,580	2,330	2,570	3,100
At Treat Boulevard	1,290	1,930	2,140	2,590
GARRITY CREEK				
At Union Pacific Railroad	1,010	1,420	1,570	1,860
At upstream side of San Pablo Avenue	645	910	1,000	1,190
GRAYSON CREEK				
At State Highway 4	3,230	4,800	5,320	6,420
Downstream of confluence with West Fork Grayson Creek	3,150	4,650	5,150	6,200

Source/Location	Discharge (cubic feet/second)			
	10-Percent Annual Chance	2--Percent Annual Chance	1-Percent Annual Chance	0.2-Percent Annual Chance
GREEN VALLEY CREEK	2,180	3,210	3,550	4,270
At Diablo Road	2,490	3,650	4,040	4,850
At Interstate 680	2,150	2,170	3,510	4,230
Downstream of confluence with East Branch Green Valley Creek	2,180	3,210	3,550	4,270
Upstream of confluence with East Branch Green Valley Creek	865	1,260	1,400	1,680
GRIZZLY CREEK				
At confluence with Las Trampas Creek	400	740	850	1,170
HAPPY VALLEY CREEK				
At Happy Valley Road	480	830	950	1,200
At State Highway 24	600	1,070	1,230	1,580
HIDDEN VALLEY CREEK				
At corporate limits	80	130	140	170
At El Nido Ranch Road	600	1,020	1,120	1,400
IVY DRIVE TRIBUTARY				
At confluence with Moraga Creek	170	280	310	360
JONAS HILL CREEK				
At Monroe Avenue	310	540	590	730
KIRKER CREEK				
At Buchanan Road	1,154	1,672	1,757	2,040
At Dow Channel	1,254[f]	1,360[f]	1,380[f]	1,400[f]
At Los Medanos Wasteway	630	1,300	1,670	2,900
At Standard Oil Avenue (Below Loveridge Road)	470[f]	1,350[f]	1,500[f]	1,500[f]
Downstream of State Highway 4	1,017[f]	1,822[f]	2,539[f]	2,539[f]
Upstream of State Highway 4	780	1,660	2,100	3,700
At State Highway 4	1,396	2,031	2,168	2,468
At Contra Costa Canal	1,154	1,672	1,757	2,040
Upstream of Brush Creek Drive	1,217	2,139	2,457	3,057
KIRKER CREEK BYPASS	576	795	971	1,095
LAFAYETTE CREEK				
At Moraga Road	800	1,520	1,740	2,200
At Third Street	1,500	2,700	3,100	4,000
LAGUNA CREEK				
At confluence with Moraga Creek	1,040	1,800	2,100	2,300
At Corliss Drive	660	1,100	1,300	1,500
At Rheem Boulevard	450	750	850	960
LARCH CREEK				
At Larch Avenue	80	140	150	200

Source/Location	Discharge (cubic feet/second)			
	10-Percent Annual Chance	2--Percent Annual Chance	1-Percent Annual Chance	0.2-Percent Annual Chance
LAS TRAMPAS CREEK	580	1,080	1,240	1,630
At corporate limits	3,300	6,200	7,000	9,000
At Fourth Street	4,650	6,870	7,650	9,180
At Freeman Road	1,560	3,000	3,600	4,800
At Paradise Court	5,410	8,090	9,000	10,800
At San Ramon Creek	700	1,300	1,500	1,900
At St. Marys Road	4,650	6,870	7,650	9,180
At Tice Creek	1,100	2,100	2,400	3,200
Upstream of Grizzly Creek confluence	580	1,080	1,240	1,630
LAUTERWASSER CREEK				
At San Pablo Creek confluence	620	1,140	1,300	1,700
LAWLOR CREEK				
At Pittsburg	170	260	310	460
At railroad	190	370	460	700
LINE A, DA-40				
At Pacheco Boulevard	605	860	945	1,130
LOS MEDANOS WASTEWAY				
Above Dow Channel	70	110	290	570
MANGINI CREEK				
At Apollo Way	530	840	970	1,200
MARSH CREEK				
At Balfour Road	890	1,900	2,500	5,100
At Santa Fe Railroad	2,300	4,000[f]	4,000[f]	4,000[f]
At Union Pacific Railroad	2,100	4,200	5,200	8,300
MCCOLLUM CREEK				
Upstream of confluence with Grayson Creek	150	220	250	300
MIRANDA CREEK				
At U.S. Interstate 680	340	620	75	1,000
MITCHELL CREEK				
At confluence with Mount Diablo Creek	1,090	1,630	1,810	2,190
MORAGA CREEK				
At confluence with Laguna Creek	1,790	3,300	3,800	4,300
At corporate limits (Ivy Drive)	540	980	1,100	1,440
At upper San Leandro Reservoir	2,300	4,300	5,000	5,900
MOUNT DIABLO CREEK				
Approximately 700 feet downstream of Kirker Pass Road	3,660	5,610	6,270	7,640
At Kirker Pass Road	3,660	5,610	6,270	7,640
At Regency Drive	3,450	5,240	5,860	7,130
Downstream of Bailey Road	960	1,430	1,590	1,930
Downstream of confluence of Donner Creek	3,670	5,670	6,350	7,760
Downstream of confluence of Mitchell Creek	3,450	5,240	5,860	7,130
Downstream of confluence of Russellmann Creek	880	1,280	1,420	1,700

Source/Location	Discharge (cubic feet/second)			
	10-Percent Annual Chance	2--Percent Annual Chance	1-Percent Annual Chance	0.2-Percent Annual Chance
Downstream of Irish Canyon	2,610	3,950	4,400	5,350
Upstream of confluence of Donner Creek	1,050	1,570	1,750	2,110
Upstream of Irish Canyon	1,900	2,840	3,170	3,840
MURDERERS CREEK				
At Oak Park Boulevard	570	940	1,120	1,600
Upstream of confluence with East Fork Grayson Creek	1,020	1,570	1,850[g]	2,650
Upstream of confluence with Tributary A	400	690	820	1,200
Upstream of confluence with Tributary B	40	410	500	710
NORTH BRANCH RELIEZ CREEK				
At mouth	60	100	110	150
NORTH BRANCH STONE VALLEY CREEK				
At Austin Lane	160	250	300	340
OLD KIRKER CREEK				
Below Dow Channel	0	330	380	380
OVERHILL CREEK				
At Moraga Way	130	225	250	320
PACHECO CREEK				
At gaging station in Walnut Creek	9,500	18,000	22,000	31,000
At Union Pacific Railroad	*b*	*b*	*b*	*b*
Near Suisun Bay	11,000	20,500	25,000	35,000
PAYTON SLOUGH				
Above U.S. Interstate 680	370	620	750	1,000
PINE CREEK				
At confluence with Contra Costa Canal	980	2,200	2,800	4,400
At confluence with Walnut Creek	3,200	6,000	7,300	10,000
At Monument Boulevard	1,700	3,400	4,300	6,400
PINOLE CREEK				
At corporate limits	1,280	1,810	1,960	2,200
At Interstate Highway 80	1,460	2,070	2,240	2,500
At San Pablo Bay	1,520	2,150	2,320	2,600
REFUGIO CREEK				
At Hercules Corporate Limits	220	290	320	350
At San Pablo Bay	680	990	1,120	1,400
At Sycamore Road	420	558	595	668
RELIEZ CREEK				
At Springhill Court	200	350	400	560
Upstream of Condit Road	1,040	1,535	1,685	2,200[i]
Upstream of Highway 24	965	1,430	1,570	2,050[i]
Upstream of Pleasant Hill Road	720	1,065	1,170	1,500[i]
Upstream of Stanley Boulevard	820	1,210	1,330	1,800[i]

Source/Location	Discharge (cubic feet/second) 10-Percent Annual Chance	2--Percent Annual Chance	1-Percent Annual Chance	0.2-Percent Annual Chance
RODEO CREEK				
At Diablo Road	1,710	2,590	2,900	3,510
At San Pablo Bay	1,760	2,660	2,960	3,590
SAND CREEK				
At Marsh Creek confluence	1,000	2,300	2,900	4,500
SAN PABLO CREEK				
2,000 feet upstream of Orinda Way	*b*	*b*	*5,040*	*b*
At Bear Creek Road	3,000	5,700	6,700	8,700
At Church Lane	2,250	4,000	5,100	7,550
At confluence with Brookside Road	*b*	*b*	*1,470*	*h*
Tributary to Orchard Road At mouth	2,450	3,920[b]	4,320[b]	4,680[b]
Downstream of West Branch (at Brookwood Road)	*b*	*b*	*4,550*	*b*
Glorietta Road to Greenwood Court	*b*	*b*	*445*	*b*
Orchard Road to Glorietta Road	*b*	*b*	*1,120*	*b*
Upstream of Brookwood Road (West Branch)	*b*	*b*	*2,550*	*b*
Upstream of Camino Encinatas	*b*	*b*	*2,250*	*b*
Upstream of Greenwood Court	*b*	*b*	*175*	*b*
Upstream of Orinda Way	*b*	*b*	*5,270*	*b*
SAN RAMON CREEK				
At La Gonda Way	3,100	6,800	8,300	13,000
At Las Trampas Creek	3301	380[h]	500[h]	1,440[h]
At Miranda Creek	6,800	10,500	11,800	14,400
At San Crainte Creek	7,620	11,800	13,200	16,100
At San Ramon Valley Boulevard	1,400	2,700	3,200	4,400
Below Sycamore Creek confluence	2,200	4,600	5,600	8,500
SAN RAMON BYPASS				
At junction of Old Channel	7,820	12,000	13,400	16,300
At San Crainte Creek	7,620	11,800	13,200	16,100
SANS CRAINTE CREEK				
At Milton Avenue	430	635	705	850
At Palmer Road	420	615	680	820
Downstream of San Miguel Avenue	780	1,160	1,290	1,350
Upstream of Palmer Road Main Branch	320	470	520	630
SOUTH BRANCH MORAGA CREEK				
At confluence with Moraga Creek	500	920	1,050	1,360
At corporate limits	320	570	640	830
SOUTH SAN RAMON CREEK				
At Alcosta Boulevard	2,650	3,920	4,350	5,300
Below Channel Z	2,180	3,020	3,290	4,050
Below Norris Creek	2,300	3,380	3,750	4,600
ST. MARYS ROAD TRIBUTARY				
At confluence with Laguna Creek	260	420	480	520

Source/Location	Discharge (cubic feet/second) 10-Percent Annual Chance	2--Percent Annual Chance	1-Percent Annual Chance	0.2-Percent Annual Chance
STONE VALLEY CREEK				
At U.S. Interstate 680	310	610	730	1,200
SYCAMORE CREEK				
At Camino Tassajara	500	1,000	1,200	1,900
At Morninghome Road	750	1,660	1,900	3,100
TICE CREEK				
At Castle Glen Tributary	700	1,170	1,470	1,730
At Las Trampas Creek	860	1,470	1,770	2,290
WALNUT CREEK				
At corporate limits at State Highway 4 (Arnold Industrial Highway)	9,520	18,000	22,300	31,000
At San Ramon Bypass	5,740	8,470	9,510	12,300
At Walnut Creek Stream Gage (upstream of Concord)	9,520	17,700	22,000	30,600
WEST ALAMO CREEK				
Approximately 4,000 feet upstream of Tassajara Road	740	1,100	1,230	1,480
Approximately 6,000 feet upstream of Tassajara Road	600	895	995	1,210
Inflow to Bettencourt Basin at Tassajara Road	800	1,200	1,340	1,630
WEST ANTIOCH CREEK				
At fairgrounds	790	1,580	2,000	2,900
WEST BRANCH REFUGIO CREEK				
At confluence with Refugio Creek	150	200	210	240
At Hercules corporate limits	50	70	75	85
WEST FORK GRAYSON CREEK				
At Oak Park Boulevard	340	610	730	990
Upstream of confluence with East Fork Grayson Creek	1,170	1,770	1,970	2,390
WILDCAT CREEK				
At Church Lane	1,250	1,950	2,300	2,600
At mouth	1,0201	1,180[a]	1,260[a]	1,330[a]
WILLOW CREEK				
Just upstream of Cape May Drive	*b*	*b*	*249*	*b*
Approximately 450 feet upstream of Nantucket Drive	*b*	*b*	*278*	*b*

a. Increase in area with decrease in flow is result of spill
b. Data not computed
c. Flows reduced by reservoir routing
d. Flows in the main channel under the influence of split flows
e. Discharge does not consider reduction due to upstream storage
f. Peaks reduced due to bypassing and/or non-returning overbank spills
g. Includes split flows
h. Flows decrease due to the effects of San Ramon Bypass
i. 0.2-percent annual chance flood flow projected using the Drainage Master Plan

Source: Flood Insurance Study, 2015b.

9.2.7 Warning Time

Due to the sequential pattern of meteorological conditions needed to cause serious flooding, it is unusual for a flood to occur without warning. Warning times for floods can be between 24 and 48 hours. Flash flooding can be less predictable, but potential hazard areas can be warned in advanced of potential flash flooding danger.

Flooding is more likely to occur due to a rain storm when the soil is already wet and/or streams are already running high from recent previous rains (conditions already in place when a storm begins are called “antecedent conditions”). Contra Costa County Flood Control and Water Conservation District maintains a flood warning system that is tied to monitoring rainfall amounts during storms as well as current antecedent conditions at multiple rain gauges throughout Contra Costa County. Critical antecedent conditions for flood warning are defined as follows:

- 7 inches of rain for the season.
- 5 inches of rain in the last 30 days.
- 3 inches of rain in the last 7 days.

If any of these conditions have been met and 2 inches of rainfall is forecast in the next 24 hours, then flooding is likely in the next 24 hours. This information has been provided to the public via the Contra Costa County Flood Control and Water Conservation District’s “7-5-3-2” outreach campaign (Contra Costa County, 2017).

9.3 SECONDARY HAZARDS

The most problematic secondary hazard for flooding is bank erosion, which in some cases can be more harmful than actual flooding. This is especially true in the upper courses of rivers with steep gradients, where floodwaters may pass quickly and without much damage, but scour the banks, edging properties closer to the floodplain or causing them to fall in. Flooding is also responsible for hazards such as landslides when high flows over-saturate soils on steep slopes, causing them to fail. Hazardous materials spills are also a secondary hazard of flooding if storage tanks rupture and spill into streams, rivers or storm sewers.

9.4 EXPOSURE

Hazus was used to assess the risk and vulnerability to flooding in the planning area. The model used census data at the block level and FEMA floodplain data, which has a level of accuracy acceptable for planning purposes. Where possible, the Hazus default data was enhanced using GIS data from local, state and federal sources.

9.4.1 Population

Population counts of those living in the floodplain within the planning area were generated by estimating percent of residential buildings in each jurisdiction within the 1-percent-annual-chance flood hazard areas and multiplying this by total population within the planning area. This approach yielded an estimated population in the planning area of 28,854 living within the 100-year floodplain (2.6 percent of the total planning area population). Table 9-5 lists population estimates by jurisdiction living in the 10-percent, 1-percent and 0.2-percent annual chance flood hazard areas.

9.4.2 Property

Structures in the Floodplain

Table 9-6, Table 9-7, and Table 9-8 summarize the total area of the 10-, 1-, and 0.2-percent-annual-chance flood hazard areas and the number of structures in each. For the 10-percent annual chance flood, floodplain area was not calculated because the FEMA FIRM dataset does not include the 10-percent-annual-chance flood. The Hazus model determined that there are 1,843 structures within the 10-percent-annual-chance flood hazard area, 9,571 structures within the 1-percent-annual-chance flood hazard area, and 21,794 structures within the 0.2-percent-annual-chance flood hazard area. In the 1-percent-annual-chance flood hazard area, about 91 percent are residential, and 7 percent are commercial and industrial.

Table 9-5. Population Within the 10-Percent, 1-Percent and 0.2-Percent Annual Chance Flood Hazard Areas

	10-Percent Annual Chance Flood Hazard Area		1-Percent Annual Chance Flood Hazard Area		0.2-Percent Annual Chance Flood Hazard Area	
	Population Exposed[a]	% of Total Population	Population Exposed[a]	% of Total Population	Population Exposed[a]	% of Total Population
Antioch	11	0.0%	497	0.4%	1,626	1.4%
Brentwood	0	0.0%	711	1.2%	1,856	3.2%
Clayton	125	1.1%	233	2.1%	242	2.2%
Concord	722	0.6%	2,401	1.9%	5,857	4.5%
Danville	65	0.2%	416	1.0%	1,264	2.9%
El Cerrito	343	1.4%	460	1.9%	460	1.9%
Hercules	0	0.0%	0	0.0%	0	0.0%
Lafayette	374	1.5%	868	3.5%	1,461	5.9%
Martinez	94	0.3%	2,558	6.9%	2,776	7.5%
Moraga	67	0.4%	206	1.2%	534	3.2%
Oakley	0	0.0%	495	1.2%	4,508	11.2%
Orinda	105	0.6%	413	2.2%	413	2.2%
Pinole	96	0.5%	114	0.6%	145	0.8%
Pittsburg	46	0.1%	785	1.2%	1,628	2.4%
Pleasant Hill	1,341	3.9%	2,087	6.1%	5,534	16.2%
Richmond	0	0.0%	517	0.5%	3,268	3.0%
San Pablo	198	0.6%	2,855	9.3%	5,725	18.6%
San Ramon	196	0.3%	450	0.6%	545	0.7%
Walnut Creek	492	0.7%	837	1.2%	1,425	2.0%
Unincorporated	1,276	0.7%	11,951	7.0%	29,029	17.0%
Total	5,549	0.5%	28,854	2.6%	68,296	6.1%

a. Represents percent of residential buildings exposed multiplied by estimated 2016 population from California Department of Finance.

Table 9-6. Structures in the 10-Percent Annual Chance Flood Hazard Area

	Number of Structures in Floodplain							
Jurisdiction	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	**Total**
Antioch	3	3	2	0	0	0	0	8
Brentwood	0	0	0	1	0	0	0	1
Clayton	45	3	0	0	0	3	1	52
Concord	199	1	0	0	0	1	0	201
Danville	23	0	0	0	1	0	0	24
El Cerrito	114	0	0	0	0	0	0	114
Hercules	0	0	0	0	0	0	0	0
Lafayette	121	12	0	0	0	0	0	133
Martinez	31	0	0	0	0	0	0	31
Moraga	22	0	0	0	0	0	0	22
Oakley	0	0	0	0	0	0	0	0
Orinda	38	11	0	0	0	0	0	49
Pinole	31	2	0	0	0	0	0	33
Pittsburg	12	0	0	0	0	0	0	12
Pleasant Hill	433	7	0	0	0	0	3	443
Richmond	0	0	0	0	0	0	0	0
San Pablo	40	1	0	0	0	0	0	41
San Ramon	58	1	0	0	0	0	0	59
Walnut Creek	188	13	0	0	0	0	0	201
Unincorporated	397	13	1	0	4	4	0	419
Total	1,755	67	3	1	5	8	4	1,843

Table 9-7. Area and Structures in the 1-Percent Annual Chance Flood Hazard Area

Jurisdiction	Area in Floodplain (acres)	Number of Structures in Floodplain							
		Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Antioch	1,177	135	24	6	0	0	7	0	172
Brentwood	303	219	4	0	2	0	0	1	226
Clayton	130	84	9	0	0	0	3	2	98
Concord	728	662	14	15	0	4	2	2	699
Danville	240	148	7	0	1	2	1	1	160
El Cerrito	26	153	1	0	0	0	0	0	154
Hercules	500	0	2	0	0	0	0	0	2
Lafayette	281	281	39	0	0	0	0	1	321
Martinez	1,512	845	149	5	0	11	11	7	1,028
Moraga	106	68	0	0	0	0	0	0	68
Oakley	4,087	139	16	1	1	1	4	0	162
Orinda	145	149	21	0	0	0	0	0	170
Pinole	374	37	2	0	0	0	0	0	39
Pittsburg	2,992	204	8	24	0	2	1	0	239
Pleasant Hill	283	674	26	0	0	0	0	3	703
Richmond	5,763	133	28	19	0	0	0	0	180
San Pablo	174	578	16	5	0	6	0	0	605
San Ramon	169	133	2	0	0	0	0	1	136
Walnut Creek	165	320	16	0	0	0	0	1	337
Unincorporated	69,479	3,718	185	36	89	14	29	1	4,072
Total	88,632	8,680	569	111	93	40	58	20	9,571

Table 9-8. Area and Structures in the 0.2-Percent Annual Chance Flood Hazard Area

Jurisdiction	Area in Floodplain (acres)	Number of Structures in Floodplain							
		Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Antioch	1,433	442	33	7	0	0	8	0	490
Brentwood	484	572	4	4	2	0	1	2	585
Clayton	143	87	17	0	0	0	3	2	109
Concord	1,235	1,615	67	16	0	5	3	5	1,711
Danville	400	450	9	0	1	2	1	1	464
El Cerrito	26	153	1	0	0	0	0	0	154
Hercules	515	0	2	0	0	0	0	0	2
Lafayette	415	473	72	0	0	0	1	2	548
Martinez	1,655	917	163	10	0	13	13	7	1,123
Moraga	169	176	16	0	0	0	0	0	192
Oakley	4,944	1,266	16	1	8	1	5	1	1,298
Orinda	157	149	24	0	0	0	0	0	173
Pinole	387	47	6	0	0	3	1	0	57
Pittsburg	3,187	423	8	37	0	3	3	0	474
Pleasant Hill	645	1,787	52	0	0	1	3	3	1,846
Richmond	6,393	841	50	62	0	6	4	1	964
San Pablo	310	1,159	45	6	0	9	4	0	1,223
San Ramon	196	161	2	0	0	0	0	2	165
Walnut Creek	325	545	158	0	0	0	2	1	706
Unincorporated	78,335	9,031	240	68	106	23	38	4	9,510
Total	101,352	20,294	985	211	117	66	90	31	21,794

Exposed Value

Table 9-9, Table 9-10 and Table 9-11 summarize the estimated value of exposed buildings in the planning area. This methodology estimated $1.3 billion worth of building-and-contents exposure to the 10-percent-annual-chance flood, representing 0.5 percent of the total replacement value of the planning area, $9.0 billion worth of building-and-contents exposure to the 1-percent-annual-chance flood, representing 3.7 percent of the total replacement value of the planning area, and $20.3 billion worth of building-and-contents exposure to the 0.2-percent-annual-chance flood, representing 8.2 percent of the total.

Land Use in the Floodplain

Some land uses are more vulnerable to flooding, such as single-family homes, while others are less vulnerable, such as agricultural land or parks. Table 9-12 shows the existing land use of all parcels in the 1- and 0.2-percent-annual-chance flood hazard areas, including a combined category of vacant parcels, rights-of-way, open water and public/open space uses. Approximately 9.6 percent of the area of the parcels in the 1-percent-annual-chance flood hazard area is used for agricultural purposes. These are favorable, lower-risk uses for the floodplain. The amount of the floodplain in the combined category that contains vacant, developable land is not known. This would be valuable information for gauging the future development potential of the floodplain.

9.4.3 Critical Facilities and Infrastructure

Table 9-13 through Table 9-18 summarize the critical facilities and infrastructure in the 10-, 1-, and 0.2-percent-annual-chance flood hazard areas. Details are provided in the following sections.

Table 9-9. Value of Structures in the 10-Percent Annual Chance Flood Hazard Area

Jurisdiction	Estimated Value within the Floodplain			% of Total Replacement Value
	Structure	Contents	**Total**	
Antioch	$11,576,065	$10,226,068	$21,802,133	0.1%
Brentwood	$338,656	$338,656	$677,313	0.0%
Clayton	$35,030,265	$27,836,703	$62,866,968	2.8%
Concord	$58,228,697	$32,802,312	$91,031,009	0.3%
Danville	$8,075,495	$4,677,797	$12,753,292	0.1%
El Cerrito	$40,991,309	$20,495,654	$61,486,963	1.1%
Hercules	$0	$0	$0	0.0%
Lafayette	$47,282,123	$28,635,562	$75,917,685	1.2%
Martinez	$8,739,287	$4,369,644	$13,108,931	0.1%
Moraga	$6,941,631	$3,470,815	$10,412,446	0.3%
Oakley	$0	$0	$0	0.0%
Orinda	$36,898,340	$32,514,822	$69,413,162	1.5%
Pinole	$9,198,459	$5,813,234	$15,011,693	0.4%
Pittsburg	$3,701,048	$1,850,524	$5,551,572	0.0%
Pleasant Hill	$218,749,943	$162,851,652	$381,601,595	4.8%
Richmond	$0	$0	$0	0.0%
San Pablo	$9,424,234	$5,239,382	$14,663,616	0.3%
San Ramon	$34,682,048	$17,397,188	$52,079,237	0.3%
Walnut Creek	$126,903,781	$91,851,535	$218,755,316	1.1%
Unincorporated	$145,613,831	$100,446,314	$246,060,144	0.6%
Total	$802,375,210	$550,817,865	$1,353,193,076	0.5%

Table 9-10. Value of Structures in the 1-Percent Annual Chance Flood Hazard Area

Jurisdiction	Estimated Value within the Floodplain			% of Total Replacement Value
	Structure	Contents	**Total**	
Antioch	$132,254,912	$130,879,913	$263,134,825	1.3%
Brentwood	$105,364,545	$74,055,379	$179,419,924	1.5%
Clayton	$55,430,883	$41,705,427	$97,136,310	4.3%
Concord	$385,730,393	$362,066,950	$747,797,343	2.9%
Danville	$69,953,764	$44,941,480	$114,895,244	1.1%
El Cerrito	$63,013,203	$32,315,491	$95,328,694	1.7%
Hercules	$4,110,594	$4,110,594	$8,221,187	0.2%
Lafayette	$171,604,463	$119,348,010	$290,952,473	4.5%
Martinez	$759,304,484	$635,992,905	$1,395,297,390	15.7%
Moraga	$22,323,526	$11,161,763	$33,485,289	0.9%
Oakley	$121,212,906	$99,688,603	$220,901,509	3.6%
Orinda	$114,666,194	$90,320,793	$204,986,987	4.3%
Pinole	$10,637,738	$6,532,874	$17,170,612	0.4%
Pittsburg	$127,080,267	$130,211,866	$257,292,133	2.1%
Pleasant Hill	$340,238,522	$258,219,035	$598,457,558	7.5%
Richmond	$281,243,215	$298,396,804	$579,640,019	2.2%
San Pablo	$220,974,237	$137,620,684	$358,594,921	7.9%
San Ramon	$79,432,846	$54,604,228	$134,037,074	0.7%
Walnut Creek	$202,741,433	$138,426,435	$341,167,868	1.8%
Unincorporated	$1,715,170,184	$1,381,902,720	$3,097,072,904	7.6%
Total	$4,982,488,310	$4,052,501,955	$9,034,990,265	3.7%

Table 9-11. Value of Structures in the 0.2-Percent Annual Chance Flood Hazard Area

Jurisdiction	Estimated Value within the Floodplain			% of Total Replacement Value
	Structure	Contents	**Total**	
Antioch	$243,304,691	$197,315,730	$440,620,421	2.1%
Brentwood	$206,175,570	$133,219,231	$339,394,801	2.8%
Clayton	$79,961,036	$65,630,349	$145,591,385	6.5%
Concord	$1,036,283,240	$889,868,971	$1,926,152,210	7.4%
Danville	$186,956,788	$111,950,436	$298,907,224	2.9%
El Cerrito	$63,013,203	$32,315,491	$95,328,694	1.7%
Hercules	$4,110,594	$4,110,594	$8,221,187	0.2%
Lafayette	$289,326,768	$202,906,212	$492,232,980	7.5%
Martinez	$812,440,557	$674,269,683	$1,486,710,240	16.7%
Moraga	$136,429,509	$103,525,563	$239,955,072	6.1%
Oakley	$569,052,945	$338,915,089	$907,968,034	15.0%
Orinda	$116,241,548	$91,896,147	$208,137,695	4.4%
Pinole	$31,217,738	$25,973,863	$57,191,602	1.5%
Pittsburg	$215,629,831	$208,248,960	$423,878,791	3.5%
Pleasant Hill	$681,102,126	$468,249,651	$1,149,351,777	14.4%
Richmond	$741,923,844	$767,930,569	$1,509,854,413	5.7%
San Pablo	$482,545,268	$339,484,281	$822,029,549	18.2%
San Ramon	$116,176,076	$86,793,348	$202,969,423	1.0%
Walnut Creek	$642,228,291	$541,382,947	$1,183,611,238	6.1%
Unincorporated	$4,579,537,624	$3,798,317,748	$8,377,855,373	20.5%
Total	$11,233,657,246	$9,082,304,863	$20,315,962,110	8.2%

Table 9-12. Land Use Within the Floodplain

	1-Percent Annual Chance		0.2-Percent Annual Chance	
	Area (acres)	% of total	Area (acres)	% of total
Residential	3,773	4.9%	6,339	7.2%
Commercial	2,578	3.4%	3,353	3.8%
Industrial	1,947	2.5%	2,347	2.7%
Agriculture	7,387	9.6%	8,568	9.7%
Religion	51	0.1%	79	0.1%
Government	4,548	5.9%	4,811	5.5%
Education	125	0.2%	223	0.3%
Vacant, Rights-of-way, Open water, Open Space	56,283	73.4%	62,472	70.8%
Total	76,692	100%	88,191	100%

Table 9-13. Critical Facilities in the 10-Percent Annual Chance Flood Hazard Area

	Number of Facilities in the Floodplain					
	Medical and Health	Government Functions	Protective Functions	Schools and Educational Facilities	Hazmat	**Total**
Antioch	0	0	0	0	0	0
Brentwood	1	0	0	0	0	1
Clayton	0	0	0	0	0	0
Concord	0	0	0	2	0	2
Danville	0	0	0	0	0	0
El Cerrito	0	0	0	0	0	0
Hercules	0	0	0	0	0	0
Lafayette	0	0	0	0	0	0
Martinez	0	0	0	0	1	1
Moraga	0	0	0	0	0	0
Oakley	0	0	1	0	0	1
Orinda	0	0	0	0	0	0
Pinole	0	0	0	0	0	0
Pittsburg	0	0	0	0	2	2
Pleasant Hill	0	0	0	0	0	0
Richmond	0	0	0	0	0	0
San Pablo	0	0	0	0	0	0
San Ramon	0	0	0	0	0	0
Walnut Creek	0	0	1	1	0	2
Unincorporated	0	0	6	1	3	10
Total	1	0	8	4	6	19

Table 9-14. Critical Infrastructure in the 10-Percent Annual Chance Flood Hazard Area

	Number of Facilities in the Floodplain							
	Bridges	Water Supply	Waste water	Power	Communications	Other Critical Functions	Other Critical Infrastructure	**Total**
Antioch	0	0	0	0	1	2	0	3
Brentwood	3	0	0	0	0	0	1	4
Clayton	0	0	0	0	0	0	0	0
Concord	3	0	1	1	0	0	1	6
Danville	0	0	0	0	0	0	0	0
El Cerrito	0	0	0	0	0	0	0	0
Hercules	0	0	0	0	0	0	0	0
Lafayette	1	0	0	0	1	0	3	5
Martinez	1	1	1	1	0	1	0	5
Moraga	0	0	0	0	0	0	0	0
Oakley	1	1	0	0	0	0	0	2
Orinda	1	0	1	1	0	0	0	3
Pinole	1	0	1	0	0	0	0	2
Pittsburg	1	0	1	1	0	0	2	5
Pleasant Hill	4	1	0	0	0	0	1	6
Richmond	1	0	0	2	0	2	0	5
San Pablo	3	0	0	0	0	0	0	3
San Ramon	0	0	0	0	0	0	0	0
Walnut Creek	1	0	0	1	0	0	1	3
Unincorporated	14	1	1	0	3	0	11	30
Total	35	4	6	7	5	5	20	82

Table 9-15. Critical Facilities in the 1-Percent Annual Chance Flood Hazard Area

	Number of Facilities in the Floodplain					
	Medical and Health	Government Functions	Protective Functions	Schools and Educational Facilities	Hazmat	**Total**
Antioch	0	0	0	0	0	0
Brentwood	1	0	0	0	0	1
Clayton	0	0	0	1	0	1
Concord	0	0	0	3	0	3
Danville	0	0	0	0	0	0
El Cerrito	0	0	0	0	0	0
Hercules	0	0	0	0	0	0
Lafayette	0	0	0	1	0	1
Martinez	1	1	3	7	1	13
Moraga	0	0	0	0	0	0
Oakley	0	0	1	0	0	1
Orinda	0	0	0	0	0	0
Pinole	0	0	0	0	0	0
Pittsburg	0	0	0	0	2	2
Pleasant Hill	0	0	0	0	0	0
Richmond	0	0	0	0	0	0
San Pablo	0	0	0	0	1	1
San Ramon	0	0	0	0	0	0
Walnut Creek	0	0	1	1	0	2
Unincorporated	0	0	9	2	5	16
Total	2	1	14	15	9	41

Table 9-16. Critical Infrastructure in the 1-Percent Annual Chance Flood Hazard Area

	Number of Facilities in the Floodplain							
	Bridges	Water Supply	Waste water	Power	Communications	Other Critical Functions	Other Critical Infrastructure	**Total**
Antioch	0	0	0	0	1	2	0	3
Brentwood	3	0	0	0	0	0	1	4
Clayton	0	0	0	0	0	0	0	0
Concord	10	0	1	2	0	0	4	17
Danville	2	0	0	0	0	0	12	14
El Cerrito	0	0	0	0	0	0	0	0
Hercules	0	0	0	0	0	0	0	0
Lafayette	1	0	0	0	1	0	3	5
Martinez	5	1	1	2	0	1	5	15
Moraga	0	0	0	0	0	0	0	0
Oakley	1	1	0	0	0	0	0	2
Orinda	2	0	2	1	0	0	0	5
Pinole	1	0	1	0	0	0	0	2
Pittsburg	2	0	1	1	0	0	2	6
Pleasant Hill	6	1	0	0	0	0	1	8
Richmond	2	0	0	2	0	3	0	7
San Pablo	3	0	0	0	0	0	0	3
San Ramon	0	0	0	0	0	0	0	0
Walnut Creek	2	0	0	1	0	0	2	5
Unincorporated	32	4	7	1	3	1	21	69
Total	72	7	13	10	5	7	51	165

Table 9-17. Critical Facilities in the 0.2-Percent Annual Chance Flood Hazard Area

	Number of Facilities in the Floodplain					
	Medical and Health	Government Functions	Protective Functions	Schools and Educational Facilities	Hazmat	**Total**
Antioch	0	0	0	1	0	1
Brentwood	1	0	0	1	0	2
Clayton	0	0	0	1	0	1
Concord	0	0	3	5	0	8
Danville	0	0	0	0	0	0
El Cerrito	0	0	0	0	0	0
Hercules	0	0	0	0	0	0
Lafayette	0	0	0	1	0	1
Martinez	1	1	4	7	1	14
Moraga	0	0	0	0	0	0
Oakley	0	0	1	2	0	3
Orinda	0	0	0	1	0	1
Pinole	0	0	0	0	0	0
Pittsburg	0	0	0	0	2	2
Pleasant Hill	0	0	1	1	0	2
Richmond	0	0	1	1	4	6
San Pablo	0	0	0	2	1	3
San Ramon	0	0	0	0	0	0
Walnut Creek	0	0	3	1	0	4
Unincorporated	0	0	12	7	5	24
Total	2	1	25	31	13	72

Table 9-18. Critical Infrastructure in the 0.2-Percent Annual Chance Flood Hazard Area

	Number of Facilities in the Floodplain							
	Bridges	Water Supply	Waste water	Power	Communications	Other Critical Functions	Other Critical Infrastructure	Total
Antioch	1	1	1	0	1	2	1	7
Brentwood	5	0	0	0	0	0	1	6
Clayton	0	0	0	0	0	0	0	0
Concord	10	0	1	2	0	0	4	17
Danville	4	1	0	0	0	0	12	17
El Cerrito	0	0	0	0	0	0	0	0
Hercules	0	0	0	0	0	0	0	0
Lafayette	3	0	0	0	2	0	3	8
Martinez	7	1	1	2	0	1	5	17
Moraga	0	0	0	0	0	0	0	0
Oakley	1	1	0	0	0	0	0	2
Orinda	2	0	2	1	0	0	0	5
Pinole	1	0	1	0	0	0	0	2
Pittsburg	2	0	1	2	0	2	2	9
Pleasant Hill	8	1	0	0	0	0	3	12
Richmond	4	0	0	2	0	3	0	9
San Pablo	3	0	0	1	0	0	0	4
San Ramon	1	0	0	0	0	0	0	1
Walnut Creek	4	0	0	1	0	0	2	7
Unincorporated	36	5	7	2	5	2	24	81
Total	92	10	14	13	8	10	57	204

Toxic Release Inventory Reporting Facilities

Toxic Release Inventory facilities are known to manufacture, process, store, or otherwise use certain chemicals above minimum thresholds. If damaged by a flood, these facilities could release chemicals that cause cancer or other human health effects, significant adverse acute human health effects, or significant adverse environmental effects (U.S. Environmental Protection Agency, 2015). During a flood event, containers holding these materials can rupture and leak into the surrounding area, disastrously affecting the environment and residents. Nine facilities within the 1-percent-annual-chance flood zone are Toxic Release Inventory reporting facilities.

Utilities and Infrastructure

It is important to determine who may be at risk if infrastructure is damaged by flooding. Roads or railroads that are blocked or damaged can isolate residents and can prevent access throughout the planning area, including for emergency service providers needing to get to vulnerable populations or to make repairs. Bridges washed out or blocked by floods or debris also can cause isolation. Water and sewer systems can be flooded or backed up, causing health problems. Underground utilities can be damaged. Dikes can fail or be overtopped, inundating the land that they protect. The following sections describe specific types of critical infrastructure.

Roads

The following major roads in the planning area pass through the 100-year floodplain and thus are exposed to flooding:

- Brentwood Boulevard
- Highway 160
- Interstate 80
- Byron Highway
- State Highway 4
- Interstate 680
- Chilpancingo Pkwy
- Grove Shafter Freeway

- Highway 24
- John T Knox Freeway
- East 18th Street
- State Highway 242
- Eastshore Freeway
- John Muir Parkway
- Pittsburg Antioch Highway
- Port Chicago Highway
- Richmond Parkway
- Windemere Parkway

Some of these roads are built above the flood level, and others function as levees to prevent flooding. Still, in severe flood events these roads can be blocked or damaged, preventing access to some areas.

Bridges

Flood events can significantly impact road bridges. These are important because often they provide the only ingress and egress to some neighborhoods. An analysis showed that there are 72 bridges that are in or cross over the 100-year floodplain and 92 bridges in the 500-year floodplain.

Water and Sewer Infrastructure

Water and sewer systems can be affected by flooding. Floodwaters can back up drainage systems, causing localized flooding. Culverts can be blocked by debris from flood events, also causing localized urban flooding. Floodwaters can get into drinking water supplies, causing contamination. Sewer systems can be backed up, causing wastewater to spill into homes, neighborhoods, rivers and streams.

Levees

Levees have historically been used to control flooding in potions of Contra Costa County. The county has over 1,100 miles of earthen levees and revetments managed by Contra Costa County Flood Control District and reclamation districts in the county. There are also levees on many smaller rivers, streams and creeks that protect small areas of land. Many of the levees are older and were built under earlier flood management goals. Many of these older levees are exposed to scouring and failure due to old age and construction methods.

9.4.4 Environment

Flooding is a natural event, and floodplains provide many natural and beneficial functions. Nonetheless, flooding can impact the environment in negative ways. Migrating fish can wash into roads or over dikes into flooded fields, with no possibility of escape. Pollution from roads, such as oil, and hazardous materials can wash into rivers and streams. During floods, these can settle onto normally dry soils, polluting them for agricultural uses. Human development such as bridge abutments and levees, and logjams from timber harvesting can increase stream bank erosion, causing rivers and streams to migrate into non-natural courses.

9.5 VULNERABILITY

Many of the areas exposed to flooding may not experience serious flooding or flood damage. This section describes vulnerabilities in terms of population, property, infrastructure and environment.

9.5.1 Population

Vulnerable Populations

A geographic analysis of demographics using the Hazus model identified populations vulnerable to the flood hazard as follows:

- **Economically Disadvantaged Populations**—It is estimated that 39 percent of the households within the 100-year floodplain are economically disadvantaged, defined as having household incomes of $50,000 or less.
- **Population over 65 Years Old**—It is estimated that 13 percent of the population in the census blocks that intersect the 100-year floodplain are over 65 years old.
- **Population under 16 Years Old**—It is estimated that 23 percent of the population within census blocks located in or near the 100-year floodplain are under 16 years of age.

Estimated Impacts on Persons and Households

Impacts on persons and households in the planning area were estimated for the 10-, 1-, and 0.2-percent-annual-chance flood events through the Hazus analysis. Table 9-19 summarizes the results.

Table 9-19. Estimated Flood Impact on Persons and Households

Jurisdiction	Number of Displaced Households			Number of Persons Requiring Short-Term Shelter		
	10% Annual Chance Flood	1% Annual Chance Flood	0.2% Annual Chance Flood	10% Annual Chance Flood	1% Annual Chance Flood	0.2% Annual Chance Flood
Antioch	0	38	189	0	28	139
Brentwood	0	38	246	0	20	178
Clayton	11	27	37	4	14	22
Concord	66	246	797	43	173	633
Danville	1	18	82	0	6	42
El Cerrito	216	226	247	201	208	231
Hercules	0	0	0	0	0	0
Lafayette	11	54	171	3	31	114
Martinez	5	1,244	1,300	1	972	998
Moraga	1	6	26	0	1	16
Oakley	0	46	1,483	0	29	1,327
Orinda	2	14	16	0	5	4
Pinole	5	6	9	1	1	2
Pittsburg	2	149	337	1	131	291
Pleasant Hill	281	475	2,057	226	380	1,841
Richmond	0	37	530	0	24	405
San Pablo	13	790	2,834	8	721	2,708
San Ramon	20	23	34	14	14	22
Walnut Creek	46	87	213	36	74	184
Unincorporated	139	2,330	8,026	103	1,863	6,677
Total	818	5,853	18,635	643	4,695	15,835

Public Health and Safety

Floods and their aftermath present numerous threats to public health and safety:

- **Unsafe food—**Floodwaters contain disease-causing bacteria, dirt, oil, human and animal waste, and farm and industrial chemicals. Their contact with food items, including food crops in agricultural lands, can make that food unsafe to eat. Refrigerated and frozen foods are affected during power outages caused by flooding. Foods in cardboard, plastic bags, jars, bottles, and paper packaging may be unhygienic with mold contamination.

- **Contaminated drinking and washing water and poor sanitation—**Flooding impairs clean water sources with pollutants. The pollutants also saturate into the groundwater. Flooded wastewater treatment plants can be overloaded, resulting in backflows of raw sewage. Private wells can be contaminated by floodwaters. Private sewage disposal systems can become a cause of infection if they or overflow.
- **Mosquitoes and animals—**Floods provide new breeding grounds for mosquitoes in wet areas and stagnant pools. The public should dispose of dead animals that can carry viruses and diseases only in accordance with guidelines issued by local animal control authorities. Leptospirosis—a bacterial disease associated predominantly with rats—often accompanies floods in developing countries, although the risk is low in industrialized regions unless cuts or wounds have direct contact with disease-contaminated floodwaters or animals.
- **Mold and mildew—**Excessive exposure to mold and mildew can cause flood victims—especially those with allergies and asthma—to contract upper respiratory diseases, triggering cold-like symptoms. Molds grow in as short a period as 24 to 48 hours in wet and damp areas of buildings and homes that have not been cleaned after flooding, such as water-infiltrated walls, floors, carpets, toilets and bathrooms. Very small mold spores can be easily inhaled by human bodies and, in large enough quantities, cause allergic reactions, asthma episodes, and other respiratory problems. Infants, children, elderly people and pregnant women are considered most vulnerable to mold-induced health problems.
- **Carbon monoxide poisoning—**In the event of power outages following floods, some people use alternative fuels for heating or cooking in enclosed or partly enclosed spaces, such as small gasoline engines, stoves, generators, lanterns, gas ranges, charcoal or wood. Built-up carbon monoxide from these sources can poison people and animals.
- **Hazards when reentering and cleaning flooded homes and buildings—**Flooded buildings can pose significant health hazards to people entering them. Electrical power systems can become hazardous. Gas leaks can trigger fire and explosion. Flood debris—such as broken bottles, wood, stones and walls—may cause injuries to those cleaning damaged buildings. Containers of hazardous chemicals may be buried under flood debris. Hazardous dust and mold can circulate through a building and be inhaled by those engaged in cleanup and restoration.
- **Mental stress and fatigue—**People who live through a devastating flood can experience long-term psychological impact. The expense and effort required to repair flood-damaged homes places severe financial and psychological burdens on the people affected. Post-flood recovery can cause, anxiety, anger, depression, lethargy, hyperactivity, and sleeplessness. There is also a long-term concern among the affected that their homes can be flooded again in the future.

Current loss estimation models such as Hazus are not equipped to measure public health impacts such as these. The best preparation for these effects includes awareness that they can occur, education of the public on prevention, and planning to deal with them during responses to flood events.

9.5.2 Property

Structures and Contents

Hazus calculates losses to structures from flooding by looking at depth of flooding and type of structure. Impacted structures are those with finished floor elevations below the flood event water surface elevation. These structures are the most likely to receive significant damage in a flood event. Using historical flood insurance claim data, Hazus estimates the percentage of damage to structures and their contents by applying established damage functions to an inventory. For this analysis, local data on facilities was used instead of the default inventory data provided with Hazus. The analysis is summarized in Table 9-20, Table 9-21 and Table 9-22 for the 10-, 1-, and 0.2-percent-annual-chance flood events, respectively.

Table 9-20. Loss Estimates for 10-Percent-Annual-Chance Flood

Jurisdiction	Structures Impacted	Estimated Loss Associated with Flood			% of Total Replacement Value
		Structure	Contents	**Total**	
Antioch	2	$471,585	$1,214,417	$1,686,002	0.0%
Brentwood	1	$64,305	$220,058	$284,363	0.0%
Clayton	50	$2,883,440	$3,507,220	$6,390,660	0.3%
Concord	198	$11,785,345	$6,561,607	$18,346,953	0.1%
Danville	24	$1,350,271	$1,177,559	$2,527,830	0.0%
El Cerrito	83	$4,186,014	$2,326,841	$6,512,855	0.1%
Hercules	0	$0	$0	$0	0.0%
Lafayette	107	$8,170,516	$6,368,312	$14,538,827	0.2%
Martinez	26	$5,883,264	$2,962,631	$8,845,895	0.1%
Moraga	22	$1,963,941	$1,081,773	$3,045,714	0.1%
Oakley	0	$0	$0	$0	0.0%
Orinda	46	$4,943,119	$7,803,362	$12,746,481	0.3%
Pinole	33	$5,767,198	$3,992,303	$9,759,501	0.3%
Pittsburg	11	$1,513,173	$830,122	$2,343,294	0.0%
Pleasant Hill	392	$18,234,937	$15,000,769	$33,235,706	0.4%
Richmond	0	$0	$0	$0	0.0%
San Pablo	29	$2,952,285	$1,911,192	$4,863,477	0.1%
San Ramon	54	$3,155,044	$1,822,304	$4,977,348	0.0%
Walnut Creek	195	$19,061,082	$21,300,107	$40,361,189	0.2%
Unincorporated County	272	$13,045,297	$11,223,106	$24,268,403	0.1%
Total	1,545	$105,430,816	$89,303,683	$194,734,499	0.1%

Note: Values shown are accurate for comparison of results in this plan. See Section 5.5 for discussion of data limitations.

Table 9-21. Loss Estimates for 1-Percent-Annual-Chance Flood

Jurisdiction	Structures Impacted	Estimated Loss Associated with Flood			% of Total Replacement Value
		Structure	Contents	**Total**	
Antioch	46	$3,711,855	$12,108,967	$15,820,822	0.1%
Brentwood	19	$561,541	$574,535	$1,136,076	0.0%
Clayton	77	$5,786,079	$7,799,343	$13,585,423	0.6%
Concord	524	$24,716,248	$16,315,988	$41,032,236	0.2%
Danville	135	$12,231,869	$15,642,004	$27,873,873	0.3%
El Cerrito	83	$4,155,493	$2,309,505	$6,464,998	0.1%
Hercules	1	$332,645	$1,710,184	$2,042,829	0.0%
Lafayette	216	$19,122,129	$17,232,701	$36,354,830	0.6%
Martinez	852	$67,391,965	$117,190,568	$184,582,533	2.1%
Moraga	29	$2,315,349	$1,283,418	$3,598,767	0.1%
Oakley	83	$12,828,727	$12,870,748	$25,699,475	0.4%
Orinda	108	$13,342,322	$19,437,677	$32,779,999	0.7%
Pinole	32	$6,092,347	$4,606,708	$10,699,055	0.3%
Pittsburg	192	$12,078,644	$13,303,041	$25,381,685	0.2%
Pleasant Hill	658	$47,942,851	$58,685,507	$106,628,358	1.3%
Richmond	131	$25,651,155	$34,913,679	$60,564,834	0.2%
San Pablo	305	$9,641,972	$5,705,890	$15,347,862	0.3%
San Ramon	88	$7,134,561	$4,732,837	$11,867,398	0.1%
Walnut Creek	290	$22,215,697	$23,863,529	$46,079,226	0.2%
Unincorporated County	2,551	$265,715,844	$252,899,116	$518,614,961	1.3%
Total	6,420	$562,969,293	$623,185,946	$1,186,155,239	0.5%

Note: Values shown are accurate for comparison of results in this plan. See Section 5.5 for discussion of data limitations.

Table 9-22. Loss Estimates for 0.2-Percent-Annual-Chance Flood

Jurisdiction	Structures Impacted	Estimated Loss Associated with Flood			% of Total Replacement Value
		Structure	Contents	**Total**	
Antioch	164	$10,010,274	$20,285,820	$30,296,095	0.1%
Brentwood	275	$9,913,456	$10,865,223	$20,778,679	0.2%
Clayton	103	$11,635,766	$19,090,169	$30,725,936	1.4%
Concord	1,027	$44,308,913	$30,586,012	$74,894,925	0.3%
Danville	229	$16,825,322	$21,329,321	$38,154,643	0.4%
El Cerrito	102	$4,905,918	$2,637,921	$7,543,840	0.1%
Hercules	1	$334,555	$1,727,371	$2,061,926	0.0%
Lafayette	437	$43,156,027	$50,734,949	$93,890,977	1.4%
Martinez	882	$72,021,107	$120,419,786	$192,440,893	2.2%
Moraga	93	$9,479,050	$21,495,234	$30,974,284	0.8%
Oakley	610	$90,935,044	$60,353,975	$151,289,020	2.5%
Orinda	152	$22,280,274	$36,972,276	$59,252,550	1.3%
Pinole	48	$6,691,199	$6,647,305	$13,338,504	0.3%
Pittsburg	236	$18,562,511	$21,734,960	$40,297,471	0.3%
Pleasant Hill	1,768	$128,167,489	$142,830,829	$270,998,318	3.4%
Richmond	408	$35,941,672	$46,901,406	$82,843,079	0.3%
San Pablo	844	$40,685,014	$29,206,243	$69,891,256	1.5%
San Ramon	116	$10,023,929	$7,000,766	$17,024,694	0.1%
Walnut Creek	588	$42,535,377	$71,715,392	$114,250,769	0.6%
Unincorporated County	4,627	$896,358,656	$1,609,586,794	$2,505,945,450	6.1%
Total	12,710	$1,514,771,554	$2,332,121,754	$3,846,893,308	1.6%

Note: Values shown are accurate for comparison of results in this plan. See Section 5.5 for discussion of data limitations.

Key results are as follows:

- There would be up to $194 million of flood loss from a 10-percent-annual-chance flood event in the planning area. This represents 0.5 percent of the total exposure to that level of flood and 0.1 percent of the total replacement value for the planning area.
- There would be up to $1.1 billion of flood loss from a 1-percent-annual-chance flood event in the planning area. This represents 3.7 percent of the total exposure to that level of flood and 0.5 percent of the total replacement value for the planning area.
- There would be $3.8 billion of flood loss from a 0.2-percent-annual-chance flood event in the planning area. This represents 8.2 percent of the total exposure to that level of flood and 1.6 percent of the total replacement value.

Flood-Caused Debris

The Hazus analysis estimated the amount of flood-caused debris within the planning area generated by flooding, as summarized in Table 9-23.

Table 9-23. Estimated Flood-Caused Debris

Jurisdiction	10% Annual-Chance Flood		1% Annual-Chance Flood		0.2% Annual-Chance Flood	
	Debris to Be Removed (tons)[a]	Estimated Number of Truckloads[b]	Debris to Be Removed (tons)[a]	Estimated Number of Truckloads[b]	Debris to Be Removed (tons)[a]	Estimated Number of Truckloads[b]
Antioch	293	12	2,220	89	3,928	157
Brentwood	20	1	100	4	401	16
Clayton	614	25	984	39	1,422	57
Concord	1,501	60	3,114	125	4,887	195
Danville	90	4	1,773	71	2,394	96
El Cerrito	523	21	521	21	591	24
Hercules	63	3	769	31	1,190	48
Lafayette	1,079	43	2,747	110	5,291	212
Martinez	1,336	53	9,567	383	10,148	406
Moraga	339	14	710	28	1,222	49
Oakley	0	0	14,620	585	19,171	767
Orinda	287	11	755	30	1,197	48
Pinole	1,497	60	2,804	112	3,183	127
Pittsburg	315	13	4,287	171	5,890	236
Pleasant Hill	1,941	78	4,509	180	10,385	415
Richmond	37	1	8,296	332	10,095	404
San Pablo	826	33	2,479	99	5,279	211
San Ramon	134	5	606	24	874	35
Walnut Creek	3,466	139	4,266	171	5,004	200
Unincorporated County	4,327	173	128,759	5,150	330,242	13,210
Total	18,688	748	193,883	7,755	422,797	16,912

a. Debris generation estimates were based on updated general building stock dataset at a Census Block analysis level.
b. Hazus assumes 25 tons/trucks.
Note: Values shown are accurate for comparison of results in this plan. See Section 5.5 for discussion of data limitations.

National Flood Insurance Program

Table 9-24 lists flood insurance statistics that help identify vulnerability in the planning area. All communities in the planning area participate in the NFIP, with 5,248 flood insurance policies providing $1.42 billion in insurance coverage. According to FEMA statistics, 988 flood insurance claims were paid between January 1, 1978 and January 31, 2017, for a total of $6.7 million, an average of $6,781 per claim.

Properties constructed after a FIRM has been adopted are eligible for reduced flood insurance rates. Such structures are less vulnerable to flooding since they were constructed after regulations and codes were adopted to decrease vulnerability. Properties built before a FIRM is adopted are more vulnerable to flooding because they do not meet code or are located in hazardous areas. The first FIRMs in Contra Costa County were available in 1978.

Table 9-24. Flood Insurance Statistics

	Date of Entry Initial FIRM Effective Date	# of Flood Insurance Policies as of 1/31/2017	Insurance In Force	Total Annual Premium	Claims, 11/1978 to 1/31/2017	Value of Claims paid, 11/1978 to 1/31/2017
City of Antioch	12/02/1980	117	$34,604,400	$129,496	60	$1,400,712.13
City of Brentwood	06/16/2009	73	$22,604,900	$60,515	2	$782.85
City of Clayton	12/04/1979	53	$15,112,500	$67,073	2	$750.00
City of Concord	07/05/1984	466	$129,154,300	$494,250	67	$117,324.52
Town of Danville	09/27/1985	137	$41,329,200	$122,730	13	$36,118.85
City of El Cerrito	06/01/1977	94	$23,167,300	$129,776	20	$81,179.49
City of Hercules	09/30/1982	22	$6,439,000	$9,870	0	$0.00
City of Lafayette	03/16/1981	209	$64,040,900	$219,199	0	$0.00
City of Martinez	03/15/1978	532	$135,670,400	$647,631	138	$750,417.41
Town of Moraga	05/19/1981	51	$16,378,000	$21,116	9	$11,267.70
City of Oakley	02/02/2002	83	$24,685,700	$78,780	0	$0.00
City of Orinda	01/06/1988	123	$38,023,800	$117,433	47	245,178,08
City of Pinole	08/15/1980	23	$6,949,300	$16,807	4	12,666,46
City of Pittsburg	08/15/1980	138	$41,120,600	$135,470	10	13,480,28
City of Pleasant Hill	09/30/1983	429	$118,894,200	$538,312	45	$430,765.00
City of Richmond	03/01/1979	165	$57,813,900	$176,911	53	$348,472.30
City of San Pablo	08/01/1977	334	$83,730,400	$436,894	66	$467,444.16
City of San Ramon	09/27/1985	96	$26,171,400	$72,507	11	$168,890.87
City of Walnut Creek	05/01/1985	338	$93,777,400	$358,154	108	$987,042.34
Unincorporated County	07/16/1987	1,765	$436,629,000	$2,064,230	333	$1,900,954.70
Total		5,248	$1,416,296,600	$5,897,154	988	$6,702,122.32

Source: FEMA, 2017

The following information from flood insurance statistics is relevant to reducing flood risk:

- The use of flood insurance in the planning area is below the national average. Only 24 percent of buildings within the 500-year floodplain planning area are covered by flood insurance. According to an NFIP study, about 49 percent of single-family homes in special flood hazard areas are covered by flood insurance nationwide.
- The average claim paid in the planning area represents about one percent of the 2016 average replacement value of structures in the floodplain.
- The percentage of policies and claims outside a mapped floodplain suggests that not all of the flood risk in the planning area is reflected in current mapping. Based on information from the NFIP, 59.6 percent of policies in the planning area are on structures within an identified SFHA, and 40.4 percent are for structures outside such areas. Of total claims paid, 21.2 percent were for properties outside an identified 100-year floodplain.

Repetitive Loss and Severe Repetitive Loss

A repetitive loss property is defined by FEMA as an NFIP-insured property that has experienced any of the following since 1978, regardless of any changes in ownership:

- Four or more paid losses in excess of $1,000
- Two paid losses in excess of $1,000 within any rolling 10-year period

- Three or more paid losses that equal or exceed the current value of the insured property.

A severe repetitive loss property is further defined as follows:

- Four or more paid losses in excess of $5,000 each, with the cumulative amount of such claim payments exceeding $20,000
- At least two separate claim payments made, with the cumulative amount of the building portion of such claims exceeding the market value of the building
- At least two of the above referenced claims occurring within any rolling 10-year period and more than 10 days apart.

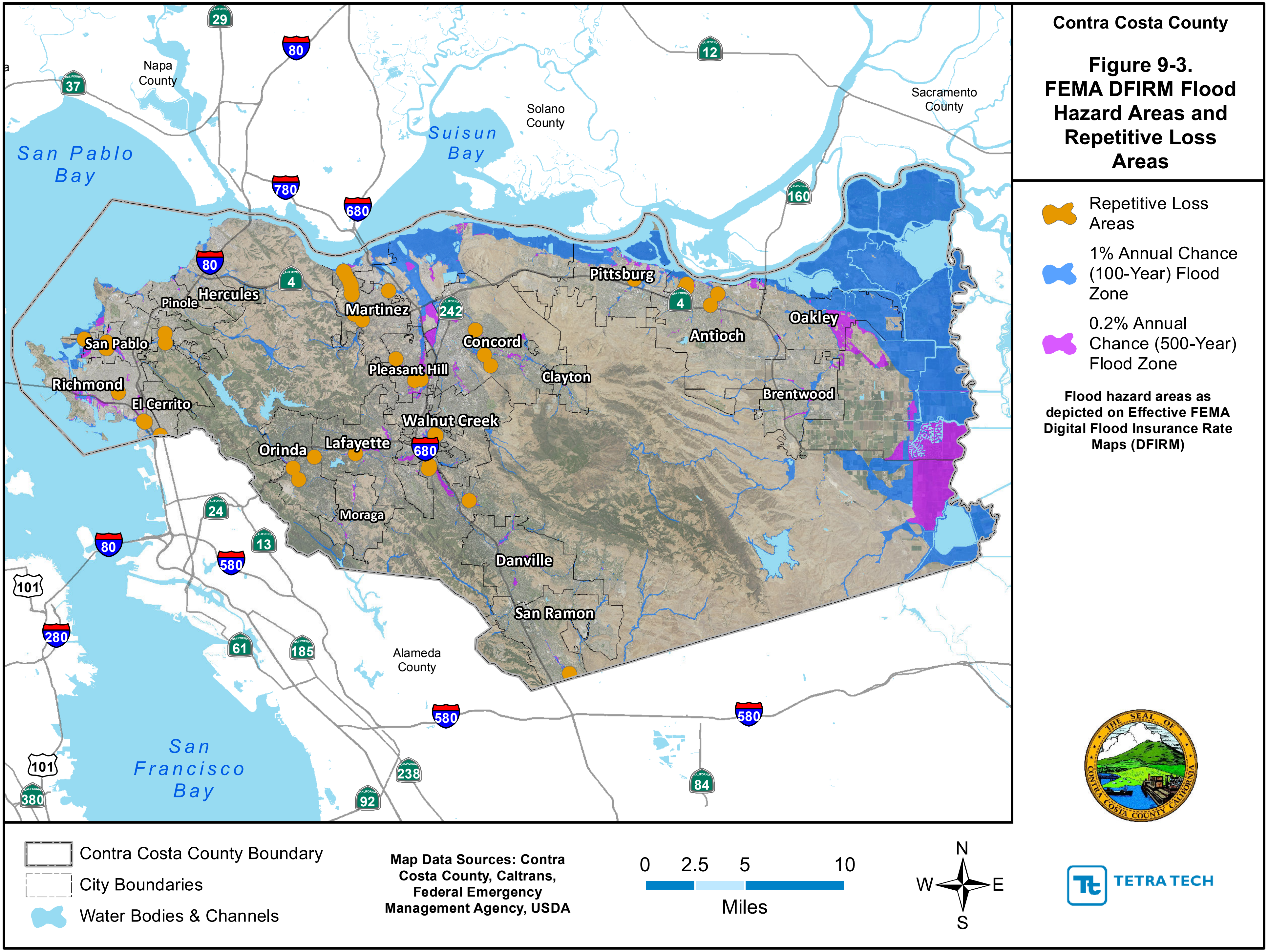
Repetitive loss properties make up only 1 to 2 percent of flood insurance policies in force nationally, yet they account for 40 percent of the nation's flood insurance claim payments. The government has instituted programs encouraging communities to identify and mitigate the causes of repetitive losses. A recent report on repetitive losses by the National Wildlife Federation found that 20 percent of these properties are outside any mapped 100-year floodplain. The key identifiers for repetitive loss properties are the existence of flood insurance policies and claims paid by the policies.

FEMA-sponsored programs, such as the CRS, require participating communities to identify repetitive loss areas. A repetitive loss area is the portion of a floodplain holding structures that FEMA has identified as meeting the definition of repetitive loss. Identifying repetitive loss areas helps to identify structures that are at risk but are not on FEMA's list of repetitive loss structures because no flood insurance policy was in force at the time of loss. Figure 9-3 shows the repetitive loss areas in Contra Costa County. FEMA's list of repetitive loss properties identifies 64 such properties in the planning area as of April 28, 2017, five of which are identified as severe repetitive loss properties. The breakdown of the properties by jurisdiction is presented in Table 9-25. Jurisdictions not listed do not have any repetitive loss properties.

Table 9-25. Repetitive Loss Properties

Jurisdiction	Repetitive Loss Properties	
	Total	Severe
Antioch	11	3
Concord	3	0
El Cerrito	2	0
Lafayette	2	0
Martinez	13	1
Orinda	2	1
Pittsburg	1	0
Pleasant Hill	3	0
Richmond	5	0
San Pablo	6	0
San Ramon	1	0
Walnut Creek	3	0
Unincorporated	12	0
Total	64	5

Based on FEMA Report of Repetitive Losses
All identified properties are residential.



Contra Costa County

Figure 9-3. FEMA DFIRM Flood Hazard Areas and Repetitive Loss Areas

A review of the repetitive loss list indicated that 56 of the properties are within the planning area's special flood hazard area. An addition three properties are within 500 feet of the 500-year floodplain and they were most likely flooded by flood events typical for the floodplain they are adjacent to. The five remaining properties outside of the 500-year floodplain appear to have minor flooding issues associated with being located along the bottom of a slope or depressed land area or localized flooding related to stormwater issues. These appear to be isolated incidents involving no more than the structures listed on the repetitive loss list. The average claim paid for these five properties was $10,912, which would appear appropriate for shallow flood damage associated with stormwater issues. Therefore it can be concluded that the overall cause of repetitive flooding is the same as has been identified for the river basins in which each repetitive loss area is found. With the potential for flood events every three to seven years, Contra Costa County considers all of the mapped floodplain areas as susceptible to repetitive flooding.

9.5.3 Critical Facilities and Infrastructure

Hazus was used to estimate the flood loss potential to critical facilities exposed to the flood risk. Using depth/damage function curves, it estimates the percent of damage to the building and contents of critical facilities. This helps to gauge how long the planning area could have limited usage of facilities deemed critical to flood response and recovery. The Hazus critical facility results for 10-, 1-, and 0.2-percent-annual-chance flood events are as follows (see Table 9-26, Table 9-27, and Table 9-28):

- **10-percent annual chance flood event**—Only 41 facilities would be affected and on average the facilities would receive 13.48 percent damage to the structure and 35.72 percent damage to the contents.
- **1- percent annual chance flood event**—On average, critical facilities would receive 18.97 percent damage to the structure and 47.72 percent damage to the contents during a 100-year flood event.
- **0.2- percent annual chance flood event**—A 500-year flood event would damage the structures an average of 16.87 percent and the contents an average 37.80 percent.

Table 9-26. Estimated Damage to Critical Facilities and Infrastructure from 10%-Annual-Chance Flood

Types of Critical Facilities and Infrastructure	Number of Facilities Affected	Average % of Total Value Damaged	
		Structure	Content
Medical Facilities	0	N/A	N/A
Government	0	N/A	N/A
Protective Functions	2	4.86	5.56
Schools & Educational Facilities	1	8.95	52.65
Hazardous Materials	2	14.01	51.37
Bridges	22	0.03	N/A
Water Supply	1	23.43	N/A
Wastewater	0	N/A	N/A
Power	2	14.81	26.55
Communication	1	8.37	42.48
Other Critical Functions	0	N/A	N/A
Other Critical Infrastructure	10	33.37	N/A
Total/Average	41	13.48	35.72

Table 9-27. Estimated Damage to Critical Facilities and Infrastructure from 1%-Annual-Chance Flood

Types of Critical Facilities and Infrastructure	Number of Facilities Affected	Average % of Total Value Damaged	
		Structure	Content
Medical Facilities	0	N/A	N/A
Government	1	10.00	20.00
Protective Functions	9	9.84	26.14
Schools & Educational Facilities	8	7.42	42.31
Hazardous Materials	9	15.05	59.62
Bridges	58	0.31	N/A
Water Supply	5	30.35	N/A
Wastewater	6	26.06	N/A
Power	8	14.52	26.01
Communication	4	23.46	87.97
Other Critical Functions	6	46.20	72.00
Other Critical Infrastructure	37	25.48	N/A
Total/Average	151	18.97	47.72

Table 9-28. Estimated Damage to Critical Facilities and Infrastructure from 0.2%-Annual-Chance Flood

Types of Critical Facilities and Infrastructure	Number of Facilities Affected	Average % of Total Value Damaged	
		Structure	Content
Medical Facilities	1	0.99	0.00
Government	1	10.00	20.00
Protective Functions	17	7.94	18.01
Schools & Educational Facilities	14	6.09	34.25
Hazardous Materials	12	13.28	59.62
Bridges	76	0.63	N/A
Water Supply	7	28.63	N/A
Wastewater	6	28.14	N/A
Power	11	13.15	23.37
Communication	7	20.70	75.15
Other Critical Functions	6	49.24	72.00
Other Critical Infrastructure	47	23.66	N/A
Total/Average	205	16.87	37.80

9.5.4 Environment

The environment vulnerable to flood hazard is the same as the environment exposed to the hazard. Loss estimation platforms such as Hazus are not currently equipped to measure environmental impacts of flood hazards. The best gauge of vulnerability of the environment would be a review of damage from past flood events. Loss data that segregates damage to the environment was not available at the time of this plan. Capturing this data from future events could be beneficial in measuring the vulnerability of the environment for future updates.

While the vulnerability assessment focuses on human vulnerability to flood events, the impact of human activities on flooding is also worth noting. Due to negative impacts of floods, many structural and other measures have been devised to limit how far a floodplain can extend. However, floodplains have many natural and beneficial functions, and disruption of natural systems can have long-term consequences for entire regions. Some well-known, water-related functions of floodplains (noted by FEMA) include:

- Natural flood and erosion control
- Provide flood storage and conveyance
- Reduce flood velocities
- Reduce flood peaks
- Reduce sedimentation
- Surface water quality maintenance
- Filter nutrients and impurities from runoff
- Process organic wastes
- Moderate temperatures of water
- Groundwater recharge
- Promote infiltration and aquifer recharge
- Reduce frequency and duration of low surface flows.

Areas in the floodplain that typically provide these natural functions are wetlands, riparian areas, sensitive areas, and habitats for rare and endangered species.

9.5.5 Economic Impact

Locations that are directly flooded experience the greatest economic impact. In these areas, renovations of commercial buildings may be necessary, disrupting associated services. Significant damage may occur in agricultural areas, with destruction of crops and other agricultural products. The tourism industry may be affected by major flood events, as popular vacation areas tend to overlap flood hazard zones. Finally, flooding can cause extensive damage to public utilities and disruptions to delivery of services. Loss of power and communications may occur; and drinking water and wastewater treatment facilities may be temporarily out of operation.

9.6 FUTURE TRENDS IN DEVELOPMENT

The planning area has experienced moderate growth in recent years, averaging a 1.1-percent increase in population every year from 2000 through 2015. The planning partners are equipped to handle future growth within flood hazard areas. All municipal planning partners have general plans that address frequently flooded areas in their safety elements. All partners have committed to linking their general plans to this hazard mitigation plan. This will create an opportunity for wise land use decisions as future growth impacts flood hazard areas.

Additionally, all municipal planning partners are participants in the NFIP and have adopted flood damage prevention ordinances in response to its requirements. With 25 percent of communities in the planning area participating in the CRS program, there is incentive to adopt consistent, appropriate, higher regulatory standards in communities with the highest degree of flood risk. All municipal planning partners have committed to maintaining their good standing under the NFIP through actions identified in this plan. Communities participating or considering participation in the CRS program will be able to refine this commitment using CRS programs and templates as a guide.

Any areas of growth could be impacted by the flood hazard if located within the identified hazard areas. The County intends to discourage development within vulnerable areas and/or to encourage higher regulatory standards on the local level. Table 9-29 summarizes developable land by land use in planning area floodplains.

9.7 SCENARIO

Floods have regularly affected the planning area. The planning area can expect heavy rains and flash flooding about once a year, with flood events every 2 to 3 years. Duration and intensity of heavy winter rains and atmospheric river events that cause flooding may increase due to climate change. The floodplains mapped and identified for the planning area will continue to take the brunt of these floods.

Table 9-29. Developable Land in the Floodplain

	1% Annual Chance Floodplain		0.2% Annual Chance Floodplain	
	Area of Developable Land in the Floodplain (acres)	% of Total Developable Land in the Floodplain	Area of Developable Land in the Floodplain (acres)	% of Total Developable Land in the Floodplain
Residential	1,496.9	73.2%	1,874.8	71.3%
Commercial-Industrial	463.9	22.7%	634.4	24.1%
Mixed Use	83.7	4.1%	120.5	4.6%
Total	2,044.4	100.0%	2,629.7	100.0%

Source: Contra Costa County, 2016.

Contra Costa County residents prepare themselves for flooding by seeking and receiving information on flood forecasting (7-5-3-2 Flood), and by making personal evacuation plans. Impacts of flood events should decrease as the Contra Costa County Flood Control and Water Conservation District continues to promote and implement hazard mitigation and preparedness.

The worst-case scenario would be a series of heavy rains or storm events, particularly if the rains occur at high tide. These rains could flood numerous areas within a short time. This could overwhelm the response and floodplain management capability within the planning area, as the planning area would be subject immediately to flash flooding and coastal flooding, with subsequent influences on the County's streams. Major roads could be blocked, preventing critical access for many residents and critical functions. High in-channel flows could cause water courses to scour, possibly washing out roads and creating more isolation problems. In the event of multi-basin flooding, Contra Costa County would not be able to make repairs quickly enough to restore critical facilities and assets.

9.8 ISSUES

The planning team has identified the following flood-related issues relevant to the planning area:

- The accuracy of the existing flood hazard mapping produced by FEMA in reflecting the true flood risk within the planning area is questionable. This is most prevalent in areas protected by levees not accredited by the FEMA mapping process.
- The extent of the flood-protection currently provided by flood control facilities (dams, dikes and levees) is not known due to the lack of an established national policy on flood protection standards.
- The levee system in the planning area is not consistently adequate to mitigate effects of a 1-percent annual chance flood.
- The risk associated with the flood hazard overlaps the risk associated with other hazards such as earthquake, landslide and fishing losses. This provides an opportunity to seek mitigation alternatives with multiple objectives that can reduce risk for multiple hazards.
- How climate change will affect flood conditions in the planning area is uncertain.
- More information is needed on flood risk to support the concept of risk-based analysis of capital projects.
- There needs to be a sustained effort to gather historical damage data, such as high water marks on structures and damage reports, to measure the cost-effectiveness of future mitigation projects.
- Ongoing flood hazard mitigation will require funding from multiple sources.
- There needs to be a coordinated hazard mitigation effort between jurisdictions affected by flood hazards in the planning area.
- Floodplain residents need to continue to be educated about flood preparedness and the resources available during and after floods.

- The concept of residual risk should be considered in the design of future capital flood control projects and should be communicated with residents living in the floodplain.
- The promotion of flood insurance as a means of protecting private property owners from the economic impacts of frequent flood events should continue.
- Existing floodplain-compatible uses such as agricultural and open space need to be maintained. There is constant pressure to convert these existing uses to more intense uses within the planning area during times of moderate to high growth.
- The economy affects a jurisdiction’s ability to manage its floodplains. Budget cuts and personnel losses can strain resources needed to support floodplain management.

10. LANDSLIDE

10.1 GENERAL BACKGROUND

The U.S. Geological Survey definition of landslides includes a wide range of ground movement, such as rock falls, deep failure of slopes, and shallow debris flows. Although gravity acting on an over-steepened slope is the primary reason for a landslide, there are other contributing factors. Landslides and mudslides can be initiated by storms, earthquakes, fires, volcanic eruptions or human modification of the land.

When landslides occur—in response to such changes as increased water content, earthquake shaking, addition of load, or removal of downslope support—they deform and tilt the ground surface. The result can be destruction of foundations, offset of roads, breaking of underground pipes, or overriding of downslope property and structures. They can move rapidly down slopes or through channels, and can strike with little or no warning at avalanche speeds, posing a serious hazard to properties on or below hillsides.

The USGS defines land subsidence as the loss of surface elevation due to the removal of subsurface support. In California, the two principal causes for land subsidence are aquifer compaction due to excessive groundwater pumping and decomposition of wetland soils exposed to air after wetland conversion to farmland.

DEFINITIONS

Landslide—The movement of masses of loosened rock and soil down a hillside or slope. Slope failures occur when the strength of the soils forming the slope is exceeded by the pressure, such as weight or saturation, acting upon them.

Mass Movement—A collective term for landslides, debris flows, and sinkholes.

Mudslide (or Debris Flow)—A river of rock, earth, organic matter and other materials saturated with water. Mudslides develop in the soil overlying bedrock on sloping surfaces when water rapidly accumulates in the ground, such as during heavy rainfall or rapid snowmelt. Water pressure in the pore spaces of the material increases to the point that the internal strength of the soil is drastically weakened. The soil's reduced resistance can then easily be overcome by gravity, changing the earth into a flowing river of mud or "slurry."

10.1.1 Landslide Types

Landslides are commonly categorized by the type of initial ground failure. Common types of slides are shown on Figure 10-1 through Figure 10-4. The most common is the shallow colluvial slide, occurring particularly in response to intense, short-duration storms. The largest and most destructive are deep-seated slides, although they are less common than other types.

Mudslides (or debris flows) are rivers of rock, earth, organic matter and other soil materials saturated with water. They develop in the soil overlying bedrock on sloping surfaces when water rapidly accumulates in the ground, such as during heavy rainfall or rapid snowmelt. Water pressure in the pore spaces of the material increases to the point that the internal strength of the soil is drastically weakened. The soil's reduced resistance can then easily be overcome by gravity, changing the earth into a flowing river of mud.

A debris avalanche (Figure 10-5) is a fast-moving debris flow that travels faster than about 10 miles per hour (mph). Speeds in excess of 20 mph are not uncommon, and speeds in excess of 100 mph, although rare, can occur. The slurry can travel miles from its source, growing as it descends, picking up trees, boulders, cars, and anything else in its path. Although these slides behave as fluids, they pack many times the hydraulic force of water due to the mass of material included in them. They can be among the most destructive events in nature.

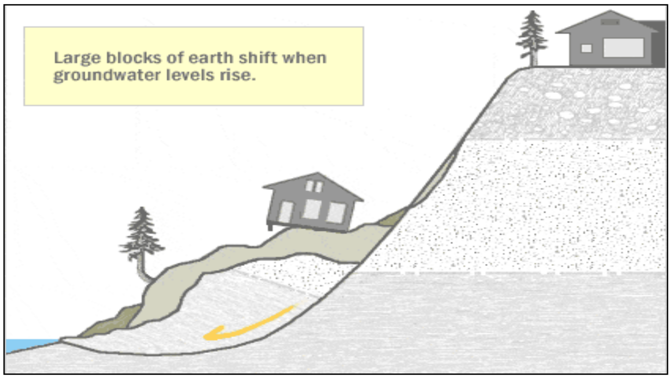


Figure 10-1. Deep Seated Slide

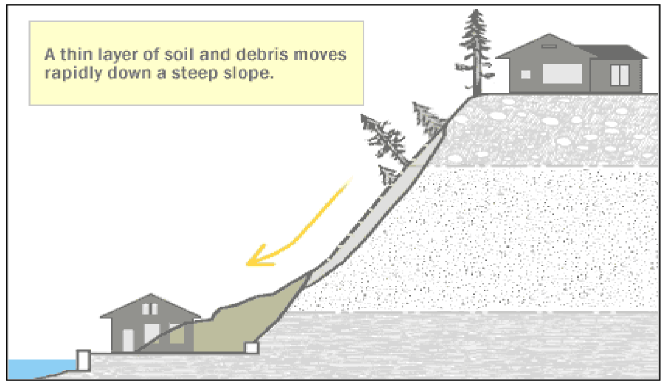


Figure 10-2. Shallow Colluvial Slide

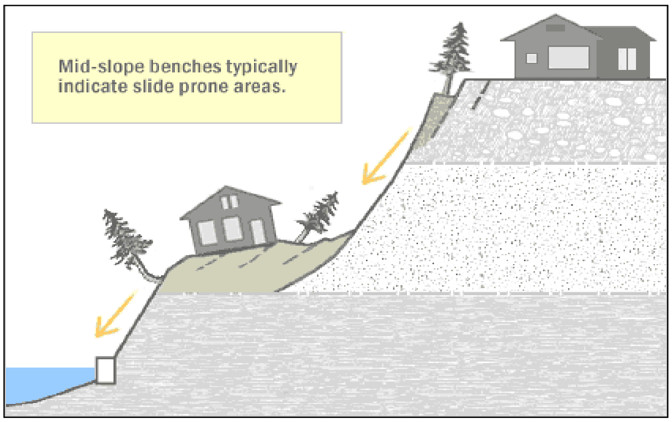


Figure 10-3. Bench Slide

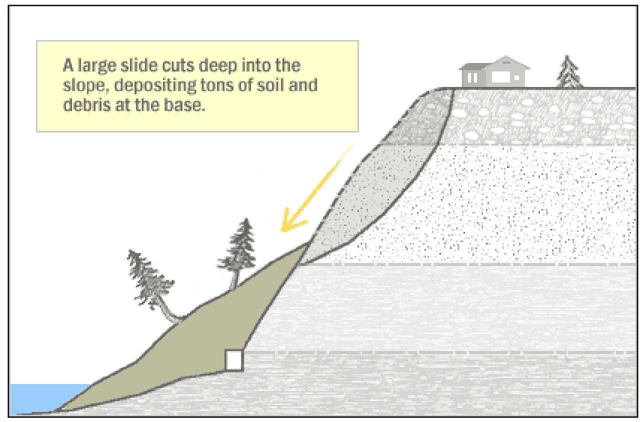


Figure 10-4. Large Slide

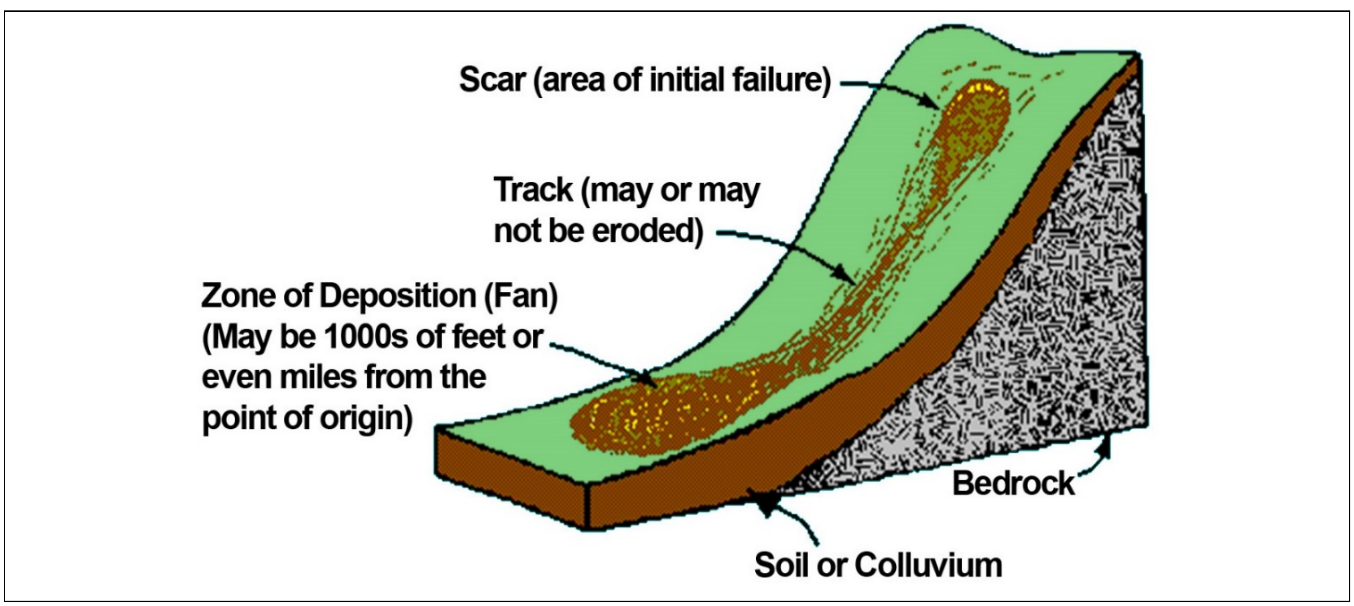


Figure 10-5. Typical Debris Avalanche Scar and Track

Landslides also include the following:

- Rock Falls—blocks of rock that fall away from a bedrock unit without a rotational component
- Rock Topples—blocks of rock that fall away from a bedrock unit with a rotational component
- Rotational Slumps—blocks of fine-grained sediment that rotate and move down slope
- Transitional Slides—sediments that move along a flat surface without a rotational component
- Earth Flows—fine-grained sediments that flow downhill and typically form a fan structure
- Creep—a slow-moving landslide often only noticed through crooked trees and disturbed structures
- Block Slides—blocks of rock that slide along a slip plane as a unit down a slope.

10.1.2 Landslide Modeling

Two characteristics are essential to conducting an accurate risk assessment of the landslide hazard:

- The type of initial ground failure that occurs, as described above
- The post-failure movement of the loosened material (“run-out”), including travel distance and velocity.

All current landslide models—those in practical applications and those more recently developed—use simplified hypothetical descriptions of mass movement to simulate the complex behavior of actual flow. The models attempt to reproduce the general features of the moving mass of material through measurable factors, such as base shear, that define a system and determine its behavior. Due to the lack of experimental data and the limited current knowledge about the behavior of the moving flows, landslide models use simplified parameters to account for complex aspects that may not be defined. These simplified parameters are not related to specific physical processes that can be directly measured, and there is a great deal of uncertainty in their definition. Some, but not all, models provide estimates of the level of uncertainty associated with the modeling approach.

Run-out modeling is complicated because the movement of materials may change over the course of a landslide event, depending on the initial composition, the extent of saturation by water, the ground shape of the path traveled and whether there is additional material incorporated during the event.

10.1.3 Landslide Causes

Mass movements are caused by a combination of geological and climate conditions, as well as encroaching urbanization. Vulnerable natural conditions are affected by residential, agricultural, commercial, and industrial development and the infrastructure that supports it. The following factors can contribute to landslide:

- Change in slope of the terrain
- Increased load on the land, shocks and vibrations
- Change in water content
- Groundwater movement
- Frost action
- Weathering of rocks
- Removing or changing the type of vegetation covering slopes.

Excavation and Grading

Slope excavation is common in development of home sites or roads on sloping terrain. Grading can result in slopes that are steeper than the pre-existing natural slopes. These steeper slopes can be at an increased risk for landslides. The added weight of fill on slopes can also result in an increased landslide hazard. Small landslides can be fairly common along roads, in either the road cut or the road fill. Landslides below new construction sites are indicators of the potential impacts stemming from excavation.

Drainage and Groundwater Alterations

Water flowing through or above ground is often the trigger for landslides. Any activity that augments the amount of water flowing into landslide-prone slopes can increase landslide hazards. Broken or leaking water or sewer lines can be especially problematic, as can water retention facilities that direct water onto slopes. However, even lawn irrigation and minor alterations to small streams in landslide-prone locations can result in damaging landslides. Ineffective stormwater management and excess runoff can also cause erosion and increase the risk of landslide hazards. Drainage can be affected naturally by the geology and topography of an area. Development that results in an increase in impervious surface impairs the ability of the land to absorb water and may redirect water to other areas. Channels, streams, flooding, and erosion on slopes all indicate potential slope problems.

Road and driveway drains, gutters, downspouts, and other constructed drainage facilities can concentrate and accelerate flow. Ground saturation and concentrated velocity flow are major causes of slope problems and may trigger landslides.

Changes in Vegetation

Removing vegetation from very steep slopes can increase landslide hazards. Areas that have experienced wildfire and land clearing for development may experience long periods of increased landslide hazard. In addition, woody debris in stream channels (both natural and man-made from logging) may cause the impacts from debris flows to be more severe.

10.1.4 Landslide Management

While small landslides are frequently a result of human activity, the largest landslides are often naturally occurring phenomena with little or no human contribution. The sites of large landslides are typically areas of previous landslide movement that are periodically reactivated by significant precipitation or seismic events. These naturally occurring landslides can disrupt roadways and other infrastructure lifelines, destroy private property, and cause flooding, bank erosion, and rapid channel migration.

Landslides can create immediate, critical threats to public safety. Engineering solutions to protect structures on or adjacent to large active landslides are often extremely or prohibitively expensive.

In spite of their destructive potential, landslides can serve beneficial functions to the natural environment. They supply sediment and large wood to stream channel networks and can contribute to complexity and dynamic channel behavior critical for aquatic and riparian ecological diversity. Effective landslide management should include the following elements:

- Continuing investigation to identify natural landslides, understand their mechanics, assess their risk to public health and welfare, and understand their role in ecological systems.
- Regulation of development in or near existing landslides or areas of natural instability through the Contra Costa County Code and City ordinances.
- Preparation for emergency response to landslides to facilitate rapid, coordinated action among Contra Costa County, local cities, and state and federal agencies, and to provide emergency assistance to affected or at-risk citizens.
- Evaluation of options including landslide stabilization or structure relocation where landslides are identified that threaten critical public structures or infrastructure.

10.1.5 Land Subsidence Effects

Subsidence is one of the most diverse forms of ground failure, ranging from small or local collapses to broad regional lowering of the earth’s surface. The causes of subsidence, mostly associated with human activities, are as diverse as the forms of failure, and include dewatering of peat or organic soils, dissolution in limestone aquifers, first-time wetting of moisture-deficient low-density soils, natural compaction, liquefaction, crustal deformation, subterranean mining, and withdrawal of fluids (groundwater, petroleum, geothermal).

The compaction of susceptible aquifer systems caused by excessive groundwater pumping is the single largest cause of subsidence in California. The 5,200 square miles affected by subsidence in the San Joaquin Valley since the latter half of the 20th century has been identified as the single largest human alteration of the Earth's topography. The second largest cause of subsidence in California is the decomposition of organic soils (USGS, 2017c).

Aquifer Compaction

Aquifer compaction due to groundwater pumping affects both manmade infrastructures and natural systems. The greatest effects are on infrastructure that traverses a subsiding area. In the San Joaquin Valley, the main problems are related to water conveyance structures. Many water conveyance structures, including long stretches of the California Aqueduct, are gravity driven through the use of very small gradients; even minor changes in these gradients can cause reductions in designed flow capacity. Managers of the canals, such as the California Department of Water Resources, the San Luis Delta-Mendota Authority, the Bureau of Reclamation, and the Central California Irrigation District, have to repeatedly retrofit their canals to keep the water flowing, even at reduced amounts. Subsidence also affects roads, railways, bridges, pipelines, buildings, and wells.

Compaction of an aquifer system may permanently decrease the aquifer's capacity to store water. Even when water levels rise, sediments can remain compacted; most compaction that occurs as a result of historically low groundwater levels is irreversible.

Additionally, as topography changes by varying amounts in different places, low areas, such as wetlands, change size and shape, migrate to lower elevations, or even disappear. Rivers may change course or erosion/deposition patterns to reach a new equilibrium.

Decomposition of Wetland Soils

The Sacramento-San Joaquin Delta of California was once a great tidal freshwater marsh. It is blanketed by peat and peaty alluvium deposited where streams that originate in the Sierra Nevada, Coast Ranges, and South Cascade Range enter San Francisco Bay. In the late 1800s, levees were built along the stream channels, and the land thus protected from flooding was drained, cleared, and planted. The leveed tracts and islands help to protect water-export facilities in the southern Delta from saltwater intrusion by displacing water and maintaining favorable freshwater gradients. However, the decomposition of organic carbon in the peat soils causes land subsidence in the Delta and increases stresses on the levees. Ongoing subsidence behind the levees, where the land has been drained, exposed to the atmosphere, and planted, increases stresses on the levee system, making it less stable. This threatens to damage agricultural and developed lands and degrade water quality in the massive water-transfer system.

10.2 HAZARD PROFILE

10.2.1 Past Events

Losses from landslides are typically lower than those from flooding. However, in the El Niño storms of early 1998, the USGS documented $150 million in losses due to approximately 300 landslides in the Bay Area including Contra Costa County. The slides ranged from a 25-cubic-meter failure of engineered material to reactivation of the 13 million-cubic-meter Mission Peak earth flow complex in Alameda County.

Landslides have occurred in conjunction heavy rains events in Contra Costa County. Table 10-1 lists landslide events that affected Contra Costa County between 1980 and February 2017. There are no records in the County of fatalities attributed to mass movement. However, deaths have occurred across the west coast as a result of slides and slope collapses.

Table 10-1. Landslide Events in Contra Costa County

Dates of Event	Event Type	FEMA Disaster #	Location	Losses/Impacts
2/27 to 3/4/2017	Mudslide	N/A	Near Concord and Brentwood	A slow moving mudslide closed the 3100 block of Morgan Territory Road from Concord to Brentwood and Livermore. It caused Contra Costa Water District's waterline to break, which affected about 90 customers.
1/03 to 1/12/2017	Severe storms, flooding, and mudslides	4301	34 counties	Trees and landslides covered roadways throughout the Bay Area.
3/13/2016	Landslide	N/A	Moraga	A landslide forced two homeowners to evacuate their homes in Moraga. A lower portion of the hill slid into San Pablo Creek in January.
2011	Winter storm	N/A	Local	Central Contra Costa Sanitary District reported landslides and damage to sewer pipes.
12/17/2005 to 1/3/2006	Severe storms, flooding, mudslides, and landslides	1628	30 counties	A series of rain storm events caused significant runoff with localized evacuations, some slope failures, and road closures throughout the declared counties. Urban flooding initiated landslides that contributed to the damage. Much of the damage was in Walnut Creek, Richmond, San Pablo, Martinez and Orinda. Damaged facilities included schools, park areas and several government agency structures.
2/13 to 2/14/2000	Flash flood	N/A	Countywide	Widespread rain occurred over 24 hours with accumulations of more than 5 inches. Several homes in Daly City had to be abandoned due to mudslides and consecutive years of above average rainfall.
2/02 to 4/30/1998	Severe winter storms and El Nino rainstorm	1203	San Francisco Bay region	Widespread flooding occurred that caused landslides in Contra Costa County.
12/28/1996 to 4/01/1997	Severe storms, flooding, mud, landslides	1155	47 counties	Minor landslide damage in Contra Costa County was attributed to heavy rains and saturated soils.
2/13 to 4/19/1995	Severe winter storms, flooding, landslides, mud flows	1046	San Francisco Bay area	Minor landslide damage in Contra Costa County was attributed to heavy rains and saturated soils.
1/03 to 2/10/1995	Severe winter storms, flooding, landslides, mud flows	1044	San Francisco Bay area	Minor landslide damage in Contra Costa County was attributed to heavy rains and saturated soils.
1/05 to 3/20/1993	Severe winter storm, mud and landslides, flooding	979	27 counties	Minor landslide damage in Contra Costa County was attributed to heavy rains and saturated soils.
1/21 to 3/30/1983	Coastal storms, floods, slides, tornadoes	677	36 counties	Heavy rains throughout coastal areas of California caused landslides.
12/19/1981 to 1/08/1982	Severe storms, flood, mudslides, high tide	651	San Francisco Bay area	Prolonged heavy rains and saturated soils caused numerous slope failures and mud flows on steep and unstable slopes throughout the San Francisco Bay area. In Contra Costa County, 335 homes were damaged by landslides.

N/A Not applicable

Sources: FEMA 2017; Hazard Mitigation Plan Annual Progress Report, California Geology 1982; USGS 1984, 1987, 1989 and 1998; NOAA, 2017

10.2.2 Location

The best available predictor of where movement of slides and earth flows might occur is the location of past movements. Past landslides can be recognized by their distinctive topographic shapes, which can remain in place for thousands of years. Most landslides recognizable in this fashion range from a few acres to several square miles. Most show no evidence of recent movement and are not currently active. A small proportion of them may become active in any given year, with movements concentrated within all or part of the landslide masses or around their edges.

The recognition of ancient dormant mass movement sites is important in the identification of areas susceptible to flows and slides because they can be reactivated by earthquakes or by exceptionally wet weather. Also, because they consist of broken materials and frequently involve disruption of groundwater flow, these dormant sites are vulnerable to construction-triggered sliding.

In 2011, the California Geological Survey conducted a statewide analysis of landslide susceptibility using a combination of regional rock strength and slope data to create classes of susceptibility. The methodology used for the analysis assumed, in general, that landslide susceptibility is low on very low slopes in all rock materials, and that susceptibility increases with slope and in weak rocks. The analysis also factored in locations of past landslides. Figure 10-6 shows the susceptibility classes grouped into low, moderate, high, and very high/existing landslide categories.

10.2.3 Frequency

Landslides are often triggered by other natural hazards such as earthquakes, heavy rain, floods or wildfires, so landslide frequency is often related to the frequency of these other hazards. In Contra Costa County, landslides typically occur during and after severe storms, so the potential for landslides largely coincides with the potential for sequential severe storms that saturate steep, vulnerable soils. According to the National Centers for Environmental Information’s storm event database, the planning area has been impacted by severe storms at least once every three years. Until better data is generated specifically for landslide hazards, this severe storm frequency is appropriate for the purpose of ranking risk associated with the landslide hazard.

10.2.4 Severity

Landslides destroy property and infrastructure and can take the lives of people. Slope failures in the United States result in an average of 25 lives lost per year and an annual cost to society of about $1.5 billion. Landslides can pose a serious hazard to properties on or below hillsides. When landslides occur — in response to such changes as increased water content, earthquake shaking, addition of load, or removal of downslope support — they deform and tilt the ground surface. The result can be destruction of foundations, offset of roads, breaking of underground pipes, or overriding of downslope property and structures.

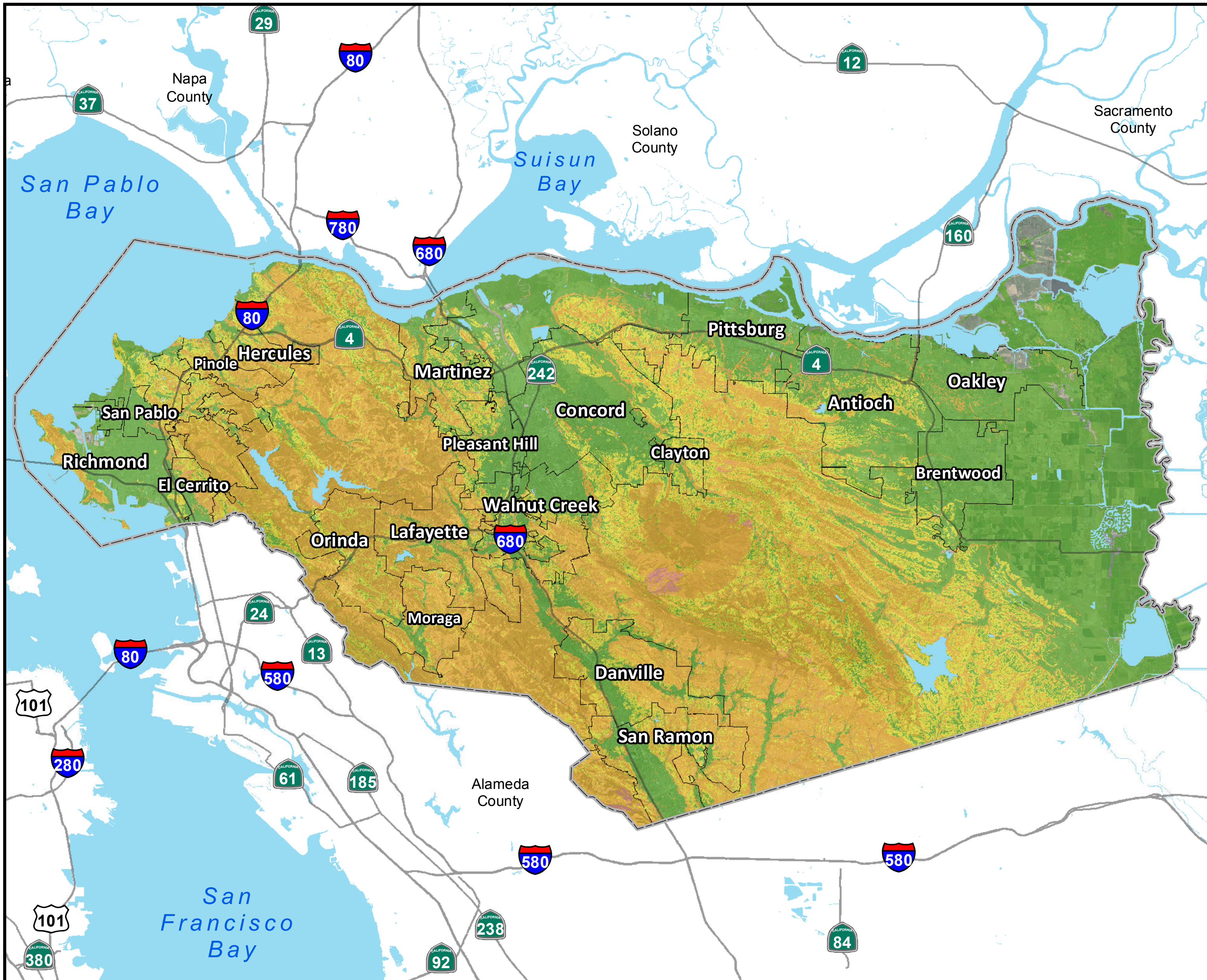
In Contra Costa County, landslides and mudslides are a common occurrence and have caused damage to homes, public facilities, roads, parks, and sewer lines in particular.

10.2.5 Warning Time

Mass movements can occur suddenly or slowly. The velocity of movement may range from a slow creep of inches per year to many feet per second, depending on slope angle, material and water content. Some methods used to monitor mass movements can provide an idea of the type of movement and the amount of time prior to failure. It is also possible to determine what areas are at risk during general time periods. Assessing the geology, vegetation and amount of predicted precipitation for an area can help in these predictions. However, there is no practical warning system for individual landslides.

Contra Costa County

Figure 10-6. Landslide Susceptibility Zones



Type

- Low
- Moderate
- High
- Very High / Existing
- Data Not Available

Source dataset created by Wills C.J., Perez, F., Gutierrez, C., 2011, Susceptibility to deep-seated landslides in California: California Geological Survey Map Sheet 58

- Contra Costa County Boundary
- City Boundaries
- Water Bodies & Channels

Map Data Sources: Contra Costa County, Caltrans, California Geological Survey, USDA, USGS

0 2.5 5 10
Miles

N W E S

TETRA TECH

The current standard operating procedure is to monitor situations on a case-by-case basis, and respond after the event has occurred. Generally accepted warning signs for landslide activity include the following:

- Springs, seeps, or saturated ground in areas that have not typically been wet before
- New cracks or unusual bulges in the ground, street pavements or sidewalks
- Soil moving away from foundations
- Ancillary structures such as decks and patios tilting and/or moving relative to the main house
- Tilting or cracking of concrete floors and foundations
- Broken water lines and other underground utilities
- Leaning telephone poles, trees, retaining walls or fences
- Offset fence lines
- Sunken or down-dropped road beds
- Rapid increase in creek water levels, possibly accompanied by increased turbidity (soil content)
- Sudden decrease in creek water levels though rain is still falling or just recently stopped
- Sticking doors and windows, and visible open spaces indicating jambs and frames out of plumb
- A faint rumbling sound that increases in volume as the landslide nears
- Unusual sounds, such as trees cracking or boulders knocking together.

10.3 SECONDARY HAZARDS

Landslides can cause several types of secondary effects, such as blocking access to roads, which can isolate residents and businesses and delay commercial, public and private transportation. This could result in economic losses for businesses. Other potential problems resulting from landslides are power and communication failures. Vegetation or poles on slopes can be knocked over, resulting in possible losses to power and communication lines. Landslides also have the potential of destabilizing the foundation of structures, which may result in monetary loss for residents. They also can damage rivers or streams, potentially harming water quality, fisheries and spawning habitat.

10.4 EXPOSURE

10.4.1 Population

Population could not be examined by landslide hazard area because census block group areas do not coincide with the hazard areas. However, population was estimated using the residential building count in each mapped hazard area and multiplying by the 2016 estimated average population per household. Using this approach, the estimated population living in the “moderate landslides” risk area is 166,205, the estimated population living in “high landslide” risk area is 221,672 and the estimated population living in “very high landslide” risk area is 1,990.

10.4.2 Property

Table 10-2, Table 10-3, and Table 10-4 show the number and replacement value of structures exposed to the moderate, high and very high landslide risks. Over 96 percent of the exposed structures are dwellings. There are 70,705 structures on parcels in the high landslide risk areas, with an estimated value of $44.6 billion. Table 10-5 shows the general land use of parcels exposed to moderate, high and very high landslide hazard in unincorporated portions of the planning area. The predominant land uses in cities are single-family, vacant and manufactured homes. Lands in the combined vacant, right-of-way, open water and open space category are the most exposed to landslide risks.

Table 10-2. Exposure and Value of Structures in Moderate Landslide Risk Areas

Jurisdiction	Estimated Value within the Landslide Risk Area			% of Total Replacement Value
	Structure	Contents	Total	
Antioch	775,806,051	427,471,996	1,203,278,047	5.83%
Brentwood	138,456,842	69,228,421	207,685,262	1.71%
Clayton	253,717,505	129,150,079	382,867,585	17.00%
Concord	544,451,611	396,017,804	940,469,415	3.60%
Danville	1,445,115,390	781,542,448	2,226,657,837	21.65%
El Cerrito	339,744,395	203,409,739	543,154,135	9.93%
Hercules	972,407,558	588,638,003	1,561,045,560	37.35%
Lafayette	877,563,816	545,371,098	1,422,934,913	21.81%
Martinez	1,143,999,321	740,517,589	1,884,516,910	21.22%
Moraga	424,147,313	235,917,231	660,064,544	16.79%
Oakley	0	0	0	0.00%
Orinda	750,155,359	472,997,038	1,223,152,397	25.81%
Pinole	907,326,109	613,139,092	1,520,465,201	39.38%
Pittsburg	297,275,200	157,536,364	454,811,564	3.75%
Pleasant Hill	598,762,825	346,277,690	945,040,515	11.84%
Richmond	1,973,189,518	1,414,147,640	3,387,337,158	12.74%
San Pablo	93,700,035	55,924,188	149,624,223	3.31%
San Ramon	2,243,320,519	1,213,891,769	3,457,212,287	17.43%
Walnut Creek	2,218,338,402	1,475,463,034	3,693,801,436	19.13%
Unincorporated	4,235,035,206	2,656,047,036	6,891,082,241	16.87%
Total	20,232,512,973	12,522,688,258	32,755,201,231	13.30%

Table 10-3. Exposure and Value of Structures in High Landslide Risk Areas

Jurisdiction	Estimated Value within the Landslide Risk Area			% of Total Replacement Value
	Structure	Contents	Total	
Antioch	1,264,695,879	709,021,416	1,973,717,294	9.57%
Brentwood	84,769,778	50,427,177	135,196,955	1.11%
Clayton	300,680,906	158,239,570	458,920,476	20.37%
Concord	280,413,820	157,628,125	438,041,945	1.68%
Danville	1,609,973,358	863,652,303	2,473,625,661	24.06%
El Cerrito	1,270,976,564	827,177,131	2,098,153,695	38.36%
Hercules	928,430,952	553,081,968	1,481,512,920	35.45%
Lafayette	1,990,348,605	1,159,413,336	3,149,761,941	48.28%
Martinez	1,104,280,337	829,694,567	1,933,974,905	21.78%
Moraga	1,162,304,051	669,866,029	1,832,170,080	46.60%
Oakley	272,686,782	149,351,753	422,038,535	6.95%
Orinda	1,952,981,688	1,039,354,082	2,992,335,770	63.13%
Pinole	886,840,906	563,189,004	1,450,029,910	37.55%
Pittsburg	882,563,729	497,984,355	1,380,548,084	11.38%
Pleasant Hill	311,384,639	169,403,083	480,787,722	6.02%
Richmond	2,137,107,025	1,357,376,852	3,494,483,878	13.14%
San Pablo	290,355,433	202,944,336	493,299,770	10.92%
San Ramon	3,342,149,997	1,947,707,706	5,289,857,703	26.67%
Walnut Creek	1,897,908,096	1,137,424,175	3,035,332,272	15.72%
Unincorporated	6,031,456,745	3,564,651,287	9,596,108,032	23.49%
Total	28,002,309,293	16,607,588,255	44,609,897,548	18.11%

Table 10-4. Exposure and Value of Structures in Very High Landslide Risk Areas

Jurisdiction	Estimated Value within the Landslide Risk Area			% of Total Replacement Value
	Structure	Contents	Total	
Antioch	$12,907,754	$7,050,515	$19,958,269	0.10%
Brentwood	$0	$0	$0	0.00%
Clayton	$1,343,796	$671,898	$2,015,694	0.09%
Concord	$1,591,394	$795,697	$2,387,091	0.01%
Danville	$10,435,385	$5,217,692	$15,653,077	0.15%
El Cerrito	$28,214,996	$14,704,136	$42,919,132	0.78%
Hercules	$1,395,982	$697,991	$2,093,973	0.05%
Lafayette	$35,899,646	$31,767,328	$67,666,973	1.04%
Martinez	$3,986,656	$1,993,328	$5,979,984	0.07%
Moraga	$4,465,795	$2,232,897	$6,698,692	0.17%
Oakley	$0	$0	$0	0.00%
Orinda	$965,445	$482,723	$1,448,168	0.03%
Pinole	$5,927,091	$2,963,545	$8,890,636	0.23%
Pittsburg	$153,843,474	$76,921,737	$230,765,211	1.90%
Pleasant Hill	$1,501,358	$750,679	$2,252,037	0.03%
Richmond	$10,118,457	$6,282,841	$16,401,298	0.06%
San Pablo	$4,672,780	$2,336,390	$7,009,171	0.16%
San Ramon	$15,159,440	$7,579,720	$22,739,160	0.11%
Walnut Creek	$27,280,065	$19,553,237	$46,833,302	0.24%
Unincorporated	$77,526,736	$51,826,737	$129,353,473	0.32%
Total	$397,236,249	$233,829,091	$631,065,341	0.26%

Table 10-5. Land Use in Landslide Risk Areas

Type of Land Use	Moderate		High		Very High	
	Area (acres)	% of total	Area (acres)	% of total	Area (acres)	% of total
Residential	13,829	23.7%	26,372	16.2%	244	12.0%
Commercial	2,687	4.6%	11,883	7.3%	192	9.4%
Industrial	1,062	1.8%	1,416	0.9%	9	0.5%
Agriculture	2,645	4.5%	9,230	5.7%	206	10.1%
Religion	203	0.3%	266	0.2%	4	0.2%
Government	1,673	2.9%	5,574	3.4%	83	4.1%
Education	635	1.1%	1,192	0.7%	26	1.3%
Vacant, Rights-of-way, Open water, Open space	35,636	61.1%	107,136	65.7%	1,275	62.5%
Total	58,370	100%	163,068	100%	2,039	100%

10.4.3 Critical Facilities and Infrastructure

Critical facilities and infrastructure exposed to the landslide hazard are summarized in Table 10-6 through Table 10-11. No loss estimation of these facilities was performed due to the lack of established damage functions for the landslide hazard.

Table 10-6. Critical Facilities in Very High Landslide Risk Areas

	Number of Facilities in the Floodplain					
	Protective Functions	Government Functions	Schools and Educational Facilities	Medical Facilities	Hazardous Materials	**Total**
Antioch	0	0	0	0	0	0
Brentwood	0	0	0	0	0	0
Clayton	0	0	0	0	0	0
Concord	0	0	0	0	0	0
Danville	0	0	0	0	0	0
El Cerrito	0	0	0	0	0	0
Hercules	0	0	0	0	0	0
Lafayette	0	0	0	0	0	0
Martinez	0	0	0	0	0	0
Moraga	0	0	0	0	0	0
Oakley	0	0	0	0	0	0
Orinda	0	0	0	0	0	0
Pinole	0	0	0	0	0	0
Pittsburg	0	0	0	0	0	0
Pleasant Hill	0	0	0	0	0	0
Richmond	0	0	0	0	0	0
San Pablo	0	0	0	0	0	0
San Ramon	0	0	0	0	0	0
Walnut Creek	0	0	0	0	0	0
Unincorporated	0	0	0	0	0	0
Total	0	0	0	0	0	0

Table 10-7. Critical Infrastructure in Very High Landslide Risk Areas

	Number of Facilities in the Floodplain							
	Power	Communications	Water Supply	Wastewater	Bridges	Other Critical Functions	Other Critical Infrastructure	**Total**
Antioch	0	0	0	0	0	0	0	0
Brentwood	0	0	0	0	0	0	0	0
Clayton	0	0	0	0	0	0	0	0
Concord	0	0	0	0	0	0	0	0
Danville	0	0	0	0	0	0	0	0
El Cerrito	0	0	0	0	0	0	0	0
Hercules	0	0	0	0	0	0	0	0
Lafayette	0	0	0	0	0	0	1	1
Martinez	0	0	0	0	0	0	0	0
Moraga	0	0	0	0	0	0	0	0
Oakley	0	0	0	0	0	0	0	0
Orinda	0	0	0	0	1	0	0	1
Pinole	0	0	0	0	0	0	0	0
Pittsburg	0	0	0	0	0	0	0	0
Pleasant Hill	0	0	0	0	0	0	0	0
Richmond	0	0	0	0	0	0	0	0
San Pablo	0	0	0	0	0	0	0	0
San Ramon	0	0	0	0	0	0	0	0
Walnut Creek	0	0	0	0	0	0	1	1
Unincorporated	0	0	0	0	1	0	2	3
Total	0	0	0	0	2	0	4	6

Table 10-8. Critical Facilities in High Landslide Risk Areas

	Number of Facilities in the Floodplain					
	Protective Functions	Government Functions	Schools and Educational Facilities	Medical Facilities	Hazardous Materials	Total
Antioch	0	0	1	0	1	2
Brentwood	0	0	0	0	0	0
Clayton	1	1	0	0	0	2
Concord	0	0	0	0	0	0
Danville	1	0	4	0	0	5
El Cerrito	0	0	6	0	0	6
Hercules	1	0	2	0	0	3
Lafayette	1	0	3	0	0	4
Martinez	1	0	0	1	0	2
Moraga	1	0	1	0	0	2
Oakley	0	0	0	0	1	1
Orinda	0	0	3	0	0	3
Pinole	1	0	1	0	0	2
Pittsburg	1	0	4	0	0	5
Pleasant Hill	0	0	1	0	0	1
Richmond	2	0	7	0	0	9
San Pablo	0	0	1	0	0	1
San Ramon	0	0	1	1	0	2
Walnut Creek	2	0	1	0	0	3
Unincorporated	9	0	11	0	1	21
Total	21	1	47	2	3	74

Table 10-9. Critical Infrastructure in High Landslide Risk Areas

	Number of Facilities in the Floodplain						
	Power	Communications	Water Supply	Wastewater	Bridges	Other Critical Functions	Other Critical Infrastructure	Total
Antioch	0	2	9	0	3	0	1	15
Brentwood	0	0	0	0	2	0	1	3
Clayton	0	0	1	0	0	0	0	1
Concord	0	0	1	0	1	0	0	2
Danville	0	0	2	0	6	0	4	12
El Cerrito	1	2	0	1	0	0	0	4
Hercules	1	1	0	0	0	0	0	2
Lafayette	0	1	1	0	11	0	3	16
Martinez	0	0	7	1	0	0	1	9
Moraga	0	1	0	0	0	0	0	1
Oakley	0	0	2	0	1	0	0	3
Orinda	1	2	0	2	3	0	1	9
Pinole	0	0	0	1	3	0	0	4
Pittsburg	0	2	0	0	2	0	0	4
Pleasant Hill	0	0	0	0	2	0	0	2
Richmond	1	0	0	3	8	1	0	13
San Pablo	0	0	0	0	1	0	0	1
San Ramon	0	0	0	0	1	0	1	2
Walnut Creek	1	0	1	0	5	0	0	7
Unincorporated	1	8	13	9	27	1	10	69
Total	6	19	37	17	76	2	22	179

Table 10-10. Critical Facilities in Moderate Landslide Risk Areas

	Number of Facilities in the Floodplain					
	Protective Functions	Government Functions	Schools and Educational Facilities	Medical Facilities	Hazardous Materials	Total
Antioch	3	0	1	0	0	4
Brentwood	0	0	0	0	0	0
Clayton	0	0	1	0	0	1
Concord	0	0	1	0	0	1
Danville	0	0	4	0	0	4
El Cerrito	1	0	2	0	0	3
Hercules	1	1	2	0	0	4
Lafayette	2	0	6	0	0	8
Martinez	1	0	0	0	1	2
Moraga	1	0	3	0	0	4
Oakley	0	0	0	0	0	0
Orinda	4	0	6	0	0	10
Pinole	0	0	4	1	0	5
Pittsburg	0	0	0	0	0	0
Pleasant Hill	1	0	4	0	0	5
Richmond	2	0	7	0	1	10
San Pablo	0	0	0	0	0	0
San Ramon	1	0	6	2	0	9
Walnut Creek	0	0	4	0	0	4
Unincorporated	3	0	16	0	0	19
Total	20	1	67	3	2	93

Table 10-11. Critical Infrastructure in Moderate Landslide Risk Areas

	Number of Facilities in the Floodplain							
	Power	Communications	Water Supply	Wastewater	Bridges	Other Critical Functions	Other Critical Infrastructure	Total
Antioch	0	2	6	0	0	0	0	8
Brentwood	0	1	0	0	0	0	0	1
Clayton	0	0	0	0	0	0	0	0
Concord	0	1	2	0	1	0	4	8
Danville	0	0	0	0	2	0	0	2
El Cerrito	0	0	0	0	0	0	0	0
Hercules	0	1	1	1	1	0	0	4
Lafayette	0	0	0	0	7	0	0	7
Martinez	0	0	4	0	1	0	1	6
Moraga	0	0	0	0	0	0	0	0
Oakley	0	0	0	0	0	0	0	0
Orinda	0	0	1	5	1	0	0	7
Pinole	0	0	0	1	3	0	1	5
Pittsburg	0	0	0	0	0	0	0	0
Pleasant Hill	0	0	0	0	2	0	0	2
Richmond	1	1	1	2	6	0	0	11
San Pablo	0	0	0	0	0	0	0	0
San Ramon	0	0	0	0	1	0	0	1
Walnut Creek	0	0	3	0	7	0	2	12
Unincorporated	4	1	6	1	12	1	3	28
Total	5	7	24	10	44	1	11	102

A significant amount of infrastructure can be exposed to landslides:

- **Roads**—Access to major roads after a disaster is crucial to safety and to response operations. Landslides can block egress and ingress on roads, causing isolation for neighborhoods, traffic problems and delays for public and private transportation. This can result in economic losses for businesses.
- **Bridges**—Landslides can significantly impact road bridges. Mass movements can knock out bridge abutments or significantly weaken the soil supporting them, making them hazardous for use.
- **Power Lines**—Power lines are generally elevated above steep slopes; but the towers supporting them can be subject to landslides. A landslide could trigger failure of the soil underneath a tower, causing it to collapse and ripping down the lines. Power and communication failures due to landslides can create problems for vulnerable populations and businesses.

10.4.4 Environment

Environmental problems as a result of mass movements can be numerous. Landslides that fall into streams may significantly impact fish and wildlife habitat, as well as affecting water quality. Hillsides that provide wildlife habitat can be lost for prolong periods of time due to landslides.

10.5 VULNERABILITY

10.5.1 Population

Due to the nature of census data, it is difficult to determine demographics of populations vulnerable to mass movements. In general, all of the estimated 166,205 persons exposed to higher risk landslide areas are considered to be vulnerable. Increasing population and the fact that many homes are built on view property atop or below bluffs and on steep slopes subject to mass movement, increases the number of lives endangered by this hazard.

10.5.2 Property

Although only a partial list of historical landslides in Contra Costa County is available, the available records suggest a significant vulnerability to this hazard. The millions of dollars in damage countywide attributable to mass movement during those events affected private property and public infrastructure and facilities.

Loss estimations for the landslide hazard are not based on modeling utilizing damage functions, because no such damage functions have been generated. Instead, loss estimates were developed representing 10 percent, 30 percent and 50 percent of the replacement value of exposed structures. This allows emergency managers to select a range of economic impact based on an estimate of the percent of damage to the general building stock. Damage in excess of 50 percent is considered to be substantial by most building codes and typically requires total reconstruction of the structure. Table 10-12 shows the general building stock loss estimates in the moderate, high, and very high landslide risk areas.

10.5.3 Critical Facilities and Infrastructure

There are 456 critical facilities exposed to the landslide hazard to some degree. A more in-depth analysis of the mitigation measures taken by these facilities to prevent damage from mass movements should be done to determine if they could withstand impacts of a mass movement.

Several types of infrastructure are exposed to mass movements, including transportation, water and sewer and power infrastructure. Highly susceptible areas of the planning area include mountain roads and transportation infrastructure. At this time all infrastructure and transportation corridors identified as exposed to the landslide hazard are considered vulnerable until more information becomes available.

Table 10-12. Loss Potential in the Combined Moderate, High and Very High Landslide Risk Areas

		Estimated Loss Potential from Landslide		
Jurisdiction	Exposed Value	10% Damage	30% Damage	50% Damage
Antioch	$3,196,953,610	$319,695,361	$959,086,083	$1,598,476,805
Brentwood	$342,882,218	$34,288,222	$102,864,665	$171,441,109
Clayton	$843,803,754	$84,380,375	$253,141,126	$421,901,877
Concord	$1,380,898,451	$138,089,845	$414,269,535	$690,449,225
Danville	$4,715,936,576	$471,593,658	$1,414,780,973	$2,357,968,288
El Cerrito	$2,684,226,961	$268,422,696	$805,268,088	$1,342,113,481
Hercules	$3,044,652,453	$304,465,245	$913,395,736	$1,522,326,227
Lafayette	$4,640,363,828	$464,036,383	$1,392,109,148	$2,320,181,914
Martinez	$3,824,471,799	$382,447,180	$1,147,341,540	$1,912,235,900
Moraga	$2,498,933,316	$249,893,332	$749,679,995	$1,249,466,658
Oakley	$422,038,535	$42,203,854	$126,611,561	$211,019,268
Orinda	$4,216,936,335	$421,693,634	$1,265,080,901	$2,108,468,168
Pinole	$2,979,385,747	$297,938,575	$893,815,724	$1,489,692,874
Pittsburg	$2,066,124,859	$206,612,486	$619,837,458	$1,033,062,429
Pleasant Hill	$1,428,080,274	$142,808,027	$428,424,082	$714,040,137
Richmond	$6,898,222,334	$689,822,233	$2,069,466,700	$3,449,111,167
San Pablo	$649,933,163	$64,993,316	$194,979,949	$324,966,582
San Ramon	$8,769,809,150	$876,980,915	$2,630,942,745	$4,384,904,575
Walnut Creek	$6,775,967,010	$677,596,701	$2,032,790,103	$3,387,983,505
Unincorporated	$16,616,543,746	$1,661,654,375	$4,984,963,124	$8,308,271,873
Total	$77,996,164,120	$7,799,616,412	$23,398,849,236	$38,998,082,060

10.5.4 Environment

The environment vulnerable to landslide hazard is the same as the environment exposed to the hazard.

10.6 FUTURE TRENDS IN DEVELOPMENT

The planning area has experienced moderate growth over the past 10 years, averaging a 1.1-percent increase in population every year from 2000 through 2015. The planning partners are equipped to handle future growth within landslide hazard areas. Landslide risk areas are addressed in the safety elements of local general plans. All planning partners have committed to linking their general plans to this hazard mitigation plan. This will create an opportunity for wise land use decisions as future growth impacts landslide hazard areas. Table 10-13 summarizes developable land by land use in landslide risk areas.

The State of California has adopted the International Building Code (IBC) by reference in its California Building Standards Code. The IBC includes provisions for geotechnical analyses in steep slope areas that have soil types considered susceptible to landslide hazards. These provisions assure that new construction is built to standards that reduce the vulnerability to landslide risk.

Table 10-13. Developable Land in Landslide Risk Areas

	Moderate Landslide Risk		High Landslide Risk		Very High Landslide Risk	
	Area of Developable Land in Risk Area (acres)	% of Total Developable Land in Risk Area	Area of Developable Land in Risk Area (acres)	% of Total Developable Land in Risk Area	Area of Developable Land in Risk Area (acres)	% of Total Developable Land in Risk Area
Residential	1,425.9	85.9%	2,276.0	82.8%	19.3	65.2%
Commercial-Industrial	115.2	6.9%	260.4	9.5%	7.0	23.6%
Mixed Use	119.4	7.2%	213.6	7.8%	3.3	11.2%
Total	1,660.5	100.0%	2,750.0	100.0%	29.6	100.0%

Source: Contra Costa County, 2016.

10.7 SCENARIO

Major landslides in Contra Costa County occur as a result of soil conditions that have been affected by severe storms, groundwater or human development. The worst-case scenario for landslide hazards in the planning area would generally correspond to a severe storm that had heavy rain and caused flooding. Landslides are most likely during late winter when the water table is high. After heavy rains from November to December, soils become saturated with water. As water seeps downward through upper soils that may consist of permeable sands and gravels and accumulates on impermeable silt, it will cause weakness and destabilization in the slope. A short intense storm could cause saturated soil to move, resulting in landslides. As rains continue, the groundwater table rises, adding to the weakening of the slope. Gravity, poor drainage, a rising groundwater table and poor soil exacerbate hazardous conditions.

Mass movements are becoming more of a concern as development moves outside of city centers and into areas less developed in terms of infrastructure. Most mass movements would be isolated events affecting specific areas. It is probable that private and public property, including infrastructure, will be affected. Mass movements could affect bridges that pass over landslide prone ravines and knock out rail service through the county. Road obstructions caused by mass movements would create isolation problems for residents and businesses in sparsely developed areas. Property owners exposed to steep slopes may suffer damage to property or structures. Landslides carrying vegetation such as shrubs and trees may cause a break in utility lines, cutting off power and communication access to residents.

Continued heavy rains and flooding will complicate the problem further. As emergency response resources are applied to problems with flooding, it is possible they will be unavailable to assist with landslides occurring all over Contra Costa County.

10.8 ISSUES

Important issues associated with landslides in the planning area include the following:

- There are existing homes in landslide risk areas throughout the planning area. The degree of vulnerability of these structures depends on the codes and standards the structures were constructed to. Information to this level of detail is not currently available.
- Future development could lead to more homes in landslide risk areas.
- Mapping and assessment of landslide hazards are constantly evolving. As new data and science become available, assessments of landslide risk should be reevaluated.
- The impact of climate change on landslides is uncertain. If climate change impacts atmospheric conditions, then exposure to landslide risks is likely to increase.

- Landslides may cause negative environmental consequences, including water quality degradation.
- The risk associated with the landslide hazard overlaps the risk associated with other hazards such as earthquake, flood and wildfire. This provides an opportunity to seek mitigation alternatives with multiple objectives that can reduce risk for multiple hazards.

11. SEVERE WEATHER

11.1 GENERAL BACKGROUND

Severe weather refers to any dangerous meteorological phenomena with the potential to cause damage, serious social disruption, or loss of human life. It includes thunderstorms, downbursts, tornadoes, waterspouts, snowstorms, ice storms, and dust storms. Severe weather can be categorized into two groups: systems that form over wide geographic areas are classified as general severe weather; those with a more limited geographic area are classified as localized severe weather. Severe weather, technically, is not the same as extreme weather, which refers to unusual weather events at the extremes of the historical distribution for a given area.

The most common severe weather events that impact the planning area are heavy rains/atmospheric rivers/thunderstorms, extreme heat, and damaging winds. These types of severe weather are described in the following sections. Flooding issues associated with severe weather are discussed in Chapter 9.

When reading this chapter, it is important to note that when the term "severe weather" is used, it is referring in aggregate to the sub-hazards profiled in this chapter (heavy rain/atmospheric rivers/thunderstorms, extreme heat and wind). These hazards have been grouped for the following reasons:

- Each hazard can impact and has impacted the entire planning area and has no clearly defined extent or location mapping.
- Records indicate that each of these hazards has impacted the planning area to some degree, and all have similar frequencies of occurrence based on these records.
- Because there is no clearly defined extent or location mapping available for these hazards, no quantitative, geospatial analysis is available to support exposure or vulnerability analysis. Therefore, the analyses for these hazards are qualitative and are based on the aggregate exposure of all the sub-hazards.

DEFINITIONS

Atmospheric River—A long, narrow region in the atmosphere that transports most of the water vapor outside of the tropics. These columns of vapor move with the weather, carrying large amounts of water vapor and strong winds. When atmospheric rivers make landfall, they release this vapor in the form of rain or snow, causing flooding and mudslide vents.

Extreme Heat—Temperatures that hover 10ºF or more above the average high temperature for a region and last for several weeks. Humid or muggy conditions occur when a "dome" of high atmospheric pressure traps hazy, damp air near the ground. Extremely dry and hot conditions can provoke dust storms and low visibility.

Severe Local Storm—Small atmospheric systems, including tornadoes, thunderstorms, windstorms, ice storms and snowstorms. Typically, major impacts from a severe storm are on transportation infrastructure and utilities. These storms may cause a great deal of destruction and even death, but their impact is generally confined to a small area.

Thunderstorm—Any rain event that includes thunder and lightning. A typical thunderstorm is about 15 miles in diameter and lasts about 30 minutes.

Tornado—Tornadoes are funnel clouds of varying sizes that touch ground. Tornadoes are measured using the Enhanced Fujita Scale ranging from EF0 to EF6.

Windstorm—A storm featuring violent winds. Windstorms are generally short-duration events involving straight-line winds or gusts of over 50 mph, strong enough to cause property damage.

11.1.1 Heavy Rain, Atmospheric River or Thunderstorm

Most severe storms in the planning area consist of atmospheric rivers, heavy rains or thunderstorms. Heavy rain refers to events where the amount of rain exceeds normal levels. The amount of precipitation needed to qualify as heavy rain varies with location and season. Heavy rain is distinct from climate change analyses on increasing precipitation. It does not mean that the total amount of precipitation at a location has increased, just that the rain is occurring in a more intense event. More frequent heavy rain events, however, can serve as indicators of changing precipitation levels. Heavy rain is most frequently measured by tracking the frequency of events, analyzing the mean return period, and measuring the amount of precipitation in a certain period (most typically inches of rain within a 24-hour period) (EPA, 2016).

A relatively common weather pattern that brings southwest winds and heavy rain to California is often referred to as an atmospheric river. Atmospheric rivers are long, narrow regions in the atmosphere that transport most of the water vapor carried away from the tropics. These columns of vapor move with the weather, carrying large amounts of water vapor and strong winds. When the atmospheric rivers make landfall, they often release this water vapor in the form of rain or snow, causing flooding and mudslide vents.

A thunderstorm is a rain event that includes thunder and lightning. A thunderstorm is classified as “severe” when it contains one or more of the following: hail with a diameter of three-quarter inch or greater, winds gusting in excess of 50 knots (57.5 mph), or tornado. Tornadoes are not common in the planning area; only four have been recorded in the County since 1950. All were F0-rated tornadoes except one rated EF1.

Three factors cause thunderstorms to form: moisture, rising unstable air (air that keeps rising when disturbed), and a lifting mechanism to provide the disturbance. The sun heats the surface of the earth, which warms the air above it. If this warm surface air is forced to rise (hills or mountains can cause rising motion, as can the interaction of warm air and cold air or wet air and dry air) it will continue to rise as long as it weighs less and stays warmer than the air around it. As the air rises, it transfers heat from the surface of the earth to the upper levels of the atmosphere (the process of convection). The water vapor it contains begins to cool and it condenses into a cloud. The cloud eventually grows upward into areas where the temperature is below freezing. Some of the water vapor turns to ice and some of it turns into water droplets. Both have electrical charges. Ice particles usually have positive charges, and rain droplets usually have negative charges. When the charges build up enough, they are discharged in a bolt of lightning, which causes the sound waves we hear as thunder. Thunderstorms have three stages (see Figure 11-1):

- The developing stage of a thunderstorm is marked by a cumulus cloud that is being pushed upward by a rising column of air (updraft). The cumulus cloud soon looks like a tower (called towering cumulus) as the updraft continues to develop. There is little to no rain during this stage but occasional lightning. The developing stage lasts about 10 minutes.
- The thunderstorm enters the mature stage when the updraft continues to feed the storm, but precipitation begins to fall out of the storm, and a downdraft begins (a column of air pushing downward). When the downdraft and rain-cooled air spread out along the ground, they form a gust front, or a line of gusty winds. The mature stage is the most likely time for hail, heavy rain, frequent lightning, strong winds, and tornadoes. The storm occasionally has a black or dark green appearance.
- Eventually, a large amount of precipitation is produced and the updraft is overcome by the downdraft beginning the dissipating stage. At the ground, the gust front moves out a long distance from the storm and cuts off the warm moist air that was feeding the thunderstorm. Rainfall decreases in intensity, but lightning remains a danger.

Source: NOAA, 2015

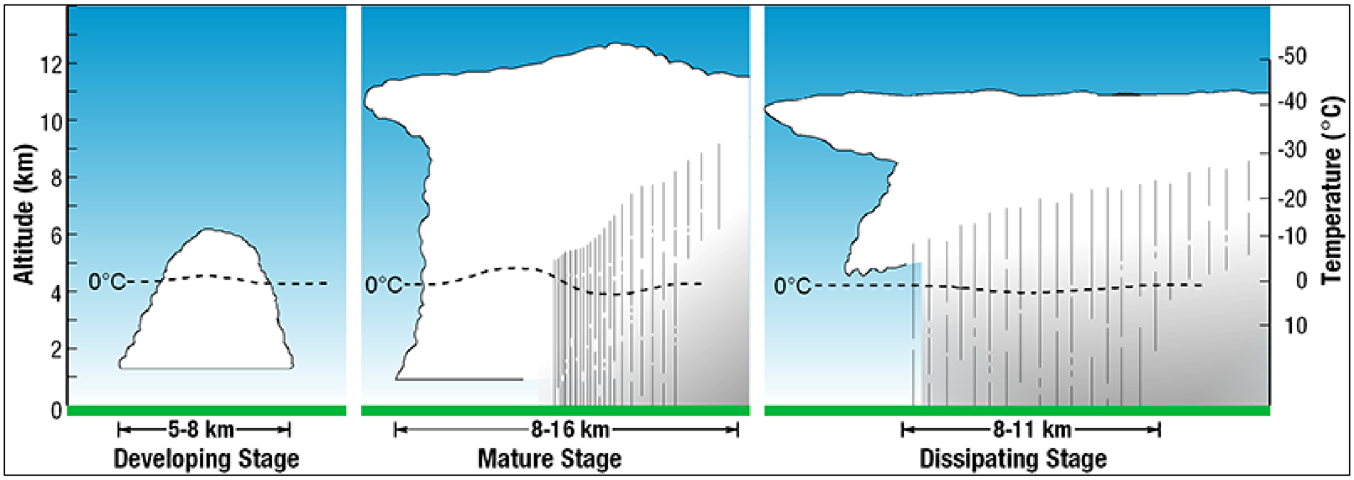


Figure 11-1. The Thunderstorm Life Cycle

There are four types of thunderstorms:

- **Single-Cell Thunderstorms—**Single-cell thunderstorms usually last 20 to 30 minutes. A true single-cell storm is rare, because the gust front of one cell often triggers the growth of another. Most single-cell storms are not usually severe, but a single-cell storm can produce a brief severe weather event. When this happens, it is called a pulse severe storm.
- **Multi-Cell Cluster Storm—**A multi-cell cluster is the most common type of thunderstorm. The multi-cell cluster consists of a group of cells, moving as one unit, with each cell in a different phase of the thunderstorm life cycle. Mature cells are usually found at the center of the cluster and dissipating cells at the downwind edge. Multi-cell cluster storms can produce moderate-size hail, flash floods and weak tornadoes. Each cell in a multi-cell cluster lasts only about 20 minutes; the multi-cell cluster itself may persist for several hours. This type of storm is usually more intense than a single cell storm.
- **Multi-Cell Squall Line**—A multi-cell line storm, or squall line, consists of a long line of storms with a continuous well-developed gust front at the leading edge. The line of storms can be solid, or there can be gaps and breaks in the line. Squall lines can produce hail up to golf-ball size, heavy rainfall, and weak tornadoes, but they are best known as the producers of strong downdrafts. Occasionally, a strong downburst will accelerate a portion of the squall line ahead of the rest of the line. This produces what is called a bow echo. Bow echoes can develop with isolated cells as well as squall lines. Bow echoes are easily detected on radar but are difficult to observe visually.
- **Super-Cell Storm—**A super-cell is a highly organized thunderstorm that poses a high threat to life and property. It is similar to a single-cell storm in that it has one main updraft, but the updraft is extremely strong, reaching speeds of 150 to 175 miles per hour. Super-cells are rare. The main characteristic that sets them apart from other thunderstorms is the presence of rotation. The rotating updraft of a super-cell (called a mesocyclone when visible on radar) helps the super-cell to produce extreme weather events, such as giant hail (more than 2 inches in diameter), strong downbursts of 80 miles an hour or more, and strong to violent tornadoes.

NOAA classifies a thunderstorm as a storm with lightning and thunder produced by cumulonimbus clouds, usually producing gusty winds, heavy rain, and sometimes hail. Thunderstorms are usually short in duration (seldom more than two hours). Heavy rains associated with thunderstorms can lead to flash flooding during the wet or dry season. According to the American Meteorological Society *Glossary of Meteorology*, thunderstorms are reported as light, medium, or heavy according to the following characteristics:

- Nature of the lightning and thunder
- Type and intensity of the precipitation, if any
- Speed and gustiness of the wind
- Appearance of the clouds
- Effect on surface temperature.

Lightning is an electrical discharge that results from the buildup of positive and negative charges within a thunderstorm. When the buildup becomes strong enough, lightning appears as a "bolt." This flash of light usually occurs within the clouds or between the clouds and the ground. A bolt of lightning reaches temperatures approaching 50,000ºF instantaneously. The rapid heating and cooling of air near the lightning causes thunder. Lightning is a major threat during a thunderstorm. In the United States, between 75 and 100 Americans are struck and killed by lightning each year.

Hail Storms

Hail occurs when updrafts in thunderstorms carry raindrops upward into extremely cold areas of the atmosphere where they freeze into ice. Recent studies suggest that super-cooled water may accumulate on frozen particles near the back-side of a storm as they are pushed forward across and above the updraft by the prevailing winds near the top of the storm. Eventually, the hailstones encounter downdraft air and fall to the ground.

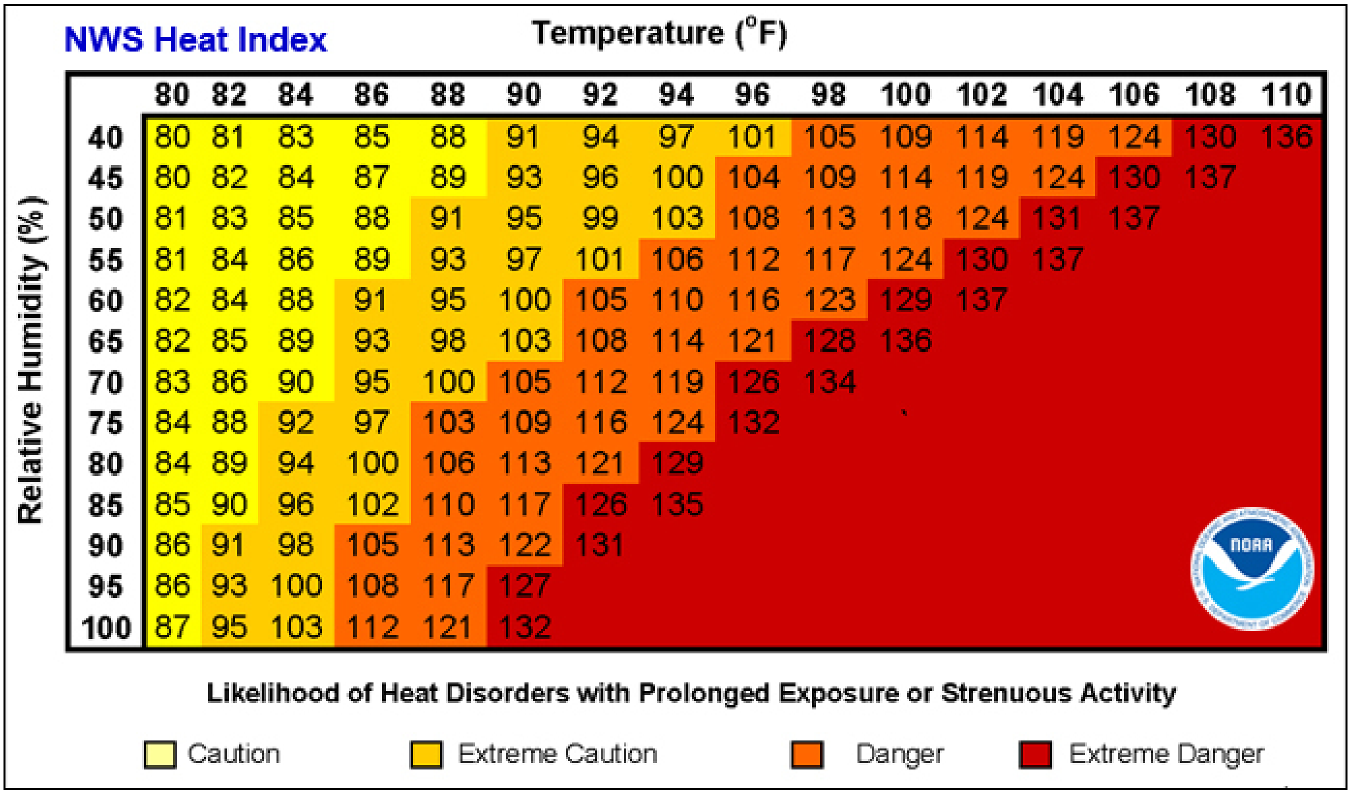
Hailstones grow two ways: by wet growth or dry growth. In wet growth, a tiny piece of ice is in an area where the air temperature is below freezing, but not super-cooled. When the tiny piece of ice collides with a super-cooled drop, the water does not freeze on the ice immediately. Instead, liquid water spreads across tumbling hailstones and slowly freezes. Since the process is slow, air bubbles can escape, resulting in a layer of clear ice. Dry growth hailstones grow when the air temperature is well below freezing and the water droplet freezes immediately as it collides with the ice particle. The air bubbles are "frozen" in place, leaving cloudy ice.

Hailstones can have layers like an onion if they travel up and down in an updraft, or they can have few or no layers if they are "balanced" in an updraft. One can tell how many times a hailstone traveled to the top of the storm by counting its layers. Hailstones can begin to melt and then re-freeze together, forming large and very irregularly shaped hail.

11.1.2 Extreme Heat

Extreme heat is unexpected, unusual, or unseasonable hot temperature that can create dangerous situations. It is defined as temperatures that hover 10ºF or more above the average high temperatures for the region for several weeks. Ambient air temperature and relative humidity are components of heat conditions, together defining a heat index, as shown in Figure 11-2. Extreme heat is the primary weather-related cause of death in the U.S. In a 30-year average of weather fatalities across the nation from 1986-2015, excessive heat claimed more lives each year than floods, lightning, tornadoes, and hurricanes. In 2015, heat claimed 45 lives, though none of them were in California (NOAA, 2017).

Source: NWS, 2016



Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Figure 11-2. NWS Heat Index

11.1.3 Damaging Winds

Windstorms are generally short-duration events involving straight-line winds or gusts of over 50 mph, strong enough to cause property damage. Windstorms are especially dangerous in areas with significant tree stands and areas with exposed property, poorly constructed buildings, mobile homes (manufactured housing units), major infrastructure, and above-ground utility lines. A windstorm can topple trees and power lines, cause damage to residential, commercial and critical facilities, and leave tons of debris in its wake.

Damaging winds are classified as those exceeding 60 mph. Damage from such winds accounts for half of all severe weather reports in the lower 48 states and is more common than damage from tornadoes. Wind speeds can reach up to 100 mph and can produce a damage path extending for hundreds of miles. There are seven types of damaging winds:

- Straight-line winds—Any thunderstorm wind that is not associated with rotation; this term is used mainly to differentiate from tornado winds. Most thunderstorms produce some straight-line winds as a result of outflow generated by the thunderstorm downdraft.
- Downdrafts—A small-scale column of air that rapidly sinks toward the ground.
- Downbursts—A strong downdraft with horizontal dimensions larger than 2.5 miles resulting in an outward burst or damaging winds on or near the ground. Downburst winds may begin as a microburst and spread out over a wider area, sometimes producing damage similar to a strong tornado. Although usually associated with thunderstorms, downbursts can occur with showers too weak to produce thunder.
- Microbursts—A small concentrated downburst that produces an outward burst of damaging winds at the surface. Microbursts are generally less than 2.5 miles across and short-lived, lasting only 5 to 10 minutes,

with maximum wind speeds up to 168 mph. There are two kinds of microbursts: wet and dry. A wet microburst is accompanied by heavy precipitation at the surface. Dry microbursts, common in places like the high plains and the intermountain west, occur with little or no precipitation reaching the ground.

- Gust front—A gust front is the leading edge of rain-cooled air that clashes with warmer thunderstorm inflow. Gust fronts are characterized by a wind shift, temperature drop, and gusty winds out ahead of a thunderstorm. Sometimes the winds push up air above them, forming a shelf cloud or detached roll cloud.
- Derecho—A derecho is a widespread thunderstorm wind caused when new thunderstorms form along the leading edge of an outflow boundary (the boundary formed by horizontal spreading of thunderstorm-cooled air). The word “derecho” is of Spanish origin and means “straight ahead.” Thunderstorms feed on the boundary and continue to reproduce. Derechos typically occur in summer when complexes of thunderstorms form over plains, producing heavy rain and severe wind. The damaging winds can last a long time and cover a large area.
- Bow Echo—A bow echo is a linear wind front bent outward in a bow shape. Damaging straight-line winds often occur near the center of a bow echo. Bow echoes can be 200 miles long, last for several hours, and produce extensive wind damage at the ground.

11.2 HAZARD PROFILE

11.2.1 Past Events

Table 11-1 summarizes severe weather events in the planning area since 1980, as recorded by the NOAA National Centers for Environmental Information Storm Events Database and FEMA disaster declarations. Contra Costa County has been included in nine FEMA declarations for severe weather events.

Table 11-1. Past Severe Weather Events Impacting Planning Area

Dates of Event	FEMA Disaster #	Event Type	Losses/Impacts
02/01 to 02/23/2017	4308	Severe storms, flooding, and mudslides	Great amounts of rain to the region caused widespread flooding, debris flow, accidents, and over topping of reservoir spillways.
1/22/2017	4305	Severe storms, flooding, and mudslides	Heavy rain, lightning, wind, hail, snow (above 2500 feet), and record breaking surf were observed in a series of three storms.
1/03 to 1/12/2017	4301	Severe storms, flooding, and mudslides	Strong winds, flooding, and debris flows occurred throughout this event. Snow was recorded at higher elevations. High winds with severe storm caused trees to cover roadways and power outages throughout the Bay Area.
10/24/2016	N/A	High Winds	Moderately strong winds occurred across the region and caused an 80-foot tree to topple over in a neighboring county.
2/6/2015	N/A	High Winds	A strong storm had wind gust of 62 mph.
12/11/2014	N/A	High Winds	A wind gust of 83 mph was measured with the severe storm event.
10/27/2013	N/A	High Winds	Strong and gusty northwest winds up to 45 mph impacted the Bay Area resulting in downed trees, downed power lines, toppled scaffolding, and blown over tractor trailers.
5/1/2013	N/A	High Winds	Strong northeast winds which gusted up to 62 mph led to critical fire weather conditions.
4/8/2013	N/A	High Winds	Strong and gusty northwest winds impacted the Bay Area, resulting in downed trees, downed power lines, and broken windows. The wind gusts were in excess of 35 mph with a few locations over 60 mph.
2/15/2011	N/A	High Winds	High winds hit the Bay Area with winds gusting to 60 mph and caused an estimated $150,000 in damage.

Dates of Event	FEMA Disaster #	Event Type	Losses/Impacts
1/23/2010	N/A	Tornado	A low topped super cell produced an EF1 tornado near Brentwood. The tornado crossed power lines and destroyed a utility pole. An eyewitness described the tornado as high winds from a swirling white cloud. The 40-foot pole was twisted to the ground and the top one-third of it was splintered. 55 customers lost power.
1/19/2010	N/A	High Winds	High winds hit the Bay Area with winds gusting to 62 mph that caused power outages.
12/17/2005 to 1/3/2006	1628	Severe storms, flooding, mudslides, and landslides	A series of rain storm events caused significant runoff with localized evacuations, some slope failures, and road closures throughout the declared counties. Urban flooding initiated landslides that contributed to the damage. Much of the damage was in Walnut Creek, Richmond, San Pablo, Martinez and Orinda. Damaged facilities included schools, parks and several government agency structures.
2/17/2004	N/A	High Winds	Strong winter storm produced a 74 mph wind gust on Kregor Peak in the East Bay Hills.
12/14/2003	N/A	High Winds	High winds hit the Bay Area with winds gusting to 62 mph at Las Trampas in the East Bay Hills, causing thousands of power outages.
11/7/2002	N/A	High Winds	For a three-day period starting on November 7, rainfall totaling 2 to 5 inches fell across the North Bay counties. Since this was the first appreciable rain of the season, no major flooding occurred, with the ground absorbing most of the rain. Only urban and small stream advisories were needed. Many trees and branches were down, blocking roads and interrupting power. Winds also blew down power poles and lines. As many as 1 million homes were without power at one time. A number of trees fell on homes and automobiles. Total damage to the area was estimated at $2.5 million. 96 mph gust at Kregor Peak, Contra Costa County on November 7.
1/25/2001	N/A	High Winds	A strong cold front from the northwest formed a squall line that produced high winds, small hail and snow as low as 800 feet. A severe thunderstorm watch was issued for only the second time in 25 years for the San Francisco Bay area. No severe thunderstorms were reported, but rotation was noted near Richmond. There was damage from mainly strong gradient winds and lightning strikes. A number of trees were downed causing power outages to the Bay area.
12/18/2000	N/A	High Winds	A gust of 71 mph was reported at the Oakland north Remote Automated Weather Station in Contra Costa County. A large Monterey Pine tree was blown down onto a house causing extensive damage in the Montclair district. Power to over 2500 customers was lost due to trees blowing into power lines. Three cars were crushed by two trees falling into the road in the Broadway terrace neighborhood. Trees blown down across Highway 13 and the entry ramp to I-580 snarled traffic.
6/14/2000	N/A	Excessive Heat	This unusual early summer record breaking heat wave was responsible for 10 deaths in the Bay Area and a large number of heat-related injuries. Temperature of 103 degrees in San Francisco tied the record high temperature. High temperature caused overloading of power resources and rolling blackouts were implemented to keep the power system from exceeding capacity, so many people lost power for a period during the heat.
12/21/1999	N/A	High Winds	A strong high pressure inland and a low offshore created strong northeasterly downslope wind in the Oakland and Contra Costa County hills. A strong offshore gradient created high down slope winds in the Oakland hills area. Many trees were downed and power was lost for 10,000 people. The event caused approximately $125,000 in damage.
2/9/1999	N/A	High Winds	Wind gusts up to 60 mph were reported in five Bay Area counties causing an estimated $1 million in damage.
12/16/1998	N/A	High Winds	Wind gusts up to 61 mph were reported in Alameda and Contra Costa Counties.

Dates of Event	FEMA Disaster #	Event Type	Losses/Impacts
12/5/1998	N/A	Tornado	An F0 tornado 150 yards wide and 1.5 miles long was reported in Richmond causing an estimated $200,000 in damage.
11/29/1998	N/A	High Winds	Wind gusts up to 75 mph were reported within eight bay area counties causing an estimated $1.8 million in damage.
2/19/1998	N/A	Tornado	Weak tornado (F0) demolished a shade structure at a nursery as well as a chicken coop and a tool shed causing an estimated $50,000 in damage.
2/02 to 4/30/1998	1203	Severe winter storms and El Nino rainstorm	$550 million; 17 deaths from El Niño causing widespread heavy rains, flooding, and landslides throughout the Bay Area. Record flooding throughout the region.
12/28/1996 to 4/01/1997	1155	Severe storms, flooding, mud, landslides	300 square miles in California were flooded including the Yosemite Valley. Over 12,000 people were evacuated in northern California. Several levee breaks were reported across the Sacramento and San Joaquin Valleys. Over 23,000 homes and business, agricultural lands, bridges, and roads were damaged. Eight deaths resulted from this event. Overall, the state had $1.8 billion in damage.
12/9/1995	N/A	Winter Storm/High Winds	Widespread winds over 40 mph many reported 60 to 80 mph. Max wind 135 mph from PG&E in San Francisco Area. An estimated $60 million in damage was reported in San Francisco Bay area. Power outages to around 1.5 million people resulted from this storm and some power was out for more than a week, causing financial damage and personal hardship, particularly in mountainous areas. The wind strength and area coverage were labeled as the worst in the San Francisco area since 1962-63. Many reports of houses and other buildings damaged by falling trees and broken glass due to wind-driven debris. 169 schools closed in the area. 14 inches of rain in a 36-hour period over the Russian River Basin. From some of the damage across the San Francisco area it was determined that a wet downburst mechanism may have contributed to the wind damage.
2/13 to 4/19/1995	1046	Severe winter storms, flooding, landslides, mud flows	Several feet of snow a day fell in the mountains. Winds to 80 mph were reported in mountains. Winds to 55 mph were reported along the coast south of Pt. Reyes. More than 1.5 million people were without power during this period, primarily the San Francisco Bay area. 89 mph winds in Belmont. Roof ripped off the San Ramon Valley High School.
1/03 to 2/10/1995	1044	Severe winter storms, flooding, landslides, mud flows	High winds with severe storm caused trees to cover roadways and power outages throughout the Bay Area.
11/4/1994	N/A	Strong Winds	South winds 42 mph gusting to 79 mph.
2/7/1994	N/A	Severe Thunderstorm	Severe weather developed in the cold air behind the first of two Pacific storm systems to hit California. The severe thunderstorm produced wind gusts in excess of 60 mph were reported within the County.
4/29/1983	N/A	Hail	Hail up to 0.75” was reported in portions of Contra Costa County.
1/05 to 3/20/1993	979	Severe winter storm, mud and landslides, flooding	High winds with severe storm caused trees to cover roadways and power outages throughout the Bay Area.
1/21 to 3/30/1983	677	Coastal storms, floods, slides, tornadoes	High winds with severe storm caused trees to cover roadways and power outages throughout the Bay Area.
12/19/1981 to 1/08/1982	651	Severe storms, flood, mudslides, high tide	High winds with severe storm caused trees to cover roadways and power outages throughout the Bay Area.

Sources: NOAA, 2017; 2011 Hazard Mitigation Plan Update

11.2.2 Location

All severe weather events profiled in this assessment have the potential to happen anywhere in the planning area. Communities in low-lying areas next to streams or lakes are more susceptible to flooding. Wind events are most damaging to areas that are heavily wooded.

Atmospheric River, Heavy Rains, and Thunderstorms

The entire Contra Costa County planning area is vulnerable to heavy rainfall, thunderstorm and atmospheric river events as they make landfall in the Bay Area. These events can drop up to 12 inches of rain over a few days and cause widespread flooding and disruption to road and air travel.

Thunderstorms affect relatively small localized areas, rather than large regions. It is estimated that there are as many as 40,000 thunderstorms each day worldwide. Thunderstorms can strike in all regions of the United States; however, they are most common in the central and southern states. Figure 11-3 shows the annual number of thunderstorms in the United States. According to this figure, the planning area can experience around five thunderstorms each year (NWS, 2016).

Source: NWS, 2016a

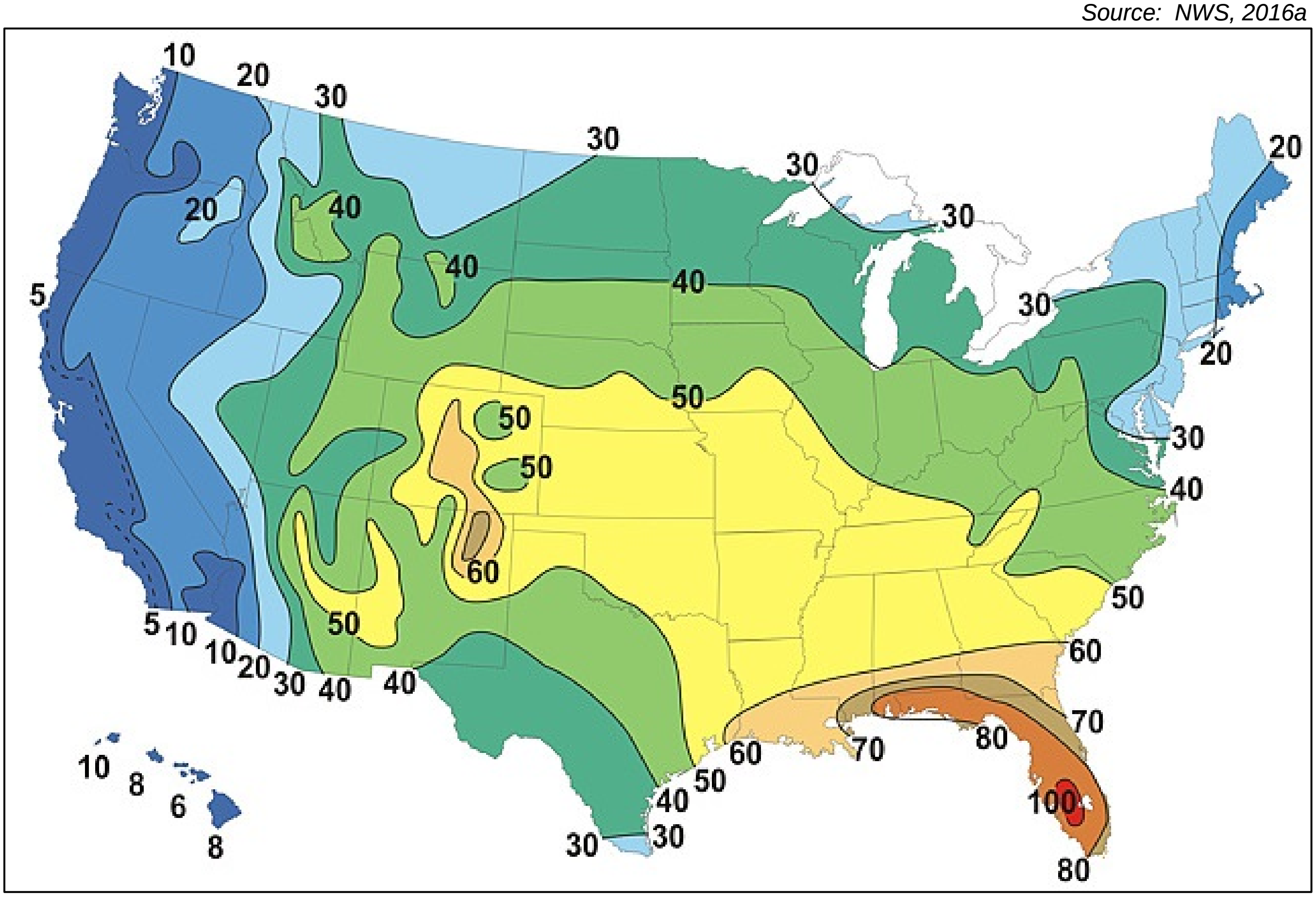


Figure 11-3. Annual Number of Thunderstorms in the United States

Extreme Heat

Extreme heat can occur anywhere in the planning area and there is no clearly defined extent and location mapping available for this hazard to support geospatial analysis. Extreme heat is a concern to people, animals and pets as well as local nursery crops, cut flowers, and vegetable crops. However, it is rare that extreme heat events directly damage property or infrastructure.

High Winds

The entire planning area is subject to high winds from thunderstorms and other severe weather events. Figure 11-4 indicates how the frequency and strength of windstorms impacts the United States and the general location of the most wind activity. The planning area is located in FEMA's Wind Zone I, where wind speeds can reach up to 130 mph.

Source: FEMA, 2010

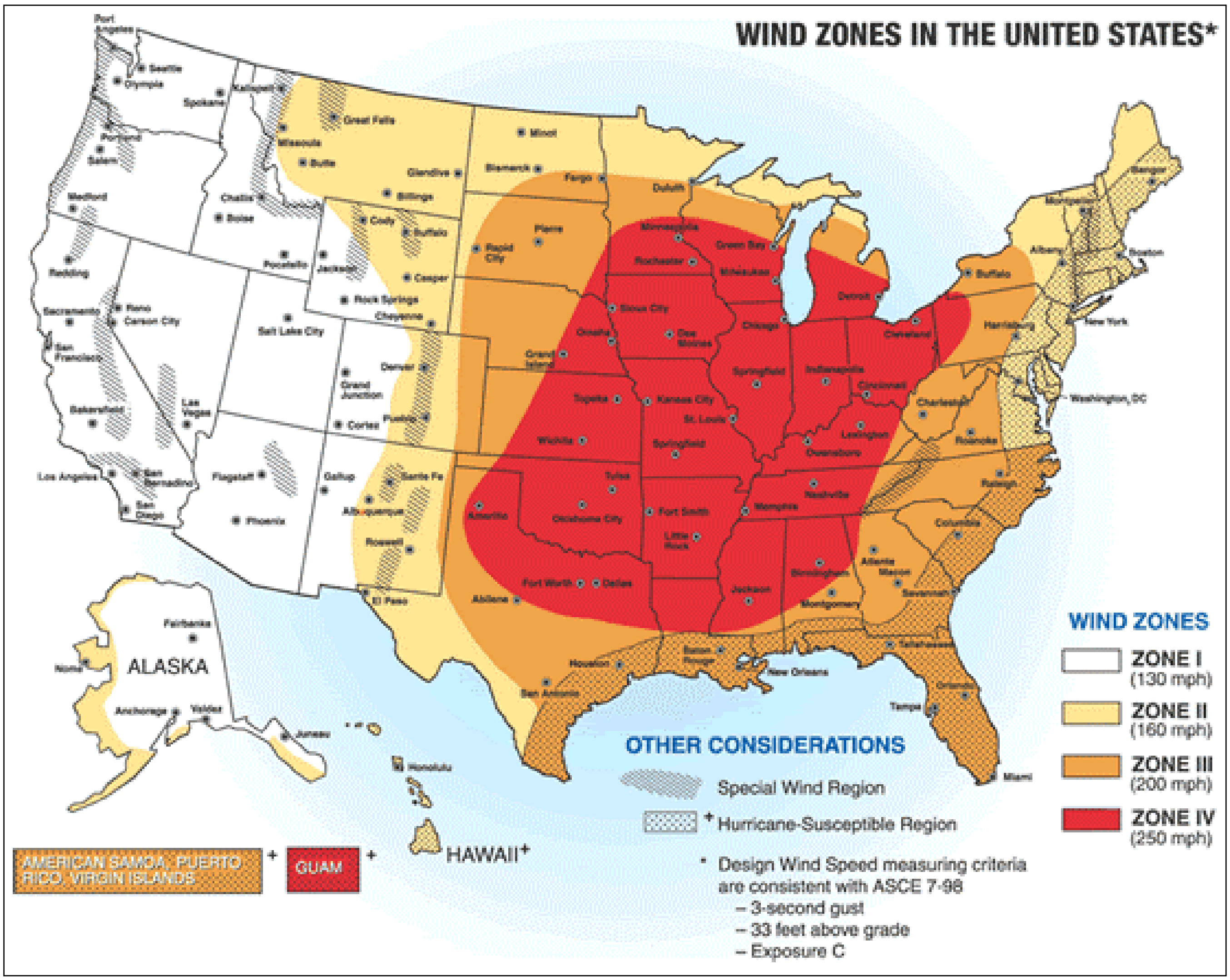


Figure 11-4. Wind Zones in the United States

11.2.3 Frequency

Predicting the frequency of severe weather events in a constantly changing climate is a difficult task. The planning area can expect to experience exposure to and adverse impacts from some type of severe weather event at least annually.

11.2.4 Severity

The most common problems associated with severe storms are immobility and loss of utilities. Fatalities are uncommon, but can occur. Citizens should pay close attention to changing weather conditions when there is a severe thunderstorm watch or warning. Lightning strikes are a danger during thunderstorms and can cause death or injury to one or several persons. Long-term injuries from lightning strike can include memory and attention loss, chronic numbness, muscle spasm, stiffness, depression, hearing loss and sleep disturbance. Seventy percent of all lightning injuries and fatalities occur in the afternoon; 85 percent of victims are children and young men (age 10 to 35) engaged in outdoor recreation and work activities. Hikers, campers, backpackers, skiers, fishermen, and hunters are especially vulnerable.

Roads may become impassable due to flooding, downed trees, or a landslide. Power lines may be downed due to high winds, and services such as water or phone may not be able to operate without power.

During periods of very high temperatures in the summer, those susceptible to extreme heat may suffer heat-related illnesses:

- **Heat Exhaustion—**Heat exhaustion is a mild form of heat-related illness that can develop after several days of exposure to high temperatures and inadequate or unbalanced replacement of fluids. It is the body's response to an excessive loss of the water and salt contained in sweat. Those most prone to heat exhaustion are elderly people, people with high blood pressure, and people working or exercising in a hot environment.
- **Heat Cramps—**Heat cramps usually affect people who sweat a lot during strenuous activity. This sweating depletes the body's salt and moisture. The low salt level in the muscles may be the cause of heat cramps. Heat cramps may also be a symptom of heat exhaustion.
- **Heat Stroke—**Heat stroke is a severe, dangerous form of heat-related illness. It occurs when the body's temperature rises rapidly, the sweating mechanism fails, and the body is unable to cool down. Body temperature may rise to 106°F or higher within 10 to 15 minutes. Heat stroke can cause death or permanent disability if emergency treatment is not provided. This is a medical emergency.

Heat has caused more than 9,000 deaths in the United States since 1979. Air-conditioning is the number one protective factor against heat-related illness and death. If a home is not air-conditioned, people can reduce their risk for heat-related illness by spending time in public facilities that are air-conditioned.

Windstorms can be a frequent problem in the planning area and have been known to cause damage to utilities. The predicted wind speed given in wind warnings issued by the National Weather Service is for a one-minute average; gusts may be 25 to 30 percent higher.

Tornadoes are potentially the most dangerous of local storms, but they are not common in the planning area. If a major tornado were to strike within the populated areas of the planning area, damage could be widespread. Businesses could be forced to close for an extended period or permanently, fatalities could be high, many people could be homeless for an extended period, and routine services such as telephone or power could be disrupted. Buildings may be damaged or destroyed. California ranks 32nd among states for frequency of tornadoes, 44th for the frequency of tornados per square mile, 36th for injuries, and 31st for cost of damage. The state has no reported deaths from tornadoes.

Heavy rain can have significant impacts, including flash flooding, mudslides and landslides. Stormwater runoff from heavy rains can also impair water quality by washing pollutants into water bodies (EPA, 2003). Thunderstorms carry the same risks as heavy rain events, and depending on the type of storm, they can also include tornados, lightning, and heavy winds, increasing risk of injury and property damage (Keller, 2008).

11.2.5 Warning Time

Meteorologists can often predict the likelihood of a severe weather event. This can give several days of warning time. However, meteorologists cannot predict the exact time of onset or severity of the storm. Some storms may come on more quickly and have only a few hours of warning time. The San Francisco Bay Area Weather Forecast Office of the NWS monitors weather stations and issues watches and warnings when appropriate to alert government agencies and the public of possible or impending weather events. The watches and warnings are broadcast over NOAA weather radio and are forwarded to the local media for retransmission using the Emergency Alert System.

11.3 SECONDARY HAZARDS

The most significant secondary hazards associated with severe local storms are floods, falling and downed trees, mudslides, landslides and downed power lines. Rapidly melting snow combined with heavy rain can overwhelm both natural and man-made drainage systems, causing overflow and property destruction. Landslides occur when the soil on slopes becomes oversaturated and fails.

11.4 EXPOSURE

11.4.1 Population

A lack of clearly defined extent and location mapping for the severe weather hazards profiled in this chapter prevented a detailed analysis for exposure and vulnerability. However, it can be assumed that the entire planning area is exposed to some extent to the severe weather hazards profiled in this assessment. Certain areas are more exposed due to geographic location and local weather patterns. Populations living at higher elevations with large stands of trees or power lines may be more susceptible to wind damage and black out, while populations in low-lying areas are at risk for possible flooding.

11.4.2 Property

According to the County Assessor, there are 346,901 buildings within the census tracts that define the planning area. Most of these buildings are residential. It is estimated that 20 percent of the residential structures were built without the influence of a structure building code with provisions that would mitigate all severe weather hazards profiled in this assessment. All of these buildings are considered to be exposed to the severe weather hazard, but structures in poor condition or in particularly vulnerable locations (located on hilltops or exposed open areas) may risk the most damage. The frequency and degree of damage will depend on specific locations.

11.4.3 Critical Facilities and Infrastructure

All critical facilities exposed to flooding (Section 9.4.3) are also likely exposed to all of the severe weather hazards profiled in this assessment. Additional facilities on higher ground may also be exposed to wind damage or damage from falling trees. The most common problems associated with severe weather are loss of utilities. Prolonged periods of extreme heat could result in power outages caused by increased demand for power for cooling. Downed power lines associated with wind and/or thunderstorm events can cause blackouts, leaving large areas isolated. Phone, water and sewer systems may not function. Roads may become impassable due to secondary hazards such as mudslides and landslides.

11.4.4 Environment

The environment is highly exposed to severe weather events profiled in this assessment. Natural habitats such as streams and trees are exposed to the elements during a severe storm and risk major damage and destruction.

Prolonged rains can saturate soils and lead to slope failure. Flood events caused by severe weather or snowmelt can produce river channel migration or damage riparian habitat. Storm surges can erode beachfront bluffs and redistribute sediment loads. Vegetation can die as a result of prolonged periods of extreme heat.

11.5 VULNERABILITY

11.5.1 Population

Vulnerable populations are the elderly, low income or linguistically isolated populations, people with life-threatening illnesses, and residents living in areas that are isolated from major roads. Power outages can be life threatening to those dependent on electricity for life support. Isolation of these populations is a significant concern. These populations face isolation and exposure during severe weather events and could suffer more secondary effects of the hazard. Population vulnerabilities to specific types of severe weather event are as follows:

- **Thunderstorms**—Nationally, lightning is one of the leading causes of weather-related fatalities (CDC, 2014). Lightning strikes are far more common in other areas of the country than they are in the west. The majority of injuries and deaths associated with lighting strikes occur when people are outdoors; however, almost one-third of lightning-related injuries occur indoors. Males are five times more likely than females to be struck by lighting and people between the ages of 15 and 34 account for 41 percent of all lightning strike victims (CDC, 2014).
- **Extreme Temperatures**—Individuals with physical or mobility constraints, cognitive impairments, economic constraints, or social isolation are typically at greater risk from the adverse effects of excessive heat events. The average summertime mortality for excessive heat events is dependent upon the methodology used to derive such estimates. Certain medical conditions, such as heat stroke, can be directly attributable to excessive heat, while others may be exacerbated by excessive heat, resulting in medical emergencies. Individuals who lack shelter and heating are particularly vulnerable to extreme cold and wind chill.
- **Damaging Winds**—Debris carried by extreme winds and trees felled by gusty conditions can contribute directly to loss of life and indirectly to the failure of protective building envelopes. Utility lines brought down by thunderstorms have also been known to cause fires, which start in dry roadside vegetation. Electric power lines falling down to the pavement create the possibility of lethal electric shock.

11.5.2 Property

All property is vulnerable during the severe weather events profiled in this chapter, but properties in poor condition or in particularly vulnerable locations may risk the most damage. Those in higher elevations and on ridges may be more prone to wind damage. Those that are located under or near overhead lines or near large trees may be vulnerable to falling ice or may be damaged in the event of a collapse. Extreme heat events are not known for causing direct damage to buildings, but may damage building systems such as heating, ventilation and air-conditioning (HVAC) systems.

Loss estimations for the severe weather hazards profiled in this assessment are not based on damage functions, because no such damage functions have been generated. Instead, loss estimates were developed representing 10 percent, 30 percent and 50 percent of the replacement value of exposed structures. This allows emergency managers to select a range of potential economic impact based on an estimate of the percent of damage to the general building stock. Damage in excess of 50 percent is considered to be substantial by most building codes and typically requires total reconstruction of the structure. Table 11-2 lists the loss estimates.

Table 11-2. Loss Potential for Severe Weather

Jurisdiction	Exposed Value	Estimated Loss Potential from Severe Weather		
		10% Damage	30% Damage	50% Damage
Antioch	$20,634,649,519	$2,063,464,952	$6,190,394,856	$10,317,324,760
Brentwood	$12,128,473,460	$1,212,847,346	$3,638,542,038	$6,064,236,730
Clayton	$2,252,467,641	$225,246,764	$675,740,292	$1,126,233,821
Concord	$26,123,025,057	$2,612,302,506	$7,836,907,517	$13,061,512,528
Danville	$10,282,590,156	$1,028,259,016	$3,084,777,047	$5,141,295,078
El Cerrito	$5,468,962,350	$546,896,235	$1,640,688,705	$2,734,481,175
Hercules	$4,178,980,493	$417,898,049	$1,253,694,148	$2,089,490,247
Lafayette	$6,524,080,333	$652,408,033	$1,957,224,100	$3,262,040,167
Martinez	$8,879,794,159	$887,979,416	$2,663,938,248	$4,439,897,079
Moraga	$3,931,573,175	$393,157,317	$1,179,471,952	$1,965,786,587
Oakley	$6,069,903,473	$606,990,347	$1,820,971,042	$3,034,951,736
Orinda	$4,739,583,178	$473,958,318	$1,421,874,954	$2,369,791,589
Pinole	$3,861,258,311	$386,125,831	$1,158,377,493	$1,930,629,156
Pittsburg	$12,127,672,643	$1,212,767,264	$3,638,301,793	$6,063,836,322
Pleasant Hill	$7,982,365,182	$798,236,518	$2,394,709,555	$3,991,182,591
Richmond	$26,588,690,622	$2,658,869,062	$7,976,607,187	$13,294,345,311
San Pablo	$4,518,650,567	$451,865,057	$1,355,595,170	$2,259,325,283
San Ramon	$19,832,689,351	$1,983,268,935	$5,949,806,805	$9,916,344,675
Walnut Creek	$19,307,555,958	$1,930,755,596	$5,792,266,787	$9,653,777,979
Unincorporated County	$40,853,385,267	$4,085,338,527	$12,256,015,580	$20,426,692,633
Total	$246,286,350,895	$24,628,635,090	$73,885,905,269	$123,143,175,448

11.5.3 Critical Facilities and Infrastructure

Incapacity and loss of roads are the primary transportation failures resulting from severe weather, mostly associated with secondary hazards. Landslides caused by heavy prolonged rains can block roads. High winds can cause significant damage to trees and power lines, blocking roads with debris, incapacitating transportation, isolating population, and disrupting ingress and egress. Snowstorms in higher elevations can significantly impact the transportation system and the availability of public safety services. Of particular concern are roads providing access to isolated areas and to the elderly.

Prolonged obstruction of major routes due to landslides, snow, debris or floodwaters can disrupt the shipment of goods and other commerce. Large, prolonged storms can have negative economic impacts for an entire region.

Severe windstorms, downed trees, and ice can create serious impacts on overhead power lines and infrastructure and above-ground communication lines. Freezing of power and communication lines can cause them to break, disrupting electricity and communication. Loss of electricity and phone connection would leave certain populations isolated because residents would be unable to call for assistance.

Extreme heat is not known for causing direct impacts on critical facilities and infrastructure, but some impacts may occur in extreme cases, such as loss of power due to brownouts.

Electric power losses for severe weather hazards can be estimated using standard values for loss of service for utilities published in FEMA's *2009 Benefit Cost Analysis Reference Guide*. These figures provide estimated costs associated with the loss of power in relation to the populations in Contra Costa County (Table 11-3). The loss of use estimates for power failure associated with severe weather are presented as a cost per person per day of loss. The estimated loss of use provided for each jurisdiction represents the loss of service of the indicated utility for one day for 10 percent of the population. These figures do not take into account physical damage to utility equipment and infrastructure.

Table 11-3. Loss of Use Estimates for Power Failure

Jurisdiction	2016 Population Estimate[a]	Estimated Affected Population 10%	Electric Loss of Use Estimate ($126 per person per day)[b]
Antioch	112,968	11,296.80	$1,423,397
Brentwood	58,784	5,878.40	$740,678
Concord	11,209	1,120.90	$141,233
Clayton	129,707	12,970.70	$1,634,308
Danville	42,865	4,286.50	$540,099
El Cerrito	24,378	2,437.80	$307,163
Hercules	24,791	2,479.10	$312,367
Lafayette	24,924	2,492.40	$314,042
Martinez	37,057	3,705.70	$466,918
Moraga	16,513	1,651.30	$208,064
Oakley	40,141	4,014.10	$505,777
Orinda	18,749	1,874.90	$236,237
Pinole	18,739	1,873.90	$236,111
Pittsburg	67,817	6,781.70	$854,494
Pleasant Hill	34,077	3,407.70	$429,370
Richmond	110,378	11,037.80	$1,390,763
San Pablo	30,829	3,082.90	$388,445
San Ramon	78,363	7,836.30	$987,374
Walnut Creek	70,018	7,001.80	$882,227
Unincorporated	171,122	95,230.70	$11,999,068
Total	1,123,429	17,112.20	$2,156,137

a. Population Estimates from California Department of Finance
b. FEMA's 2009 Benefit Cost Analysis Reference Guide

11.5.4 Environment

The vulnerability of the environment to severe weather is the same as the exposure.

11.6 FUTURE TRENDS IN DEVELOPMENT

All future development will be affected by severe storms, extreme heat, and high winds. The ability to withstand impacts lies in sound land use practices and consistent enforcement of codes and regulations for new construction. Contra Costa County is StormReady-certified by the NWS, which means that the County has achieved the industry standard for severe weather preparedness and communication. The planning partners have adopted the International Building Code in response to California mandates. This code is equipped to deal with the impacts of severe weather events. Land use policies identified in general plans within the planning area also address many of the secondary impacts (flood and landslide) of the severe weather hazard. With these tools, the planning partners are well equipped to deal with future growth and the associated impacts of severe weather.

11.7 SCENARIO

Although severe local storms are infrequent, impacts can be significant, particularly when secondary hazards of flood and landslide occur. A worst-case event would involve prolonged high winds during a winter storm accompanied by an atmospheric river event. Such an event would have both short-term and longer-term effects. Initially, schools and roads would be closed due to power outages caused by high winds and downed tree obstructions. In more rural areas, some subdivisions could experience limited ingress and egress. Prolonged rain could produce flooding, overtopped culverts with ponded water on roads, mud over roadways, and landslides on steep slopes. Floods and landslides could further obstruct roads and bridges, further isolating residents.

11.8 ISSUES

Important issues associated with a severe weather in the planning area include the following:

- Older building stock in the planning area is built to low code standards or none at all. These structures could be highly vulnerable to severe weather events such as windstorms.
- Cities may need to open cooling centers during extreme heat events.
- Redundancy of power supply must be evaluated.
- The capacity for backup power generation is limited.
- Dead or dying trees as a result of drought conditions are more susceptible to falling during severe storm events.
- Public education on dealing with the impacts of severe weather needs to continue to be provided so that citizens can be better informed and prepared for severe weather events. In particular, fog should be considered, since fog may be downplayed despite its potential for transportation accidents.
- Debris management (downed trees, etc.) must be addressed, because debris can impact the severity of severe weather events, requires coordination efforts, and may require additional funding.
- The effects of climate change may result in an increase of heavy rain or more atmospheric storm events, and will likely lead to increased temperatures and changes in overall precipitation amounts.

12. TSUNAMI

12.1 GENERAL BACKGROUND

12.1.1 Tsunami

A tsunami is a series of high-energy waves radiating outward from an area where a generating event occurs. Earthquakes may produce displacements of the sea floor that can set the overlying column of water in motion, initiating a tsunami, depending on the magnitude of the earthquake and the type of faulting.

DEFINITIONS

Tsunami—A series of traveling ocean waves of extremely long wavelength usually caused by displacement of the ocean floor and typically generated by seismic or volcanic activity or by underwater landslides.

Tsunamis are typically classified as local or distant. Locally generated tsunamis have minimal warning times, leaving few options except to run to high ground. They may be accompanied by damage resulting from the triggering earthquake due to ground shaking, surface faulting, liquefaction or landslides. Distant tsunamis may travel for hours before striking a coastline, giving a community a chance to implement evacuation plans. In the open ocean, a tsunami may be only a few inches or feet high, but it can travel with speeds approaching 600 miles per hour. Tsunami waves arrive at shorelines over an extended period. Figure 12-1 shows likely travel times across the Pacific Ocean for a tsunami generated along the California coastline near the San Francisco Bay Area.

Source: NOAA, 2016

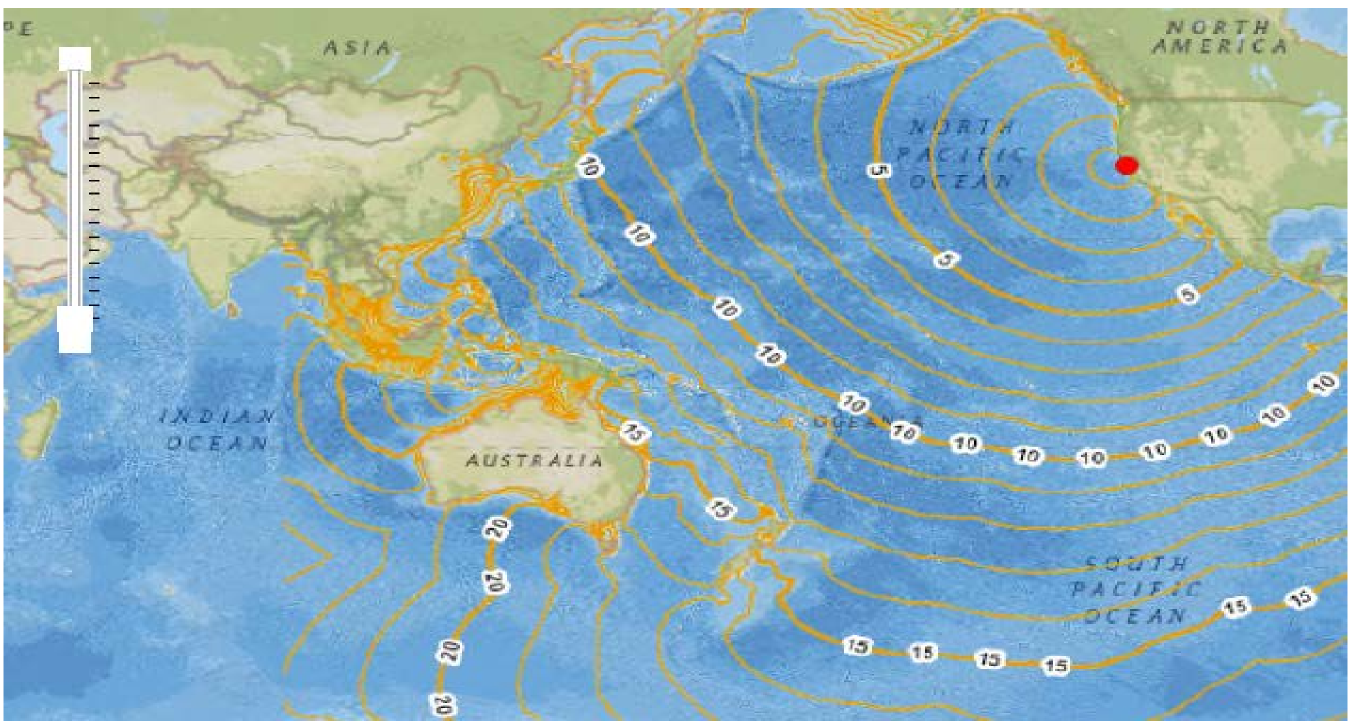


Figure 12-1. Potential Tsunami Travel Times in the Pacific Ocean, in Hours

As a tsunami enters the shoaling waters near a coastline, its speed diminishes, its wavelength decreases, and its height increases greatly. The first wave usually is not the largest. Several larger and more destructive waves often follow the first one. As tsunamis reach the shoreline, they may take the form of a fast-rising tide, a cresting wave, or a bore (a large, turbulent wall-like wave). The bore phenomenon resembles a step-like change in the water level that advances rapidly (from 10 to 60 miles per hour).

The configuration of the coastline, the shape of the ocean floor, and the characteristics of advancing waves play important roles in the destructiveness of the waves. Offshore canyons can focus tsunami wave energy and islands can filter the energy. The orientation of the coastline determines whether the waves strike head-on or are refracted from other parts of the coastline. A wave may be small at one point on a coast and much larger at other points. Bays, sounds, inlets, rivers, streams, offshore canyons, islands, and flood control channels may cause various effects that alter the level of damage. It has been estimated, for example, that a tsunami wave entering a flood control channel could reach a mile or more inland, especially if it enters at high tide.

The first visible indication of an approaching tsunami may be recession of water (draw down) caused by the trough preceding the advancing, large inbound wave crest. Rapid draw down can create strong currents in harbor inlets and channels that can severely damage coastal structures due to erosive scour around piers and pilings. As the water’s surface drops, piers can be damaged by boats or ships straining at or breaking their mooring lines. The vessels can overturn or sink due to strong currents, collisions with other objects, or impact with the harbor bottom.

Conversely, the first indication of a tsunami may be a rise in water level. The advancing tsunami may initially resemble a strong surge increasing the sea level like the rising tide, but the tsunami surge rises faster and does not stop at the shoreline. Even if the wave height appears to be small, 3 to 6 feet for example, the strength of the accompanying surge can be deadly. Waist-high surges can cause strong currents that float cars, small structures, and other debris. Boats and debris are often carried inland by the surge and left stranded when the water recedes.

At some locations, the advancing turbulent wave front will be the most destructive part of the wave. In other situations, the greatest damage will be caused by the outflow of water back to the sea between crests, sweeping all before it and undermining roads, buildings, bulkheads, and other structures. This outflow action can carry enormous amounts of highly damaging debris with it, resulting in further destruction. Ships and boats, unless moved away from shore, may be dashed against breakwaters, wharves, and other craft, or be washed ashore and left grounded after the withdrawal of the seawater.

12.2 HAZARD PROFILE

12.2.1 Past Events

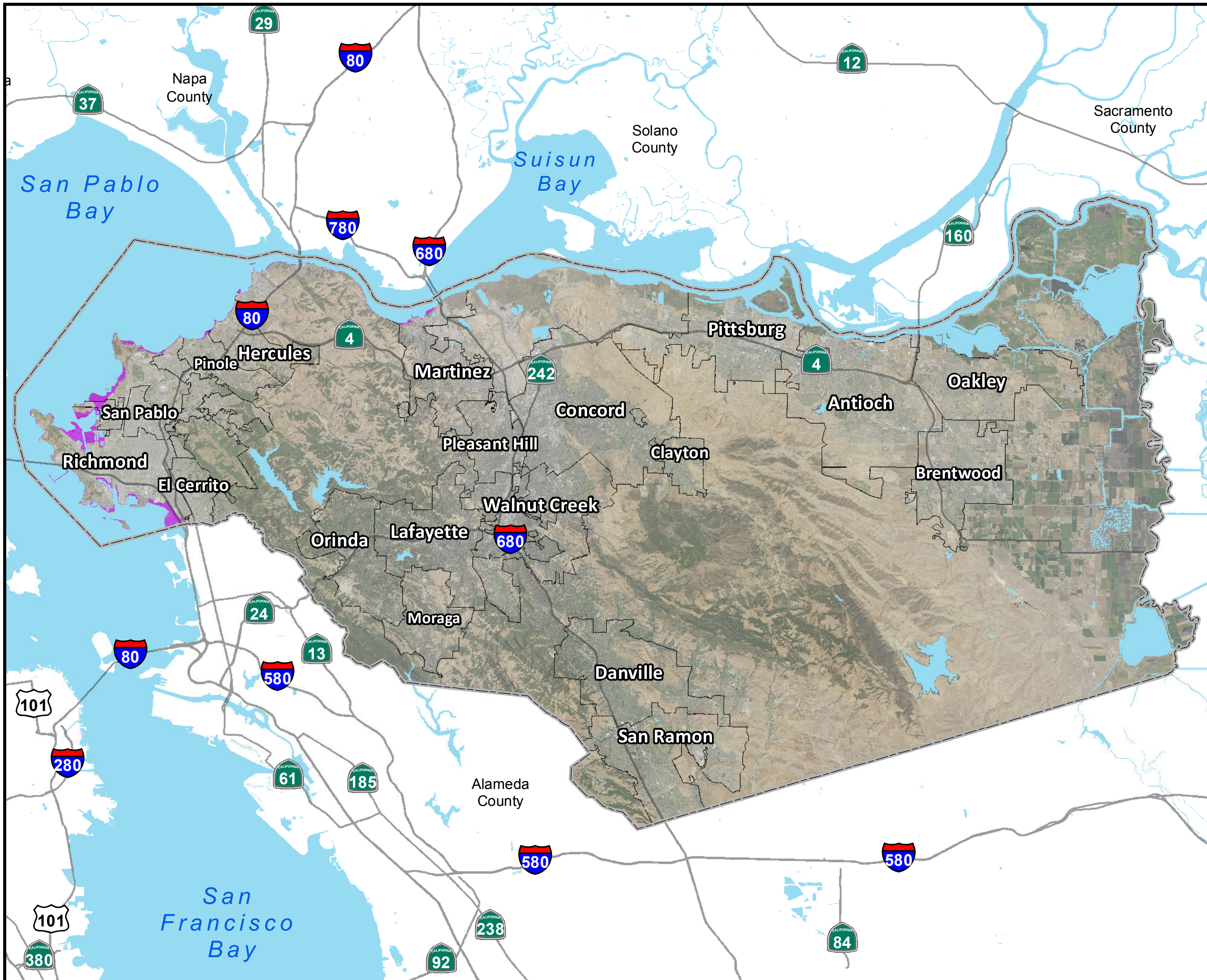
According to the National Centers for Environmental Information, the California coastline has been impacted by tsunami wave events on four dates since 2005: November 15, 2006, February 27, 2010, March 11, 2011, and September 16, 2015. Together these events caused approximately $45 million in property damage. Contra Costa County has never been impacted by a tsunami. The closest tsunami to affect the planning area was the tsunami event on March 10, 2011 that was generated by an earthquake in Japan and traveled across the Pacific Ocean to create wave surges that damaged coastal areas in nearby Santa Cruz and Monterey Counties. These counties were included in FEMA-1968-DR-CA declaration.

12.2.2 Location

The most likely site of tsunami impacts in Contra Costa County is along the San Pablo Bay area that would rise with floodwaters from a San Francisco Bay tsunami caused by a local earthquake. Figure 12-2 shows tsunami inundation mapping affecting the cities of Hercules, Martinez, Pinole, Richmond and unincorporated county prepared by the California Department of Conservation.

Contra Costa County

Figure 12-2. Tsunami Inundation Zones



Tsunami Evacuation Planning Scenario

This tsunami inundation map was prepared to assist cities and counties in identifying their tsunami hazard. It is intended for local jurisdictional, coastal evacuation planning uses only.

Contra Costa County Boundary

City Boundaries

Water Bodies & Channels

Map Data Sources: Contra Costa County, Caltrans, ABAG, USDA

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12.2.3 Frequency

The frequency of tsunamis is related to the frequency of the events that cause them, so it is similar to the frequency of seismic or volcanic activities or landslides. The 2005 California Seismic Safety Commission report, *The Tsunami Threat to California; Findings and Recommendations on Tsunami Hazards Risks*, indicates that over 80 tsunamis have been observed or recorded along the coast of California in the past 150 years, which amounts to a tsunami every two years on average. While this recorded frequency may not be directly attributable to the defined planning area (there are no recorded tsunami impacts within Contra Costa County), it does show the frequency of potential sources that could impact the planning area. The report includes findings that tsunamis generated either locally or from events elsewhere in the Pacific basin pose a significant threat to life and property in California, and that tsunamis present a substantial risk to the economy of the state and nation primarily through the impact on ports. It is important to note that, according to the International Tsunami Information Center, any earthquake with a magnitude of 7.5 or greater can cause a tsunami. The probability of a tsunami impacting the planning area is unknown due to the lack of historical records indicating such events.

12.2.4 Severity

Tsunamis are a threat to life and property to anyone living near the ocean. From 1950 to 2007, 478 tsunamis were recorded globally. Fifty-one of these events caused fatalities, to a total of over 308,000 coastal residents. The overwhelming majority of these events occurred in the Pacific basin. Recent tsunamis have struck Nicaragua, Indonesia, and Japan, killing several thousand people. Property damage due to these waves was nearly $1 billion. Historically, tsunamis originating in the northern Pacific and along the west coast of South America have caused more damage on the west coast of the United States than tsunamis originating in Japan and the Southwest Pacific.

It is general consensus that Contra Costa County could see moderate impacts from a tsunami originating in the Pacific Ocean. But a local earthquake tsunami can occur any time, and the resulting floodwater waves can carry damaging debris and inundate homes, businesses, and government buildings in the City of Pinole, unincorporated county, and the City of Richmond.

12.2.5 Warning Time

Typical signs of a tsunami hazard are earthquakes and/or sudden and unexpected rise or fall in coastal water. The large waves are often preceded by coastal flooding and followed by a quick recession of the water. Tsunamis are difficult to detect in the open ocean; with waves less than 3 feet high. The tsunami’s size and speed, as well as the coastal area’s form and depth, affect the impact of a tsunami; wave heights of 50 feet are not uncommon. In general, scientists believe it requires an earthquake of at least a magnitude 7 to produce a tsunami.

The Pacific tsunami warning system evolved from a program initiated in 1946. It is a cooperative effort involving 26 countries along with numerous seismic stations, water level stations and information distribution centers. The National Weather Service operates two regional information distribution centers. One is located in Ewa Beach, Hawaii, and the other is in Palmer, Alaska. The Ewa Beach center also serves as an administrative hub for the Pacific warning system.

The warning system only begins to function when a Pacific basin earthquake of magnitude 6.5 or greater triggers an earthquake alarm. When this occurs, the following sequence of actions occurs:

- Data is interpolated to determine epicenter and magnitude of the event.
- If the event is magnitude 7.5 or greater and located at sea, a TSUNAMI WATCH is issued.
- Participating tide stations in the earthquake area are requested to monitor their gages. If unusual tide levels are noted, the tsunami watch is upgraded to a TSUNAMI WARNING.

- Tsunami travel times are calculated, and the warning is transmitted to the disseminating agencies and thus relayed to the public.
- The Ewa Beach center will cancel the watch or warning if reports from the stations indicate that no tsunami was generated or that the tsunami was inconsequential.

This system is not considered to be effective for communities located close to the tsunami because the first wave would arrive before the data were processed and analyzed. In this case, strong ground shaking would provide the first warning of a potential tsunami.

12.3 SECONDARY HAZARDS

By the time a tsunami wave reaches Contra Costa County, it may carry floating debris that can cause damage to any affected areas.

12.4 EXPOSURE AND VULNERABILITY

The Hazus analysis was used to assess the risk and vulnerability to tsunami hazard in the planning area. The model used Contra Costa County tax assessor data and tsunami inundation zone data from California Department of Conservation website, which has a level of accuracy acceptable for planning purposes.

12.4.1 Population

In the City of Richmond, it is estimated that 1,204 residents are exposed to tsunami inundation areas.

12.4.2 Property

There are 346 buildings in the tsunami inundation area in Contra Costa County: 337 in the City of Richmond, eight in unincorporated county, and one in City of Pinole. Table 12-1 summarizes the estimated value of exposed buildings, showing a total estimated building-and-contents exposure of $620.4 million. The predominant land uses in the inundation area are vacant, open water, and open space in tsunami risk areas. Table 12-2 shows the general land use of parcels exposed to tsunami in the planning area.

12.4.3 Critical Facilities and Infrastructure

Table 12-3 and Table 12-4 summarize the critical facilities and infrastructure in the tsunami inundation area. Details are provided in the following sections.

Roads

Roads are the primary resource for evacuation to higher ground before and during a tsunami event. Roads also can serve as flood control facilities for low depth, low velocity floods by acting as levees or berms and diverting or containing flood flows.

The major roads in the planning area that intersect tsunami inundation areas are East-shore Freeway, John T. Knox Freeway, and Richmond Parkway. These are major roads that may be impacted by a tsunami, based on exposure; they are NOT evacuation routes for tsunami events. Evacuation routes are identified in emergency response plans in effect within the planning area.

Bridges

Bridges exposed to tsunami events can be extremely vulnerable to forces transmitted by wave run-up and by debris carried by the wave action. Hazus identified three bridges within the tsunami inundation areas.

Table 12-1. Value of Structures in the Tsunami Inundation Area

Jurisdiction	Estimated Value within the Floodplain			% of Total Replacement Value
	Structure	Contents	**Total**	
Pinole	$752,073	$752,073	$1,504,146	0.04%
Richmond	$274,112,797	$288,684,690	$562,797,487	2.12%
Unincorporated	$22,453,638	$33,680,457	$56,134,095	0.14%
Total	$297,318,508	$323,117,220	$620,435,728	0.25%

Table 12-2. Land Use in Tsunami Risk Area

Type of Land Use	Area (acres)	% of total
Residential	17	0.7%
Commercial	102	3.9%
Industrial	529	20.0%
Agriculture	0	0.0%
Religion	0	0.0%
Government	240	9.1%
Education	0	0.0%
Vacant, Rights-of-way, Open water, Open space	1,752	66.4%
Total	2,641	100%

Table 12-3. Critical Facilities in the Tsunami inundation areas

	Number of Facilities in the Floodplain					
	Medical and Health	Government Functions	Protective Functions	Schools and Educational Facilities	Hazmat	**Total**
Martinez	0	0	0	0	0	0
Pinole	0	0	0	0	0	0
Richmond	0	0	0	0	2	2
Unincorporated	0	0	0	0	0	0
Total	0	0	0	0	2	2

Table 12-4. Critical Infrastructure in the Tsunami Inundation areas

	Number of Facilities in the Floodplain							
	Power	Communications	Water Supply	Wastewater	Bridges	Other Critical Functions	Other Critical Infrastructure	**Total**
Martinez	0	0	0	0	0	1	0	1
Pinole	0	0	0	1	0	0	0	1
Richmond	1	0	1	0	2	4	0	8
Unincorporated	0	0	1	0	1	1	2	2
Total	1	0	2	1	3	6	2	15

Water, Sewer, Utilities

Water and sewer systems can be affected by the flooding associated with tsunami events. Floodwaters can back up drainage systems, causing localized flooding. Culverts can be blocked by debris from flood events, also causing localized urban flooding. Floodwaters can get into drinking water supplies, causing contamination. Sewer systems can be backed up, causing waste to spill into homes, neighborhoods, rivers and streams. Tsunami waves can knock down power lines and radio/cellular communication towers. Power generation facilities can be severely impacted by wave action and by inundation from floodwater. Hazus identified four utilities within tsunami inundation areas.

12.4.4 Environment

Inundation of water by tsunami and introduction of foreign debris could be hazardous to the environment. All wildlife inhabiting the inundation area is exposed. The vulnerability of aquatic habit and associated ecosystems would be highest in low-lying areas close to the southern portion of San Francisco Bay coastline. Tsunami waves can carry destructive debris and pollutants that can devastate the environment. Millions of dollars spent on habitat restoration and conservation in Contra Costa County could be wiped out by one significant tsunami. There are currently no tools available to measure these impacts. However, the potential financial impact of a tsunami event on the environment could equal or exceed the impact on property. Community planners and emergency managers should take this into account when preparing for the tsunami hazard and considering future development.

12.5 FUTURE TRENDS IN DEVELOPMENT

Table 12-5 summarizes developable land by land use in the tsunami inundation area.

Table 12-5. Developable Land in Tsunami Inundation Area

	Area of Developable Land in Tsunami Inundation Area (acres)	% of Total Developable Tsunami Inundation Area
Residential	2.5	13.9%
Commercial-Industrial	15.7	86.1%
Mixed Use	0.0	0.0%
Total	18.2	100.0%

Source: Contra Costa County, 2016.

12.6 SCENARIO

The worst-case scenario for Contra Costa County is a local tsunami event originating in the San Francisco Bay triggered by a seismic event. This can occur anytime and the series of floodwater waves can carry damaging debris, inundate homes and businesses, and cause environmental impacts.

12.7 ISSUES

Important issues associated with a tsunami in the planning area include the following:

- As tsunami warning technologies evolve, the tsunami warning capability within Contra Costa County will need to be enhanced to provide the highest degree of warning.
- With the possibility of climate change, the issue of sea level rise may become an important consideration as tsunami inundation areas are identified through future studies.
- Special attention will need to be focused on the vulnerable communities in the tsunami zone and on hazard mitigation through public education and outreach.

13. WILDFIRE

13.1 GENERAL BACKGROUND

A wildfire is any uncontrolled fire occurring on undeveloped land that requires fire suppression. Wildfires can be ignited by lightning or by human activity such as smoking, campfires, equipment use, and arson.

Fire hazards present a considerable risk to vegetation and wildlife habitats. Short-term loss caused by a wildfire can include the destruction of timber, wildlife habitat, scenic vistas, and watersheds. Long-term effects include smaller timber harvests, reduced access to affected recreational areas, and destruction of cultural and economic resources and community infrastructure. Vulnerability to flooding increases due to the destruction of watersheds. The potential for significant damage to life and property exists in areas designated as “wildland urban interface areas,” where development is adjacent to densely vegetated areas.

DEFINITIONS

Interface Area—An area susceptible to wildfires and where wildland vegetation and urban or suburban development occur together. An example would be smaller urban areas and dispersed rural housing in forested areas.

Wildfire—Fires that result in uncontrolled destruction of forests, brush, field crops, grasslands, and real and personal property in non-urban areas. Because of their distance from firefighting resources, they can be difficult to contain and can cause a great deal of destruction.

13.1.1 Wildfire Protection Responsibility in California

There are hundreds of agencies that have fire protection responsibility for wildfires in California. Local, state, tribal, and federal organizations have primary legal (and financial) responsibility for wildfire protection. In many instances, two fire organizations have dual primary responsibility on the same parcel of land—one for wildfire protection and the other for structural or “improvement” fire protection. This layering of responsibility and resulting dual practices can cause conflict or confusion. To address wildfire jurisdictional responsibilities, the California state legislature in 1981 adopted Public Resource Code Section 4291.5 and Health and Safety Code Section 13108.5 establishing the following responsibility areas:

- **Federal Responsibility Areas (FRAs)—**FRAs are fire-prone wildland areas that are owned or managed by a federal agency such as the U.S. Forest Service, National Park Service, Bureau of Land Management, U.S. Fish and Wildlife Service, or U.S. Department of Defense. Primary financial and rule-making jurisdictional authority rests with the federal land agency. In many instances, FRAs are interspersed with private land ownership or leases. Fire protection for developed private property is usually not the responsibility of the federal land management agency; structural protection responsibility is that of a local government agency.
- **State Responsibility Areas (SRAs)**—SRAs are lands in California where CAL FIRE has legal and financial responsibility for wildfire protection and administers fire hazard classifications and building standard regulations. SRAs are defined as lands that meet the following criteria:
    - Are county unincorporated areas
    - Are not federally owned
    - Have wildland vegetation cover rather than agricultural or ornamental plants
    - Have watershed and/or range/forage value
    - Have housing densities not exceeding three units per acre.
    - Where SRAs contain built environment or development, the responsibility for fire protection of those improvements (non-wildland) is that of a local government agency.

- **Local Responsibility Areas (LRAs)**—LRAs include land in cities, cultivated agriculture lands and non-flammable areas in unincorporated areas, and lands that do not meet the criteria for SRA or FRA. LRA fire protection is typically provided by city fire departments, fire protection districts, and counties, or by CAL FIRE under contract to local governments. LRAs may include flammable vegetation and wildland-urban interface areas where the financial and jurisdictional responsibility for improvement and wildfire protection is that of a local government agency.

SRAs were originally mapped in 1985 and have not been updated since, except with respect to changes in boundaries. LRAs were originally mapped in 1996, and also have not been updated since, although many local governments have made similar designations under their own authority.

13.2 HAZARD PROFILE

13.2.1 Past Events

The planning area has a rich fire history. Table 13-1 lists the causes of all fires tracked by CAL FIRE from 2010 through 2015.

Table 13-1. Record of Fire by Cause, 2010 -2015

	2015	2014	2013	2012	2011	2010	**Total**
Arson	11	1	7	2	3	0	24
Campfire	2	1	1	0	0	1	5
Debris Burning	1	1	1	0	3	1	7
Equipment Use	8	5	4	2	5	2	26
Electric Power	5	1	4	0	1	0	11
Lightning	0	0	0	1	32	25	58
Miscellaneous	3	3	3	4	1	0	14
Power line	0	0	0	0	0	1	1
Smoking	0	0	0	0	0	0	0
Undetermined	10	15	22	10	21	9	87
Vehicle	3	2	1	2	2	1	11
Total	2058	2043	2056	2033	2079	2050	244

Source: CAL FIRE, 2017b

According to the 2013 *State of California Multi-Hazard Mitigation Plan* and the California Department of Forestry and Fire Protection, Contra Costa historically experiences wildfires every two to three years. With drought conditions in recent years, wildfires have occurred annually. None of its fires have caused sufficient damage to trigger a state or federal disaster declaration. The following wildfires of over 10 acres have been recorded in or near the planning area in recent years (CAL FIRE, 2017):

- July 24, 2016, Franklin Fire—Burned 40 acres along Cummings Skyway and Franklin Canyon, 6 miles southeast of Rodeo.
- July 30, 2015, Vasco Fire—Burned 195 acres along Vasco Road, 3 miles southwest of Byron.
- June 24-25, 2015, Loma Fire—Burned 533 acres in Contra Loma Regional Park located in Antioch.
- July 11-12, 2014, Marsh Fire—Burned 80 acres east of Clayton, off Marsh Creek Road and Aspara Drive.
- September 8-14, 2013, Morgan Fire—Burned 3,111 acres southeast of Clayton, off Morgan Territory Road.
- July 1, 2013, Concord Fire—Burned 274 acres in Brentwood, near Concord Avenue and Vineyard Parkway.

- July 1, 2013, Kirker Fire—Burned 492 acres south of Pittsburg along Kirker Pass Road.
- December 1-2, 2011, Collier Fire—Burned 198 acres near San Ramon Valley, along Collier Canyon Road and Highland Road.
- August 24-26, 2010, Curry Fire—Burned 375 acres east of Clayton, along Curry Canyon Road and Morgan Territory Road.
- June 11, 2010, Vista Fire—Burned 186 acres east of Walnut Creek (Shell Ridge Recreation Area).

13.2.2 Location

Fire Hazard Severity Zones

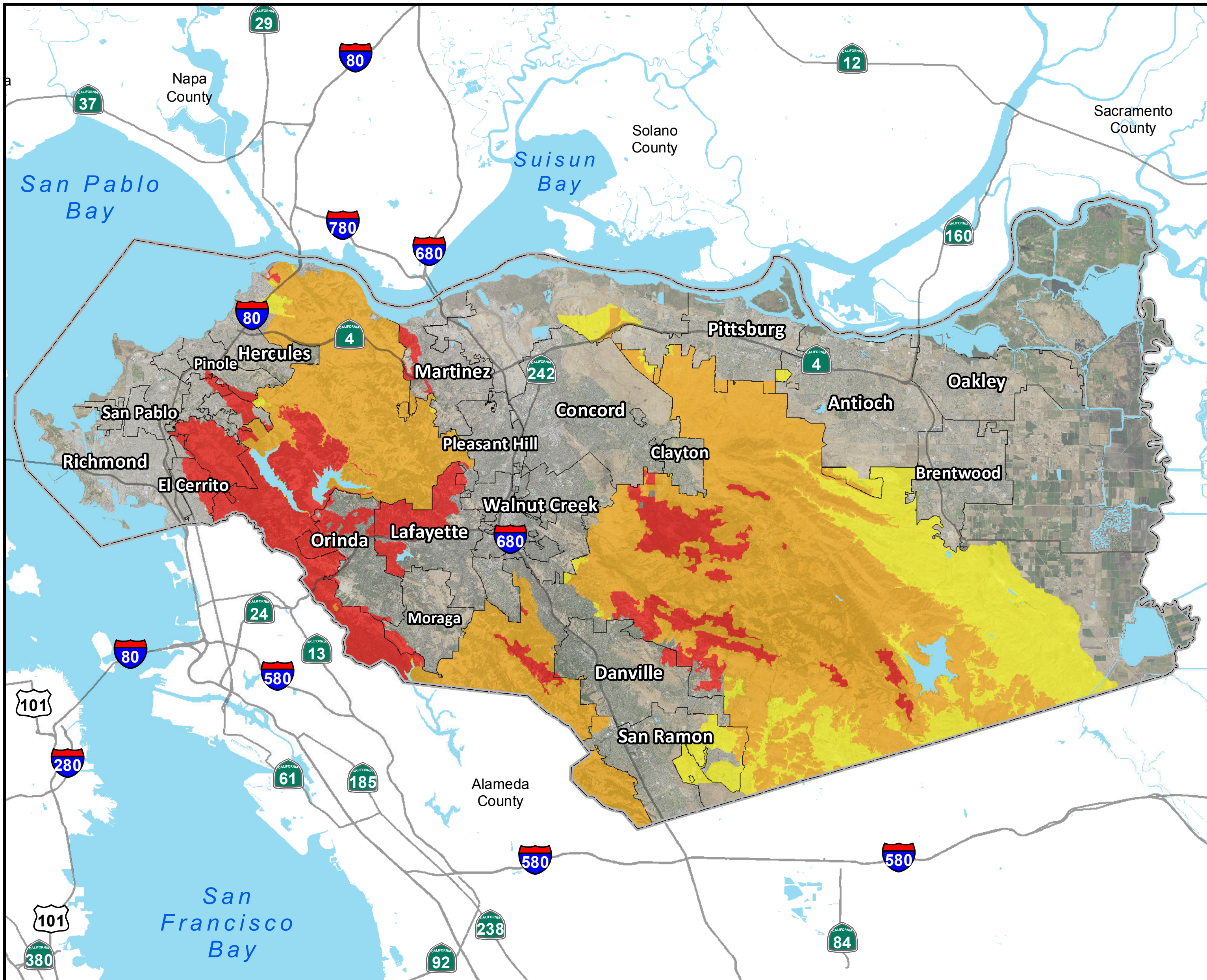
CAL FIRE's Fire and Resource Assessment Program has modeled and mapped wildfire hazard zones using a science-based and field-tested computer model that designates moderate, high or very high fire hazard severity zones (FHSZ). The FHSZ model is built from existing CAL FIRE data and hazard information based on factors such as the following (CAL FIRE, 2017a):

- **Fuel**—Fuel may include living and dead vegetation on the ground, along the surface as brush and small trees, and above the ground in tree canopies. Lighter fuels such as grasses, leaves and needles quickly expel moisture and burn rapidly, while heavier fuels such as tree branches, logs and trunks take longer to warm and ignite. Trees killed or defoliated by forest insects and diseases are more susceptible to wildfire.
- **Weather**—Relevant weather conditions include temperature, relative humidity, wind speed and direction, cloud cover, precipitation amount and duration, and the stability of the atmosphere. Of particular importance for wildfire activity are wind and thunderstorms:
  - Strong, dry winds produce extreme fire conditions. Such winds generally reach peak velocities during the night and early morning hours.
  - The thunderstorm season typically begins in June with wet storms, and turns dry with little or no precipitation reaching the ground as the season progresses into July and August.
- **Terrain**—Topography includes slope and elevation. The topography of a region influences the amount and moisture of fuel; the impact of weather conditions such as temperature and wind; potential barriers to fire spread, such as highways and lakes; and elevation and slope of land forms (fire spreads more easily uphill than downhill).

The model also is based on frequency of fire weather, ignition patterns, and expected rate-of spread. It accounts for flying ember production, which is the principal driver of the wildfire hazard in densely developed areas. A related concern in built-out areas is the relative density of vegetative fuels that can serve as sites for new spot fires within the urban core and spread to adjacent structures. The model refines the zones to characterize fire exposure mechanisms that cause ignitions to structures. Significant land-use changes need to be accounted for through periodic model updates. Figure 13-1 shows the FHSZ mapping for Contra Costa County. Table 13-2 lists the total area mapped in each zone. Most of the mapped zones are in the unincorporated county.

Table 13-2. Record of Fire Affecting Planning Area

Fire Hazard Severity Zone (FHSZ)	Total Area in Zone (acres)	Area Burned, 1878 – 2015	
		Acres	Percent of Total
Moderate FHSZ	44,309	3,016	6.8
High FHSZ	130,589	17,847	13.7
Very High FHSZ	42,225	6,459	15.3
Total	217,123	27,322	12.6



Contra Costa County

Figure 13-1. Wildfire Severity Zones

Wildfire Severity Zone

- Moderate
- High
- Very High

These maps have been created using CAL FIRE's Fire and Resource Assessment Program (FRAP) data and models describing development patterns, estimated fire behavior characteristics based on potential fuels over a 30-50 year time horizon, and expected burn probabilities to quantify the likelihood and nature of vegetation fire exposure to new construction. Details on the project and specific modeling methodology can be found at http://frap.cdf.ca.gov/projects/hazard/methods.htm

- Contra Costa County Boundary
- City Boundaries
- Water Bodies & Channels

Map Data Sources: Contra Costa County, Caltrans, CalFIRE, USDA

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Local Conditions Related to Wildfire

The geography, weather patterns and vegetation in the East Bay area provide ideal conditions for recurring wildfires. Especially vulnerable are the East Bay Hills in Lamorinda, which includes Lafayette, Moraga, and Orinda. Parts of Walnut Creek, including the area surrounding Rossmoor, are vulnerable to wildfires, as are Clayton, the Danville/San Ramon area, and the San Pablo-El Cerrito, El Sobrante area.

Because the natural vegetation and dry-farmed grain areas of the county are extremely flammable during late summer and fall, wildfire is a serious hazard in undeveloped areas and on large lot home sites with extensive areas of un-irrigated vegetation.

Grassland fires are easily ignited, particularly in dry seasons. These fires are relatively easily controlled if they can be reached by fire equipment; the burned slopes, however, are highly subject to erosion and gullying. While brush-lands are naturally adapted to frequent light fires, fire protection in recent decades has resulted in heavy fuel accumulation on the ground. Brush fires, particularly near the end of the dry season, tend to burn fast and very hot, threatening homes and leading to serious destruction of vegetative cover. A brush fire that spreads to a woodland can generate a destructive hot crown fire. No suitable management technique of moderate cost has been devised to reduce the risk of brush fires.

Peat fires represent a special hazard in that once ignited, they are extremely difficult to extinguish. In some instances, islands have been flooded in order to extinguish peat fires. Any area lying landward of the mean high water line may be peaty due to the marshy origin of the soil.

13.2.3 Frequency

Wildfire frequency can be assessed through review of the percent of a given area that has been burned in previous wildfire events. Table 13-2 includes a summary of CAL FIRE records of fires over the 130 years from 1878 to 2015. About 13 percent of the mapped wildfire risk zones in the planning area have burned in that period.

13.2.4 Severity

Potential losses from wildfire include human life, structures and other improvements, and natural resources. There are no recorded incidents of loss of life from wildfires in Contra Costa County. However, the most destructive wildfire in the region to date—the October 1991 Oakland/Berkeley Hills “Tunnel Fire”—occurred close to Contra Costa County and resulted in 25 lives lost, including a fire battalion chief and an Oakland police officer, 148 people injured, and 3,500 homes destroyed. The blaze started from a grass fire in the Berkeley Hills and burned 1,600 acres. The estimated private property loss was $1.7 billion at the time, according to the Insurance Information Institute.

Given the immediate response times to reported fires, the likelihood of injuries and casualties is minimal. Smoke and air pollution from wildfires can be a health hazard, especially for sensitive populations including children, the elderly and those with respiratory and cardiovascular diseases. Wildfire may also threaten the health and safety of those fighting the fires. First responders are exposed to the dangers from the initial incident and after-effects from smoke inhalation and heat stroke. In addition, wildfire can lead to ancillary impacts such as landslides in steep ravine areas and flooding due to the impacts of silt in local watersheds.

13.2.5 Warning Time

Wildfires are often caused by humans, intentionally or accidentally. There is no way to predict when one might break out. Since fireworks often cause brush fires, extra diligence is warranted around the Fourth of July when the use of fireworks is highest. Dry seasons and droughts are factors that greatly increase fire likelihood. Dry lightning may trigger wildfires. Severe weather can be predicted, so special attention can be paid during weather events that may include lightning. Reliable National Weather Service lightning warnings are available on average 24 to 48 hours prior to a significant electrical storm.

If a fire does break out and spread rapidly, residents may need to evacuate within days or hours. A fire's peak burning period generally is between 1 p.m. and 6 p.m. Once a fire has started, fire alerting is reasonably rapid in most cases. The rapid spread of cellular and two-way radio communications in recent years has further contributed to a significant improvement in warning time.

13.3 SECONDARY HAZARDS

Wildfires can generate a range of secondary effects, which in some cases may cause more widespread and prolonged damage than the fire itself. Fires can cause direct economic losses in the reduction of harvestable timber and indirect economic losses in reduced tourism. Wildfires cause the contamination of reservoirs, destroy transmission lines and contribute to flooding. They strip slopes of vegetation, exposing them to greater amounts of runoff. This in turn can weaken soils and cause failures on slopes. Major landslides can occur several years after a wildfire. Most wildfires burn hot and for long durations that can bake soils, especially those high in clay content, thus increasing the imperviousness of the ground. This increases the runoff generated by storm events, thus increasing the chance of flooding.

13.4 EXPOSURE

13.4.1 Population

Population could not be examined by FHSZ because the boundaries of census block groups do not coincide with the zone boundaries. However, population was estimated using the structure count of buildings in each mapped FHSZ and multiplying by the 2016 estimated average population per household (Calif. Department of Finance, 2017). Table 13-3 presents the results.

13.4.2 Property

Property damage from wildfires can be severe and can significantly alter entire communities. The number of homes in the various wildfire hazard zones within the planning area and their values are summarized in Table 13-4 through Table 13-6. Table 13-7 shows the general land use of parcels exposed to the wildfire hazard in the unincorporated portions of the planning area.

13.4.3 Critical Facilities and Infrastructure

Critical facilities and infrastructure exposed to the wildfire hazard in the planning area are summarized in Table 13-8 through Table 13-13. Currently there are two registered Tier II hazardous material containment sites in wildfire risk zones. During a wildfire event, these materials could rupture due to excessive heat and act as fuel for the fire, causing rapid spreading and escalating the fire to unmanageable levels. In addition, they could leak into surrounding areas, saturating soils and seeping into surface waters, and have a disastrous effect on the environment.

In the event of wildfire, there would likely be little damage to the majority of infrastructure. Most road and railroads would be without damage except in the worst scenarios. Power lines are the most at risk to wildfire because most are made of wood and susceptible to burning. In the event of a wildfire, pipelines could provide a source of fuel and lead to a catastrophic explosion.

Table 13-3. Population within Wildfire Hazard Areas

Jurisdiction	Moderate FHSZ			High FHSZ			Very High FHSZ		
		Population			Population			Population	
	Buildings	Number	% of Total	Buildings	Number	% of Total	Buildings	Number	% of total
Antioch	0	0	0.0%	0	0	0.0%	0	0	0.0%
Brentwood	0	0	0.0%	0	0	0.0%	0	0	0.0%
Clayton	0	0	0.0%	0	0	0.0%	0	0	0.0%
Concord	0	0	0.0%	0	0	0.0%	0	0	0.0%
Danville	0	0	0.0%	0	0	0.0%	193	542	1.3%
El Cerrito	0	0	0.0%	0	0	0.0%	2,800	8,349	34.2%
Hercules	0	0	0.0%	0	0	0.0%	0	0	0.0%
Lafayette	0	0	0.0%	0	0	0.0%	2,675	8,223	33.0%
Martinez	0	0	0.0%	84	254	0.7%	943	2,758	7.4%
Moraga	0	0	0.0%	0	0	0.0%	0	0	0.0%
Oakley	0	0	0.0%	0	0	0.0%	0	0	0.0%
Orinda	0	0	0.0%	0	0	0.0%	1,593	4,406	23.5%
Pinole	0	0	0.0%	0	0	0.0%	30	93	0.5%
Pittsburg	0	0	0.0%	0	0	0.0%	0	0	0.0%
Pleasant Hill	0	0	0.0%	0	0	0.0%	0	0	0.0%
Richmond	0	0	0.0%	0	0	0.0%	553	2,067	1.9%
San Pablo	0	0	0.0%	0	0	0.0%	0	0	0.0%
San Ramon	4,159	14,008	17.9%	1	3	0.0%	0	0	0.0%
Walnut Creek	0	0	0.0%	0	0	0.0%	0	0	0.0%
Unincorporated	1,785	5,317	3.1%	5,617	16,962	9.9%	5,298	16,766	9.8%
Total	5,944	19,324	1.7%	5,702	17,220	1.5%	14,085	43,203	3.8%

Table 13-4. Exposure and Value of Structures in Very High Wildfire Hazard Areas

Jurisdiction	Buildings Exposed	Value Exposed			% of Total Replacement Value
		Structure	Contents	**Total**	
Antioch	0	$0	$0	$0	0.0%
Brentwood	0	$0	$0	$0	0.0%
Clayton	0	$0	$0	$0	0.0%
Concord	0	$0	$0	$0	0.0%
Danville	193	$101,964,894	$50,982,447	$152,947,341	1.5%
El Cerrito	2,800	$925,192,159	$516,769,244	$1,441,961,403	26.4%
Hercules	0	$0	$0	$0	0.0%
Lafayette	2,675	$1,237,954,144	$669,576,094	$1,907,530,238	29.2%
Martinez	943	$560,111,800	$452,403,858	$1,012,515,658	11.4%
Moraga	0	$0	$0	$0	0.0%
Oakley	0	$0	$0	$0	0.0%
Orinda	1,593	$651,598,388	$347,887,697	$999,486,085	21.1%
Pinole	30	$10,671,917	$5,335,958	$16,007,875	0.4%
Pittsburg	0	$0	$0	$0	0.0%
Pleasant Hill	0	$0	$0	$0	0.0%
Richmond	553	$191,999,610	$109,299,762	$301,299,372	1.1%
San Pablo	0	$0	$0	$0	0.0%
San Ramon	0	$0	$0	$0	0.0%
Walnut Creek	0	$0	$0	$0	0.0%
Unincorporated	5,298	$2,142,545,829	$1,186,919,669	$3,329,465,498	8.1%
Total	14,085	$5,822,038,741.09	$3,339,174,729.82	$9,161,213,471	3.7%

Table 13-5. Exposure and Value of Structures in High Wildfire Hazard Areas

Jurisdiction	Buildings Exposed	Value Exposed			% of Total Replacement Value
		Structure	Contents	**Total**	
Antioch	0	$0	$0	$0	0.0%
Brentwood	0	$0	$0	$0	0.0%
Clayton	0	$0	$0	$0	0.0%
Concord	0	$0	$0	$0	0.0%
Danville	0	$0	$0	$0	0.0%
El Cerrito	0	$0	$0	$0	0.0%
Hercules	0	$0	$0	$0	0.0%
Lafayette	0	$0	$0	$0	0.0%
Martinez	84	$53,501,447	$26,750,723	$80,252,170	0.9%
Moraga	0	$0	$0	$0	0.0%
Oakley	0	$0	$0	$0	0.0%
Orinda	0	$0	$0	$0	0.0%
Pinole	0	$0	$0	$0	0.0%
Pittsburg	0	$0	$0	$0	0.0%
Pleasant Hill	0	$0	$0	$0	0.0%
Richmond	0	$0	$0	$0	0.0%
San Pablo	0	$0	$0	$0	0.0%
San Ramon	1	$488,888	$244,444	$733,331	0.0%
Walnut Creek	0	$0	$0	$0	0.0%
Unincorporated	5,617	$2,823,891,364	$1,642,786,201	$4,466,677,565	10.9%
Total	5,702	$2,877,881,698.31	$1,669,781,367.78	$4,547,663,066	1.8%

Table 13-6. Exposure and Value of Structures in Moderate Wildfire Hazard Areas

Jurisdiction	Buildings Exposed	Value Exposed			% of Total Replacement Value
		Structure	Contents	**Total**	
Antioch	0	$0	$0	$0	0.0%
Brentwood	0	$0	$0	$0	0.0%
Clayton	0	$0	$0	$0	0.0%
Concord	0	$0	$0	$0	0.0%
Danville	0	$0	$0	$0	0.0%
El Cerrito	0	$0	$0	$0	0.0%
Hercules	0	$0	$0	$0	0.0%
Lafayette	0	$0	$0	$0	0.0%
Martinez	0	$0	$0	$0	0.0%
Moraga	0	$0	$0	$0	0.0%
Oakley	0	$0	$0	$0	0.0%
Orinda	0	$0	$0	$0	0.0%
Pinole	0	$0	$0	$0	0.0%
Pittsburg	0	$0	$0	$0	0.0%
Pleasant Hill	0	$0	$0	$0	0.0%
Richmond	0	$0	$0	$0	0.0%
San Pablo	0	$0	$0	$0	0.0%
San Ramon	4,159	$2,008,636,868	$1,106,297,587	$3,114,934,455	15.7%
Walnut Creek	0	$0	$0	$0	0.0%
Unincorporated	1,785	$1,233,350,847	$921,019,152	$2,154,369,999	5.3%
Total	5,944	$3,241,987,714.80	$2,027,316,739.11	$5,269,304,454	2.1%

Table 13-7. Land Use Within the Wildfire Hazard Areas

Land Use	Moderate FHSZ		High FHSZ		Very High FHSZ	
	Area (acres)	% of total	Area (acres)	% of total	Area (acres)	% of total
Residential	1,912	4.4%	7,455	5.8%	7,189	17.7%
Commercial	1,147	2.7%	9,725	7.6%	3,186	7.9%
Industrial	659	1.5%	371	0.3%	59	0.1%
Agriculture	4,186	9.7%	11,216	8.7%	295	0.7%
Religion	8	0.0%	32	0.0%	37	0.1%
Government	1,436	3.3%	4,442	3.5%	2,834	7.0%
Education	138	0.3%	324	0.3%	184	0.5%
Vacant, Rights-of-way, Open water, Open Space	33,621	78.0%	94,946	73.9%	26,782	66.0%
Total	43,106	100%	128,511	100%	40,567	100%

Table 13-8. Critical Facilities in Very High Wildfire Risk Areas

	Number of Facilities in the Floodplain					
	Protective Functions	Government Functions	Schools and Educational Facilities	Medical Facilities	Hazardous Materials	**Total**
Antioch	0	0	0	0	0	0
Brentwood	0	0	0	0	0	0
Clayton	0	0	0	0	0	0
Concord	0	0	0	0	0	0
Danville	0	0	0	0	0	0
El Cerrito	1	0	4	0	0	5
Hercules	0	0	0	0	0	0
Lafayette	1	0	3	0	0	4
Martinez	1	1	2	0	0	4
Moraga	0	0	0	0	0	0
Oakley	0	0	0	0	0	0
Orinda	0	0	1	0	0	1
Pinole	0	0	0	0	0	0
Pittsburg	0	0	0	0	0	0
Pleasant Hill	0	0	0	0	0	0
Richmond	0	0	0	0	0	0
San Pablo	0	0	0	0	0	0
San Ramon	0	0	0	0	0	0
Walnut Creek	0	0	0	0	0	0
Unincorporated	5	0	6	0	0	11
Total	8	1	16	0	0	25

Table 13-9. Critical Infrastructure in Very High Wildfire Risk Areas

	Number of Facilities in the Floodplain							
	Power	Communications	Water Supply	Wastewater	Bridges	Other Critical Functions	Other Critical Infrastructure	**Total**
Antioch	0	0	0	0	0	0	0	0
Brentwood	0	0	0	0	0	0	0	0
Clayton	0	0	0	0	0	0	0	0
Concord	0	0	0	0	0	0	0	0
Danville	0	0	0	0	0	0	0	0
El Cerrito	0	1	0	1	0	1	0	3
Hercules	0	0	0	0	0	0	0	0
Lafayette	0	0	0	0	2	0	0	2
Martinez	0	0	4	0	1	0	0	5
Moraga	0	0	0	0	0	0	0	0
Oakley	0	0	0	0	0	0	0	0
Orinda	0	1	2	3	3	0	1	10
Pinole	0	0	0	0	0	0	0	0
Pittsburg	0	0	0	0	0	0	0	0
Pleasant Hill	0	0	0	0	0	0	0	0
Richmond	0	0	0	1	1	0	0	2
San Pablo	0	0	0	0	0	0	0	0
San Ramon	0	0	0	0	0	0	0	0
Walnut Creek	0	0	0	0	0	0	0	0
Unincorporated	2	1	6	4	1	0	1	15
Total	2	3	12	9	8	0	2	37

Table 13-10. Critical Facilities in High Wildfire Risk Areas

	Number of Facilities in the Floodplain					
	Protective Functions	Government Functions	Schools and Educational Facilities	Medical Facilities	Hazardous Materials	**Total**
Antioch	0	0	0	0	0	0
Brentwood	0	0	0	0	0	0
Clayton	0	0	0	0	0	0
Concord	0	0	0	0	0	0
Danville	0	0	0	0	0	0
El Cerrito	0	0	0	0	0	0
Hercules	0	0	0	0	0	0
Lafayette	0	0	0	0	0	0
Martinez	1	0	0	0	0	1
Moraga	0	0	0	0	0	0
Oakley	0	0	0	0	0	0
Orinda	0	0	0	0	0	0
Pinole	0	0	0	0	0	0
Pittsburg	0	0	0	0	0	0
Pleasant Hill	0	0	0	0	0	0
Richmond	0	0	0	0	0	0
San Pablo	0	0	0	0	0	0
San Ramon	0	0	0	0	0	0
Walnut Creek	0	0	0	0	0	0
Unincorporated	9	0	4	1	1	15
Total	10	0	4	1	1	16

Table 13-11. Critical Infrastructure in High Wildfire Risk Areas

	Number of Facilities in the Floodplain							
	Power	Communications	Water Supply	Wastewater	Bridges	Other Critical Functions	Other Critical Infrastructure	**Total**
Antioch	0	0	0	0	0	0	0	0
Brentwood	0	0	0	0	0	0	0	0
Clayton	0	0	0	0	0	0	0	0
Concord	0	0	0	0	0	0	0	0
Danville	0	0	0	0	0	0	0	0
El Cerrito	0	0	0	0	0	0	0	0
Hercules	0	0	0	0	0	0	0	0
Lafayette	0	0	0	0	0	0	0	0
Martinez	0	0	4	0	0	0	0	4
Moraga	0	0	0	0	0	0	0	0
Oakley	0	0	0	0	0	0	0	0
Orinda	0	0	0	0	0	0	0	0
Pinole	0	0	0	0	0	0	0	0
Pittsburg	0	0	0	0	0	0	0	0
Pleasant Hill	0	0	0	0	0	0	0	0
Richmond	0	0	0	0	0	0	0	0
San Pablo	0	0	0	0	0	0	0	0
San Ramon	0	0	0	0	0	0	0	0
Walnut Creek	0	0	0	0	0	0	0	0
Unincorporated	2	10	7	1	16	1	6	43
Total	2	10	11	1	16	1	6	47

Table 13-12. Critical Facilities in Moderate Wildfire Risk Areas

	Number of Facilities in the Floodplain					
	Protective Functions	Government Functions	Schools and Educational Facilities	Medical Facilities	Hazardous Materials	**Total**
Antioch	0	0	0	0	0	0
Brentwood	0	0	0	0	0	0
Clayton	0	0	0	0	0	0
Concord	0	0	0	0	0	0
Danville	0	0	0	0	0	0
El Cerrito	0	0	0	0	0	0
Hercules	0	0	0	0	0	0
Lafayette	0	0	0	0	0	0
Martinez	0	0	0	0	0	0
Moraga	0	0	0	0	0	0
Oakley	0	0	0	0	0	0
Orinda	0	0	0	0	0	0
Pinole	0	0	0	0	0	0
Pittsburg	0	0	0	0	0	0
Pleasant Hill	0	0	0	0	0	0
Richmond	0	0	0	0	0	0
San Pablo	0	0	0	0	0	0
San Ramon	0	0	5	0	0	5
Walnut Creek	0	0	0	0	0	0
Unincorporated	0	0	0	0	0	0
Total	0	0	5	0	0	5

Table 13-13. Critical Infrastructure in Moderate Wildfire Risk Areas

	Number of Facilities in the Floodplain							
	Power	Communications	Water Supply	Wastewater	Bridges	Other Critical Functions	Other Critical Infrastructure	**Total**
Antioch	0	0	0	0	0	0	0	0
Brentwood	0	0	0	0	0	0	0	0
Clayton	0	0	0	0	0	0	0	0
Concord	0	0	0	0	0	0	0	0
Danville	0	0	0	0	0	0	0	0
El Cerrito	0	0	0	0	0	0	0	0
Hercules	0	0	0	0	0	0	0	0
Lafayette	0	0	0	0	0	0	0	0
Martinez	0	0	0	0	0	0	0	0
Moraga	0	0	0	0	0	0	0	0
Oakley	0	0	0	0	0	0	0	0
Orinda	0	0	0	0	0	0	0	0
Pinole	0	0	0	0	0	0	0	0
Pittsburg	0	0	0	0	0	0	0	0
Pleasant Hill	0	0	0	0	0	0	0	0
Richmond	0	0	0	0	0	0	0	0
San Pablo	0	0	0	0	0	0	0	0
San Ramon	0	0	0	0	0	0	0	0
Walnut Creek	0	0	0	0	0	0	0	0
Unincorporated	0	6	3	0	13	1	6	29
Total	0	6	3	0	13	1	6	29

13.4.4 Environment

Fire is a natural and critical ecosystem process in most terrestrial ecosystems, dictating in part the types, structure, and spatial extent of native vegetation. However, wildfires can cause severe environmental impacts:

- Damaged Fisheries—Critical fisheries can suffer from increased water temperatures, sedimentation, and changes in water quality.
- Soil Erosion—The protective covering provided by foliage and dead organic matter is removed, leaving the soil fully exposed to wind and water erosion. Accelerated soil erosion occurs, causing landslides and threatening aquatic habitats.
- Spread of Invasive Plant Species—Non-native woody plant species frequently invade burned areas. When weeds become established, they can dominate the plant cover over broad landscapes, and become difficult and costly to control.
- Disease and Insect Infestations—Unless diseased or insect-infested trees are swiftly removed, infestations and disease can spread to healthy forests and private lands. Timely active management actions are needed to remove diseased or infested trees.
- Destroyed Endangered Species Habitat—Fire can have devastating consequences for endangered species.
- Soil Sterilization—Topsoil exposed to extreme heat can become water repellant, and soil nutrients may be lost. It can take decades or even centuries for ecosystems to recover from a fire. Some fires burn so hot that they can sterilize the soil.

Many ecosystems are adapted to historical patterns of fire. These patterns, called “fire regimes,” include temporal attributes (e.g., frequency and seasonality), spatial attributes (e.g., size and spatial complexity), and magnitude attributes (e.g., intensity and severity), each of which have ranges of natural variability. Ecosystem stability is threatened when any of the attributes for a given fire regime diverge from its range of natural variability.

13.5 VULNERABILITY

Structures, above-ground infrastructure, critical facilities and natural environments are all vulnerable to the wildfire hazard. There is currently no validated damage function available to support wildfire mitigation planning. Except as discussed in this section, vulnerable populations, property, infrastructure and environment are assumed to be the same as described in the section on exposure.

13.5.1 Population

There are no recorded incidents of loss of life from wildfires within the planning area. Given the immediate response times to reported fires, the likelihood of injuries and casualties is minimal; therefore, injuries and casualties were not estimated for the wildfire hazard.

Smoke and air pollution from wildfires can be a severe health hazard, especially for sensitive populations, including children, the elderly and those with respiratory and cardiovascular diseases. Smoke generated by wildfire consists of visible and invisible emissions that contain particulate matter (soot, tar, water vapor, and minerals), gases (carbon monoxide, carbon dioxide, nitrogen oxides), and toxics (formaldehyde, benzene). Emissions from wildfires depend on the type of fuel, the moisture content of the fuel, the efficiency (or temperature) of combustion, and the weather. Public health impacts associated with wildfire include difficulty in breathing, odor, and reduction in visibility.

Wildfire may also threaten the health and safety of those fighting the fires. First responders are exposed to the dangers from the initial incident and after-effects from smoke inhalation and heat stroke.

13.5.2 Property

Loss estimations for the wildfire hazard are not based on damage functions, because no such damage functions have been generated. Instead, loss estimates were developed representing 10 percent, 30 percent and 50 percent of the replacement value of exposed structures. This allows emergency managers to select a range of economic impact based on an estimate of the percent of damage to the general building stock. Damage in excess of 50 percent is considered to be substantial by most building codes and typically requires total reconstruction of the structure. Table 13-14 lists the loss estimates for the general building stock for jurisdictions that have an exposure to the moderate, high, and very high fire hazard severity zone.

13.5.3 Critical Facilities and Infrastructure

Critical facilities of wood frame construction are especially vulnerable during wildfire events. In the event of wildfire, there would likely be little damage to most infrastructure. Most roads and railroads would be without damage except in the worst scenarios. Power lines are the most at risk from wildfire because most poles are made of wood and susceptible to burning. Fires can create conditions that block or prevent access and can isolate residents and emergency service providers. Wildfire typically does not have a major direct impact on bridges, but it can create conditions in which bridges are obstructed. Many bridges in areas of high to moderate fire risk are important because they provide the only ingress and egress to large areas and in some cases to isolated neighborhoods.

13.6 FUTURE TRENDS IN DEVELOPMENT

The planning area has experienced moderate growth over the past 16 years, averaging a 1.1 percent increase in population every year from 2000 through 2015. All municipalities have experienced growth. Table 13-15 summarizes developable land by land use in fire hazard severity zones.

Table 13-14. Loss Estimates for Wildfire in Combined Moderate, High and Very High FHSZ

Jurisdiction	Exposed Value	Estimated Loss Potential from Wildfire		
		10% Damage	30% Damage	50% Damage
Antioch	$0	$0	$0	$0
Brentwood	$0	$0	$0	$0
Clayton	$0	$0	$0	$0
Concord	$0	$0	$0	$0
Danville	$152,947,341	$15,294,734	$45,884,202	$76,473,671
El Cerrito	$1,441,961,403	$144,196,140	$432,588,421	$720,980,702
Hercules	$0	$0	$0	$0
Lafayette	$1,907,530,238	$190,753,024	$572,259,071	$953,765,119
Martinez	$1,092,767,828	$109,276,783	$327,830,349	$546,383,914
Moraga	$0	$0	$0	$0
Oakley	$0	$0	$0	$0
Orinda	$999,486,085	$99,948,608	$299,845,825	$499,743,042
Pinole	$16,007,875	$1,600,787	$4,802,362	$8,003,937
Pittsburg	$0	$0	$0	$0
Pleasant Hill	$0	$0	$0	$0
Richmond	$301,299,372	$30,129,937	$90,389,812	$150,649,686
San Pablo	$0	$0	$0	$0
San Ramon	$3,115,667,787	$311,566,779	$934,700,336	$1,557,833,893
Walnut Creek	$0	$0	$0	$0
Unincorporated	$9,950,513,061	$995,051,306	$2,985,153,918	$4,975,256,531
Total	$18,978,180,991	$1,897,818,099	$5,693,454,297	$9,489,090,495

Table 13-15. Developable Land in Fire Hazard Severity Zones

	Moderate Wildfire Risk		High Wildfire Risk		Very High Wildfire Risk	
	Area of Developable Land in FHSZ (acres)	% of Total Developable Land in FHSZ	Area of Developable Land in FHSZ (acres)	% of Total Developable Land in FHSZ	Area of Developable Land in FHSZ (acres)	% of Total Developable Land in FHSZ
Residential	370.5	84.5%	1,101.7	99.0%	709.8	99.8%
Commercial-Industrial	17.2	3.9%	10.8	1.0%	0.0	0.0%
Mixed Use	50.8	11.6%	0.5	0.0%	1.4	0.2%
Total	438.5	100.0%	1,112.9	100.0%	711.2	100.0%

Source: Contra Costa County, 2016.

The highly urbanized portions of the planning area have little or no wildfire risk exposure. Urbanization tends to alter the natural fire regime, and can create the potential for the expansion of urbanized areas into wildland areas. The expansion of the wildland urban interface can be managed with strong land use and building codes. The planning area is well equipped with these tools and this planning process has assessed capabilities with regards to the tools. As the planning area experiences future growth, it is anticipated that the exposure to this hazard will remain as assessed or even decrease over time due to these capabilities.

13.7 SCENARIO

A major wildfire in the planning area might begin with a wet spring, adding to fuels already present on the forest floor. Flashy fuels would build throughout the spring. The summer could see the onset of insect infestation. A dry summer could follow the wet spring, exacerbated by dry hot winds. Carelessness with combustible materials or a tossed lit cigarette, or a sudden lighting storm could trigger a multitude of small isolated fires.

The embers from these smaller fires could be carried miles by hot, dry winds. The deposition zone for these embers would be deep in the forests and interface zones. Fires that start in flat areas move slower, but wind still pushes them. It is not unusual for a wildfire pushed by wind to burn the ground fuel and later climb into the crown and reverse its track. This is one of many ways that fires can escape containment, typically during periods when response capabilities are overwhelmed. These new small fires would most likely merge. Suppression resources would be redirected from protecting the natural resources to saving more remote subdivisions.

The worst-case scenario would include an active fire season throughout the American west, spreading resources thin. Firefighting teams would be exhausted or unavailable. Many federal assets would be responding to other fires that started earlier in the season.

To further complicate the problem, heavy rains could follow, causing flooding and landslides and releasing tons of sediment into rivers, permanently changing floodplains and damaging sensitive habitat and riparian areas. Such a fire followed by rain could release millions of cubic yards of sediment into streams for years, creating new floodplains and changing existing ones. With the forests removed from the watershed, stream flows could easily double. Floods that could be expected every 50 years may occur every couple of years. With the streambeds unable to carry the increased discharge because of increased sediment, the floodplains and floodplain elevations would increase.

13.8 ISSUES

The major issues for wildfire are the following:

- Public education and outreach to people living in or near the fire hazard zones should include information about and assistance with mitigation activities such as defensible space, and advance identification of evacuation routes and safe zones.
- Wildfires could cause landslides as a secondary natural hazard.
- Climate change could affect the wildfire hazard.
- Future housing growth into interface areas should continue to be managed.
- Area fire districts need to continue to train on wildland-urban interface events.
- Vegetation management activities. This would include enhancement through expansion of the target areas as well as additional resources.
- Regional consistency of higher building code standards such as residential sprinkler requirements and prohibitive combustible roof standards.
- Fire department water supply in high risk wildfire areas.
- Expand certifications and qualifications for fire department personnel. Ensure that all firefighters are trained in basic wildfire behavior, basic fire weather, and that all company officers and chief level officers are trained in the wildland command and strike team leader level.

14. CLIMATE CHANGE

14.1 GENERAL BACKGROUND

14.1.1 What is Climate Change?

Climate, consisting of patterns of temperature, precipitation, humidity, wind and seasons, plays a fundamental role in shaping natural ecosystems and the human economies and cultures that depend on them. “Climate change” refers to changes over a long period of time. Worldwide, average temperatures have increased 1.78ºF since 1880 (NASA, 2017). Although this change may seem small, it can lead to large changes in climate and weather.

The warming trend and its related impacts are caused by increasing concentrations of carbon dioxide and other greenhouse gases in the earth’s atmosphere. Greenhouse gases are gases that trap heat in the atmosphere, resulting in a warming effect. Carbon dioxide is the most commonly known greenhouse gas; however, methane, nitrous oxide and fluorinated gases also contribute to warming. Emissions of these gases come from a variety of sources, such as the combustion of fossil fuels, agricultural production, changes in land use and volcanic eruptions. According to the U.S. Environmental Protection Agency (EPA), carbon dioxide concentrations measured about 280 parts per million before the industrial era began in the late 1700s and reached 401 parts per million in 2015 (EPA, 2016) (see Figure 14-1). In addition, the concentration of methane has almost doubled and nitrous oxide is being measured at a record high of 328 parts per billion (EPA, 2016a). In the United States, electricity generation is the largest source of these emissions, followed by transportation (EPA, 2016b).

Scientists are able to place this rise in carbon dioxide in a longer historical context through the measurement of carbon dioxide in ice cores. According to these records, carbon dioxide concentrations in the atmosphere are the highest that they have been in 650,000 years (NASA, 2016). According to NASA, most of this trend is very likely human-induced and it is proceeding at an unprecedented rate (NASA, 2016a). There is broad scientific consensus (97 percent of scientists) that climate-warming trends are very likely due to human activities (NASA, 2016b). Unless emissions of greenhouse gases are substantially reduced, this warming trend is expected to continue.

Climate change will affect the people, property, economy and ecosystems of the planning area in a variety of ways. Climate change impacts are most frequently associated with negative consequences, such as increased flood vulnerability or increased heat-related illnesses/public health concerns; however, other changes may present opportunities. The most important effect for the development of this plan is that climate change will have a measurable impact on the occurrence and severity of natural hazards.

14.1.2 How Climate Change Affects Hazard Mitigation

An essential aspect of hazard mitigation is predicting the likelihood of hazard events. Typically, predictions are based on statistical projections from records of past events. This approach assumes that the likelihood of hazard events remains essentially unchanged over time. Thus, averages based on the past frequencies of, for example, floods are used to estimate future frequencies: if a river has flooded an average of once every 5 years for the past 100 years, then it can be expected to continue to flood an average of once every 5 years.

Source: EPA, 2016

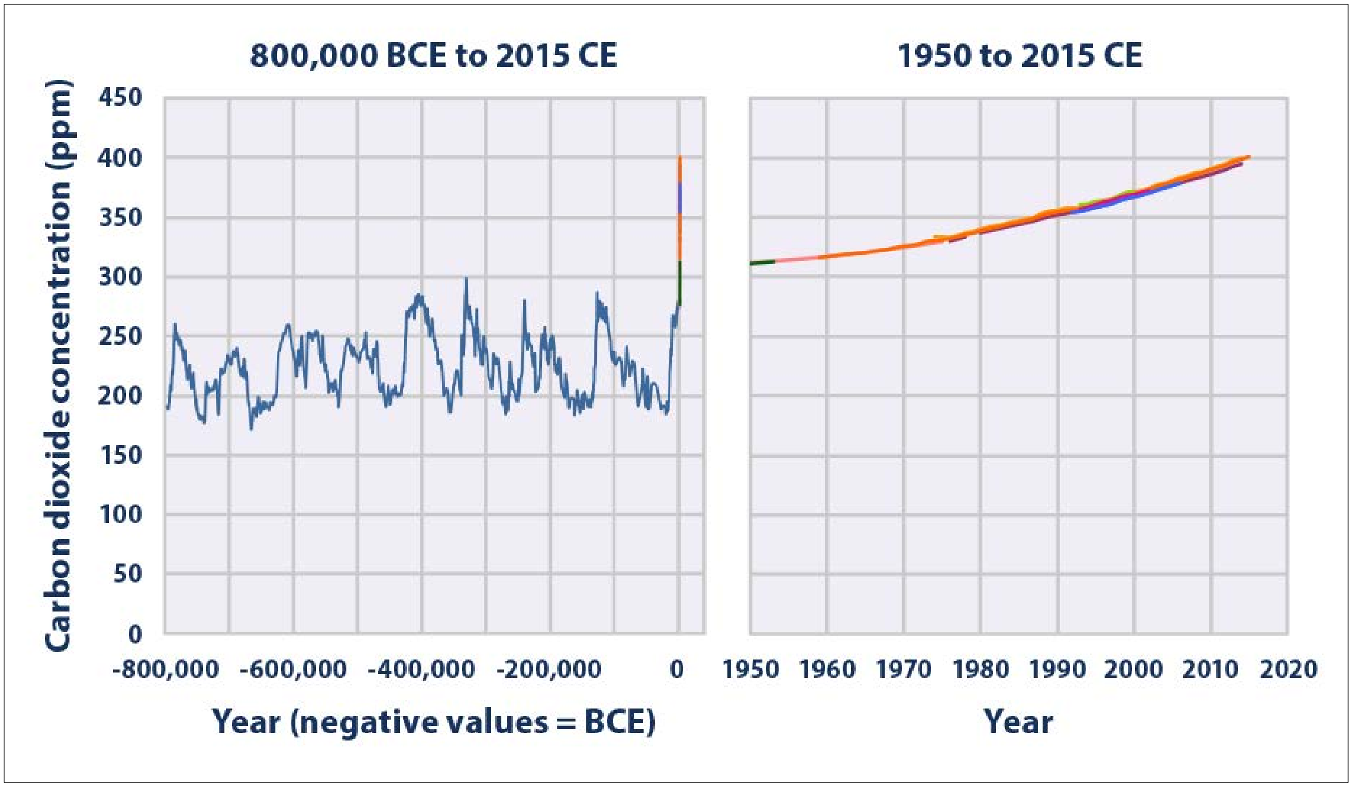


Figure 14-1. Global Carbon Dioxide Concentrations Over Time

For hazards that are affected by climate conditions, the assumption that future behavior will be equivalent to past behavior is not valid if climate conditions are changing. As flooding is generally associated with precipitation frequency and quantity, for example, the frequency of flooding will not remain constant if broad precipitation patterns change over time. Floods currently considered to be 1-percent-annual-chance events (100-year floods) might strike more often, leaving many communities at greater risk. The risks of landslide, severe storms, extreme heat and wildfire are all affected by climate patterns as well. For this reason, an understanding of climate change is pertinent to efforts to mitigate natural hazards. Information about how climate patterns are changing provides insight on the reliability of future hazard projections used in mitigation analysis. This chapter summarizes current understandings about climate change in order to provide a context for the recommendation and implementation of hazard mitigation measures.

14.1.3 Current Indicators of Climate Change

The major scientific agencies of the United States and the world—including NASA, NOAA and the Intergovernmental Panel on Climate Change (IPCC)—agree that climate change is occurring. Multiple temperature records from all over the world have shown a warming trend. The IPCC has stated that the warming of the climate system is unequivocal (IPCC, 2014). Sixteen of the 17 warmest years on record occurred since 2001, and 2016 was the warmest year on record (NASA, 2017a).

Rising global temperatures have been accompanied by other changes in weather and climate. Many places have experienced changes in rainfall resulting in more intense rain, as well as more frequent and severe heat waves (IPCC, 2014a). The planet's oceans and glaciers have also experienced changes: oceans are warming and becoming more acidic, ice caps are melting, and sea levels are rising. Global sea level has risen approximately 6.7 inches, on average, in the last 100 years (NASA, 2016d). This has already put some coastal homes, beaches, roads, bridges, and wildlife at risk (USGCRP, 2009). At the time of the development of this plan, NASA reports the following trends (NASA, 2017):

- Carbon Dioxide—Increasing trend, currently at 406.17 parts per million
- Global Temperature—Increasing trend, increase of 1.7ºF since 1880
- Arctic Ice Minimum—Decreasing trend, 13.3 percent per decade
- Land Ice—Decreasing trend, 287.0 gigatonnes per year
- Sea Level—Increasing trend, 3.4 millimeters (0.04 inches) per year.

14.1.4 Projected Future Impacts

The *Third National Climate Assessment Report for the United States* indicates that impacts resulting from climate change will continue through the 21st century and beyond. Although not all changes are understood at this time and the impacts of those changes will depend on global emissions of greenhouse gases and sensitivity in human and natural systems, the following impacts are expected in the United States (NASA, 2014):

- Temperatures will continue to rise.
- Growing seasons will lengthen.
- Precipitation patterns will change.
- Droughts and heat waves will increase.
- Hurricanes will become stronger and more intense.
- Sea level will rise 1 to 4 feet by 2100.
- The Arctic may become ice free.

The *California Climate Adaptation Planning Guide* outlines the following climate change impact concerns for Bay Area communities (Cal EMA et al., 2012):

- Increased temperature
- Reduced precipitation
- Sea level rise – coastal inundation and erosion
- Public health – heat and air pollution
- Reduced agricultural productivity
- Inland flooding
- Reduced tourism.

Some of these changes are direct or primary climatic changes, such as increased temperature, while others are indirect climatic changes or secondary impacts resulting from these direct changes, such as heat and air pollution. Some direct changes may interact with one another to create unique secondary impacts. These primary and secondary impacts may then result in impacts on human and natural systems. The primary and secondary impacts likely to affect the planning area are summarized in Table 14-1.

Climate change projections contain inherent uncertainty, largely derived from the fact that they depend on future greenhouse gas emission scenarios. Generally, the uncertainty in greenhouse gas emissions is addressed by the presentation of differing scenarios: low-emissions or high-emissions scenarios. In low-emissions scenarios, greenhouse gas emissions are reduced substantially from current levels. In high-emissions scenarios, greenhouse gas emissions generally increase or continue at current levels. Uncertainty in outcomes is generally addressed by averaging a variety of model outcomes.

Table 14-1. Summary of Primary and Secondary Impacts

Primary Impact	Secondary Impact	Example Human and Natural System Impacts
Increased temperature	Heat wave	• Increased frequency of illness and death • Increased stress on mechanical systems, such as HVAC systems
Increased temperature and changes in precipitation	Changed seasonal patterns	• Reduced agricultural productivity • Reduced tourism
	Intense rainstorms	• Increased frequency of flood or flash flood events • Reduction in water quality
Increased temperature and/or reduced precipitation	Drought	• Reduced agricultural productivity • Decreased water supply
	Reduced Snowpack	• Decreased water supply • Reduced tourism
	Wildfire	• Increased incidence of landslide or mudslide • Reduced tourism • Increase in air pollution and related health impacts
Sea level rise	Permanent inundation of previously dry land	• Loss of assets and tax base • Loss of coastal habitat
	Larger area impacted by extreme high tide	• More people and structures impacted by storms • Increased incidence of loss of utilities and lifeline systems
	Increased coastal erosion	• Loss of assets and tax base
	Saltwater intrusion into freshwater systems	• Decreased water supply • Ecosystem disruption
Changes in wind patterns	Increased extreme events, including severe storms and fires	• More frequent disruption to systems resulting from severe storms
Ocean acidification		• Decreased biodiversity in marine ecosystems

Source: Adapted and expanded from California Adaptation Planning Guide: Planning for Adaptive Communities

Despite this uncertainty, climate change projections present valuable information to help guide decision-making for possible future conditions. The following sections summarize information developed for the planning area by Cal-Adapt, a resource for public information on how climate change might impact local communities, based on the most current data available. The projections are averaged across the county-wide planning area and include information from two emissions scenarios, which were developed by the IPCC:

- Low Emissions Scenario—Emissions peak around 2040 and then decline (this was designated Scenario B1 in previous IPCC analyses but is Scenario RCP 4.5 under more recent IPCC analyses)
- High Emissions Scenario—In RCP 8.5 emissions continue to rise strongly through 2050 and plateau around 2100 (this was designated Scenario A2 in previous IPCC analyses but is Scenario RCP 8.5 under more recent IPCC analyses).

Temperature

The historical (1950-2005) average maximum temperature in Contra Costa County was 71.4ºF and the average minimum temperature was 47.8ºF. While average temperatures may fluctuate from year-to-year, and may differ from one municipality to the next, the trend for the County indicates that average temperatures are increasing (see Figure 14-2). The annual average maximum temperature increased by 0.7 ºF when comparing 1950 to 1990 and 1990 to 2005 records. Average temperatures are expected to continue to rise. Table 14-2 shows the estimated average temperatures for 2050 and 2099 under the low and high emission scenario.

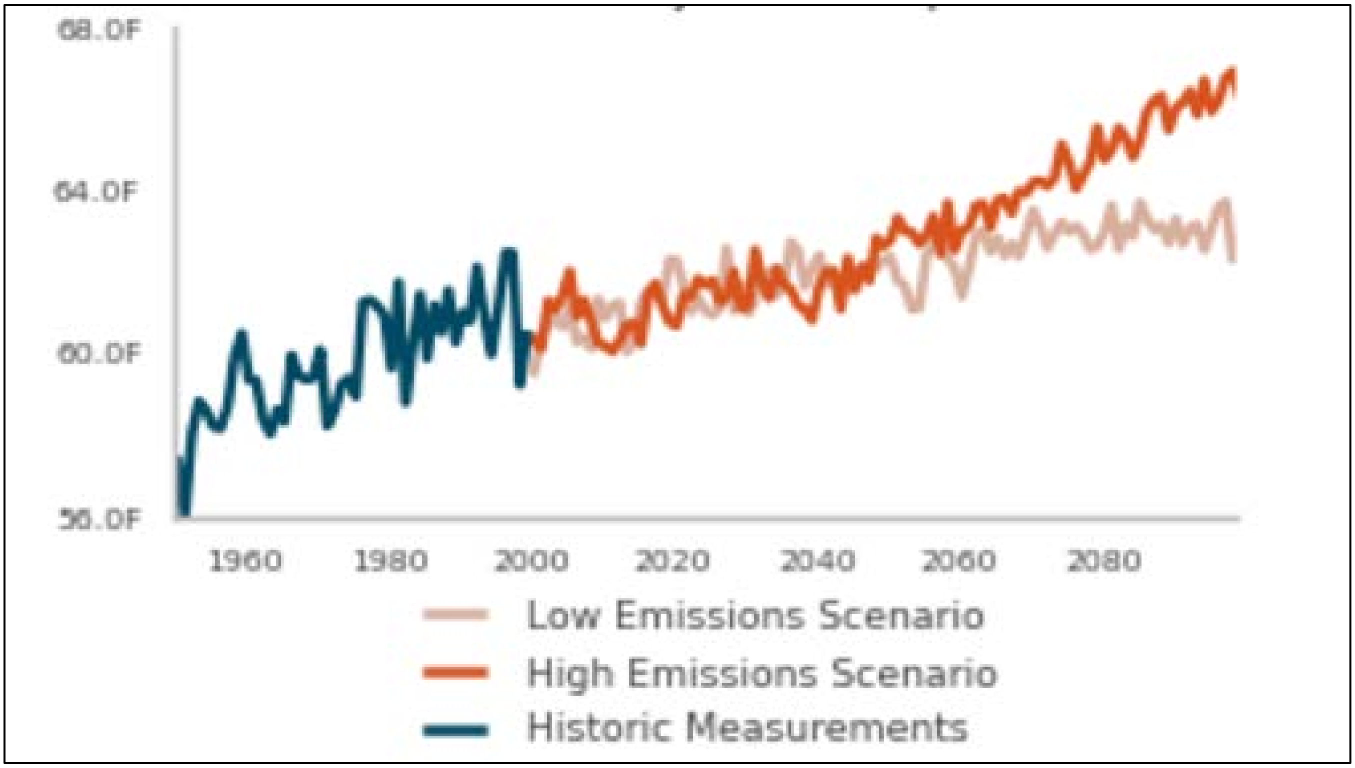


Figure 14-2. Observed and Projected Average Temperatures in Contra Costa County

Table 14-2. Average Temperature Projections in Contra Costa County

	2050 Projection (°F)				2099 Projection (°F)			
	Average Temperature		Difference from Historical Average		Average Temperature		Difference from Historical Average	
Emission Scenario	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Low Emissions (RCP 4.5)	75.3	51.7	+4.1	+3.9	75.5	52.5	+4.3	+4.7
High Emissions (RCP 8.5)	75.9	52.3	+4.8	+4.5	80.3	57.5	+9.1	+9.7

Extreme Heat

The extreme heat day temperature threshold for the planning area is 96.8°F. The historical average (1961-1990) number of extreme heat days is 4.3 days. In the low-emissions scenario, there are projected to be an annual average of 13 days with temperatures over the extreme heat day threshold between 2017 and 2050 and an average of 19 days per year between 2051 and 2099. In the high-emissions scenario, there are projected to be an annual average of 14 days with temperatures over the extreme heat day threshold between 2017 and 2050 and an average of 32 days per year between 2051 and 2099 (see Figure 14-3).

Precipitation

Precipitation projections for California remain uncertain. On average, total annual precipitation in the state is not projected to change substantially; however, modeled projections do not show a consistent trend. In general, most precipitation is expected to continue to fall during the winter. Small changes in precipitation patterns in the state will have the potential to cause significant disruption to built and natural systems.

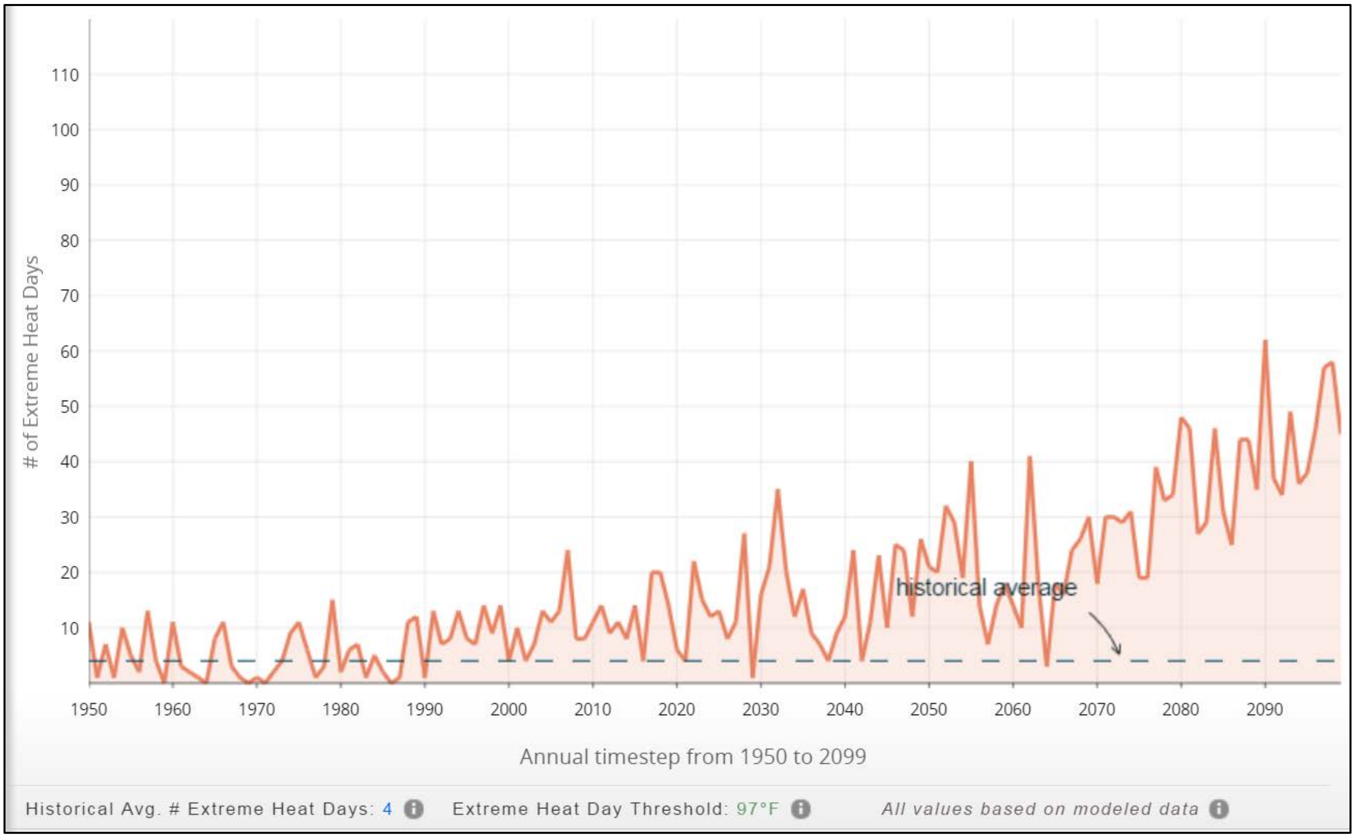


Figure 14-3. Projected Number of Extreme Heat Days by Year in Contra Costa County

Cal-Adapt shows that the historical annual mean precipitation (1950-2005) for Contra Costa County was 19 inches. Under the low emission scenario, annual precipitation is expected to average 21.2 inches from 2017 to 2050 and 20.3 inches from 2017 to 2099. For the high emission scenario annual precipitation is expected to average 20.3 inches from 2017 to 2050 and 22.1 inches from 2051 to 2099.

Snowpack

While there are no snow-water equivalency measurements for the planning area, Cal-Adapt indicates that changes in precipitation patterns may result in a reduction in snowpack. For example, Sierra Nevada snowpack may be reduced by as much as 70 to 90 percent.

Wildfire

Wildfire risk is expected to change in the coming decades (see Figure 14-4). Under both high- and low-emissions scenarios, the change in area burned in Contra Costa County decreases by 10 to 20 percent by 2050.

Sea Level Rise

Sea levels have been rising over the past several decades and are expected to continue to rise. Sea level rise is mostly attributed to two factors: the expansion of water as it warms (thermal expansion) and the melting of ice sheets and glaciers. As average ocean temperatures continue to increase, thermal expansion will continue and can be projected with some degree of certainty. Less certain is how quickly ice sheets will melt, accounting for most of the uncertainty in projections.

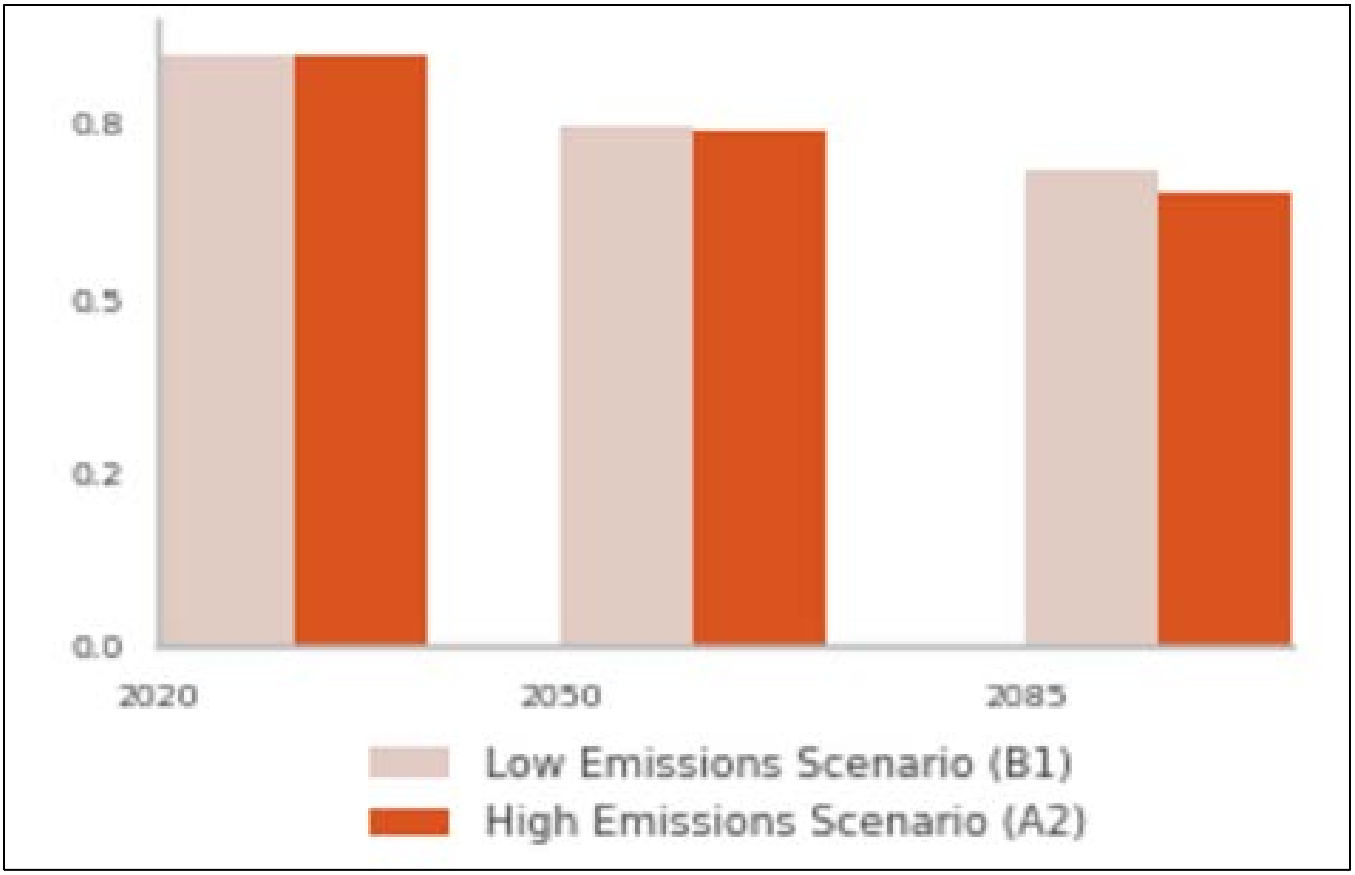


Figure 14-4. Projected Changes in Fire Risk in Contra Costa County, Relative to 2010 Levels

Sea level rise will cause currently dry areas to be permanently or chronically inundated. Temporary inundation from extreme tide events and storm surge also will change. Unlike many other impacts resulting from climate change, sea level rise will have a defined extent and location. This allows for a more-detailed risk assessment to be conducted for this climate change impact. Although the extent and timing of sea level rise is still uncertain, conducting an assessment of potential areas at risk provides information appropriate for planning purposes.

14.1.5 Responses to Climate Change

Communities and governments worldwide are working to address, evaluate and prepare for climate changes that are likely to impact communities in coming decades. Generally, climate change discussions encompass two separate but inter-related considerations: mitigation and adaptation. The term "mitigation" can be confusing, because its meaning changes across disciplines:

- Mitigation in restoration ecology and related fields generally refers to policies, programs or actions that are intended to reduce or to offset the negative impacts of human activities on natural systems. Generally, mitigation can be understood as avoiding, minimizing, rectifying, reducing or eliminating, or compensating for known impacts.
- Mitigation in climate change discussions is defined as "a human intervention to reduce the impact on the climate system." It includes strategies to reduce greenhouse gas sources and emissions and enhance greenhouse gas sinks (EPA, 2013).
- Mitigation in emergency management is typically defined as the effort to reduce loss of life and property by lessening the impact of disasters (FEMA, 2013).

In this chapter, mitigation is used as defined by the climate change community. In the other chapters of this plan, mitigation is primarily used in an emergency management context.

The IPCC defines adaptation as "the process of adjustment to actual or expected climate and its effects." Mitigation and adaptation are related, as the world's ability to reduce greenhouse gas emissions will affect the degree of adaptation that will be necessary. Some actions can both reduce greenhouse gas emissions and support adaptation to likely future conditions. Some adaptation actions also help communities reach other community goals (often referred to as co-benefits). The ability to adapt to changing conditions is often referred to as adaptive capacity, which is "the ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences" (IPCC, 2014b).

Societies across the world are facing the need to adapt to changing conditions and to identify ways to increase their adaptive capacity. Some efforts are already underway. Farmers are altering crops and agricultural methods to deal with changing rainfall and rising temperature; architects and engineers are redesigning buildings; planners are looking at managing water supplies to deal with droughts or flooding.

Adaptive capacity goes beyond human systems, as some ecosystems are able to adapt to change and to buffer surrounding areas from the impacts of change. Forests can bind soils and hold large volumes of water during times of plenty, releasing it through the year; floodplains can absorb vast volumes of water during peak flows; coastal ecosystems can hold out against storms, attenuating waves and reducing erosion. Other ecosystem services—such as food provision, timber, materials, medicines and recreation—can provide a buffer to societies in the face of changing conditions. Ecosystem-based adaptation is the use of biodiversity and ecosystem services as part of an overall strategy to help people adapt to the adverse effects of climate change. This includes the sustainable management, conservation and restoration of specific ecosystems that provide key services.

Assessment of the current efforts and adaptive capacity of the planning partners participating in this hazard mitigation plan are included in the jurisdiction-specific annexes in Volume 2.

14.2 VULNERABILITY ASSESSMENT— HAZARDS OF CONCERN

The following sections provide information on how each identified hazard of concern for this planning process may be impacted by climate change and how these impacts may alter current exposure and vulnerability to these hazards for the people, property, critical facilities and the environment in the planning area.

14.2.1 Dam and Levee Failure

Climate Change Impacts on the Hazard

On average, changes in California's annual precipitation levels are not expected to be dramatic; however, small changes may have significant impacts for water resource systems, including dams and levees. Dams and levees are designed partly based on assumptions about a river's flow behavior, expressed as hydrographs. Changes in weather patterns can have significant effects on the hydrograph used for the design of a dam or levee. If the hygrograph changes, it is conceivable that the dam or levee can lose some or all of its designed margin of safety, also known as freeboard.

In the case of dams, if freeboard is reduced, dam operators may be forced to release increased volumes earlier in a storm cycle in order to maintain the required margins of safety. Such early releases of increased volumes can increase flood potential downstream. According to the California Department of Water Resources, flood flows on many California rivers have been record-setting since the 1950s. This means that water infrastructure, such as dams, have been forced to manage flows for which they were not designed (DWR, 2007). The California Division of Dam Safety has indicated that climate change may result in the need for increased safety precautions to address higher winter runoff, frequent fluctuations of water levels, and increased potential for sedimentation and debris accumulation from changing erosion patterns and increases in wildfires. According to the Division, climate change also will impact the ability of dam operators to estimate extreme flood events (DWR, 2008).

Dams are constructed with safety features known as “spillways.” Spillways are put in place on dams as a safety measure in the event of the reservoir filling too quickly. Spillway overflow events, often referred to as “design failures,” result in increased discharges downstream and increased flooding potential. Although climate change will not increase the probability of catastrophic dam failure, it may increase the probability of design failures.

For levees, a reduction in freeboard caused by a changing hydrograph means that a levee may no longer protect an area against the design-storm standard for which it was originally built (for example 1-percent-annual chance). This means that risk to the area that a levee is protecting from inundation will increase. Levee accreditation may be rescinded, resulting in currently protected areas being mapped within a flood hazard area.

Exposure, Sensitivity and Vulnerability

Population

Population exposure and vulnerability to the dam and levee failure hazard are unlikely to change as a result of climate change. However, if areas previously protected by accredited levees are mapped in a special flood hazard area, the number of people residing in flood hazard areas may increase.

Property

Property exposure and vulnerability to the dam failure hazard are unlikely to change as a result of climate change. However, if areas previously protected by accredited levees are mapped in a special flood hazard area, the assets considered to be exposed to the flood hazard may increase.

Critical facilities

The exposure and vulnerability of critical facilities are unlikely to change as result of climate change. Dam owners and operators are sensitive to the risk and may need to alter maintenance and operations to account for changes in the hydrograph and increased sedimentation. Critical facility owners and operators in levee failure inundation areas should always be aware of residual risk from flood events that may overtop the levee system.

Environment

The exposure and vulnerability of the environment to dam and levee failure are unlikely to change as a result of climate change. Ecosystem services may be used to mitigate some factors that could increase the risk of design failures, such as increasing the natural water storage capacity in watersheds above dams.

Economy

Changes in the dam failure hazard related to climate change are unlikely to affect the local economy. Economic impacts may result from changes to the levee failure hazard if accreditation is lost.

14.2.2 Drought

Climate Change Impacts on the Hazard

The long-term effects of climate change on regional water resources are unknown, but global water resources are already experiencing the following stresses without climate change:

- Growing populations
- Increased competition for available water
- Poor water quality
- Environmental claims
- Uncertain reserved water rights
- Groundwater overdraft
- Aging urban water infrastructure.

With a warmer climate, droughts could become more frequent, more severe, and longer-lasting. According to the National Climate Assessment, "higher surface temperatures brought about by global warming increase the potential for drought. Evaporation and the higher rate at which plants lose moisture through their leaves both increase with temperature. Unless higher evapotranspiration rates are matched by increases in precipitation, environments will tend to dry, promoting drought conditions" (NCA, 2014a).

Because expected changes in precipitation patterns are still uncertain, the potential impacts and likelihood of drought are uncertain. DWR has noted impacts of climate change on statewide water resources by charting changes in snowpack, sea level, and river flow. As temperatures rise and more precipitation comes in the form of rain instead of snow, these changes will likely continue or grow even more significant. DWR estimates that the Sierra Nevada snowpack, which provides a large amount of the water supply for other parts of the state, will experience a 48- to 65-percent loss by the end of the century compared to historical averages (DWR, 2016b). Increasing temperatures may also increase net evaporation from reservoirs by 15 to 37 percent (DWR, 2013). The planning area's water supply is mostly derived from groundwater and surface water resources. Increased incidence of drought may cause a drawdown in groundwater resources without allowing for the opportunity for aquifer recharge.

Exposure, Sensitivity and Vulnerability

Population

Population exposure and vulnerability to drought are unlikely to increase as a result of climate change. While greater numbers of people may need to engage in behavior change, such as water saving efforts, significant life or health impacts are unlikely.

Property

Property exposure and vulnerability may increase as a result of increased drought resulting from climate change, although this would most likely occur in non-structural property such as crops and landscaping. It is unlikely that structure exposure and vulnerability would increase as a direct result of drought, although secondary impacts of drought, such as wildfire, may increase and threaten structures.

Critical facilities

Critical facility exposure and vulnerability are unlikely to increase as a result of increased drought resulting from climate change; however, critical facility operators may be sensitive to changes and need to alter standard management practices and actively manage resources, particularly in water-related service sectors.

Environment

The vulnerability of the environment may increase as a result of increased drought resulting from climate change. Ecosystems and biodiversity in the Bay Area are already under stress from development and water diversion activities. Prolonged or more frequent drought resulting from climate change may further stress the ecosystems in the region, which include many special status species.

Economy

Increased incidence of drought could increase the potential for impacts on the local economy. Increased drought may impact the wine industry and related tourism activities.

14.2.3 Earthquake

Climate Change Impacts on the Hazard

The impacts of global climate change on earthquake probability are unknown. Some scientists say that melting glaciers could induce tectonic activity. As ice melts and water runs off, tremendous amounts of weight are shifted on the earth's crust. As newly freed crust returns to its original, pre-glacier shape, it could cause seismic plates to slip and stimulate volcanic activity, according to research into prehistoric earthquakes and volcanic activity. NASA and USGS scientists found that retreating glaciers in southern Alaska may be opening the way for future earthquakes (NASA, 2004).

Secondary impacts of earthquakes could be magnified by climate change. Soils saturated by repetitive storms or heavy precipitation could experience liquefaction or an increased propensity for slides during seismic activity due to the increased saturation. Dams storing increased volumes of water due to changes in the hydrograph could fail during seismic events.

Exposure, Sensitivity and Vulnerability

Because impacts on the earthquake hazard are not well understood, increases in exposure and vulnerability of the local resources are not able to be determined.

14.2.4 Flood

Climate Change Impacts on the Hazard

Use of historical hydrologic data has long been the standard of practice for designing and operating water supply and flood protection projects. For example, historical data are used for flood forecasting models and to forecast snowmelt runoff for water supply. This method of forecasting assumes that the climate of the future will be similar to that of the period of historical record. However, the hydrologic record cannot be used to predict changes in frequency and severity of extreme climate events such as floods. Scientists project greater storm intensity with climate change, resulting in more direct runoff and flooding. High frequency flood events (e.g. 10-year floods) in particular will likely increase with a changing climate. What is currently considered a 1-percent-annual-chance (100-year flood) also may strike more often, leaving many communities at greater risk. Going forward, model calibration must happen more frequently, new forecast-based tools must be developed, and a standard of practice that explicitly considers climate change must be adopted.

Climate change is already impacting water resources, and resource managers have observed the following:

- Historical hydrologic patterns can no longer be solely relied upon to forecast the water future.
- Precipitation and runoff patterns are changing, increasing the uncertainty for water supply and quality, flood management and ecosystem functions.
- Extreme climatic events will become more frequent, necessitating improvement in flood protection, drought preparedness and emergency response.

The amount of snow is critical for water supply and environmental needs, but so is the timing of snowmelt runoff into rivers and streams. Rising snowlines caused by climate change will allow more mountain areas, such as the Sierra Nevada watersheds, to contribute to peak storm runoff. Changes in watershed vegetation and soil moisture conditions will likewise change runoff and recharge patterns. As stream flows and velocities change, erosion patterns will also change, altering channel shapes and depths, possibly increasing sedimentation behind dams, and affecting habitat and water quality. With potential increases in the frequency and intensity of wildfires due to climate change, there is potential for more floods following fire, which increase sediment loads and water quality impacts.

Exposure, Sensitivity and Vulnerability

Population and Property

Population and property exposure and vulnerability may increase as a result of climate change impacts on the flood hazard. Runoff patterns may change, resulting in flooding in areas where it has not previously occurred.

Critical Facilities

Critical facility exposure and vulnerability may increase as a result of climate change impacts on the flood hazard. Runoff patterns may change, resulting in risk to facilities that have not historically been at risk from flooding. Changes in the management and design of flood protection critical facilities may be needed as additional stress is placed on these systems. Planners will need to factor a new level of safety into the design, operation, and regulation of flood protection facilities such as dams, bypass channels and levees, as well as the design of local sewers and storm drains.

Environment

The exposure and vulnerability of the environment may increase as a result of climate change impacts on the flood hazard. Changes in the timing and frequency of flood events may have broader ecosystem impacts that alter the ability of already stressed species to survive.

Economy

If flooding becomes more frequent, there may be impacts on the local economy. More resources may need to be directed to response and recovery efforts, and businesses may need to close more frequently due to loss of service or access during flood events.

14.2.5 Landslide

Climate Change Impacts on the Hazard

Climate change may impact storm patterns, increasing the probability of more frequent, intense storms with varying duration. Increase in global temperature is likely to affect the snowpack and its ability to hold and store water. Warming temperatures also could increase the occurrence and duration of droughts, which would increase the probability of wildfire, reducing the vegetation that helps to support steep slopes. All of these factors would increase the probability for landslide occurrences.

Exposure, Sensitivity and Vulnerability

Population and Property

Population and property exposure and vulnerability would be unlikely to increase as a result of climate change impacts on the landslide hazard. Landslide events may occur more frequently, but the extent and location should be contained within mapped hazard areas or recently burned areas.

Critical facilities

Critical facility exposure and vulnerability would be unlikely to increase as a result of climate change impacts on the landslide hazard; however, critical facility owners and operators may experience more frequent disruption to service provision as a result of landslide hazards. For example, transportation systems may experience more frequent delays if slides blocking these systems occur more frequently. In addition, increased sedimentation resulting from landslides may negatively impact flood control facilities, such as dams.

Environment

Exposure and vulnerability of the environment would be unlikely to increase as a result of climate change, but more frequent slides in river systems may impact water quality and have negative impacts on stressed species.

Economy

Changes to the landslide hazard resulting from climate change are unlikely to result in impacts on the local economy.

14.2.6 Severe Weather

Climate Change Impacts on the Hazard

Climate change presents a challenge for risk management associated with severe weather. The number of weather-related disasters during the 1990s was four times that of the 1950s and led to 14 times as much in economic losses. The science for linking the severity of specific severe weather events to climate change is still evolving; however, a number or trends provide some indication of how climate change may be impacting these events. According to the *U.S. National Climate Change Assessment* (2014), there were more than twice as many high temperature records as low temperature records broken between 2001 and 2012, and heavy rainfall events are becoming more frequent and more severe.

The increase in average surface temperatures can also lead to more intense heat waves that can be exacerbated in urbanized areas by what is known as the urban heat island effect. Evidence suggests that heat waves are already increasing, especially in western states. Extreme heat days in the planning area are likely to increase.

Climate change impacts on other severe weather events such as thunderstorms and high winds are still not well understood.

Exposure, Sensitivity and Vulnerability

Population and Property

Population and property exposure and vulnerability would be unlikely to increase as a direct result of climate change impacts on the severe weather hazard. Severe weather events may occur more frequently, but exposure and vulnerability will remain the same. Secondary impacts, such as the extent of localized flooding, may increase, impacting greater numbers of people and structures.

Critical Facilities

Critical facility exposure and vulnerability would be unlikely to increase as a result of climate change impacts on the severe weather hazard; however, critical facility owners and operators may experience more frequent disruption to service provision. For example, more frequent and intense storms may cause more frequent disruptions in power service.

Environment

Exposure and vulnerability of the environment would be unlikely to increase; however, more frequent storms and heat events and more intense rainfall may place additional stress on already stressed systems.

Economy

Climate change impacts on the severe weather hazard may impact the local economy through more frequent disruption to services, such as power outages.

14.2.7 Tsunami

Climate Change Impacts on the Hazard

The impacts of global climate change on tsunami probability are unknown. Some scientists say that melting glaciers could induce tectonic activity, inducing earthquakes. Other scientists have indicated that underwater avalanches (also caused by melting glaciers), may also result in tsunamis. Even if climate change does not increase the frequency with which tsunamis occur, it may result in more destructive waves. As sea levels continue to rise, tsunami inundation areas would likely reach further into communities than current mapping indicates.

Exposure, Sensitivity and Vulnerability

As land area likely to be inundated by tsunami waves increases, exposure and vulnerability to the tsunami hazard may increase for population, property, critical facilities and the environment. Changes to the tsunami hazard from climate change may result in more direct economic impacts on a greater number of businesses and economic centers, as well as the infrastructure systems that support those businesses.

14.2.8 Wildfire

Climate Change Impacts on the Hazard

Wildfire is determined by climate variability, local topography, and human intervention. Climate change has the potential to affect multiple elements of the wildfire system: fire behavior, ignitions, fire management, and vegetation fuels. Hot dry spells create the highest fire risk. Increased temperatures may intensify wildfire danger by warming and drying out vegetation.

Changes in climate patterns may impact the distribution and perseverance of insect outbreaks that create dead trees (increase fuel). When climate alters fuel loads and fuel moisture, forest susceptibility to wildfires changes. Climate change also may increase winds that spread fires. Faster fires are harder to contain, and thus are more likely to expand into residential neighborhoods.

Exposure, Sensitivity and Vulnerability

Population

According to Cal-Adapt projections, wildfire risk in the vicinity of the planning area may actually decrease over the next century. Other areas of California and the western United States are expected to have increased risk to wildfire, with increases in annual acres burned. Although planning area residents may not experience increased risk to wildfire directly, secondary impacts, such as poor air quality may increase.

Property and Critical Facilities

If wildfire risk decreases, the exposure and vulnerability of property and critical facilities would remain the same.

Environment

It is possible that the exposure and vulnerability of the environment will be impacted by changes in wildfire risk due to climate change. Natural fire regimes may change, resulting in more or less frequent or higher intensity burns. These impacts may alter the composition of the ecosystems in areas in and surrounding planning area.

Economy

As the risk from wildfire is currently projected to decrease, direct impacts on the economy would not be likely.

14.3 VULNERABILITY ASSESSMENT—SEA LEVEL RISE

14.3.1 Climate Change Impacts on the Hazard

In addition to impacts on the identified hazards of concern, climate change presents risks related to sea level rise.

14.3.2 Exposure, Sensitivity and Vulnerability

The following assessment was conducted using data provided by the San Francisco Bay Conservation and Development Commission (Adapting to Rising Tides, 2016). Two sea level rise scenarios were assessed:

- 12 inches of rise by 2030 in the average height of the higher high tides of each day (also referred to as mean higher high water), compared to 2000
- 66 inches of rise by 2100 in the mean higher high water, compared to 2000.

For both scenarios, estimates were developed for two conditions:

- Areas that would be permanently inundated (subject to tidal flooding on a daily basis)
- Areas that would be temporarily inundated (inundated when the 1-percent annual chance extreme tide occurs). Extreme tide is a combination of relatively high astronomical, normal tides coupled with storm surge, an abnormal rise generated by a storm system (Adapting to Rising Tides, 2016). These areas will not be permanently inundated, but will experience flooding at a rate equivalent to or greater than today's regulated special flood hazard areas. This condition represents how the regulatory floodplain and asset exposure will change as sea levels rise.

This assessment is based on current conditions and does consider any adaptation or mitigation measures that may be taken in the coming decades. Figure 14-5 shows the temporary and permanent inundation areas for the 2100 (66-inch) sea level rise scenario. Mapping of additional scenarios can be found in the annexes of impacted jurisdictions in Volume 2 of this plan.

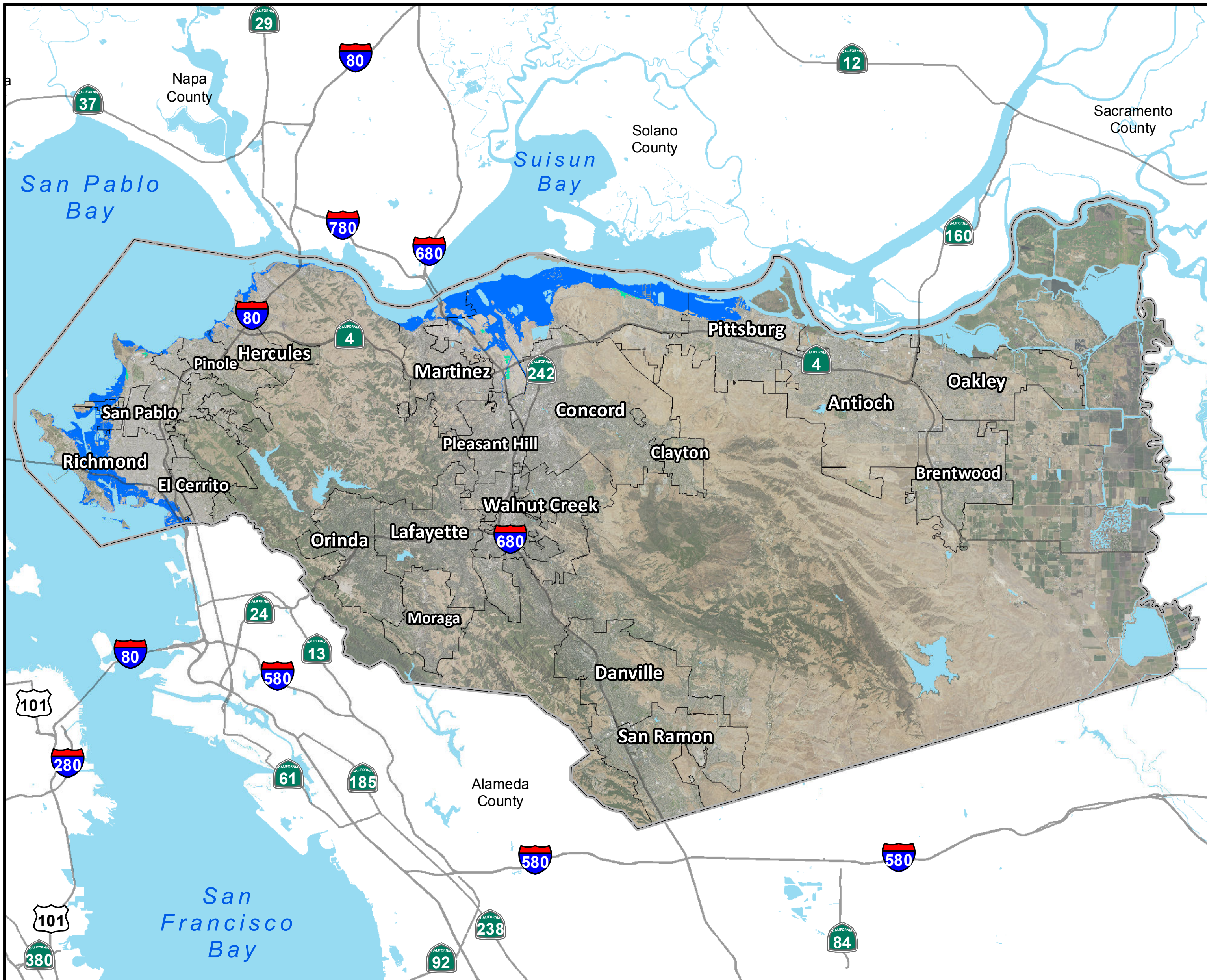
Population

Sea level rise will increase the population exposed to both permanent and temporary inundation. Currently, approximately 0.02 percent of the population (266 people) is estimated to reside in areas that are likely to be permanently inundated by 2030 and 0.21 percent (2,408 persons) reside in areas that are likely to be permanently inundated by 2100. Additionally, 1,096 and 10,862 additional persons will be exposed to a 1-percent annual chance risk to coastal flooding by 2030 and 2100, respectively. Total population exposure related to sea level rise impacts is estimated to be 0.12 percent of the population by 2030 and 1.18 percent of the population by 2100. Table 14-3 and Table 14-4 show exposed population by jurisdiction.

Contra Costa County

Figure 14-5.

Sea Level Rise
66" Mean Higher High Water + 1% Annual Chance Extreme Tide Scenario



66" MHHW + 1% Annual Chance Extreme Tide

Low Lying Areas

This map is a planning-level tool to illustrate the potential for inundation and coastal flooding under a future sea-level rise scenario. It does not represent the exact location or depth of flooding or shoreline overtopping. The map is based on model outputs and does not account for all dynamic Bay processes or future regional conditions that may occur in response to sea-level rise, such as erosion, subsidence, construction, or shoreline protection upgrades. For more context, including a description of data and methods used, please see Adapting to Rising Tides: Transportation Vulnerability and Risk Assessment Pilot Project Technical Report (November 2011).

Contra Costa County Boundary

City Boundaries

Water Bodies & Channels

Map Data Sources: Contra Costa County, Caltrans, San Francisco Bay Conservation & Development Commission, USDA

0 2.5 5 10
Miles

N W E S

TETRA TECH

Table 14-3. Estimated Population Residing in Sea Level Rise Inundation Areas by 2030

Jurisdiction[a]	Estimated Population	Population Exposed to Inundation with 12 Inches of Sea Level Rise					
		Permanent		Temporary (1% Annual Chance)		Total	
		Estimated Population	% of Population	Estimated Population	% of Population	Estimated Population	% of Population
El Cerrito	24,378	0	0.00%	0	0.00%	0	0.00%
Hercules	24,791	0	0.00%	0	0.00%	0	0.00%
Martinez	37,057	0	0.00%	21	0.06%	21	0.06%
Pinole	18,739	0	0.00%	0	0.00%	0	0.00%
Pittsburg	67,817	177	0.26%	385	0.57%	562	0.83%
Richmond	110,378	89	0.08%	385	0.35%	474	0.43%
Unincorporated	171,122	0	0.00%	305	0.18%	305	0.18%
Total	1,123,429	266	0.02%	1,096	0.10%	1,362	0.12%

a. Only jurisdictions with exposure to sea level rise are included. All other jurisdictions can be assumed to have zero exposure.

Table 14-4. Estimated Population Residing in Sea Level Rise Inundation Areas by 2100

Jurisdiction[a]	Estimated Population	Population Exposed to Inundation with 66 Inches of Sea Level Rise					
		Permanent		Temporary (1% Annual Chance)		Total	
		Estimated Population	% of Population	Estimated Population	% of Population	Estimated Population	% of Population
El Cerrito	24,378	78	0.32%	256	1.05%	334	1.37%
Hercules	24,791	0	0.00%	187	0.75%	187	0.75%
Martinez	37,057	30	0.08%	45	0.12%	76	0.20%
Pinole	18,739	15	0.08%	176	0.94%	192	1.02%
Pittsburg	67,817	785	1.16%	2,191	3.23%	2,976	4.39%
Richmond	110,378	812	0.74%	6,551	5.93%	7,363	6.67%
Unincorporated	171,122	688	0.40%	1,456	0.85%	2,144	1.25%
Total	1,123,429	2,408	0.21%	10,862	0.97%	13,272	1.18%

a. Only jurisdictions with exposure to the sea level rise are included. All other jurisdictions can be assumed to have zero exposure.

Property

There are 459 structures currently located in areas subject to sea level rise impacts by 2030. Of these approximately 19 percent will be permanently inundated. By 2100 4,072 structures will be impacted with approximately 9 percent of these structures experiencing permanent inundation. The majority of these structures are residential. Table 14-5 through Table 14-8 show the distribution of structure types exposed.

Structures that will be permanently inundated by 2030 and 2100 represent 0.07 percent and 0.78 percent of the total current replacement value of the planning area, respectively. When temporary inundation is taken into account, total replacement value exposure is 0.38 percent and 2.22 percent ($945 million and $5.47 billion), respectively. Table 14-9 and Table 14-10 show the estimated replacement value of structures exposed to permanent inundation. The majority of these structures are in Pittsburg, Richmond and the unincorporated county.

Table 14-5. Structure Type in Permanent 2030 Sea Level Rise Inundation Areas

Jurisdiction[a]	Residential	Commercial	Industrial	Agricultural	Religious	Government	Education	Total
El Cerrito	0	0	0	0	0	0	0	0
Hercules	0	0	0	0	0	0	0	0
Martinez	0	1	0	0	0	0	0	1
Pinole	0	0	0	0	0	0	0	0
Pittsburg	46	2	3	0	0	0	0	51
Richmond	23	0	1	0	0	0	0	24
Unincorporated	0	2	6	0	0	2	0	10
Total	69	5	10	0	0	2	0	86

a. Only jurisdictions with exposure to the sea level rise are included. All other jurisdictions can be assumed to have zero exposure.

Table 14-6. Structure Type in Temporary 2030 Sea Level Rise Inundation Areas

Jurisdiction[a]	Residential	Commercial	Industrial	Agricultural	Religious	Government	Education	Total
El Cerrito	0	0	0	0	0	0	0	0
Hercules	0	0	0	0	0	0	0	0
Martinez	7	0	1	0	0	2	0	10
Pinole	0	0	0	0	0	0	0	0
Pittsburg	100	3	5	0	1	1	0	110
Richmond	99	11	30	0	0	0	0	140
Unincorporated	95	1	17	0	0	0	0	113
Total	301	15	53	0	1	3	0	373

a. Only jurisdictions with exposure to the sea level rise are included. All other jurisdictions can be assumed to have zero exposure.

Table 14-7. Structure Type in Permanent 2100 Sea Level Rise Inundation Areas

Jurisdiction[a]	Residential	Commercial	Industrial	Agricultural	Religious	Government	Education	Total
El Cerrito	26	0	0	0	0	0	0	26
Hercules	0	0	0	0	0	0	0	0
Martinez	10	4	6	0	0	3	0	23
Pinole	5	0	0	0	0	0	0	5
Pittsburg	204	5	9	0	1	1	0	220
Richmond	209	18	75	0	0	0	0	302
Unincorporated	214	9	31	0	0	4	0	258
Total	668	36	121	0	1	8	0	834

a. Only jurisdictions with exposure to the sea level rise are included. All other jurisdictions can be assumed to have zero exposure.

Table 14-8. Structure Type in Temporary 2100 Sea Level Rise Inundation Areas

Jurisdiction[a]	Residential	Commercial	Industrial	Agricultural	Religious	Government	Education	Total
El Cerrito	85	0	0	0	0	0	0	85
Hercules	62	0	0	0	0	0	0	62
Martinez	15	21	5	0	0	0	0	41
Pinole	57	0	0	0	0	1	0	58
Pittsburg	569	0	0	0	1	1	0	571
Richmond	1,686	53	128	0	15	7	0	1,889
Unincorporated	453	38	29	0	9	2	1	532
Total	2,927	112	162	0	25	11	1	3,238

a. Only jurisdictions with exposure to the sea level rise are included. All other jurisdictions can be assumed to have zero exposure.

Table 14-9. Structure and Contents Value in Permanent 2030 Sea Level Rise Inundation Areas

Jurisdiction[a]	Structures Exposed	Estimated Value of Exposed Structures	Estimated Value of Exposed Contents	Estimated Total Value	% of Total Replacement Value
El Cerrito	0	$0	$0	$0	0.00%
Hercules	0	$0	$0	$0	0.00%
Martinez	1	$1,193,275	$1,193,275	$2,386,550	0.03%
Pinole	0	$0	$0	$0	0.00%
Pittsburg	51	$15,286,026	$12,505,586	$27,791,611	0.23%
Richmond	24	$11,055,910	$6,698,784	$17,754,694	0.07%
Unincorporated	10	$51,897,778	$67,280,629	$119,178,407	0.29%
Total	0	$79,432,989	$87,678,274	$167,111,262	0.07%

a. Only jurisdictions with exposure to the sea level rise are included. All other jurisdictions can be assumed to have zero exposure.

Table 14-10. Structure and Contents Value in Permanent 2100 Sea Level Rise Inundation Areas

Jurisdiction[a]	Structures Exposed	Estimated Value of Exposed Structures	Estimated Value of Exposed Contents	Estimated Total Value	% of Total Replacement Value
El Cerrito	26	11,517,320	5,758,660	17,275,980	0.32%
Hercules	0	0	0	0	0.00%
Martinez	23	35,911,824	38,341,080	74,252,903	0.84%
Pinole	5	806,450	403,225	1,209,674	0.03%
Pittsburg	220	133,743,910	145,712,104	279,456,014	2.30%
Richmond	302	497,496,091	636,267,038	1,133,763,129	4.26%
Unincorporated	258	190,906,273	221,964,713	412,870,986	1.01%
Total	834	870,381,867	1,048,446,820	1,918,828,687	0.78%

a. Only jurisdictions with exposure to the sea level rise are included. All other jurisdictions can be assumed to have zero exposure.

Critical Facilities and Roads

There are eight critical facilities at risk from permanent inundation from sea level rise by 2030 and an additional 23 exposed to temporary inundation. By 2100 47 facilities will be permanently inundated with an additional 43 exposed to temporary inundation. This represents 2 percent of critical facilities in the planning area exposed by 2030 and 5 percent by 2100. Table 14-11 through Table 14-14 show the distribution of exposed facilities by jurisdiction and the facility type.

Table 14-11. Critical Facilities in 2030 Sea Level Rise Inundation Areas

Jurisdiction	Medical and Health	Government Functions	Protective Functions	Schools and Educational Facilities	Hazmat	**Total**
El Cerrito	0	0	0	0	0	0
Hercules	0	0	0	0	0	0
Martinez	0	0	0	0	0 (1)	0 (1)
Pinole	0	0	0	0	0	0
Pittsburg	0	0	0	0	0	0
Richmond	0	0	0 (1)	0 (1)	0 (1)	0 (3)
Unincorporated	0	0	0 (1)	0	1 (1)	1 (2)
Total	0	0	0 (2)	0 (1)	1 (3)	1 (6)

Note: Number of facilities in parenthesis indicates the number of additional facilities that are exposed to temporary inundation.

Table 14-12. Critical Infrastructure in 2030 Sea Level Rise Inundation Areas

Jurisdiction	Bridges	Water Supply	Waste water	Power	Communications	Other Critical Functions	Other Critical Infrastructure	Total
El Cerrito	0	0	0	0	0	0	0	0
Hercules	0	0	0	0	0	0	0	0
Martinez	1 (1)	0	0 (1)	0 (2)	0	0 (1)	0 (2)	1 (7)
Pinole	0 (1)	0	0 (1)	0	0	0	0	0 (2)
Pittsburg	0	0	0 (1)	1	0	0	0	1 (1)
Richmond	0 (2)	0	0	1 (1)	0	0	0	1 (3)
Unincorporated	3 (3)	0	1 (1)	0	0	0	0	4 (4)
Total	4 (7)	0	1 (4)	2 (3)	0	0 (1)	0 (2)	7 (17)

Note: Number of facilities in parenthesis indicates the number of additional facilities that are exposed to temporary inundation.

Table 14-13. Critical Facilities in 2100 Sea Level Rise Inundation Areas

Jurisdiction	Medical and Health	Government Functions	Protective Functions	Schools and Educational Facilities	Hazmat	**Total**
El Cerrito	0	0	0	0	0	0
Hercules	0	0	0	0	0	0
Martinez	0	0	0 (2)	0	1	1 (2)
Pinole	0	0	0	0	0	0
Pittsburg	0	0	0	0	0	0
Richmond	0 (1)	0	1 (3)	1	6 (3)	8 (7)
Unincorporated	0	0	2 (2)	1(2)	4 (3)	7 (7)
Total	0 (1)	0	3 (7)	2 (2)	11 (6)	16 (16)

Note: Number of facilities in parenthesis indicates the number of additional facilities that are exposed to temporary inundation.

Table 14-14. Critical Infrastructure in 2100 Sea Level Rise Inundation Areas

Jurisdiction	Bridges	Water Supply	Waste water	Power	Communications	Other Critical Functions	Other Critical Infrastructure	Total
El Cerrito	0	0	0	0	0	0	0	0
Hercules	0	0	0	0	0	0	0	0
Martinez	2 (1)	0	1 (1)	2	0	1	2 (1)	8 (3)
Pinole	1	0	1	0	0	0	0	2
Pittsburg	0	0	1	1	0 (1)	0 (2)	0	2 (3)
Richmond	5 (3)	0 (1)	1 (2)	2 (1)	0	0 (2)	0	8 (9)
Unincorporated	8 (3)	0	3 (7)	0	0 (1)	0 (1)	0	11 (12)
Total	16 (7)	0 (1)	7 (10)	5 (1)	0 (2)	1 (5)	2 (1)	31 (27)

Note: Number of facilities in parenthesis indicates the number of additional facilities that are exposed to temporary inundation.

The following major roads in the planning area cross through areas at risk from permanent sea level rise by 2030:

- Interstate 680
- State Highway 4
- Eastshore Freeway
- John T Knox Freeway
- Marina Bay Parkway
- Richmond Parkway

Environment

All sea level rise inundation areas are exposed and vulnerable to impacts. Important coastal habitat may be lost as sea level rise permanently inundates areas, or it may be damaged due to extreme tide and storm surge events. Saltwater intrusion into freshwater resources may occur, further altering habitat and ecosystems. Protective ecosystem services may be lost as land area and wetlands are permanently inundated.

Economy

Sea level rise will impact the local economy. The tourism industry may be impacted as historic coastal properties are inundated. Critical facilities and other important assets may be damaged by temporary inundation, resulting in loss of services such as power or wastewater treatment. Coastal businesses may relocate to other areas rather than face high costs from increased risk to storm surge and costs associated with managed retreat. Local tax revenue may decline as areas that were previously occupied by houses and businesses are permanently inundated.

Future Development

The land area of Contra Costa County will be reduced as sea level rise permanently inundates areas. This will have significant impacts on land use and planning in local communities. Local general plans in the planning area will guide this future development. Table 14-15 shows the total acres of land subject to permanent impacts from sea level rise by 2030 and 2100. Table 14-16 shows the developable acres of land subject to permanent impacts from sea level rise by 2030 and 2100 for the overall planning area.

Table 14-15. Acres of Land Subject to Permanent Inundation by Jurisdiction

Jurisdiction	Total (acres)	2030 Projection Inundated Areas (acres)[a] Permanent Inundation	2030 % of Total	2100 Projection Inundated Areas (acres)[a] Permanent Inundation	2100 % of Total
Concord	19,537	0.4	0.0%	10	0.1%
El Cerrito	2,359	0	0.0%	6	0.3%
Hercules	12,329	10	0.1%	54	0.4%
Martinez	8,811	523	5.9%	821	9.3%
Pinole	7,430	9	0.1%	36	0.5%
Pittsburg	12,423	767	6.2%	1,057	8.5%
Richmond	33,653	1,041	3.1%	1	0.0%
Unincorporated	311,726	4,059	1.3%	2,487	0.8%
Total County	516,186	6,410	1.2%	6,668	1.3%

a. These estimates may include some amount of acreage that is open water (e.g. channels)

Table 14-16. Acres of Developable Land Subject to Permanent Inundation Land Use Classification

Use Classification	12" Sea Level Rise Area (acres)	12" Sea Level Rise % of total	66" Sea Level Rise Area (acres)	66" Sea Level Rise % of total
Residential	0.8	0.6%	14.0	4.6%
Commercial - Industrial	133.3	99.3%	278.3	90.9%
Mixed Use	0.2	0.1%	14.0	4.6%
Total	134.3	100.0%	306.3	100.0%

Source: Contra Costa County, 2016.

14.4 ISSUES

The major issues for climate change are the following:

- Planning for climate change related impacts can be difficult due to inherent uncertainties in projection methodologies.
- Average temperatures are expected to continue to increase in the planning area, which may lead to a host of primary and secondary impacts, such as an increased incidence of heat waves.
- Expected changes in precipitation patterns are still poorly understood and could have significant impacts on the water supply and flooding in the planning area.
- Some impacts of climate change are poorly understood such as potential impacts on the frequency and severity of earthquakes, thunderstorms and tsunamis.
- Heavy rain events may result in inland stormwater flooding after stormwater management systems are overwhelmed.
- Permanent and temporary inundation resulting from sea level rise has the potential to impact significant portions of the population and assets in the planning area.

15. OTHER HAZARDS OF INTEREST

15.1 HUMAN-CAUSED HAZARDS

15.1.1 General Background

Although the DMA does not require an assessment of human-caused hazards, Contra Costa County officials decided to include human-caused hazards in this hazard mitigation plan for the following reasons:

- Contra Costa County takes a proactive approach to disaster preparedness in order to protect the public safety of all citizens.
- Preparation for and response to a human-caused disaster involves much of the same staff training, critical decision-making, and commitment of resources as a natural hazard.
- The multi-hazard mitigation planning effort is an opportunity to inform the public about all hazards, including human-caused hazards.
- The likelihood of a human-caused hazard event in the planning area is greater than that of several of the natural hazards identified in this plan.
- Contra Costa County has a 2016 *Hazardous Materials Area Plan* with emergency response procedures.

The following human-caused hazards discussed in this plan:

- **Terrorism and cyber security threats**—These are malicious, intentional, and criminal acts.
- **Hazardous materials incidents**—These are accidental events with unintended consequences arising from the manufacture, transportation, storage and use of hazardous materials.
- **Utility interruptions**—These are electrical, natural gas, sewage, telecommunication, or water failures or interruptions that affect people.
- **Active shooter incident**—These are criminal attempts to kill people in a confined and populated area. Such incidents have been increasing in numbers and human causalities and have captured significant public and police attention.

DEFINITIONS

Active shooter—An individual actively engaged in killing or attempting to kill people in a confined and populated area. In most cases, active shooters use firearms and there is no pattern or method to their selection of victims.

Cyber security threat—An attempt to exploit a vulnerability in a computer system's security to annoy, steal, and cause possible harm.

Hazardous material—A substance or combination of substances that, because of quantity, concentration, or physical, chemical, or infectious characteristics, may cause or contribute to an increase in mortality or an increase in serious illness, or otherwise pose a hazard to human life, property, or the environment.

Terrorism—The unlawful use or threatened use of force or violence against people or property with the intention of intimidating or coercing societies or governments. Terrorism is either foreign or domestic, depending on the origin, base, and objectives of the terrorist or organization.

Utility interruptions—Electrical, natural gas, sewage, telecommunication, or water failure or interruption that affects people.

Weapons of mass destruction—Chemical, biological, radiological, nuclear, and explosive weapons associated with terrorism.

Terrorism

FEMA defines terrorism as the use of weapons of mass destruction (WMDs), including biological, chemical, nuclear and radiological weapons; arson, incendiary, explosive and armed attacks; industrial sabotage and intentional hazardous materials releases; agro-terrorism; and cyber-terrorism (FEMA 2003a). The three key elements to defining a terrorist event are as follows:

- Activities involve the use of illegal force.
- Actions are intended to intimidate or coerce.
- Actions are committed in support of political or social objectives.

Types of Terrorism

The Federal Bureau of Investigation (FBI) categorizes two types of terrorism in the United States:

- Domestic terrorism involves groups or individuals without foreign direction whose terrorist activities, including the use of WMDs, are directed at the government or population. The bombing of the Alfred P. Murrah federal building in Oklahoma City is an example of domestic terrorism. The FBI, the primary response agency for domestic terrorism, coordinates domestic preparedness programs and activities to limit domestic terrorism.
- International terrorism involves groups or individuals whose terrorist activities are foreign-based and/or directed by countries or groups outside the United States, or whose activities transcend national boundaries. Examples include the 1993 bombing of the World Trade Center and the attacks of September 11, 2001 at the World Trade Center and the Pentagon.

Terrorism Methods and Impacts

The effects of terrorism can include injuries, loss of life, property damage, or disruption of services such as electricity, water supplies, transportation, or communications. Effects may be immediate or delayed. Terrorists often choose targets that offer limited danger to themselves and areas with relatively easy public access. Foreign terrorists look for visible targets where they can avoid detection before and after an attack, such as international airports, large cities, major special events, and high-profile landmarks. Table 15-1 provides a hazard profile summary of common terrorism methods. Most terrorist events in the United States have been bombing attacks, involving detonated and undetonated explosive devices, tear gas, pipe bombs, and firebombs.

Terrorism Preparation and Response

To prepare for terrorism, the unpredictability of human beings must be considered. People with a desire to perform such acts may seek out targets of opportunity that may not fall into established lists of critical areas or facilities. While education, heightened awareness, and early warning of unusual circumstances may deter terrorism, intentional acts that harm people and property are possible at any time. Public safety entities must react to the threat, locating, isolating, and neutralizing further damage and investigating potential scenes and suspects to bring criminals to justice.

Those involved with terrorism response, including public health and public information staff, are trained to deal with the public’s emotional reaction swiftly as response to the event occurs. The area of the event must be clearly identified in all emergency alert messages to prevent those not affected by the incident from overwhelming local emergency rooms and response resources, which can reduce service to those actually affected. The public needs to be informed clearly and frequently about what government agencies are doing to mitigate the impacts of the event. The public also needs clear direction on how to protect the health of individuals and families.

Table 15-1. Event Profiles for Terrorism

Hazard	Application Mode[a]	Hazard Duration[b]	Static/Dynamic Characteristics[c]	Mitigating and Exacerbating Conditions[d]
Conventional Bomb	Detonation of explosive device on or near target; delivery via person, vehicle, or projectile.	Instantaneous; additional secondary devices, or diversionary activities may be used, lengthening the duration of the hazard until the attack site is determined to be clear.	Extent of damage is determined by type and quantity of explosive. Effects generally static other than cascading consequences, incremental structural failure, etc.	Overpressure at a given standoff is inversely proportional to the cube of the distance from the blast; thus, each additional increment of standoff provides progressively more protection. Terrain, forestation, structures, etc. can provide shielding by absorbing and/or deflecting energy and debris. Exacerbating conditions include ease of access to target; lack of barriers and shielding; poor construction; and ease of concealment of device.
Chemical Agent	Liquid/aerosol contaminants dispersed using sprayers or other aerosol generators; liquids vaporizing from puddles/ containers; or munitions.	Hours to weeks, depending on the agent and the conditions in which it exists.	Contamination can be carried out of the initial target area by persons, vehicles, water, and wind. Chemicals may be corrosive or otherwise damaging over time if not remediated.	Air temperature can affect evaporation of aerosols. Ground temperature affects evaporation of liquids. Humidity can enlarge aerosol particles, reducing inhalation hazard. Precipitation can dilute and disperse agents but can spread contamination. Wind can disperse vapors but also cause target area to be dynamic. The micro-meteorological effects of buildings and terrain can alter travel and duration of agents. Shielding in the form of sheltering in place can protect people and property from harmful effects.
Arson/ Incendiary Attack	Initiation of fire or explosion on or near target via direct contact or remotely via projectile.	Generally minutes to hours.	Extent of damage is determined by type and quantity of device, accelerant, and materials present at or near target. Effects generally static other than cascading consequences, incremental structural failure, etc.	Mitigation factors include built-in fire detection and protection systems and fire-resistive construction techniques. Inadequate security can allow easy access to target, easy concealment of an incendiary device, and undetected initiation of a fire. Non-compliance with fire and building codes, as well as failure to maintain existing fire protection systems, can substantially increase the effectiveness of a fire weapon.
Armed Attack	Tactical assault or sniping from remote location, or random attack based on fear, emotion, or mental instability.	Generally minutes to days.	Varies based on the perpetrators' intent and capabilities.	Inadequate security can allow easy access to target, easy concealment of weapons, and undetected initiation of an attack.
Biological Agent	Liquid or solid contaminants dispersed using sprayers/ aerosol generators or by point or line sources such as munitions, covert deposits, and moving sprayers.	Hours to years, depending on the agent and the conditions in which it exists.	Depending on the agent used and the effectiveness with which it is deployed, contamination can be spread via wind and water. Infection can spread via humans or animals.	Altitude of release above ground can affect dispersion; sunlight is destructive to many bacteria and viruses; light to moderate wind will disperse agents but higher winds can break up aerosol clouds; the micro-meteorological effects of buildings and terrain can influence aerosolization and travel of agents.

Hazard	Application Mode[a]	Hazard Duration[b]	Static/Dynamic Characteristics[c]	Mitigating and Exacerbating Conditions[d]
Agro-terrorism	Direct, generally covert contamination of food supplies or introduction of pests and/or disease agents to crops and livestock.	Days to months.	Varies by type of incident. Food contamination events may be limited to specific distribution sites, whereas pests and diseases may spread widely. Generally no effects on built environment.	Inadequate security can facilitate adulteration of food and introduction of pests and disease agents to crops and livestock.
Radiological Agent	Radioactive contaminants dispersed using sprayers/ aerosol generators, or by point or line sources such as munitions.	Seconds to years, depending on material used.	Initial effects will be localized to site of attack; depending on meteorological conditions, subsequent behavior of radioactive contaminants may be dynamic.	Duration of exposure, distance from source of radiation, and the amount of shielding between source and target determine exposure to radiation.
Nuclear Bomb	Detonation of nuclear device underground, at the surface, in the air, or at high altitude.	Light/heat flash and blast/shock wave last for seconds; nuclear radiation and fallout hazards can persist for years. Electromagnetic pulse from a high-altitude detonation lasts for seconds and affects only unprotected electronic systems.	Initial light, heat, and blast effects of a subsurface, ground or air burst are static and determined by the device's characteristics and employment; fallout of radioactive contaminants may be dynamic, depending on meteorological conditions.	Harmful effects of radiation can be reduced by minimizing the time of exposure. Light, heat, and blast energy decrease logarithmically as a function of distance from seat of blast. Terrain, forestation, structures, etc. can provide shielding by absorbing and/or deflecting radiation and radioactive contaminants.
Intentional Hazardous Material Release (fixed facility or transportation)	Solid, liquid, and/or gaseous contaminants released from fixed or mobile containers	Hours to days.	Chemicals may be corrosive or otherwise damaging over time. Explosion and/or fire may be subsequent. Contamination may be carried out of the incident area by persons, vehicles, water and wind.	Weather conditions directly affect how the hazard develops. The micro-meteorological effects of buildings and terrain can alter travel and duration of agents. Shielding in the form of sheltering in place can protect people and property from harmful effects. Non-compliance with fire and building codes, as well as failure to maintain existing fire protection and containment features, can substantially increase the damage from a hazardous materials release.

a. Application Mode—Application mode describes the human acts or unintended events necessary to cause the hazard event to occur.
b. Duration—Duration is the length of time the hazard is present. For example, a chemical warfare agent such as mustard gas, if un-remediated, can persist for hours or weeks under the right conditions.
c. Dynamic or Static Characteristics—These characteristics of a hazard describe its tendency, or that of its effects, to either expand, contract, or remain confined in time, magnitude, and space. For example, the physical destruction caused by an earthquake is generally confined to the place in which it occurs, and it does not usually get worse unless aftershocks or other cascading failures occur; in contrast, a cloud of chlorine gas leaking from a storage tank can change location by drifting with the wind and can diminish in danger by dissipating over time.
d. Mitigation and Exacerbating Conditions—Mitigating conditions are characteristics of the target and its physical environment that can reduce the effects of a hazard. For example, earthen berms can provide protection from bombs; exposure to sunlight can render some biological agents ineffective; and effective perimeter lighting and surveillance can minimize the likelihood of someone approaching a target unseen. In contrast, exacerbating conditions are characteristics that can enhance or magnify the effects of a hazard. For example, depressions or low areas in terrain can trap heavy vapors, and a proliferation of street furniture (trash receptacles, newspaper vending machines, mail boxes, etc.) can provide hiding places for explosive devices.

Source: FEMA 386-7

Cyber Security Threat

A cyber security threat is an intentional and malicious crime that compromises the digital infrastructure of a person or organization, often for financial or terror-related reasons. Generally, attacks last minutes to days, but large-scale events and their impacts can last much longer. As information technology continues to grow in capability and interconnectivity, cyber threats become increasingly frequent and destructive.

Cyber threats differ by motive, attack type and perpetrator profile. Motives range from the pursuit of financial gain to political or social aims. Cyber threats are difficult to identify and comprehend. Types of threats include using viruses to erase entire systems, breaking into systems and altering files, using someone's personal computer to attack others, or stealing confidential information. The spectrum of cyber risks is limitless, with threats having a wide range of effects on the individual, community, organizational, and national threat (FEMA 2014a).

Cyber-attacks and cyberterrorism are terms for cyber security threats that often are used interchangeably, though they are not the same. All cyberterrorism is a form of cyber-attack, but not all cyber-attacks are cyberterrorism.

Cyber-Attacks

Public and private computer systems can experience a variety of cyber-attacks, from blanket malware infection to targeted attacks on system capabilities. Cyber-attacks specifically seek to breach IT security measures designed to protect an individual or organization. The initial attack is followed by more severe attacks for the purpose of causing harm, stealing data, or financial gain. Organizations are prone to different types of attacks that can be automated or targeted. Table 15-2 describes the most common cyber-attack mechanisms in use today.

Table 15-2. Common Mechanisms for Cyber-Attacks

Type	Description
Trojans	Programs designed to mimic legitimate processes (e.g. updating software, running fake antivirus software) with the end goal of human-interaction caused infection. When the victim runs the fake process, the Trojan is installed on the system.
Unpatched Software	Nearly all software has weak points that may be exploited by malware. Most common software exploitations occur with Java, Adobe Reader, and Adobe Flash. These vulnerabilities are often exploited as small amounts of malicious code are often downloaded via drive-by download.
Phishing	Malicious email messages that ask users to click a link or download a program. Phishing attacks may appear as legitimate emails from trusted third parties.
Password Attacks	Third party attempts to crack a user's password and subsequently gain access to a system. Password attacks do not typically require malware, but rather stem from software applications on the attacker's system. These applications may use a variety of methods to gain access, including generating large numbers of generated guesses, or dictionary attacks, in which passwords are systematically tested against all of the words in a dictionary.
Drive-by Downloads	Malware is downloaded unknowingly by the victims when they visit an infected site.
Denial of Service Attacks	Attacks that focus on disrupting service to a network in which attackers send high volumes of data until the network becomes overloaded and can no longer function.
Man in the Middle	Man-in-the-Middle attacks mirror victims and endpoints for online information exchange. In this type of attack, the attacker communicates with the victims, who believe they are interacting with a legitimate endpoint website. The attacker is also communicating with the actual endpoint website by impersonating the victim. As the process goes through, the attacker obtains entered and received information from both the victim and endpoint.
Malvertising	Malware downloaded to a system when the victim clicks on an affected ad.
Advanced Persistent Threat (APT)	An attack in which the attacker gains access to a network and remains undetected. APT attacks are designed to steal data instead of cause damage.

Since 2013, a new type of cyber-attack is becoming increasingly common against individuals and small- and medium-sized organizations. This attack is called cyber ransom. Cyber ransom occurs when an individual downloads ransom malware, or ransomware, often through phishing or drive-by download, and the subsequent execution of code results in encryption of all data and personal files stored on the system. The victim then receives a message that demands a fee in the form of electronic currency or cryptocurrency, such as Bitcoin, for the decryption code (Figure 15-1). In October 2015, the FBI said that commonly used ransomware is so difficult to override, that victims should pay the ransom to retrieve their data (Danielson 2015).

Source: Danielson 2015

Figure 15-1. Pop-Up Message Indicating Ransomware Infection

With millions of threats created each day, the importance of protection against cyber-attacks becomes a necessary function of everyday operations for individuals, medical facilities, schools, government facilities, and businesses. The increasing dependency on technology for vital information storage and the often automated method of infection mean higher stakes for the success of measurable protection and education.

Cyberterrorism

Cyberterrorism is the use of computers and information, particularly over the Internet, to recruit others to an organization’s cause, cause physical or financial harm, or cause a severe disruption of infrastructure service. Such disruptions can be driven by religious, political, or other motives. Like traditional terrorism tactics, cyberterrorism seeks to evoke very strong emotional reactions, but it does so through information technology rather than a physically violent or disruptive action.

Cyberterrorism has three main types of objectives:

- **Organizational**—Cyberterrorism with an organizational objective includes specific functions outside of or in addition to a typical cyber attack. Terrorist groups today use the internet on a daily basis. This daily use may include recruitment, training, fundraising, communication, or planning. Organizational cyberterrorism can use platforms such as social media as a tool to spread a message beyond country borders and instigate physical forms of terrorism. Additionally, systematic attacks may be used as tools for training new members in cyberterrorism.
- **Undermining**—Cyberterrorism with undermining as an objective seeks to hinder the normal functioning of computer systems, services, or websites. Such methods include defacing, denying, and exposing information. While undermining tactics are typically used due to high dependence on online structures to support vital operational functions, they typically do not result in grave consequences unless undertaken as part of a larger attack. Undermining attacks on computers include the following (Waldron 2011):
  - ➢ Directing conventional kinetic weapons against computer equipment, a computer facility, or transmission lines to create a physical attack that disrupts the reliability of equipment.
  - ➢ Using electromagnetic energy, most commonly in the form of an electromagnetic pulse, against computer equipment or data transmissions. By overheating circuitry or jamming communications, an electronic attack disrupts the reliability of equipment and the integrity of data.
  - ➢ Directing malicious code against computer processing code, instruction logic, or data. The malicious code can generate a stream of network packets that disrupt data or logic by exploiting vulnerability in computer software, or a weakness in computer security practices. This type of cyber attack can disrupt the reliability of equipment, the integrity of data, and the confidentiality of communications (Wilson 2008)
- **Destructive**—The destructive objective for cyberterrorism is what organizations fear most. Through the use of computer technology and the Internet, the terrorists seek to inflict destruction or damage on tangible property or assets, and even death or injury to individuals. There are no cases of pure destructive cyberterrorism as of the date of this plan.

Hazardous Materials Incident

Hazardous materials are present in nearly every city and county in the United States in facilities that produce, store, or use them. For example, water treatment plants use chlorine on-site to eliminate bacterial contaminants. Hazardous materials are transported along interstate highways and railways daily. Even the natural gas used in every home and business is a dangerous substance when a leak occurs. Many businesses, through intentional action, lack of awareness or accidental occurrences, have contamination in and around their property.

Title 49 of the CFR lists thousands of hazardous materials, including gasoline, insecticides, household cleaning products, and radioactive materials. State-regulated substances that have the greatest probability of adversely impacting the community are listed in the CCR, Title 19.

Types of Incidents

The following are the most common type of hazardous material incidents:

- **Fixed-Facility Hazardous Materials Incident**—This is the uncontrolled release of materials from a fixed site capable of posing a risk to health, safety and property. It is possible to identify and prepare for a fixed-site incident because laws require facilities to notify state and local authorities about what is being used or produced at the site.
- **Hazardous Materials Transportation Incident**—A hazardous materials transportation incident is any event resulting in uncontrolled release of materials during transport that can pose a risk to health, safety,

and property. Transportation incidents are difficult to prepare for because there is little if any notice about what materials could be involved should an accident happen. Hazardous materials transportation incidents can occur anywhere, although most occur on interstate highways or major federal or state highways, or on the major rail lines. In addition to materials such as chlorine that are shipped throughout the country by rail, thousands of shipments of radiological materials, mostly medical materials and low-level radioactive waste, take place via ground transportation across the United States. Many incidents occur in sparsely populated areas and affect very few people.

- **Interstate Pipeline Hazardous Materials Incident**—A significant number of interstate natural gas, heating oil, and petroleum pipelines run through California. These are used to provide natural gas to utilities in California and to transport these materials from production facilities to end-users.

Oversight

Business practices and the laws that regulate them have changed dramatically over the years. Hazardous materials management is regulated by federal and state codes. The state fire marshal and the Pipeline and Hazardous Materials Safety Administration enforce oil and gas pipeline safety regulations. The federal government enforces hazardous material transport pursuant to its interstate commerce regulation authority.

The Department of Toxic Substances Control (DTSC), a Division of the California Environmental Protection Agency, acts to protect California from exposure to hazardous wastes by cleaning up existing contamination and looking for ways to reduce the hazardous waste produced in the state. The DTSC regulates hazardous waste in California primarily under the authority of the federal Resource Conservation and Recovery Act, and the California Health and Safety Code. Other laws that affect hazardous waste are specific to handling, storage, transportation, disposal, treatment, reduction, cleanup, and emergency planning.

DTSC reviews and monitors legislation to ensure that proposed regulations reflect DTSC goals. DTSC's major program areas develop regulations and consistent policies and procedures. Under the Resource Conservation and Recovery Act, DTSC has the authority to implement permitting, inspection, compliance and corrective action programs to ensure that people who manage hazardous waste follow state and federal requirements. As such, the management of hazardous sites in the planning area is under regulation by the DTSC, to ensure that state and federal regulations pertaining to hazardous waste are followed.

Businesses are required to disclose all hazardous materials and waste above certain designated quantities that they use, store, or handle at their facility. They must prepare chemical inventory and business emergency plans, review the plans regularly, and perform annual training. Any release or possible release of hazardous material must be reported to the Cal OES Warning Center. Businesses using certain regulated substances (a list of about 260 specific flammable or toxic chemicals) must develop a risk management plan. The risk management plan includes analysis of operations on-site, and projection of off-site consequences with accompanying mitigation plans.

Utility Interruption

Power Failure

A power failure is any interruption or loss of electrical service due to disruption of power generation or transmission caused by an accident, sabotage, natural hazards, equipment failure, or fuel shortage. These interruptions can last anywhere from a few seconds to several days. Power failures are considered significant only if the local emergency management organization is required to coordinate basic services such as the provision of food, water, and heating as a result. Power failures are common with severe weather and winter storm activity.

Pacific Gas and Electric (PG&E) is responsible for operating and maintaining the electrical transmission and distribution system in the planning area. Calpine Corporation energy centers in the Cities of Antioch and Pittsburg generate electricity from natural gas and geothermal resources and sell it to PG&E. Crockett Cogeneration operates a natural gas fired plant in Crockett, California and sells to PG&E. Refineries in the planning area have power generation plants that supply their operations. A co-generation facility next to the Tesoro refinery produces electricity for Tesoro and can sell it to PG&E.

Water or Wastewater Disruption

Water or wastewater disruption is a secondary impact from a natural disaster or intentional act. In the planning area, water service is provided by the City of Antioch, Contra Costa Water District, East Bay Municipal Utility District, Diablo Water District, Golden State Water Company and the Martinez Water District. Sewer services are provided by Central Contra Costa Sanitary District, Ironhouse Sanitary District, Delta Diablo Sanitation District, Mountain View Sanitary District, West County Wastewater District, Dublin San Ramon Services District, Rodeo Sanitary District, Pinole Sanitary District, Hercules Sanitary District, and Crockett Community Services District.

A breach in the pipelines that carry water through the planning area would have significant temporary impacts until alternative water sources are pumped and treated. Long-term disruption would have significant impacts on residences and businesses in the planning area if demand exceeds secondary supplies and water conservation measures do not provide enough relief to reduce demand to equal the secondary supplies.

Disruption of the planning area’s wastewater collection and wastewater treatment plants would have significant regional impacts. Such disruption could result if the system were to be overwhelmed by a significant storm or discharge of materials in such quantities that the treatment plant could not adequately treat the waste. Natural hazards such as earthquake or flood, major power outages, or terrorism directed at the facilities and systems could disrupt the process of collecting and treating millions of gallons of sewage. Wastewater treatment plants may also have emergencies internal to the plant such as oxygen deficiencies that render them incapable of treating waste. The disruption of service may also have significant environmental impacts on the waterways adjacent to the treatment plants.

Data and Telecommunications Interruptions

The loss of data or telecommunications is often a secondary hazard to natural and other human-caused hazards. Data and telecommunications provide a primary method for service to the community by the government and the private sector. A loss of data and telecommunications could result in loss of emergency dispatch capabilities, emergency planning services, infrastructure monitoring capabilities, access to statistical data, and access to financial and personnel records.

Pipeline Interruptions

Pipelines are often considered the safest and most reliable way to transport natural gas, crude oil, liquid petroleum products, and chemical products, but there is still an inherent risk due to the nature of the hazardous materials. Failures of pipelines can occur when pipes corrode, are damaged during excavation, are incorrectly operated, or are damaged by other forces. One of the worst hazardous material incidents in the County involved a pipeline carrying gasoline in November 2004 in Walnut Creek. The released gasoline ignited, and five people were killed.

Intra-state liquid petroleum pipelines are regulated by the Office of the State Fire Marshal Pipeline Safety Division. Natural gas pipelines are regulated by the California Public Utilities Commission. Pipelines are also monitored by supervisory control and data acquisition systems that measure flow rate, temperature and pressure. These systems transfer real-time data via satellite from the pipelines to a control center where valves, pumps, and motors are remotely operated. If tampering with the pipeline occurs, an alarm sounds. The ensuing valve reaction is instantaneous, with the system isolating any rupture and setting off a chain reaction that shuts down pipeline pumps and alerts pipeline operators within seconds.

Transmission pipelines and distribution pipelines provide different services. Transmission pipelines transport raw material for further refinement. These pipes are large and far reaching, operating under high pressure. Distribution pipelines provide processed materials to end users. These are smaller in diameter, some as small as a half an inch, and operate under lower pressure. More serious accidents occur on distribution pipelines than on any other type due to their number, intricate networking, and location in highly populated areas.

Active Shooter Incident

Active shooter attacks are typically motivated by the desire to maximize human casualties. They are differentiated from other attack types by the indiscriminate nature of the victim's targets of opportunity rather than actions directed toward a specific target. Active shooter attacks have evolved over the last decade ranging from "lone wolf" shooters who act alone and without any organizational affiliation to organized groups acting in concert to achieve a specific objective.

Active shooter threat force tactics employ a blend of lone shooters and multi-person teams as part of a larger assault, as seen in the attacks in Paris in November 2015. They may use small arms (revolvers, automatic pistols, rifles, shotguns, assault rifles, light machine guns, etc.), light weapons (medium caliber and explosive ordinance, grenade launchers, rocket propelled grenades, etc.), or both, depending on the type of attack. The following are characteristics that police and sheriff departments have often seen associated with active shooters.

- Active shooters may focus on specific individuals or they may be intent on killing as many randomly chosen people as possible.
- Their purpose is usually an expression of hatred or rage, rather than financial gain or motives associated with other types of crimes. Thus, police tactics of containment and negotiation may be an inadequate response to an active shooter.
- They chose a site that they are familiar with and have made detailed plans for the attack. In many cases, they are very well armed.
- Active shooters often, but not always, are suicidal. Escaping the police is not usually a priority and in general, they have not attempted to hide their identity.
- The location chosen for the incident usually has a tactical advantage.

Active shooter incidents are unpredictable and evolve quickly. Because active shooter incidents are often over within 5 to 10 minutes, before law enforcement arrives on the scene, individuals at the scene must be prepared both mentally and physically to deal with the shooting in progress situation. In most cases, active shooters use firearms and there is no pattern or method to their selection of victims.

15.1.2 Hazard Profile

Past Events

Terrorism

According to the Cal OES Terrorism Response Plan, the State of California has had a long history of defending the public against domestic and foreign terrorists. Domestic terrorist groups in California have been focused on political or social issues, while the limited internationally based incidents have targeted the state's immigrant communities due to foreign disputes. Advanced technologies and communication have allowed these groups to become more sophisticated and better organized, with remote members linked electronically.

Terrorism incidents in Contra Costa County have been limited. The most recent was a pipe bomb found in December 2015 at a person's home that threatened a Richmond mosque.

Cyber Security Threat

No cyber security threats have been publically reported against local government agencies, schools, hospitals, or businesses in Contra Costa County.

Hazardous Material Incident

Table 15-3 lists the number of hazardous material incidents in Contra Costa County reported to the Cal OES Warning Center from 2012 through 2016. Additional historical hazardous material spill report data is available on the Cal OES website. The records show 1,242 hazardous materials spills in Contra Costa County over the 5-year timeframe.

Table 15-3. Hazard Materials Spills in Contra Costa County Reported to Cal OES

Spill Site	2012	2013	2014	2015	2016	Total
Airport	1	0	1	0	0	2
Industrial Plant	8	7	3	8	2	28
Merchant/Business	19	21	22	24	30	116
Military Base	1	0	1	0	0	2
Oil Field	0	0	0	1	0	1
Other	26	27	19	13	23	108
Pipeline	3	4	7	4	1	19
Rail Road	24	11	26	25	37	123
Refinery	41	18	27	40	29	155
Residence	40	28	28	28	30	154
Road	40	40	32	36	33	181
School	1	2	2	1	2	8
Service Station	14	19	11	16	9	69
Ship/Harbor/Port	26	19	11	16	4	76
Treatment/Sewage Facility	16	3	3	2	5	29
Utilities/Substation	1	1	0	1	3	6
Waterways	36	27	33	33	36	165
Total	297	227	226	248	244	1,242

Source: Cal OES, 2017

Utility Interruption

EBMUD water services have been interrupted by landslides and erosion that have damaged underground water lines. The most recent occurred along Canyon Road below 947-951 Augusta Drive in April 2017, on Moraga Creek in late January 2016, and along Augusta Drive in Merion Terrace in June 2016.

Contra Costa Water District services have also been interrupted by landslides and storm-related damage. The most recent occurred in January and February 2017; severe storms caused surficial slides on the face of the Los Vaqueros Dam, the Contra Costa Canal system, trails and other district facilities. Landslides on Morgan Territory Road in Clayton damaged the roadway, resulting in multiple breaks in the District's 8-inch pipeline and creating temporary water service outage for over 100 customers.

Contra Costa County has experienced the cutting of fiber optic cable at four communication vaults since 2014. This disrupts internet and phone service. The FBI is investigating these acts of vandalism. Security experts believe the attacks may be the work of a disgruntled employee or of terrorist aiming to determine how long it takes to repair the infrastructure.

Active Shooter Incident

There have not been any active shooter incidents in Contra Costa County, but the following incidents have occurred recently in California:

- February 17, 2017, Oakland—A lone shooter, a computer science engineer, fired several shots over the course of an hour-long manhunt. The suspect died after he was hit by police gunfire.
- December 2, 2015, San Bernardino—A radicalized Islamic couple opened fire inside a building and killed 14 people and injured 21 at the Inland Regional Center. They were later killed in a shootout with police.
- May 2014, Santa Barbara—A student at a university in Santa Barbara killed six students at several locations on and near campus; 12 others were injured. The gunman killed himself.
- November 2013, Los Angeles International Airport—A gunman opened fire in a terminal. A Transportation Security Administration officer was killed, two other TSA officers and a traveler were wounded. The gunman was shot and arrested by police.

Location

Terrorism

Contra Costa County has identified numerous high profile targets for potential terrorists. Large population centers, high visibility tourist attractions, and critical infrastructure accessible to the public present security challenges of an ongoing nature in the planning area.

Cyber Security Threat

This hazard is not geography-based. Attacks can originate from any computer to affect any other computer in the world. If a system is connected to the Internet or operating on a wireless frequency, it is susceptible to exploitation. Targets of cyber-attacks can be individual computers, networks, organizations, business sectors, or governments. Financial institutions and retailers are often targeted to extract personal and financial data that can be used to steal money from individuals and banks. The most affected sectors are finance, energy and utilities, and defense and aerospace, as well as communication, retail, and health care. Both public and private operations in Contra Costa County are threatened on a near-daily basis by millions of current cyberattacks developed to automatically seek technological vulnerabilities.

Hazardous Material Incident

The following locations have the potential of hazardous materials releases:

- **Business and Industrial Areas**—Retail, manufacturing and light industrial firms are areas of concern. These facilities have the highest concentration of hazardous materials at fixed facilities in the planning area due to their manufacturing operations. Each business is required to file a detailed plan with the Contra Costa Health Services Hazardous Materials Program regarding materials on-site and safety measures taken to protect the public.
- **Agricultural Areas**—Accidental releases of pesticides, fertilizers, and other agricultural chemicals may be harmful to both humans and the environment. Agricultural pesticides are transported daily in and around the planning area en route to destinations in rural areas.
- **Illegal Drug Operations**—Illegal operations such as laboratories for methamphetamine can pose a threat. Laboratory residues are often dumped along roadways or left in rented hotel rooms, creating a serious health threat to unsuspecting individuals and to the environment.
- **Illegal Dumping Sites**—Hazardous wastes such as used motor oil, solvents, or paint are occasionally dumped in remote areas or along roadways, creating a potential health threat to unsuspecting individuals and to the environment.

- **Transportation Routes**—The County's transportation system consists of a network of federal, state, and county roads, airports, and rail service that all have the potential for hazardous material incidents:
  - ➢ Interstates 80, 580, and 680, State Routes 4, 24, 123, and 242
  - ➢ Amtrak long distance and intercity trains through the County
  - ➢ Railroad lines—Union Pacific owns 60 miles of lines, BNSF Railway has 55 miles of line, and two smaller lines (Sacramento Northern and Bay Point) operate in the County
  - ➢ General Aviation Airports—Buchanan Field, in the unincorporated county near Concord and Pleasant Hill; and Byron Airport near the Town of Byron.

- **Pipelines**—Figure 15-2 shows gas and hazardous liquid pipelines in Contra Costa County, as well as the locations of accidents and incidents. This information is provided by the National Pipeline Mapping System and is available to general public.

Source: PHMSA National Pipeline Mapping System 2017

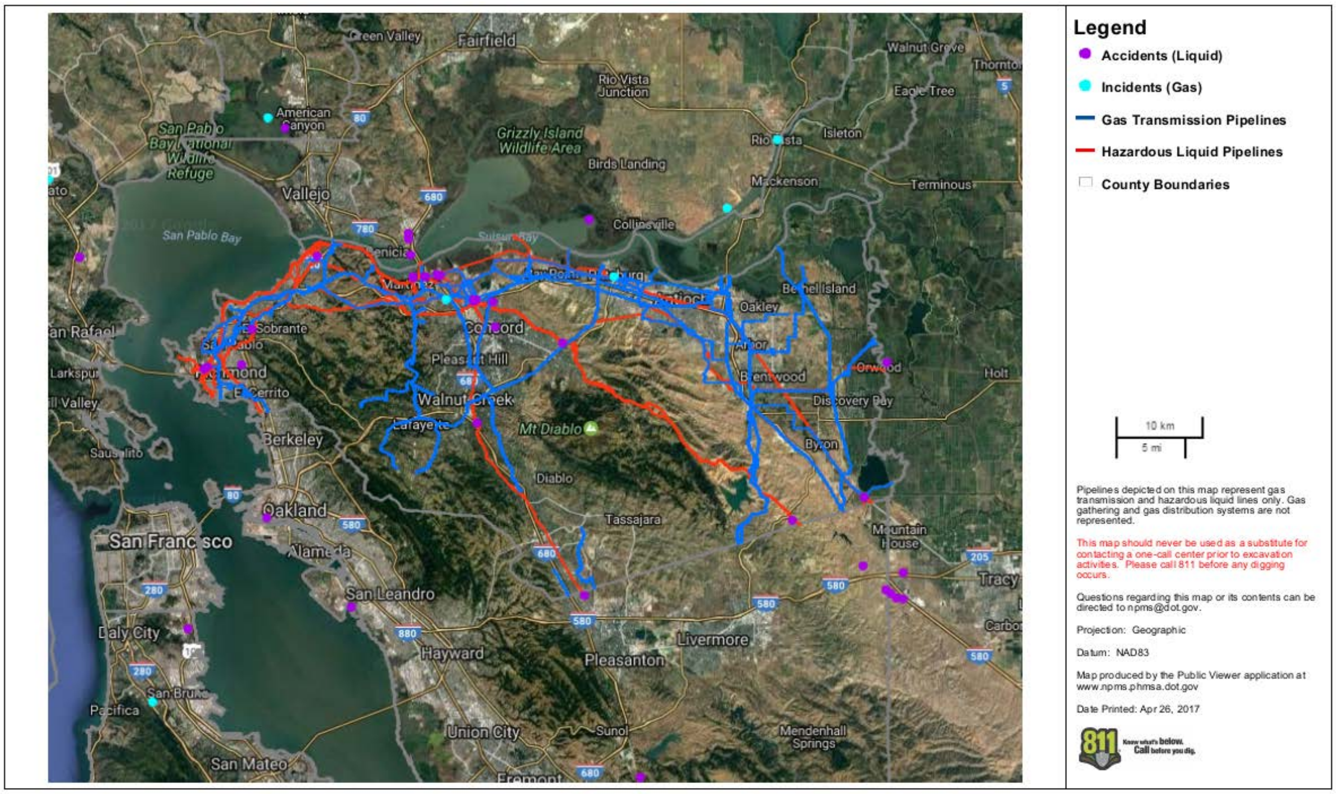


Figure 15-2. Pipelines in Contra Costa County

Utility Interruption

Electrical generation, transmission, and distribution system are located throughout the planning area.

Active Shooter Incident

According to recent studies, 77 percent of active shooter incidents occur in commercial, education, or government environments. Usually, the shooter is familiar with the chosen area and the area offers a tactical advantage.

Frequency

Terrorism

The likelihood of a terrorist event varies with the method of attack, as follows:

- **Chemical**—The risk of a chemical event is present in the planning area. The petroleum and agricultural community uses and stores significant amounts of chemicals that could be used in destructive ways.
- **Explosives**—The elements necessary to construct a WMD explosive are readily available. Agricultural communities maintain sufficient products for use in explosive devices. Pipe bomb and suspicious package events have occurred in Contra Costa County, though none have been specifically identified as a WMD.
- **Radiological/Nuclear**—The major transportation arteries for vehicles or rail that cross through or near the planning area contribute to the risk of a radiological event. Such products can pass through any of the regional transportation corridors.
- **Biological**—Anthrax incidents that occurred in the U.S. in October 2001 demonstrate the potential for spreading terror through biological weapons. An agent also could be introduced to livestock, causing harm to public health and the economy.
- **Combined Hazards**—WMD agents can be combined to have a greater total effect. Given the risks associated with chemical agents in Contra Costa County, the possibility of a combined event exists.

Cyber Security Threat

Cyber security threats are experienced on a daily basis, often without being noticed. Up-to-date virus protection software used in public and private sectors prevents most cyber-attacks from becoming successful. Programs that promote public education on virus protection are an effective way to mitigate cyber-threats. Cyberterrorism is much less common than cyber-attacks, though the frequency is unknown.

Hazardous Material Incident

Hazardous material incidents may occur at any time in the planning area, given the presence of transportation routes dividing the planning area, the location of businesses and industry that use hazardous materials, the presence of scattered illegitimate businesses such as clandestine drug laboratories, and the improper disposal of hazardous waste. Table 15-3 lists 1,242 incidents that occurred in the planning area over a 5-year timeframe.

Utility Interruption

The frequency of utility failure and power interruption is likely to remain constant, but the length of time a utility is shut down should lessen in the future as more redundancies are built into infrastructure and utilities. In addition, leak detection sensors alert utilities to faults and failures more quickly.

Active Shooter Incident

There have not been any active shooter incidents in the planning area, so the frequency of occurrence is low. Recent FBI studies found the average annual number of incidents in the U.S. to be 11.4 from 2000 to 2013 and 20 from 2014 to 2015.

Severity

Terrorism

The severity of a terrorist attack may vary from a few injured people to multiple injuries and fatalities.

Cyber Security Threat

An international study released by Malwarebytes in 2016 found that cyber-ransom threats caused 34 percent of business victims to lose revenue and 20 percent had to stop business immediately. The study also reported that nearly 60 percent of all cyber-ransom attacks demanded over $1,000, over 20 percent asked for more than $10,000, and 1 percent asked for over $150,000.

Hazardous Materials

Hazardous materials come in the form of explosives, flammable and combustible substances, poisons and radioactive materials. Hazards can occur during production, storage, transportation, use or disposal. The release or spill of hazardous materials requires a different response depending on factors such as the amount, type and location of the spill. Each location should have its own specific cleanup procedure, and all personnel handling such material should have received instruction on that procedure. There has been no fatality in the County from hazardous material release since the Walnut Creek pipeline explosion in 2004. The last hazardous material release that had a fatality at a fixed facility was the MBA Polymers dust explosion in 2000.

Utility Interruption

The severity of utility failure and power interruptions varies too widely to be able to measured. Electricity, for example, may be out for a few hours to several weeks, depending on the cause of the event.

Active Shooter Incident

The severity of an active shooter incident may vary from a few injured people to multiple injuries and fatalities. Between 2000 and 2013, the national average number of deaths per incident was 3.5 and the average number of wounded per incident was 5.8 according to the FBI (Blair, 2013). Approximately 40 percent of incidents involved three or more fatalities, meeting the federal definition of mass killing.

Warning Time

Terrorism

According to experts, fewer than 5 percent of all terrorism incidents are preceded by a warning or threat.

Cyber Security Threat

There is no warning time for cyber security threats. The top vector for spreading cyber-ransom threats is email.

Hazardous Material Incident

Hazardous material incidents occur without predictability under circumstances that give responders little time to prepare. Contra Costa County uses the Community Warning System to disseminate information to the public in the event of a release or threatened release of a hazardous material. The system includes the integration of warning sirens, the local media, NOAA weather radios, computer terminals, emergency response personnel pages, and emergency phone notification through the telephone emergency notification system. The system also sends out text messages and provides information over Facebook and Twitter. Contra Costa Health Services' Hazardous Materials Incident Response Team provides general data to first responders to advise evacuations or sheltering in place.

Utility Interruption

Utility failure and power interruptions occur at anytime without warning. However, they usually are a secondary effect from a storm event, landslide, earthquake, and human-caused issues.

Active Shooter Incident

The only warning of an active shooter incident is if a citizen notices unusual happenings and reports them before the shooting starts. The incident itself may be over in 5 to 10 minutes.

15.1.3 Secondary Hazards

The following are the most likely secondary hazards associated with human-caused hazards:

- A terrorist act can disrupt business activity and have long-term emotional impacts. Recovery can take significant resources and expense at the local level.
- Utility losses can cause a reduction in employment and in wholesale and retail sales, require utility repairs, and increase medical risk. Local government may lose tax revenue, and the finances of private utility companies and the businesses that rely on them can be disrupted.
- Computer security breaches associated with data and telecommunications losses can have significant economic impact.
- Roadway or railroad closures due to a transportation-related hazardous material spill would have serious effects on the local economy and ability to provide services. Loss of major travel routes would result in loss of commerce, and could impact the ability to provide emergency services to citizens. The ability to receive fuel deliveries could be impacted.
- An active shooter incident can make the general public nervous about going out, so that more people stay at home.

15.1.4 Exposure

Population and Property

Terrorism

Large-scale terrorism incidents have the potential to kill or injure many citizens in the immediate vicinity, and may also affect people a relative distance from the initial event. This report does not consider a set distance to determine those more or less at risk. Variables affecting exposure in the event of a WMD attack include the type of product used, the ambient temperature, wind speed, wind direction, barometric pressure, and humidity. Terrorism can pose a serious long-term threat to property.

Cyber Security Threat

The entire planning area population is exposed to cyber security threat personally or at places of employment. All populations who directly use a computer or receive services from automated systems are exposed to cyber-terrorism. Structures are usually not impacted by cyber security threats, but systems operated by electronics and computers are exposed.

Hazardous Material Incident

According to the California Department of Finance, there are 409,783 housing units in Contra Costa County as of January 1, 2016. Variables affecting exposure in the event of a hazardous materials incident include the type of product, the physical and chemical properties of the substance, the physical state of the product (solid, liquid, or gas), the ambient temperature, wind speed, wind direction, barometric pressure, and humidity. With so many variables, distances are difficult to forecast. In general, those close to transportation corridors or businesses with acutely hazardous materials are more at risk for some sort of effect; but, each chemical incident is different and the scenarios are numerous.

Hazardous materials pose a significant risk to emergency response personnel. All potential first responders and follow-on emergency personnel in the planning area currently are and will be properly trained to the level of emergency response actions required of their individual position at the response scene. Hazardous materials also pose a serious long-term threat to public health and safety, property and the environment.

Utility Interruption

All residents and visitors are exposed to utility interruptions. This will continue as people are dependent on basic utility services such as electricity, water, wastewater, gasoline, natural gas, etc. All property is exposed to some type of utility infrastructure throughout the planning area.

Active Shooter Incident

The entire population in the planning area is exposed to being active shooter victims. A shooting can happen anywhere and anytime. Property may play a role in the chosen site for the shooter, but the intent is to quickly cause harm to persons before police arrive; damage to the property itself is not the focus of the attack.

Critical Facilities and Infrastructure

Terrorism and Hazardous Material Incident

Hazardous materials may be stored at or transported along critical facilities. In the industrial corridor along the northern and northwestern portions of the county, Chevron, Phillips 66, Shell, Tesoro Golden Eagle Refinery, Dow Chemical, and USS-Posco Industries all house hazardous materials. These facilities are susceptible to accidents and are visible targets for terrorism. The exposure of critical facilities and infrastructure to a terrorism event or hazardous material incident is based on the facility's criticality and physical vulnerability:

- Criticality is a measure of the potential consequence of an accidental or terrorist event as well as the attractiveness of the facility to a potential adversary or threat. The criticality for each critical facility is based on the factors shown in Table 15-4.
- Vulnerability is a measure of the physical opportunity for an accident or an adversarial attack. This assessment takes into consideration physical design, existing countermeasures, and site layout. The vulnerability for each critical facility is based on the criteria shown in Table 15-5.

Table 15-4. Criticality Factors

Criterion	Low Criticality	Medium Criticality	High Criticality
Awareness[a]	Not known/Neighborhood	City/Region/County	State/National
Hazardous Materials[b]	None / limited and secure	Moderate to large and secure	Large, minimum or no security
Collateral Damage Potential[c]	None or low	Moderate/immediate area or within 1 mile radius	High/immediate area or within 1 mile radius
Site Population[d]	0 – 300	301 – 1,000	1,001 or greater
Public/ Emergency Function[e]	No emergency function, or could be used for emergency function in the future	Support emergency function—redundant site	Emergency function—critical service with or without redundancy

a. Awareness—How aware is the public of the existence of the facility, site, system, or location?
b. Hazardous Materials—Are flammable, explosive, biological, chemical and/or radiological materials present on site?
c. Collateral Damage Potential—What are the potential consequences for the surrounding area if the asset is attacked or damaged?
d. Site Population—What is the potential for mass causalities, based on the capacity of the facility.
e. Public or Emergency Functions—Does the facility perform a function during an emergency? Is this facility or function capable of being replicated elsewhere?

Table 15-5. Vulnerability Criteria

Criterion	Low Vulnerability	Medium Vulnerability	High Vulnerability
Accessibility[a]	Remote location, secure perimeter, tightly controlled access	Controlled access, protected or unprotected entry	Open access, unrestricted, patrolling security, sign restrictions
Automobile Proximity[b]	Not within 75' – 100'	Not within 25' – 50'	Adjacent or not within 10'
Asset Mobility[c]	Moves or is relocated frequently	Moves or is relocated occasionally	Permanent/Fixed
Proximity to other Critical Facilities[d]	Greater than 1.5 – 2 miles	Greater than 3/4 - 1 mile	Within 1/2 – 3/4 mile
Secure Design[e]	No areas for concealment of packages, air intakes are on roof, access ways are not under the structure.	Area of concealment present, greater than 25' from the structure; Air intakes located at least 10' above ground, may have under structure access drives.	Areas of concealment within 25', air intakes at ground level, under structure access drives.

a. Accessibility—How accessible is the facility or site to the public?
b. Automobile Proximity—How close can an automobile get to the facility? How vulnerable is the facility to a car bomb attack?
c. Asset Mobility—Is the facility or asset's location fixed or mobile? If mobile, how often is it moved, relocated, or repositioned?
d. Proximity to other critical facilities—If the facility is close to other critical facilities then there could be an increased probability of the facility receiving collateral damage.
e. Secure design—General evaluation of areas of obstruction, air intake locations, parking lot and road design and locations and other site design aspects.

Cyber Security Threat

All critical facilities and infrastructure that operate by electricity and/or a computer system are exposed to cyber security threats.

Utility Interruption

Critical facilities are exposed to utility interruption. Damage to critical facilities can disrupt health care, fire and police services and impair search and rescue and emergency medical care.

Active Shooter Incident

Critical facilities do not play a role for an active shooter incident. The location of infrastructure such as roads and highways may play a role in the chosen site for an active shooter, but the intent is to obtain inflict extensive personal harm before police arrive and the shooters are usually not planning to flee the scene.

Environment

Terrorism

The environment is exposed to terrorism events, which, depending on the methods used, can kill wildlife, destroy habitat, and contaminate critical resources in the food chain.

Cyber Security Threat

The environment is not exposed to cyber security threats and thus would not risk damage. It would only be through a secondary effect that the environment could be effected by a cyber-attack. For example if a cyber-attack shut down a hydroelectric dam so that a river would be affected.

Hazardous Material Incident

The risk of hazardous material spills to the environment is considerable. Hazardous materials spilled along roads or railways can pollute rivers, streams, wetlands, riparian areas and adjoining fields. Other hazardous materials released into the air can severely impact plant and animal species. Reducing risk exposure to the built environment will also mitigate potential losses to the natural environment.

Utility Interruption

The environment is usually not exposed to utility interruption unless it is a spill that contaminates water or open land or creates a wildfire that burns acres.

Active Shooter Incident

The environment does not play a role for an active shooter incident.

15.1.5 Vulnerability

Population

Terrorism

Although terrorism has not resulted in a large number of deaths in the planning area, it can be deadly and widespread. Any individuals exposed to human-caused hazards are considered to be at risk, particularly those working as first responders.

Cyber Security Threat

All populations who directly use a computer or receive services from automated systems are vulnerable to cyber security threats. Certain types of attacks would impact specific segments of the population. If the cyber security threat targeted the PG&E power or utility grid, individuals with medical needs would be impacted the greatest. These populations are most vulnerable because many of the life-saving systems they rely on require power. If an attack occurred during extreme hot weather, those 65 and older would be vulnerable to the effects of the lack of air conditioning. These individuals might require an air-conditioned shelter operating on a back-up generator. If a cyber-attack targeted a facility storing or manufacturing hazardous materials, individuals living adjacent to these facilities would be vulnerable.

Hazardous Material Incident

People near facilities producing, storing, or transporting hazardous substances are at higher risk. Populations downstream, downwind, and downhill of a released substance are particularly vulnerable. A spill of a toxic airborne chemical in a populated area could have greater potential for loss of life. Depending on the characteristics of the substance released, more people in a larger area may be in danger from explosion, absorption, injection, ingestion, or inhalation. Often, people in the radius area (outside the immediate affected area) are evacuated as a precaution or told to shelter-in-place, depending on the release type and wind conditions.

Utility Interruption

The entire planning area is vulnerable to utility interruptions. FEMA has developed standard loss-of-use estimates in conjunction with its benefit-cost analysis methodologies to estimate the cost of lost utilities on a per-person, per-use basis, as summarized in Table 15-6.

Table 15-6. FEMA Standard Value for Loss of Service for Utilities and Roads/Bridges

Interruption	Total Economic Impact
Complete Loss of Electric Power	$126 per person per day
Complete Loss of Potable Water Service	$93 per person per day
Complete Loss of Wastewater Service	$41 per person per day
Complete Loss of Road/Bridge Service	$38.15 per vehicle per hour of vehicle delay detour time $0.55 per mile of vehicle delay (or current federal mileage rate)

Source: FEMA BCA Reference Guide, June 2009, Appendix C

Active Shooter Incident

All individuals in the planning area are considered to be at risk to active shooter incidents.

Property

Terrorism

All structures in the planning area are physically vulnerable to a terrorism event. Factors that affect vulnerability include an emphasis on accessibility, opportunities for roof access, driveways underneath structures, unmonitored areas, and the proximity of structures to transportation corridors and underground pipelines.

Cyber Security Threat

Cyber-threats can cause physical damage if real assets or end consumers are affected by service disruption. This might occur if cyber-threats target industries related to utilities, life support, transportation, human services, or telecommunications. In many cases, attacks on these systems initially will not be detected, and any malfunction will be thought to be system failure. Cyber-incidents can result in the theft or modification of important data—including personal, agency, or corporate information— and the sabotage of critical processes, including the provision of basic services by government or private-sector entities.

Hazardous Material Incident

The impact of a fixed-facility hazardous materials incident will likely be localized to the property where it occurs. The impact of a spill of a small amount of a liquid chemical may be limited to remediation of soil.

Utility Interruption

All property is exposed and vulnerable to some type of utility infrastructure failure throughout the planning area.

Active Shooter Incident

The intent of an active shooter is to harm persons; property may be incidentally damaged, but the shooter's intent does not generally focus on property.

Critical Facilities and Infrastructure

Terrorism

The U.S. Office of Homeland Security created the 2003 *National Strategy for the Physical Protection of Critical Infrastructure of Critical Infrastructure and Key Assets*, which lays a foundation to work together to prepare and protect critical infrastructure and key assets nationwide from terrorist events. Owners of critical facilities and infrastructure know that they are vulnerable to terrorism and have executed preparedness planning and exercises for years and fortified these facilities to minimize their vulnerability.

Cyber Security Threat

A catastrophic cyber security threat can have far-ranging effects on public and private infrastructure systems. All critical facilities and infrastructure that are operated by electricity and/or a computer system are vulnerable to the cyber security threat. Cyber-threats may affect structures if any critical electronic systems suffer service disruption. For instance, a cyber-attack may cripple the electronic system that controls a cooling system or pressure system, resulting in physical damage to the structure from components overheating, or an explosion if pressure relief systems are rendered inoperable.

Hazardous Material Incident

The impact of a hazardous material spill or transportation incident will likely be localized to the particular facility, hospital, port, airport, railroad, road, highway, or interstate. The potential losses vary because of the variable nature of the hazardous material spill, but costs from product loss, property damage and decontamination and other costs can add up to millions of dollars.

Utility Interruption

Critical facilities are vulnerable to utility interruption. But the adverse effect of damaged critical facilities can extend beyond direct physical damage. It can disrupt health care, fire, and police services, impair search and rescue, and emergency medical care.

Active Shooter Incident

Critical facilities are unlikely to experience significant damage from an active shooter incident.

Environment

Terrorism

A terrorism event using a WMD could cause harm to the environment, but no platforms currently existing for estimating the level of harm. The best gauge of vulnerability of the environment would be a review of damage from past terrorism events. Capturing such data from future events could be beneficial in measuring the vulnerability of the environment.

Cyber Security Threat

While effects of cyber-threats on the natural environment are unlikely, they can occur. Such effects may come from a system failure that, for example, allows a release of hazardous materials or improper disposal of waste.

Hazardous Material Incident

Depending on the characteristic of the hazardous material or the volume of product involved, the affected area can be as small as a room in a building or as large as many square miles that require soil remediation. More widespread effects occur when a product contaminates the municipal water supply or water system such as a port, river, lake, or aquifer. Such environmental damage can linger for decades.

Utility Interruption

The environment is vulnerable to utility interruption if the utility has a spill that contaminants water and/or open land or creates a wildfire that burns acres.

Active Shooter Incident

The environment is unlikely to experience significant damage from an active shooter incident.

Economic impacts

Terrorism

Economic impacts from a terrorist event could be significant. The cost of a terrorist act would be felt in terms of loss of life and property and disruption of business activity. Recovery would take significant resources and expense at the local level.

Cyber Security Threat

Cyber-threats can have extensive fiscal impacts. Companies and government services can lose large sums of unrecoverable revenue from site downtime and compromise of sensitive confidential data. The economic impact of data and telecommunications losses can be high as computer security breaches, crime conducted via the internet such as identify theft, and many other forms of cyber-attack occur daily. Millions of dollars are lost each year as criminals and cyber-terrorists steal sensitive information and funds from individuals and organizations.

Hazardous Material Incident

Large hazardous material spills can drive away tourists. Transportation incidents can temporarily shut down transportation routes. Studies that look at economic effects from bridge and highway losses consistently report job loss and economic losses in the billions of dollars. For example, 43 percent of businesses reporting losses after the 1994 Northridge Earthquake said they were due to transportation issues.

Utility Interruption

Utility losses could cause a reduction in employment and wholesale and retail sales, a need for utility repairs, and increased medical risks. Local governments might lose tax revenues, and the finances of private utility companies and the businesses that rely on them would be disrupted.

Active Shooter Incident

Economic impacts can occur from loss of patrons coming to a local business where an incident occurred, down time from a closed business, and loss of wages for an individual who was injured or killed.

15.1.6 Future Trends in Development

Terrorism

As more people and business enters the County, the possibility of a future terrorism event will increase.

Cyber Security Threat

Contra Costa County will continue to be impacted and compelled to respond to cyber-threats in the future. The nature of these threats is projected to evolve in sophistication over time. The County is expected to remain vigilant in its efforts to prevent attacks from occurring or disrupting business operations. The reality remains that many computers and networks in organizations of all sizes and industries around the U.S. will continue to suffer intrusion attempts on a daily basis from viruses and malware that are passed through web sites and emails.

Hazardous Material Incident

The number and types of hazardous chemicals stored in and transported through Contra Costa County will likely continue to increase. As population grows, the number of people vulnerable to the impacts of hazardous materials spills and transportation incidents will increase. Population and business growth along major transportation corridors increases the vulnerability to transportation-related hazardous material spills.

Utility Interruption

The likelihood of utility interruption in the future will continue as development and population growth continue in the County. The majority of utilities in the County are privately owned, and market forces are, as a rule, insufficient to induce needed investments in protection. Private organizational strategies and policies will need to work together to ensure reliable and resilient services for the long term.

Active Shooter Incident

The Contra Costa County Sheriff's Office and numerous local agencies train and exercise for active shooter incidents together in the county, and this will continue in the future. Citizen engagement and proactive community preparedness will need to continue to help prevent incidents by reporting things that look unusual to authorities. To increase survivability in active shooter incidents, Contra Costa County will need to teach and empower non-professional first care providers (i.e. citizen bystanders) to initiate basic care of the wounded.

15.1.7 Scenario

Terrorism

A scenario that could have a significant impact on the planning area would be a terrorist event at a large gathering place such as a mall or event center. Terrorist events happen with little or no warning. With a population in excess of 1 million people, Contra Costa County does possess potential targets for terrorist activities.

Cyber Security Threat

A cyber-ransom against all County departments would leave County employees locked out of all files and computer systems until the issue is resolved, which could be hours, days, or weeks.

Hazardous Material Incident

An incident involving hazardous materials being transported via Interstate 680 could have a significant impact on the planning area. A release of hazardous materials could impact large population centers within the planning area. Advance knowledge of shipments and their contents would play a role in preparedness for this scenario, thus reducing its potential impact. The biggest issue in response to hazardous materials is material identification and containment.

Utility Interruption

A worst-case scenario is when an entire region's electrical grid is out. This would leave residences without power, cause stores to be closed, cell service to fail and broadband internet to stop working, require hospitals to operate on generators, eliminate travel by train or air, and prevent automobile fueling at gas stations.

Active Shooter Incident

A worst-case scenario may involve a gunman who gets access to a local elementary school and fires at random students, facility, and staff. The death toll could be high before the gunman is apprehended and the police arrive.

15.1.8 Issues

The following are important needs to address issues associated with human-caused hazards in the planning area:

- Participate in regional, state and federal efforts to gather terrorism information at all levels and keep public safety officials briefed at all times regarding local threats. Further develop response capabilities based on emerging threats.

- Encourage local businesses to adopt information technology and telecommunications recovery plans.
- Prepare and present a human-caused hazard risk and preparedness program to the public through meetings, town hall gatherings, and preparedness fairs and outreach.
- Maintain any and all citizen advisory groups and periodically e-mail emergency preparedness information including human-caused hazard preparedness instructions and reminders.
- Continue all facets of emergency preparedness training for police, fire, public works, and public information staff in order to respond quickly in the event of a human-caused disaster.
- Train first responders and all appropriate local government staff to implement protocols contained in the *Contra Costa County Hazardous Materials Area Plan*.
- Work proactively with hazardous materials facilities to follow best management practices:
    - Placards and labeling of containers
    - Emergency plans and coordination
    - Standardized response procedures
    - Notification of the types of materials being transported through the planning area at least annually
    - Random inspections of transporters as allowed by each company
    - Installation of mitigating techniques along critical locations
    - Routine hazard communication initiatives
    - Consideration of using alternative products that are safer.
- Continue all facets of the hazardous materials team training and response through commitment of resources from the Health Services budget.
- Work with the private sector to enhance and create business continuity plans in the event of an emergency.
- Coordinate with planning area school districts to ensure that their emergency preparedness plans include preparation for human-caused incidents.

15.2 PUBLIC HEALTH

15.2.1 General Background

The following sections describe commonly recognized human health hazards. In Contra Costa County, the Mosquito and Vector Control District works to reduce the risk of diseases spread by insects and animals in a responsible and environmentally conscious manner.

Influenza

Epidemics of the flu typically occur in the fall and winter. Because flu seasons fluctuate in length and severity, a single estimate cannot be used to summarize influenza-associated deaths. The U.S. Centers for Disease Control and Prevention (CDC) estimates that from 2010-2011 to 2013-2014, flu-associated deaths ranged from a low of about 12,000 to a high of about 56,000. Yearly vaccination is the primary method for preventing influenza.

H1N1

In April 2009, the World Health Organization (WHO) issued a health advisory on an outbreak of influenza-like illness caused by a new subtype of influenza A (A/H1N1) in Mexico and the United States.

DEFINITIONS

Epidemic—The spread of an infectious disease beyond a local population, reaching people in a wider geographical area. Several factors determine whether an outbreak will become an epidemic: the ease with which the disease spreads from vectors, such as animals, to people and the ease with which it spreads from person to person.

Influenza—A viral infection that attacks the respiratory system; commonly called flu.

Pandemic—A worldwide epidemic.

Vector—An organism (such as an insect or rodent) that transmits pathogens that cause disease

Vector-Borne Illness—Diseases transmitted to people from insects and other animals. These include, but are not limited to, Hanta Virus, Plague, Tularemia, Lyme Disease, West Nile Virus and the Zika Virus.

The disease spread rapidly, and in June the WHO declared an H1N1 pandemic, marking the first global pandemic since the 1968 Hong Kong flu. In October, the U.S. declared H1N1 a national emergency. In August 2010, the WHO declared an end to the pandemic globally. H1N1 viruses and seasonal influenza viruses are co-circulating in many parts of the world. It is likely that the 2009 H1N1 virus will continue to spread for years to come, like a regular seasonal influenza virus.

H5N1/H7N9

The highly pathogenic H5N1 avian influenza virus is an influenza A subtype that occurs mainly in birds, causing high mortality among birds and domestic poultry. Outbreaks of highly pathogenic H5N1 among poultry and wild birds are ongoing in a number of countries such as Cambodia, China, Indonesia, Thailand, and Vietnam.

H5N1 virus infections of humans are rare and most cases have been associated with direct poultry contact during poultry outbreaks. Rare cases of limited human-to-human spread of H5N1 virus may have occurred, but there is no evidence of sustained human-to-human transmission. Nonetheless, because all influenza viruses have the ability to change and mutate, scientists are concerned that H5N1 viruses one day could be able to infect humans more easily and spread more easily from one person to another, potentially causing another pandemic.

While the H5N1 virus does not infect people easily, infection in humans is much more serious when it occurs than is infection with H1N1. More than half of people reported infected with H5N1 have died.

Infections in humans and poultry by a new Asian lineage avian influenza A (H7N9) virus was first reported in China in March 2013, and China is experiencing its fifth epidemic of this in 2017. It is the largest annual epidemic to date. While mild illness in human cases has been seen, most patients have had severe respiratory illness and some have died. The only case identified outside of China was recently reported in Malaysia.

Source investigation by Chinese authorities is ongoing. Many of the people infected with H7N9 are reported to have had contact with poultry. Close contacts of confirmed H7N9 patients are being followed to determine whether any human-to-human spread of H7N9 is occurring. No sustained person-to-person spread of the H7N9 virus has been found at this time. However, based on previous experience with avian flu viruses, some limited human-to-human spread of this the virus would not be surprising.

As of the publication of this document, H5N1 and the new H7N9 virus have not been detected in people or birds in the United States.

Smallpox

Smallpox is a sometimes fatal infectious disease. There is no specific treatment, and the only prevention is vaccination. Symptoms include raised bumps on the face and body of an infected person. The oldest evidence of smallpox was found on the body of Pharaoh Ramses V of Egypt who died in 1157 BC.

Outbreaks have occurred from time to time for thousands of years, but the disease is now eradicated after a successful worldwide vaccination program. The last case of smallpox in the United States was in 1949. The last naturally occurring case in the world was in Somalia in 1977. As of the publication of this document, there are no cases of smallpox in the world. Currently only two locations in the world have samples of smallpox: the CDC in Atlanta and the Ivanovsky Institute of Virology in Russia.

After the disease was eliminated, routine vaccination among the general public was stopped. Therefore, any cases of smallpox in the world would be considered an immediate international emergency. In 2003, the Wisconsin Division of Public Health conducted an investigation of state residents who became ill after having contact with prairie dogs. The cases appeared in May and June of 2003, and symptoms in the human cases included fever, cough, pox-like rash and swollen lymph nodes. CDC laboratory test results indicated that the cause of the human illness was Monkeypox, an orthopox virus that could be transmitted by prairie dogs. This outbreak, and the potential use of smallpox as a weapon of bioterrorism, brought the fear of smallpox back to the forefront of the population. A detailed nationwide smallpox response plan created at the end of 2002 is designed to quickly contain a potential outbreak and vaccinate the population.

Viral Hemorrhagic Fevers

Viral hemorrhagic fevers (VHFs) are a group of illnesses caused by several distinct families of viruses. VHFs represent a multisystem syndrome (multiple systems in the body are affected). Characteristically, the overall vascular system is damaged and the body's ability to regulate itself is impaired. These symptoms are often accompanied by hemorrhage (bleeding); however, the bleeding itself is rarely life-threatening. While some types of hemorrhagic fever viruses can cause relatively mild illnesses, many cause severe, life-threatening disease.

The viruses that cause VHFs are distributed over much of the globe. However, because each virus is associated with one or more particular host species, the virus and the disease it causes are usually seen only where the host species live. Some hosts, such as the rodent species carrying several of the New World arenaviruses, live in geographically restricted areas. Therefore, the risk of getting VHFs caused by these viruses is restricted to those areas. Other hosts range over continents, such as the rodents that carry viruses that cause the hantavirus pulmonary syndrome in North and South America, or the rodents that carry viruses that cause hemorrhagic fever with renal syndrome in Europe and Asia.

Ebola

The 2014 Ebola virus outbreak was unprecedented in geographical reach and impact on health care systems across the globe. This was the largest and deadliest Ebola virus outbreak ever recorded. It was the first time the West African countries of Guinea, Liberia, Sierra Leone, Nigeria, Mali, and Senegal saw the virus. Ebola is more common in Central African countries, such as the Democratic Republic of Congo and Sudan, where it was first discovered in 1976. It was also the first time that Ebola made it to the United States and Europe, prompting world-wide preparedness and response efforts. Figure 15-3 shows areas that ultimately were affected. The outbreak was closely monitored and traveler screenings were developed for those returning to the U.S. from West Africa.

In August 2014, two U.S. healthcare workers returned to the United States for treatment for Ebola. The case that most impacted the health care system in the United States was a patient diagnosed with Ebola in Dallas, Texas who died due to Ebola in October 2014. The nurse who provided care for him later tested positive for Ebola. This caused responses across the country from hospitals, emergency medical teams, fire departments and public health agencies to enhance isolation precautions, develop emergency policies, train with personal protective equipment and conduct multi-agency emergency exercises in case the spread of Ebola became a pandemic.

Before the 2014 outbreak, only 2,200 cases of Ebola had been recorded and 68 percent were fatal. Twenty percent of new Ebola infections were linked to burial traditions in which family and community members wash and touch dead bodies before burial. In Guinea, 60 percent of Ebola infections were linked to traditional burial practices.

Hantavirus

Hantavirus is a rodent-borne disease. It was discovered in 1993 in the southwestern U.S., and it has been determined that the disease had been present, but unrecognized, at least as early as 1959. It has now been identified in over half of the states of the U.S. In 2013, seven cases of hantavirus occurred in Yosemite National Park. Hantavirus has also been detected in the Sierra Nevada region.

Source: World Health Organization

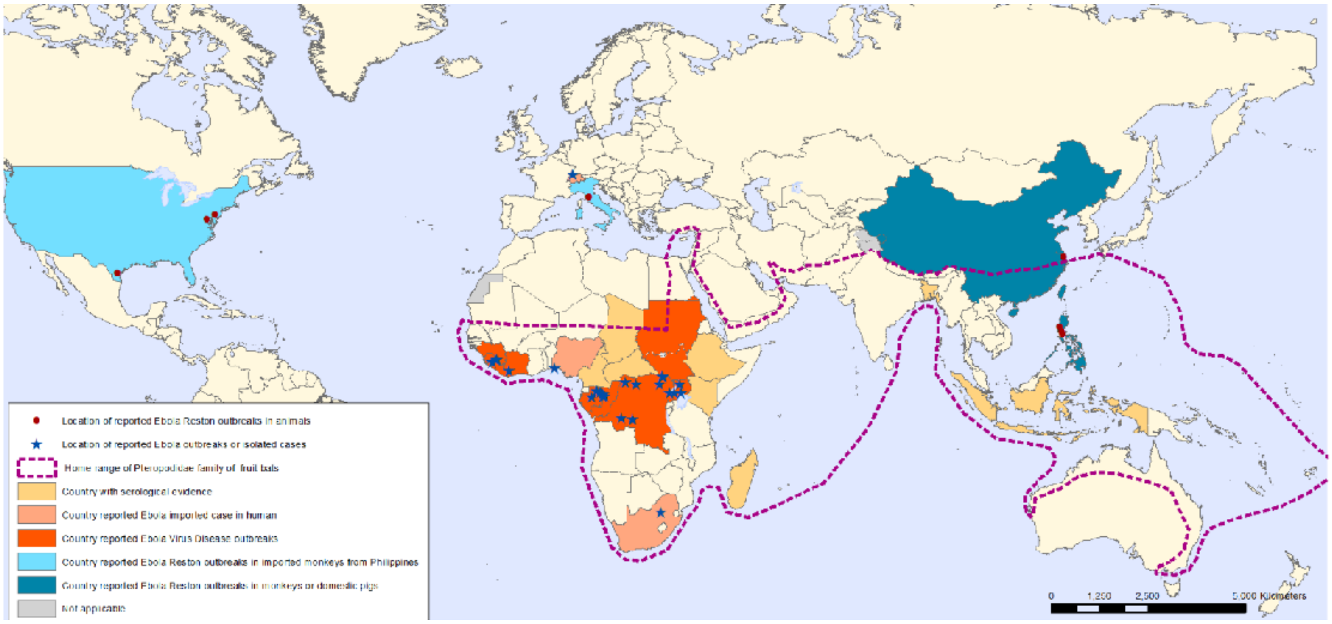


Figure 15-3. 2014 Distribution of Ebola Virus Outbreaks in Humans and Animals

The hantavirus spreads when individuals touch or eat something contaminated with infected rodent urine, droppings or saliva. It can also be transmitted through aerosolization, which occurs when dried materials contaminated by infected rodent droppings or saliva are disturbed and brought up into the air and inhaled.

Infected persons first develop symptoms one to five weeks after exposure. Early symptoms include fever, headache, and muscle aches, especially in the thighs, hips, back, and shoulders. Other early symptoms include dizziness, chills, nausea, vomiting, diarrhea, and abdominal pain. After two to seven days of these symptoms, patients develop breathing difficulties that range from cough and shortness of breath to severe respiratory failure. Approximately 40 percent of hantavirus patients die from the disease.

Plague

Plague is a potentially fatal infectious disease of animals and humans caused by the *Yersinia pestis* bacterium. People usually get plague from being bitten by a flea that is carrying the plague bacterium or by handling an infected animal. Today, modern antibiotics are effective against plague, but if an infected person is not treated promptly, the disease is likely to cause illness or death.

Plague is an ancient disease but outbreaks throughout the world continue. Major plague epidemics occurred in the middle of the sixth century in Egypt, Europe and Asia; during the 14th century in Europe; in the 18th century in Austria and the Balkans; and in the late 19th century worldwide (but mostly in China and India). Manchuria in 1910–1911 witnessed about 60,000 deaths due to pneumonic plague with a repeat in 1920–1921. A minor outbreak occurred as recently as the summer of 1994 in Surat, India. Globally, the WHO reports 1,000 to 3,000 cases of plague every year.

In North America, plague is found in certain animals and their fleas from the Pacific Coast to the Great Plains, and from southwestern Canada to Mexico. The last urban plague epidemic in the United States occurred in Los Angeles in 1924-25. Since then, human plague in the U.S. has occurred as mostly scattered cases in rural areas (an average of 10 to 15 persons each year per the CDC). Most human cases in the United States occur in northern New Mexico, northern Arizona, southern Colorado, California, southern Oregon, and far western Nevada.

Tick-Borne Disease

Ticks are small, insect-like creatures most often found in naturally vegetated areas. They feed by attaching to animals and humans, sticking their mouthparts into the skin, and sucking blood for up to several days. Ticks do not fall from trees, jump or fly. Most species are found on wild grasses and low plants. Adult ticks wait at the ends of grass or other foliage for a host to brush by so they may attach. Sometimes ticks carry bacteria or viruses that can be transmitted to a person while the tick is attached and feeding. The following species of ticks are known to commonly bite humans:

- Western blacklegged tick (*Ixodes pacificus*)
- American dog tick (*Dermacentor variabilis*)
- Pacific Coast tick (*Dermacentor occidentalis*)
- Wood tick (*Dermacentor andersoni*)
- Brown dog tick (*Rhipicephalus sanguineus*)
- *Ornithodoros hermsi*
- *Ornithodoros parkeri*
- *Ornithodoros coriaceus.*

Tularemia

Tularemia, named after Tulare County in California where it was first described in 1911, is a tick-borne disease of animals and humans caused by the bacterium *Francisella tularensis*. Tularemia is similar to plague, but is typically spread differently. While plague is usually spread to humans by fleas, humans usually become infected with Tularemia by tick and deer fly bites, skin contact with infected animals, ingestion of contaminated water or meat, or inhalation of contaminated dusts or aerosols. Symptoms vary depending upon the route of infection.

Rabbits, hares, and rodents are especially susceptible and often die in large numbers during outbreaks. Although Tularemia can be life-threatening, most infections can be treated successfully with antibiotics. Steps to prevent Tularemia include use of insect repellent, wearing gloves when handling sick or dead animals, and not mowing over dead animals. In the United States, naturally occurring infections have been reported from all states except Hawaii.

Lyme Disease

Lyme disease, named after the city in Connecticut where it was first identified in 1975, is a tick-borne disease caused by the bacterium *Borrelia burgdorferi,* which normally lives in mice, squirrels and other small animals. It is transmitted among these animals and to humans through the bites of certain species of ticks. In the northeastern and north-central United States, the black-legged tick (or deer tick, *Ixodes scapularis*) transmits Lyme disease. In the Pacific coastal United States, the disease is spread by the western black-legged tick (*Ixodes pacificus*). Other major tick species found in the United States have not been shown to transmit the disease.

Typical symptoms include fever, headache, fatigue, and a skin rash. If left untreated, infection can spread to joints, the heart, and the nervous system. Lyme disease is diagnosed based on symptoms, physical findings (e.g., rash), and the possibility of exposure to infected ticks. Laboratory testing is helpful in later stages of the disease. Most cases of Lyme disease can be treated successfully with a few weeks of antibiotics. Steps to prevent Lyme disease include using insect repellent, removing ticks promptly, landscaping, and integrated pest management. The ticks that transmit Lyme disease can occasionally transmit other tick-borne diseases as well.

Rocky Mountain Spotted Fever

Rocky Mountain spotted fever is a potentially fatal tick-borne disease caused by the bacterium *Rickettsia rickettsii*. It is transmitted to humans by the bite of an infected American dog tick (*Dermacentor variabilis*), Rocky Mountain wood tick (*Dermacentor andersoni*), or brown dog tick (*Rhipicephalus sanguineus).*

Typical symptoms include fever, headache, abdominal pain, vomiting, and muscle pain. A rash may also develop, but is often absent in the first few days, and in some patients, never develops. Rocky Mountain spotted fever can be a severe or even fatal illness if not treated in the first few days of symptoms. It can be treated successfully with a few weeks of antibiotics. Steps to prevent the disease include using insect repellent, removing ticks promptly, landscaping, and integrated pest management. The ticks that transmit Rocky Mountain spotted fever can occasionally transmit other tick-borne diseases as well.

Mosquito-Borne Disease

Malaria

Malaria is a sometimes fatal mosquito-borne disease caused by a parasite that commonly infects the *Anopheles* mosquito, which feeds on humans. People who contract malaria are typically very sick with high fevers, chills, and flu-like illness. Although malaria can be fatal, illness and death can usually be prevented.

On average 1,500 cases of malaria are diagnosed in the United States each year. The vast majority are in travelers and immigrants returning from countries where malaria transmission occurs, many from sub-Saharan Africa and South Asia. In many temperate areas, such as western Europe and the United States, economic development and public health measures have succeeded in eliminating malaria. However, most of these areas have *Anopheles* mosquitoes that can transmit malaria, and reintroduction of the disease is a constant risk.

Individuals in areas with malaria need to reduce their likelihood of being bitten by mosquitoes. Screens on windows and doors should be examined to confirm that they are in good repair. Repellents containing 20 to 30 percent DEET should be applied to exposed skin and clothing to keep mosquitoes from biting.

West Nile Virus

West Nile virus (WNV) is a potentially serious mosquito-borne that may affect residents in the planning area. Experts believe WNV is established as a seasonal epidemic in North America that flares up in the summer and continues into the fall. Mosquitoes transmit the virus to birds, livestock and humans. As of January 2017, human-infection cases of the virus had been reported in all states of the continental U.S. except Maine and New Hampshire, and New Hampshire had reported non-human infections.

According to the CDC, approximately 80 percent of people who are infected with WNV will show no symptoms. Up to 20 percent have symptoms such as fever, headache, and body aches, nausea, vomiting, and sometimes swollen lymph glands or a skin rash on the chest, stomach and back. Symptoms can last for as short as a few days, though even healthy people have become sick for several weeks. About 1 percent of people infected with WNV will develop severe illness, with symptoms that can include high fever, headache, neck stiffness, stupor, disorientation, coma, tremors, convulsions, muscle weakness, vision loss, numbness and paralysis. These symptoms may last several weeks, and neurological effects may become permanent. There is no specific treatment for WNV infection. In more severe cases, people may need to go to the hospital where they can receive supportive treatment including intravenous fluids, help with breathing and nursing care.

Individuals in areas with WNV need to reduce their likelihood of being bitten by mosquitoes. Screens on windows and doors should be examined to confirm that they are in good repair. Repellents containing 20 to 30 percent DEET should be applied to exposed skin and clothing to keep mosquitoes from biting.

Dengue Fever

Dengue is a mosquito-borne disease caused by any of four closely related dengue viruses (DENV-1, DENV-2, DENV-3 and DENV-4). People get dengue from the bite of an infected mosquito. The mosquito becomes infected when it bites a person who has dengue virus in their blood. It takes a week or more for the dengue virus to replicate in the mosquito; then the mosquito can transmit the virus to another person when it bites. Dengue is transmitted by the yellow fever mosquito (*Aedes aegypti)* and the Asian tiger mosquito *(Aedes albopictus)*. Dengue virus cannot be transmitted from person to person.

Generally, younger children and those with their first dengue infection have a milder illness than older children and adults. The main symptoms are high fever, severe headache, severe pain behind the eyes, joint pain, muscle and bone pain, rash, bruising, and sometimes mild bleeding from the nose or mouth. Severe dengue patients proceed to experience more bleeding, severe pain in the abdomen, respiratory distress, and fluid accumulation in the abdomen and around the lungs as the smallest blood vessels (capillaries) begin to leak. If not treated, severe dengue can result in death. There is no specific treatment for dengue infection. Rest and fluids are generally sufficient for persons with dengue. Severe dengue may require hospitalization and intensive medical care.

Individuals in areas with dengue need to reduce their likelihood of being bitten by mosquitoes. Screens on windows and doors should be examined to confirm that they are in good repair. Repellents containing 20 to 30 percent DEET should be applied to exposed skin and clothing to keep mosquitoes from biting.

Zika Virus

Zika is a mosquito-borne disease. The most common symptoms of Zika are fever, rash, joint pain, and conjunctivitis (red eyes). The illness is usually mild, with symptoms lasting for several days to a week after being bitten by an infected mosquito. People usually do not get sick enough to go to the hospital, and they rarely die of Zika. For this reason, many people might not realize they have been infected. However, Zika virus infection during pregnancy can cause a serious birth defect called microcephaly, as well as other severe fetal brain defects. Once a person has been infected, he or she is likely to be protected from future infections.

Zika virus is transmitted by yellow fever mosquito (*Aedes aegypti)* and the Asian tiger mosquito *(Aedes albopictus)*. An *Aedes* mosquito can only transmit Zika virus after it bites a person who has this virus in their blood. Zika virus is not spread through casual contact, but can be spread by infected men to their sexual partners. There is a growing association between Zika and microcephaly (abnormally small head and brain) in newborns, as well as Zika and Guillain-Barré Syndrome, a disease affecting the nervous system. Studies are ongoing to further evaluate these associations.

Chikungunya

Chikungunya (pronounced chik-en-gun-ye) is an infectious mosquito-borne disease with symptoms that typically include fever and severe joint pain. It is caused by the chikungunya virus, which is transmitted by yellow fever mosquito (*Aedes aegypti)* and the Asian tiger mosquito *(Aedes albopictus)*. An *Aedes* mosquito can only transmit chikungunya virus after it bites a person who has this virus in their blood. A person with chikungunya is not contagious. As of the publication of this document, chikungunya infections have been documented only in persons who were infected while traveling outside the United States.

Anthrax

Anthrax is a disease caused by *Bacillus anthracis*, a bacterium that forms spores (a spore is a cell that is dormant but may come to life with the right conditions). There are three forms of anthrax:

- **Cutaneous**—The first symptom is a small sore that develops into a blister. The blister then develops into a skin ulcer with a black area in the center. The sore, blister and ulcer do not hurt.
- **Gastrointestinal**—The first symptoms are nausea, loss of appetite, bloody diarrhea, and fever, followed by bad stomach pain.
- **Inhalation**—The first symptoms of inhalation anthrax are like cold or flu symptoms and can include a sore throat, mild fever and muscle aches. Later symptoms include cough, chest discomfort, shortness of breath, tiredness and muscle aches.

Anthrax is a naturally occurring illness and isolated cases occur all over the world yearly. Humans can become infected with anthrax by handling products from infected animals or by breathing in anthrax spores from infected animal products (such as wool). People can become infected with gastrointestinal anthrax by eating undercooked meat from infected animals. Anthrax can be treated successfully with antibiotics.

Anthrax can be used as a weapon, as happened in the United States in 2001, when anthrax was spread through the postal system by sending letters with powder containing anthrax spores. This caused 22 cases of anthrax infection and brought anthrax back into the public eye.

Severe Acute Respiratory Syndrome

Severe Acute Respiratory Syndrome (SARS) is a viral respiratory illness caused by a coronavirus (SARS-CoV). SARS was first reported in Asia in February 2003. Over the next few months, the illness spread to more than two dozen countries in North America, South America, Europe, and Asia before the global outbreak was contained. According to the WHO, 8,098 people worldwide became sick with SARS during the 2003 outbreak and 774 died. In the United States, only 11 people had laboratory evidence of SARS-CoV infection. All of these people had traveled to parts of the world where SARS was present. SARS did not spread more widely in the United States.

In general, SARS begins with a high fever, headache, an overall feeling of discomfort and body aches. Some people also have mild respiratory symptoms at the outset. About 10 percent to 20 percent of patients have diarrhea. After two to seven days, SARS patients may develop a dry cough. Most patients develop pneumonia.

The main way that SARS seems to spread is by close person-to-person contact. The virus that causes SARS is thought to be transmitted most readily by respiratory droplets produced when an infected person coughs or sneezes. Droplet spread can happen when droplets from the cough or sneeze of an infected person are propelled a short distance (generally up to 3 feet) through the air and deposited on the mucous membranes of the mouth, nose, or eyes of persons nearby. The virus also can spread when a person touches a surface or object contaminated with infectious droplets and then touches his or her mouth, nose, or eyes. It is also possible that the SARS virus might spread more broadly through the air or by other ways that are not now known.

According to the CDC, there is no remaining sustained SARS transmission anywhere in the world. However, CDC has developed recommendations and guidelines to help public health and healthcare officials plan for and respond quickly to the reappearance of SARS if it occurs again. Lessons learned from the SARS outbreak helped healthcare facilities and communities successfully plan and respond to the 2009 H1N1 pandemic.

15.2.2 Hazard Profile

The severity of human health hazards is dependent upon the hazard and the population exposed to it. As the population increases, so does the risk of exposure to public health hazards. The key to reducing the disease hazard is isolation so that the infected population does not continue to spread the hazard to the uninfected population. For disease health hazards, promoting education and personal preparedness will help to mitigate and reduce the severity of the hazard.

Past Events

The following is a summary of recent disease outbreak events:

- In the United States during the April 2009 through August 2010 H1N1 influenza pandemic, there were 59,979,608 confirmed cases of the disease, 270,435 people hospitalized due to the illness and 12,271 deaths. In California, there were 2,114 people hospitalized due to the illness and 596 deaths. In Contra Costa County, there were 54 confirmed cases, with 12 deaths due to the illness. The pandemic was mild

compared to the Spanish Flu pandemic of 1918, which caused 100 million deaths worldwide—a total of 3 percent of the world's total population.
- West Nile Virus arrived in Contra Costa County in 2004 and since 2005, 39 people have been diagnosed with the virus in Contra Costa County and two people have died.
- There were two confirmed cases of SARS in California during the worldwide outbreak in 2002-2003, neither of them in Contra Costa County.
- From 2011 through 2015, there were 484 cases of Lyme disease in California, 18 of them in Contra Costa County.
- From 2011 through 2015, there were 16 cases of hantavirus in California, including one in Contra Costa County.
- From 2011 through 2015, no cases of tularemia or plague were reported in Contra Costa County, but cases of these diseases have been reported in California and nearby counties.

Location

All of the planning area is susceptible to the human health hazards discussed in this chapter. While some hazards, such as the West Nile Virus and Lyme Disease, can have a geographic presence within the planning area, other diseases can cause exposure to the planning area from outside the local region. Local residents who travel can become exposed to diseases while abroad and bring the diseases back with them, potentially placing the region at risk for exposure. It is difficult to map the extent of human-health hazards compared to others, such as floods, wildfires and dam failures.

Frequency

Due to increased air travel and growing population, the probability of a communicable disease epidemic is a growing threat. Certain human health hazards, such as influenza, can be expected seasonably, with variations on specific strains year to year. Additionally, tick-borne diseases are likely to increase during spring and fall, when people participate in outdoor activities such as hiking. The frequency of other health hazards is difficult to establish and depends largely on the unique circumstances surrounding a localized outbreak and its subsequent expansion into epidemics.

Severity

The severity of the human health hazard varies from individual to individual. Typically, young children and older adults are more susceptible to acquiring communicable diseases due to developing or diminishing immune systems or experiencing adverse effects from extreme weather conditions. These populations often experience the most severe of symptoms, as their immune systems are not capable of fighting off infection or efficiently regulating temperature. In general, severity varies depending on the pathology of the disease, the health of the infected, and the availability of treatments for alleviating symptoms or curing the disease.

15.2.3 Secondary Hazards

The largest secondary impact caused by human health hazards would be economic. Large outbreaks of any human health hazard could reduce the workforce significantly, causing schools, businesses and agencies to close or be greatly impacted.

Another secondary impact could be stigmatization. The fear of the human health hazard and fear of the unknown could lead to isolation, violence and self-inflicted injury. Hospitals and healthcare providers could be overwhelmed with the "worried well" seeking care and comfort. Education and providing key and critical information can reduce and mitigate this secondary risk.

15.2.4 Exposure and Vulnerability

Population

All citizens in the planning area could be susceptible to the human health hazards discussed in this chapter. A large outbreak or epidemic, a pandemic or a use of biological agents as a weapon of mass destruction could have devastating effects on the population.

While all of the population in the planning area is at risk to the human health hazards discussed in this chapter, the young and the elderly, those with compromised immune systems, and those with special needs are most vulnerable. The introduction of a disease such as the plague or influenza could rapidly impact those at risk.

Property

None of the health hazards discussed in this chapter would have significant impact on the structural environment or property of the planning area.

Critical Facilities and Infrastructure

None of the health hazards discussed in this chapter would have significant impact on the critical facilities or infrastructure of the planning area. However, health care facilities (including long-term care and clinics and even veterinary offices) have adopted the recommended "all-hazards" approach to preparedness and have prepared for the health hazards addressed in this chapter.

The multiple acute care hospitals have collaborated, trained and planned on a local, regional, state and national level to provide immediate and comprehensive medical care to the Contra Costa County population. Emergency management and preparedness planning incorporates all response disciplines (fire, law, first responder ground and air ambulance agencies, public health, mental and spiritual health). Planning includes identifying shelters, alternate treatment facilities, isolation capacity and methods to immediately expand physical and human resources.

Environment

None of the health hazards discussed in this chapter would have significant impact on the environment of the planning area. While many of the vectors of the health hazards discussed in this chapter (mosquitoes, rodents, fleas, ticks and deer flies) rely on local or regional environments for their survival, the human health hazard that they carry or potentially transmit would have no significant impact on the environment.

Economy

The economic impact of a human health hazard could be localized to a single region or population, or could be widespread. The impact could be significant, depending on the hazard, number of cases and the availability of resources to care for those affected by the hazard. Other financial impacts could be absorbed or managed by the organization affected.

15.2.5 Future Trends in Development

Unless a catastrophic incident occurs, it is estimated that the planning area population will continue to grow. The potential for communicable diseases and vector-borne diseases in the planning area is not likely to lessen or prohibit growth or development.

15.2.6 Scenario

A human health worst-case scenario for the planning area would be an epidemic of any of the human health hazards discussed in this chapter. Medical treatment facilities in the planning area would be overwhelmed and taxed beyond their capabilities as the number of patients begins to escalate. The impacts on the workforce within the planning area could have acute and long-term economic impacts on primary employers. First responders would be exposed to the human health hazards, which could deplete the medical workforce and could have profound impact on the potential escalation of the scenario.

15.2.7 Issues

Important issues associated with the human health hazards include the following:

- Prevention through vaccination and personal emergency and disaster preparation will help to reduce the impacts of human health hazards.
- Medical and response personnel need to be integrated in a unified command to provide care when needed in response to human health hazards.
- Medical and response personnel must be adequately trained and supplied.
- Up-to-date and functional all-hazard contingency planning should be carried out.
- A system needs to be in place for informing the public with a unified message about the human health hazard.
- Health agencies and facilities require surge capacity management and adaptation to the rising number and needs of the region.

16. RISK RANKING

FEMA requires all hazard mitigation planning partners to have jurisdiction-specific mitigation actions based on local risk, vulnerability and community priorities (FEMA, 2011). This plan included a risk ranking protocol for each planning partner, in which "risk" was calculated by multiplying probability by impact on people, property and the economy. The risk estimates were generated using methodologies promoted by FEMA. The Steering Committee reviewed, discussed and approved the methodology and results. All planning partners ranked risk for their own jurisdictions following the same methodology.

Numerical ratings of probability and impact were based on the hazard profiles and exposure and vulnerability evaluations presented in Chapters 6 through 14. Using that data, each planning partner ranked the risk of all the natural hazards of concern described in this plan. When available, estimates of risk were generated with data from Hazus or GIS. For hazards of concern with less specific data available, qualitative assessments were used. As appropriate, results were adjusted based on local knowledge and other information not captured in the quantitative assessments. The hazards of interest described in Chapter 15 were not ranked for the following reasons:

- A key component of risk as defined for the planning effort is probability of occurrence. While it is possible to assign a recurrence interval for natural hazards because of historical occurrence, it is not feasible to assign recurrence intervals for the other hazards of interest, which lack such historical precedent.
- Federal hazard mitigation planning regulations do not require the assessment of non-natural hazards (44 CFR, 201.6). It is FEMA's position that this is a local decision.

The risk ranking at the planning partner scale was used to inform the action plan development process for each partner. Planning partners were directed to identify mitigation actions addressing hazards that, at a minimum, had a "high" risk ranking (see Section 16.3). Actions that address hazards with a medium, low or no hazard ranking are considered optional by this planning process.

Volume 2 presents the risk rankings for each planning partner. The following planning-area-wide risk ranking was prepared by the planning team. The results are used in establishing mitigation priorities.

16.1 PROBABILITY OF OCCURRENCE

The probability of occurrence of a hazard is indicated by a probability factor based on likelihood of annual occurrence:

- High—Hazard event is likely to occur within 25 years (Probability Factor = 3)
- Medium—Hazard event is likely to occur within 100 years (Probability Factor =2)
- Low—Hazard event is not likely to occur within 100 years (Probability Factor =1)
- No exposure—There is no probability of occurrence (Probability Factor = 0)

The assessment of hazard frequency is based on past hazard events in the area and the potential for changes in the frequency of these events resulting from climate change. Table 16-1 summarizes the probability assessment for each natural hazard of concern for this plan.

Table 16-1. Probability of Hazards

Hazard Event	Probability (high, medium, low)	Probability Factor
Dam and Levee Failure[a]	Medium	2
Drought	High	3
Earthquake[b]	High	3
Flood[c]	High	3
Landslide	High	3
Sea Level Rise[d]	Medium	2
Severe Weather	High	3
Tsunami	Medium	2
Wildfire[e]	High	3

a. Based on the level of detail conducted in the risk assessment, the risk ranking for this hazard is focused solely on dam failure impacts. See Chapter 6.4 for combined dam inundation list on which this assessment is based.
b. Haywired M7.05 event was used to assign probability and impacts
c. 1-percent annual chance event was used to assign probability and impacts
d. 2100 upper range estimates and extreme tide are used to assign probability and impacts
e. Very High and High severity zones were used to assign probability and impacts

16.2 IMPACT

Hazard impacts were assessed in three categories: impacts on people, impacts on property and impacts on the local economy. Numerical impact factors were assigned as follows:

- **People**—Values were assigned based on the percentage of the total ***population exposed*** to the hazard event. The degree of impact on individuals will vary and is not measurable, so the calculation assumes for simplicity and consistency that all people exposed to a hazard because they live in a hazard zone will be equally impacted when a hazard event occurs. It should be noted that planners can use an element of subjectivity when assigning values for impacts on people. Impact factors were assigned as follows:
  - High—25 percent or more of the population is exposed to a hazard (Impact Factor = 3)
  - Medium—10 percent to 25 percent of the population is exposed to a hazard (Impact Factor = 2)
  - Low—10 percent or less of the population is exposed to the hazard (Impact Factor = 1)
  - No impact—None of the population is exposed to a hazard (Impact Factor = 0)
- **Property**—Values were assigned based on the percentage of the total ***property value exposed*** to the hazard event:
  - High—25 percent or more of the total assessed property value is exposed to a hazard (Impact Factor = 3)
  - Medium—10 percent to 25 percent of the total assessed property value is exposed to a hazard (Impact Factor = 2)
  - Low—10 percent or less of the total assessed property value is exposed to the hazard (Impact Factor = 1)
  - No impact—None of the total assessed property value is exposed to a hazard (Impact Factor = 0)
- **Economy**—Values were assigned based on the percentage of the total ***property value vulnerable*** to the hazard event. Values represent estimates of the loss from a major event of each hazard in comparison to the total replacement value of the property exposed to the hazard. For some hazards, such as wildfire, landslide and severe weather, vulnerability was considered to be the same as exposure due to the lack of

loss estimation tools specific to those hazards. Loss estimates separate from the exposure estimates were generated for the earthquake and flood hazards using Hazus.

- High—Estimated loss from the hazard is 10 percent or more of the total exposed property value (Impact Factor = 3)
- Medium—Estimated loss from the hazard is 5 percent to 10 percent of the total exposed property value (Impact Factor = 2)
- Low—Estimated loss from the hazard is 5 percent or less of the total exposed property value (Impact Factor = 1)
- No impact—No loss is estimated from the hazard (Impact Factor = 0)

The impacts of each hazard category were assigned a weighting factor to reflect the significance of the impact. These weighting factors are consistent with those typically used for measuring the benefits of hazard mitigation actions: impact on people was given a weighting factor of 3; impact on property was given a weighting factor of 2; and impact on the economy was given a weighting factor of 1.Table 16-2, Table 16-3 and Table 16-4 summarize the impacts for each hazard.

Table 16-2. Impact on People from Hazards

Hazard Event	Impact (high, medium, low)	Impact Factor	Multiplied by Weighting Factor (3)
Dam and Levee Failure	Medium	2	6
Drought	No impact	0	0
Earthquake	High	3	9
Flood	*Low*	1	3
Landslide	*Medium*	2	6
Sea Level Rise	*Low*	1	3
Severe Weather	Medium	2	6
Tsunami	Low	1	3
Wildfire[a]	Medium	2	6

a. Population directly exposed to the wildfire hazard is low, but medium impacts were assigned to account for air quality concerns related to smoke.

Table 16-3. Impact on Property from Hazards

Hazard Event	Impact (high, medium, low)	Impact Factor	Multiplied by Weighting Factor (2)
Dam and Levee Failure	Medium	2	4
Drought	No impact	0	0
Earthquake	High	3	6
Flood	*Low*	1	2
Landslide	*Medium*	2	4
Sea Level Rise	*Low*	1	2
Severe Weather	Low	1	2
Tsunami	Low	1	2
Wildfire	Low	1	2

Table 16-4. Impact on Economy from Hazards

Hazard Event	Impact (high, medium, low)	Impact Factor	Multiplied by Weighting Factor (1)
Dam and Levee Failure	Low	1	1
Drought	High	3	3
Earthquake	High	3	3
Flood	Low	1	1
Landslide[a]	High	3	3
Sea Level Rise	*Low*	1	1
Severe Weather	Medium	2	2
Tsunami[a]	Low	1	1
Wildfire[a]	Low	1	1

a. Impacts on economy were assumed to be half of exposure.

16.3 RISK RATING AND RANKING

The risk rating for each hazard was determined by multiplying the probability factor by the sum of the weighted impact factors for people, property and operations, as summarized in Table 16-5. Based on these ratings, a priority of high, medium or low was assigned to each hazard. The hazards ranked as being of highest concern are earthquake and landslide. Hazards ranked as being of medium concern are severe weather, wildfire and flooding. The hazards ranked as being of lowest concern are sea level rise, dam failure, tsunami, and drought. Table 16-6 shows the hazard risk ranking for the planning area. Hazard risk ranking for each participating planning partner can be found in Volume 2 of this plan.

Table 16-5. Hazard Risk Rating

Hazard Event	Probability Factor	Sum of Weighted Impact Factors	Total (Probability x Impact)
Dam and Levee Failure	2	(6+4+1)=11	22
Drought	3	(0+0+3)=3	9
Earthquake	3	(9+6+3)=18	54
Flood	3	(3+2+1)=6	18
Landslide	3	(6+4+3)=13	39
Sea Level Rise	2	(3+2+1)=6	12
Severe Weather	3	(6+2+2)=10	30
Tsunami	2	(3+2+1)=6	12
Wildfire	3	(6+2+1)=9	27

Table 16-6. Hazard Risk Ranking

Hazard Ranking	Hazard Event	Category
1	Earthquake	High
2	Landslide	High
3	Severe Weather	Medium
4	Wildfire	Medium
5	Dam and Levee Failure	Medium
6	Flood	Medium
7	Sea Leve Rise	Low
7	Tsunami	Low
8	Drought	Low

Contra Costa County Hazard Mitigation Plan

PART 3—MITIGATION STRATEGY

17. GOALS AND OBJECTIVES

Hazard mitigation plans must identify goals for reducing long-term vulnerabilities to identified hazards (44 CFR Section 201.6(c)(3)(i)). The Steering Committee established a guiding principle, a set of goals and measurable objectives for this plan, based on data from the preliminary risk assessment and the results of the public involvement strategy. The guiding principle, goals, objectives and actions in this plan all support each other. Goals were selected to support the guiding principle. Objectives were selected that met multiple goals. Actions were prioritized based on the action meeting multiple objectives.

17.1 GUIDING PRINCIPLE

A guiding principle focuses the range of objectives and actions to be considered. This is not a goal because it does not describe a hazard mitigation outcome, and it is broader than a hazard-specific objective. The guiding principle for this hazard mitigation plan is as follows:

> *To reduce the vulnerability from hazards within the planning area in a cost-effective manner, within the capabilities of the partnership.*

17.2 GOALS

The following are the mitigation goals for this plan:

6. Save (or protect) lives and reduce injury.
7. Increase resilience of infrastructure and critical facilities.
8. Avoid (minimize, or reduce) damage to property.
9. Encourage the development and implementation of long-term, cost-effective and environmentally sound mitigation projects.
10. Build and support capacity to enable local government and the public to prepare for, respond to and recover from the impact of natural hazards.

The effectiveness of a mitigation strategy is assessed by determining how well these goals are achieved.

17.3 OBJECTIVES

The selected objectives meet multiple goals, as listed in Table 17-1. Therefore, the objectives serve as a stand-alone measurement of the effectiveness of a mitigation action, rather than as a subset of a goal. The objectives also are used to help establish priorities.

Table 17-1. Objectives for Natural Hazard Mitigation Plan Update

Objective Number	Objective Statement	Goals for Which It Can Be Applied
O-1	Increase resilience of infrastructure and critical facilities.	2, 3, 5
O-2	Sustain reliable local emergency operations and facilities during and after a disaster.	1, 5
O-3	Inform the public on the risk from hazards of concern and increase awareness, preparation, mitigation, response, and recovery activities to promote public safety.	1, 3, 5
O-4	Minimize the impacts of known hazards on current and future land uses by providing incentives for hazard mitigation.	1, 3, 5
O-5	Prevent or discourage new development in hazardous areas or ensure that, if building occurs in high-risk areas, it is done in a way to minimize risk.	1, 3, 5
O-6	At the local government level, continually improve understanding of the location and potential impacts of hazards, using the best available data and science.	1, 2, 3, 4, 5
O-7	Encourage all development to meet applicable standards for life safety	1, 2, 3, 5
O-8	Monitor plan progress annually to integrate the local hazard mitigation plan with the results of disaster- and hazard-specific planning efforts.	1, 2, 3, 5
O-9	Promote development and use of floodplain management best practices through programs such as CRS.	3, 4, 5
O-10	Provide or improve flood protection with flood control structures and drainage maintenance plans.	2, 3, 4
O-11	Enhance codes and their enforcement where feasible, so that new construction can withstand the impacts of known hazards and to lessen the impact of development on the environment's ability to absorb the impact of natural hazards.	1, 3
O-12	Consider the impacts of known hazards in all planning mechanisms that address current and future land uses within the planning area.	1, 3
O-13	Eliminate or minimize disruption of local government operations caused by known hazards.	1, 3, 4
O-14	Consider open space land uses within identified high-hazard risk zones.	1, 2, 3, 4, 5
0-15	Retrofit, acquire or relocate identified high-risk structures, including those known to experience repetitive losses.	1, 3, 4
0-16	Establish a partnership among all levels of government and the business community to improve and implement methods to protect property	1, 2, 3, 4, 5
0-17	Encourage hazard mitigation measures that promote and enhance natural processes and minimize adverse impacts on the ecosystem.	2, 3, 4
0-18	Promote and implement hazard mitigation plans and projects that are consistent with state, regional, and local climate action and adaptation goals, policies, and programs.	1, 2, 3, 4, 5

18. MITIGATION BEST PRACTICES AND ADAPTIVE CAPACITY

18.1 MITIGATION BEST PRACTICES

Catalogs of hazard mitigation best practices were developed that present a broad range of alternatives to be considered for use in Contra Costa County, in compliance with 44 CFR (Section 201.6(c)(3)(ii)). One catalog was developed for each hazard of concern evaluated in this plan. The catalogs present alternatives that are categorized in two ways:

- By who would have responsibility for implementation:
  - Individuals (personal scale)
  - Businesses (corporate scale)
  - Government (government scale).
- By what the alternative would do:
  - Manipulate the hazard
  - Reduce exposure to the hazard
  - Reduce vulnerability to the hazard
  - Build local capacity to respond to or be prepared for the hazard.

The alternatives presented include actions that will mitigate current risk from hazards and actions that will help reduce risk from changes in the impacts of these hazards resulting from climate change. Hazard mitigation actions recommended in this plan were selected from among the alternatives presented in the catalogs. The catalogs provide a baseline of mitigation alternatives that are backed by a planning process, are consistent with the established goals and objectives, and are within the capabilities of the planning partners to implement. Some of these actions may not be feasible based on the selection criteria identified for this plan. The purpose of the catalogs was to provide a list of what could be considered to reduce risk from natural hazards within the planning area. Actions in the catalog that are not included for the partnership's action plan were not selected for one or more of the following reasons:

- The action is not feasible.
- The action is already being implemented.
- There is an apparently more cost-effective alternative.
- The action does not have public or political support.

The catalogs for each hazard are presented in Table 18-1 through Table 18-10.

Table 18-1. Alternatives to Mitigate the Dam and Levee Failure Hazard

Personal-Scale	Corporate-Scale	Government-Scale
• Manipulate the hazard: ❖ None • Reduce exposure to the hazard: ❖ Relocate out of dam failure inundation areas • Reduce vulnerability to the hazard: ❖ Elevate home to appropriate levels • Build local capacity to respond to or be prepared for the hazard: ❖ Learn about risk reduction for the dam failure hazard ❖ Learn the evacuation routes for a dam failure event ❖ Educate yourself on early warning systems and the dissemination of warnings	• Manipulate the hazard: ❖ Remove dams ❖ Remove levees ❖ Harden dams • Reduce exposure to the hazard: ❖ Replace earthen dams with hardened structures • Reduce vulnerability to the hazard: ❖ Flood-proof facilities within dam failure inundation areas • Build local capacity to respond to or be prepared for the hazard: ❖ Educate employees on the probable impacts of a dam failure ❖ Develop a continuity of operations plan	• Manipulate the hazard: ❖ Remove dams ❖ Remove levees ❖ Harden dams • Reduce exposure to the hazard: ❖ Replace earthen dams with hardened structures ❖ Relocate critical facilities out of dam failure inundation areas ❖ Consider open space land use in designated dam failure inundation areas • Reduce vulnerability to the hazard: ❖ Adopt higher floodplain standards in mapped dam failure inundation areas ❖ Retrofit critical facilities within dam failure inundation areas • Build local capacity to respond to or be prepared for the hazard: ❖ Map dam failure inundation areas ❖ Enhance emergency operations plan to include a dam failure component ❖ Institute monthly communications checks with dam operators ❖ Inform the public on risk reduction techniques ❖ Adopt real-estate disclosure requirements for the re-sale of property located within dam failure inundation areas ❖ Consider the probable impacts of climate change in assessing the risk associated with the dam failure hazard ❖ Establish early warning capability downstream of listed high hazard dams ❖ Consider the residual risk associated with protection provided by dams in future land use decisions

Table 18-2. Alternatives to Mitigate the Drought Hazard

Personal-Scale	Corporate-Scale	Government-Scale
• Manipulate the hazard: ❖ None • Reduce exposure to the hazard: ❖ None • Reduce vulnerability to the hazard: ❖ Drought-resistant landscapes ❖ Reduce water system losses ❖ Modify plumbing systems (through water saving kits) • Build local capacity to respond to or be prepared for the hazard: ❖ Practice active water conservation	• Manipulate the hazard: ❖ None • Reduce exposure to the hazard: ❖ None • Reduce vulnerability to the hazard: ❖ Drought-resistant landscapes ❖ Reduce private water system losses ❖ Support alternative irrigation techniques to reduce water use and encourage use of climate-sensitive water supplies • Build local capacity to respond to or be prepared for the hazard: ❖ Practice active water conservation	• Manipulate the hazard: ❖ Groundwater recharge through stormwater management ❖ Develop a water recycling program ❖ Increase "above-the-dam" regional natural water storage systems • Reduce exposure to the hazard: ❖ Identify and create groundwater backup sources • Reduce vulnerability to the hazard: ❖ Water use conflict regulations ❖ Reduce water system losses ❖ Distribute water saving kits • Build local capacity to respond to or be prepared for the hazard: ❖ Public education on drought resistance ❖ Identify alternative water supplies for times of drought; mutual aid agreements with alternative suppliers ❖ Develop drought contingency plan ❖ Develop criteria "triggers" for drought-related actions ❖ Improve accuracy of water supply forecasts ❖ Modify rate structure to influence active water conservation techniques

Table 18-3. Alternatives to Mitigate the Earthquake Hazard

Personal-Scale	Corporate-Scale	Government-Scale
• Manipulate the hazard: ❖ None • Reduce exposure to the hazard: ❖ Locate outside of hazard area (off soft soils) • Reduce vulnerability to the hazard: ❖ Retrofit structure (anchor house structure to foundation) ❖ Secure household items that can cause injury or damage (such as water heaters, bookcases, and other appliances) ❖ Build to higher design • Build local capacity to respond to or be prepared for the hazard: ❖ Practice "drop, cover, and hold" ❖ Develop household mitigation plan, such as creating a retrofit savings account, communication capability with outside, 72-hour self-sufficiency during an event ❖ Keep cash reserves for reconstruction ❖ Become informed on the hazard and risk reduction alternatives available. ❖ Develop a post-disaster action plan for your household	• Manipulate the hazard: ❖ None • Reduce exposure to the hazard: ❖ Locate or relocate mission-critical functions outside hazard area where possible • Reduce vulnerability to the hazard: ❖ Build redundancy for critical functions and facilities ❖ Retrofit critical buildings and areas housing mission-critical functions • Build local capacity to respond to or be prepared for the hazard: ❖ Adopt higher standard for new construction; consider "performance-based design" when building new structures ❖ Keep cash reserves for reconstruction ❖ Inform your employees on the possible impacts of earthquake and how to deal with them at your work facility. ❖ Develop a continuity of operations plan	• Manipulate the hazard: ❖ None • Reduce exposure to the hazard: ❖ Locate critical facilities or functions outside hazard area where possible • Reduce vulnerability to the hazard: ❖ Harden infrastructure ❖ Provide redundancy for critical functions ❖ Adopt higher regulatory standards • Build local capacity to respond to or be prepared for the hazard: ❖ Provide better hazard maps ❖ Provide technical information and guidance ❖ Enact tools to help manage development in hazard areas (e.g., tax incentives, information) ❖ Include retrofitting and replacement of critical system elements in capital improvement plan ❖ Develop strategy to take advantage of post-disaster opportunities ❖ Warehouse critical infrastructure components such as pipe, power line, and road repair materials ❖ Develop and adopt a continuity of operations plan ❖ Initiate triggers guiding improvements (such as <50% substantial damage or improvements) ❖ Further enhance seismic risk assessment to target high hazard buildings for mitigation opportunities. ❖ Develop a post-disaster action plan that includes grant funding and debris removal components. ❖ Consider the probable impacts of climate change on the risk associated with the drought hazard

Table 18-4. Alternatives to Mitigate the Flood Hazard

Personal-Scale	Corporate-Scale	Government-Scale
• Manipulate the hazard: ❖ Clear storm drains and culverts ❖ Use low-impact development techniques • Reduce exposure to the hazard: ❖ Locate outside of hazard area ❖ Elevate utilities above base flood elevation ❖ Use low-impact development techniques • Reduce vulnerability to the hazard: ❖ Raise structures above base flood elevation ❖ Elevate items within house above base flood elevation ❖ Build new homes above base flood elevation ❖ Flood-proof structures • Build local capacity to respond to or be prepared for the hazard: ❖ Buy flood insurance ❖ Develop household plan, such as retrofit savings, communication with outside, 72-hour self-sufficiency during and after an event	• Manipulate the hazard: ❖ Clear storm drains and culverts ❖ Use low-impact development techniques • Reduce exposure to the hazard: ❖ Locate critical facilities or functions outside hazard area ❖ Use low-impact development techniques • Reduce vulnerability to the hazard: ❖ Build redundancy for critical functions or retrofit critical buildings ❖ Provide flood-proofing when new critical infrastructure must be located in floodplains • Build local capacity to respond to or be prepared for the hazard: ❖ Keep cash reserves for reconstruction ❖ Support and implement hazard disclosure for sale of property in risk zones. ❖ Solicit cost-sharing through partnerships with others on projects with multiple benefits.	• Manipulate the hazard: ❖ Maintain drainage system ❖ Institute low-impact development techniques on property ❖ Dredging, levee construction, and providing regional retention areas ❖ Structural flood control, levees, channelization, or revetments. ❖ Stormwater management regulations and master planning ❖ Acquire vacant land or promote open space uses in developing watersheds to control increases in runoff • Reduce exposure to the hazard: ❖ Locate or relocate critical facilities outside of hazard area ❖ Acquire or relocate identified repetitive loss properties ❖ Promote open space uses in identified high hazard areas via techniques such as: planned unit developments, easements, setbacks, greenways, sensitive area tracks. ❖ Adopt land development criteria such as planned unit developments, density transfers, clustering ❖ Institute low impact development techniques on property ❖ Acquire vacant land or promote open space uses in developing watersheds to control increases in runoff ❖ Preserve undeveloped and vulnerable shoreline ❖ Restore existing flood control and riparian corridors • Reduce vulnerability to the hazard: ❖ Harden infrastructure, bridge replacement program ❖ Provide redundancy for critical functions and infrastructure ❖ Adopt regulatory standards such as freeboard standards, cumulative substantial improvement or damage, lower substantial damage threshold; compensatory storage, non-conversion deed restrictions. ❖ Stormwater management regulations and master planning. ❖ Adopt "no-adverse impact" floodplain management policies that strive to not increase the flood risk on downstream communities ❖ Facilitate managed retreat from, or upgrade of, the most at-risk areas ❖ Require accounting of sea level rise in all applications for new development in shoreline areas ❖ Implement Assembly Bill 162 (2007) requiring flood hazard information in local general plans • Build local capacity to respond to or be prepared for the hazard: ❖ Produce better hazard maps ❖ Provide technical information and guidance ❖ Enact tools to help manage development in hazard areas (stronger controls, tax incentives, and information) ❖ Incorporate retrofitting or replacement of critical system elements in capital improvement plan ❖ Develop strategy to take advantage of post-disaster opportunities ❖ Warehouse critical infrastructure components ❖ Develop and adopt a continuity of operations plan ❖ Consider participation in the Community Rating System ❖ Maintain and collect data to define risks and vulnerability ❖ Train emergency responders ❖ Create an elevation inventory of structures in the floodplain ❖ Develop and implement a public information strategy ❖ Charge a hazard mitigation fee ❖ Integrate floodplain management policies into other planning mechanisms within the planning area. ❖ Consider the probable impacts of climate change on the risk associated with the flood hazard ❖ Consider the residual risk associated with structural flood control in future land use decisions ❖ Enforce National Flood Insurance Program requirements ❖ Adopt a Stormwater Management Master Plan ❖ Develop an adaptive management plan to address the long-term impacts of sea level rise

Table 18-5. Alternatives to Mitigate the Landslide Hazard

Personal-Scale	Corporate-Scale	Government-Scale
• Manipulate the hazard: ❖ Stabilize slope (dewater, armor toe) ❖ Reduce weight on top of slope ❖ Minimize vegetation removal and the addition of impervious surfaces. • Reduce exposure to the hazard: ❖ Locate structures outside of hazard area (off unstable land and away from slide-run out area) • Reduce vulnerability to the hazard: ❖ Retrofit home • Build local capacity to respond to or be prepared for the hazard: ❖ Institute warning system, and develop evacuation plan ❖ Keep cash reserves for reconstruction ❖ Educate yourself on risk reduction techniques for landslide hazards	• Manipulate the hazard: ❖ Stabilize slope (dewater, armor toe) ❖ Reduce weight on top of slope • Reduce exposure to the hazard: ❖ Locate structures outside of hazard area (off unstable land and away from slide-run out area) • Reduce vulnerability to the hazard: ❖ Retrofit at-risk facilities • Build local capacity to respond to or be prepared for the hazard: ❖ Institute warning system, and develop evacuation plan ❖ Keep cash reserves for reconstruction ❖ Develop a continuity of operations plan ❖ Educate employees on the potential exposure to landslide hazards and emergency response protocol.	• Manipulate the hazard: ❖ Stabilize slope (dewater, armor toe) ❖ Reduce weight on top of slope • Reduce exposure to the hazard: ❖ Acquire properties in high-risk landslide areas. ❖ Adopt land use policies that prohibit the placement of habitable structures in high-risk landslide areas. • Reduce vulnerability to the hazard: ❖ Adopt higher regulatory standards for new development within unstable slope areas. ❖ Armor/retrofit critical infrastructure against the impact of landslides. • Build local capacity to respond to or be prepared for the hazard: ❖ Produce better hazard maps ❖ Provide technical information and guidance ❖ Enact tools to help manage development in hazard areas: better land controls, tax incentives, information ❖ Develop strategy to take advantage of post-disaster opportunities ❖ Warehouse critical infrastructure components ❖ Develop and adopt a continuity of operations plan ❖ Educate the public on the landslide hazard and appropriate risk reduction alternatives. ❖ Consider the probable impacts of climate change on the risk associated with the landslide hazard

Table 18-6. Alternatives to Mitigate the Severe Weather Hazard

Personal-Scale	Corporate-Scale	Government-Scale
• Manipulate the hazard: ❖ None • Reduce exposure to the hazard: ❖ None • Reduce vulnerability to the hazard: ❖ Insulate house ❖ Provide redundant heat and power ❖ Insulate structure ❖ Plant appropriate trees near home and power lines ("Right tree, right place" National Arbor Day Foundation Program) • Build local capacity to respond to or be prepared for the hazard: ❖ Trim or remove trees that could affect power lines ❖ Promote 72-hour self-sufficiency ❖ Obtain a NOAA weather radio. ❖ Obtain an emergency generator.	• Manipulate the hazard: ❖ None • Reduce exposure to the hazard: ❖ None • Reduce vulnerability to the hazard: ❖ Relocate critical infrastructure (such as power lines) underground ❖ Reinforce or relocate critical infrastructure such as power lines to meet performance expectations ❖ Install tree wire • Build local capacity to respond to or be prepared for the hazard: ❖ Trim or remove trees that could affect power lines ❖ Create redundancy ❖ Equip facilities with a NOAA weather radio ❖ Equip vital facilities with emergency power sources.	• Manipulate the hazard: ❖ None • Reduce exposure to the hazard: ❖ Develop an urban heat island reduction program that includes an urban forest program or plan • Reduce vulnerability to the hazard: ❖ Harden infrastructure such as locating utilities underground ❖ Trim trees back from power lines ❖ Designate snow routes and strengthen critical road sections and bridges • Build local capacity to respond to or be prepared for the hazard: ❖ Support programs such as "Tree Watch" that proactively manage problem areas through use of selective removal of hazardous trees, tree replacement, etc. ❖ Establish and enforce building codes that require all roofs to withstand snow loads ❖ Increase communication alternatives ❖ Modify land use and environmental regulations to support vegetation management activities that improve reliability in utility corridors. ❖ Modify landscape and other ordinances to encourage appropriate planting near overhead power, cable, and phone lines ❖ Provide NOAA weather radios to the public ❖ Consider the probable impacts of climate change on the risk associated with the severe weather hazard ❖ Review and update heat response plan in light of climate change (heat events) projections

Table 18-7. Alternatives to Mitigate the Tsunami Hazard

Personal-Scale	Corporate-Scale	Government-Scale
• Manipulate the hazard: ❖ None • Reduce exposure to the hazard: ❖ Locate outside of hazard area • Reduce vulnerability to the hazard: ❖ Apply personal property mitigation techniques to your home such as anchoring your foundation and foundation openings to allow flow though. • Build local capacity to respond to or be prepared for the hazard: ❖ Develop and practice a household evacuation plan ❖ Educate yourself on the risk exposure from the tsunami hazard and ways to minimize that risk	• Manipulate the hazard: ❖ None • Reduce exposure to the hazard: ❖ Locate structure or mission critical functions outside of hazard area whenever possible • Reduce vulnerability to the hazard: ❖ Mitigate personal property for the impacts of tsunami • Build local capacity to respond to or be prepared for the hazard: ❖ Develop and practice a corporate evacuation plan ❖ Educate employees on the risk exposure from the tsunami hazard and ways to minimize that risk	• Manipulate the hazard: ❖ Build wave abatement structures (e.g. the “Jacks” looking structure designed by the Japanese) • Reduce exposure to the hazard: ❖ Locate structure or functions outside of hazard area whenever possible ❖ Harden infrastructure for tsunami impacts ❖ Relocate identified critical facilities located in tsunami high hazard areas • Reduce vulnerability to the hazard: ❖ Adopt higher regulatory standards that will provide higher levels of protection to structures built in a tsunami inundation area ❖ Utilize tsunami mapping to guide development away from high risk areas through land use planning • Build local capacity to respond to or be prepared for the hazard: ❖ Create a probabilistic tsunami map for the planning area ❖ Provide incentives to guide development away from hazard areas ❖ Develop a tsunami warning and response system ❖ Provide residents with tsunami inundation maps ❖ Join NOAA’s Tsunami Ready program ❖ Develop and communicate evacuation routes ❖ Enhance the public information program to include risk reduction options for the tsunami hazard

Table 18-8. Alternatives to Mitigate the Wildfire Hazard

Personal-Scale	Corporate-Scale	Government-Scale
• Manipulate the hazard: ❖ Clear potential fuels on property such as dry overgrown underbrush and diseased trees • Reduce exposure to the hazard: ❖ Create and maintain defensible space around structures ❖ Locate outside of hazard area ❖ Mow regularly • Reduce vulnerability to the hazard: ❖ Create and maintain defensible space around structures and provide water on site ❖ Use fire-retardant building materials ❖ Create defensible spaces around home • Build local capacity to respond to or be prepared for the hazard: ❖ Employ techniques from the National Fire Protection Association's Firewise Communities program to safeguard home ❖ Identify alternative water supplies for fire fighting ❖ Install/replace roofing material with non-combustible roofing materials.	• Manipulate the hazard: ❖ Clear potential fuels on property such as dry underbrush and diseased trees • Reduce exposure to the hazard: ❖ Create and maintain defensible space around structures and infrastructure ❖ Locate outside of hazard area • Reduce vulnerability to the hazard: ❖ Create and maintain defensible space around structures and infrastructure and provide water on site ❖ Use fire-retardant building materials ❖ Use fire-resistant plantings in buffer areas of high wildfire threat. • Build local capacity to respond to or be prepared for the hazard: ❖ Support Firewise community initiatives. ❖ Create /establish stored water supplies to be utilized for fire fighting.	• Manipulate the hazard: ❖ Clear potential fuels on property such as dry underbrush and diseased trees ❖ Implement best management practices on public lands • Reduce exposure to the hazard: ❖ Create and maintain defensible space around structures and infrastructure ❖ Locate outside of hazard area ❖ Enhance building code to include use of fire resistant materials in high hazard area. • Reduce vulnerability to the hazard: ❖ Create and maintain defensible space around structures and infrastructure ❖ Use fire-retardant building materials ❖ Use fire-resistant plantings in buffer areas of high wildfire threat. ❖ Consider higher regulatory standards (such as Class A roofing) ❖ Establish biomass reclamation initiatives ❖ Reintroduce fire (controlled or prescribed burns) to fire-prone ecosystems ❖ Manage fuel load through thinning and brush removal • Build local capacity to respond to or be prepared for the hazard: ❖ More public outreach and education efforts, including an active Firewise program ❖ Possible weapons of mass destruction funds available to enhance fire capability in high-risk areas ❖ Identify fire response and alternative evacuation routes ❖ Seek alternative water supplies ❖ Become a Firewise community ❖ Use academia to study impacts/solutions to wildfire risk ❖ Establish/maintain mutual aid agreements between fire service agencies ❖ Develop, adopt, and implement integrated plans for mitigating wildfire impacts in wildland-urban interface areas ❖ Consider the probable impacts of climate change on the risk associated with the wildfire hazard in future land use decisions ❖ Establish a management program to track forest and rangeland health

Table 18-9. Alternatives to Mitigate Non-Natural Hazards—Human-Caused

Personal-Scale	Corporate-Scale	Government-Scale
• Manipulate the hazard: ❖ None • Reduce exposure to the hazard: ❖ None • Reduce vulnerability to the hazard: ❖ None • Build local capacity to respond to or be prepared for the hazard: ❖ Increase awareness of vulnerability to threats ❖ Neighborhood watch program ❖ Keep informed ❖ Develop an emergency response plan ❖ Report suspicious activities	• Manipulate the hazard: ❖ None • Reduce exposure to the hazard: ❖ Incorporate anti-terrorism and security mitigation measures in site and layout design of facilities ❖ Consider site security in landscape design of facilities • Reduce vulnerability to the hazard: ❖ Restrict access by implementing controlled access zones ❖ Increase security measures ❖ Install physical barriers around critical facilities ❖ Employ parking restrictions as a means to reduce vulnerability • Build local capacity to respond to or be prepared for the hazard: ❖ Become a partner (stakeholder) in mitigation and prevention ❖ Educate employees ❖ Develop an emergency response plan ❖ Develop a continuity of operations plan ❖ Use liberal signage techniques to inform and increase capability of users of facilities	• Manipulate the hazard: ❖ None • Reduce exposure to the hazard: ❖ Construct new critical facilities with clear zones ❖ Retrofit existing critical facilities • Reduce vulnerability to the hazard: ❖ Restrict access by implementing controlled access zones ❖ Reduce single-point vulnerabilities such as: redundancy for critical lifelines and infrastructure ❖ Install physical barriers around critical facilities • Build local capacity to respond to or be prepared for the hazard: ❖ Educate public on threats and vulnerability ❖ Enhance emergency response capability by contingency planning for specific events based on identified vulnerabilities ❖ Consider performance-based zoning as a land use alternative to mitigate impacts of human-caused hazards ❖ Employ Crime Prevention Through Environmental Design techniques in design of public facilities ❖ Consider providing incentives for mitigation

Table 18-10. Alternatives to Mitigate Non-Natural Hazards—Public Health

Personal-Scale	Corporate-Scale	Government-Scale
• Manipulate the hazard: ❖ None • Reduce exposure to the hazard: ❖ Eliminate or reduce environments on private property that favor mosquito infestation • Reduce vulnerability to the hazard: ❖ Immunization • Build local capacity to respond to or be prepared for the hazard: ❖ Get informed	• Manipulate the hazard: ❖ None • Reduce exposure to the hazard: ❖ Eliminate or reduce environments on private property that favor mosquito infestation • Reduce vulnerability to the hazard: ❖ Immunize employees • Build local capacity to respond to or be prepared for the hazard: ❖ Inform employees on human health hazards	• Manipulate the hazard: ❖ Mosquito abatement • Reduce exposure to the hazard: ❖ Eliminate or reduce environments on public property that favor mosquito infestation • Reduce vulnerability to the hazard: ❖ Immunize employees • Build local capacity to respond to or be prepared for the hazard: ❖ Collaborate with the County Health Department to ensure the health and welfare of the community ❖ Public education on mosquito abatement and general human health issues ❖ Consider the probable impacts of climate change on the risk associated with public health hazards ❖ Refine emergency preparedness and response to address health impacts

18.2 ADAPTIVE CAPACITY

Adaptive capacity is defined as “the ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences” (IPCC, 2014b). This term is typically used while discussing climate change adaptation; however, it is similar to the alternatives presented in the tables for building local capacity. In addition to hazard-specific capacity building, the following list provides general alternatives that planning partners considered to build capacity for adapting to both current and future risks (Cal EMA, et al., 2012a and 2012b):

- Incorporate climate change adaptation into relevant local and regional plans and projects.
- Establish a climate change adaptation and hazard mitigation public outreach and education program.
- Build collaborative relationships between regional entities and neighboring communities to promote complementary adaptation and mitigation strategy development and regional approaches.
- Establish an ongoing monitoring program to track local and regional climate impacts and adaptation strategy effectiveness.
- Increase participation of low-income, immigrant, non-English-speaking, racially and ethnically diverse, and special-needs residents in planning and implementation.
- Ask local employers and business associations to participate in local efforts to address climate change and natural hazard risk reduction.
- Conduct a communitywide assessment and develop a program to address health, socioeconomic, and equity vulnerabilities.
- Focus planning and intervention programs on neighborhoods that currently experience social or environmental injustice or bear a disproportionate burden of potential public health impacts.
- Use performance metrics and data to evaluate and monitor the impacts of climate change and natural hazard risk reduction strategies on public health and social equity.
- Develop coordinated plans for mitigating future flood, landslide, and related impacts through concurrent adoption of updated general plan safety elements and local hazard mitigation plans.
- Implement general plan safety elements through zoning and subdivision practices that restrict development in floodplains, landslide, and other natural hazard areas.
- Identify and protect locations where native species may shift or lose habitat due to climate change impacts (sea level rise, loss of wetlands, warmer temperatures, drought).
- Collaborate with agencies managing public lands to identify, develop, or maintain corridors and linkages between undeveloped areas.
- Promote economic diversity.
- Incorporate consideration of climate change impacts as part of infrastructure planning and operations.
- Conduct a climate impact assessment on community infrastructure.
- Identify gaps in legal and regulatory capabilities and develop ordinances or guidelines to address those gaps.
- Identify and pursue new sources of funding for mitigation and adaptation activities.
- Hire new staff or provide training to current staff to ensure an adequate level of administrative and technical capability to pursue mitigation and adaptation activities.

19. AREA-WIDE ACTION PLAN AND IMPLEMENTATION

The Steering Committee reviewed the catalogs of hazard mitigation alternatives and selected area-wide actions to be included in a hazard mitigation action plan. The selection of area-wide actions was based on the risk assessment of identified hazards of concern and the defined hazard mitigation goals and objectives. Table 19-1 lists the recommended hazard mitigation actions that make up the action plan. The timeframe indicated in the table is defined as follows:

- Short Term = to be completed in 1 to 5 years
- Long Term = to be completed in greater than 5 years
- Ongoing = currently being funded and implemented under existing programs.

19.1.1 Benefit-Cost Review

The action plan must be prioritized according to a benefit/cost analysis of the proposed projects (44 CFR, Section 201.6(c)(3)(iii)). The benefits of proposed projects were weighed against estimated costs as part of the project prioritization process. The benefit/cost analysis was not of the detailed variety required by FEMA for project grant eligibility under the Hazard Mitigation Grant Program (HMGP) and Pre-Disaster Mitigation (PDM) grant program. A less formal approach was used because some projects may not be implemented for up to 10 years, and associated costs and benefits could change dramatically in that time. Therefore, a review of the apparent benefits versus the apparent cost of each project was performed. Parameters were established for assigning subjective ratings (high, medium, and low) to the costs and benefits of these projects.

Cost ratings were defined as follows:

- **High**—Existing funding will not cover the cost of the project; implementation would require new revenue through an alternative source (for example, bonds, grants, and fee increases).
- **Medium**—The project could be implemented with existing funding but would require a re-apportionment of the budget or a budget amendment, or the cost of the project would have to be spread over multiple years.
- **Low**—The project could be funded under the existing budget. The project is part of or can be part of an ongoing existing program.

Benefit ratings were defined as follows:

- **High—**Project will provide an immediate reduction of risk exposure for life and property.
- **Medium—**Project will have a long-term impact on the reduction of risk exposure for life and property, or project will provide an immediate reduction in the risk exposure for property.
- **Low—**Long-term benefits of the project are difficult to quantify in the short term.

Using this approach, projects with positive benefit versus cost ratios (such as high over high, high over medium, medium over low, etc.) are considered cost-beneficial and are prioritized accordingly.

Table 19-1. Action Plan

Hazards Addressed	Funding Options	Timeframe	Objectives Met	In Previous Plan? (# from previous plan)
Action #CW-1—Continue to maintain a County-wide hazard mitigation website that will store the hazard mitigation plan and provide the public an opportunity to monitor plan implementation progress. Each planning partner can support this initiative by including an initiative in its action plan of creating a link to the County hazard mitigation website. Responsible Agency: Contra Costa County OES				
All Hazards	County Administrative Budget	Ongoing	3, 6, 8, 16	Yes, CW-1
Action #CW-2—Leverage public outreach partnering capabilities in the planning area (such as CERT) to promote a uniform and consistent message on the importance of proactive hazard mitigation. Responsible Agency: *Contra Costa County OES, CERT				
All Hazards	OES Operation Budget	Ongoing	2, 3, 6, 16	Yes, CW-2
Action #CW-3—Coordinate mitigation planning and project efforts in the planning area to leverage all resources available to the planning partnership. Lead Agency: *Contra Costa County OES, Contra Costa County Public Works				
All Hazards	FEMA mitigation grant funding will reimburse for grant application preparation. General fund allocations of all planning partners.	Short term	6, 16	Yes, CW-3
Action #CW-4—Where appropriate, support retrofitting, purchase, or relocation of structures in hazard-prone areas to protect the structures from future damage, with repetitive loss and severe repetitive loss properties as a priority. Seek opportunities to leverage partnerships in the planning area in these pursuits. Responsible Agency: *Contra Costa County OES, Contra Costa County Public Works				
All Hazards	FEMA mitigation grant funding	Long term; depends on funding	7, 15, 16	Yes, CW-4
Action #CW-5—Continue to update hazard mapping with best available data and science as it evolves, within the capabilities of the partnership. Support FEMA's RiskMAP initiative. Responsible Agency: *Contra Costa County Public Works, Contra Costa County OES				
All Hazards	FEMA mitigation grant funding, FEMA's Cooperating Technical Partners program, County capital improvement program funding	Long term; depends on funding	3, 6, 16	Yes, CW-5
Action #CW-6—To the extent possible based on available resources, provide coordination and technical assistance in applying for grant funding. Responsible Agency: *Contra Costa County OES, Cal OES, FEMA Region IX				
All Hazards	FEMA mitigation grant funding will reimburse for grant application preparation.	Short term	6, 16	Yes, CW-6 (action was re-worded)
Action #CW-7—A steering committee will remain as a working body over time to monitor progress of the hazard mitigation plan, provide technical assistance to planning partners, manage data, and oversee the update of the plan according to schedule. This body will continue to operate under the ground rules established at its inception. Responsible Agency: Contra Costa County OES				
All Hazards	OES Operation Budget	Ongoing	8, 16	Yes, CW-7 (action was re-worded)

* Where multiple responsible agencies for an action are identified, an asterisk identifies the lead agency.

For many of the strategies identified in this action plan, financial assistance may be available through the HMGP or PDM programs, both of which require detailed benefit/cost analyses. These analyses will be performed on projects at the time of application using the FEMA benefit-cost model. For projects not seeking financial assistance from grant programs that require detailed analysis, "benefits" can be defined according to parameters that meet the goals and objectives of this plan.

19.1.2 Area-Wide Action Plan Prioritization

Table 19-2 lists the priority of each area-wide action. A qualitative benefit-cost review was performed for each of these actions. The priorities are defined as follows:

- **High Priority**—A project that meets multiple objectives (i.e., multiple hazards), has benefits that exceed cost, has funding secured or is an ongoing project and meets eligibility requirements for the HMGP or PDM grant program. High priority projects can be completed in the short term (1 to 5 years).
- **Medium Priority**—A project that meets goals and objectives, that has benefits that exceed costs, and for which funding has not been secured but that is grant eligible under HMGP, PDM or other grant programs. Project can be completed in the short term, once funding is secured. Medium priority projects will become high priority projects once funding is secured.
- **Low Priority**—A project that will mitigate the risk of a hazard, that has benefits that do not exceed the costs or are difficult to quantify, for which funding has not been secured, that is not eligible for HMGP or PDM grant funding, and for which the time line for completion is long term (1 to 10 years). Low priority projects may be eligible for other sources of grant funding from other programs.

Table 19-2. Prioritization of Area-Wide Mitigation Actions

Action #	# of Objectives Met	Benefits	Costs	Do Benefits Equal or Exceed Costs?	Is Project Grant Eligible?	Can Project be Funded under Existing Programs/ Budgets?	Priority (High, Med., Low)
CW-1	4	Low	Low	Yes	No	Yes	High
CW-2	4	Low	Low	Yes	Yes	Yes	High
CW-3	2	Medium	Low	Yes	Yes	Yes	High
CW-4	3	High	High	Yes	Yes	No	Medium
CW-5	3	Medium	Medium	Yes	Yes	No	Medium
CW-6	2	Medium	Low	Yes	Yes	No	High
CW-7	2	Low	Low	Yes	No	Yes	High

19.1.3 Analysis of Area-Wide Mitigation Actions

Each recommended action was classified based on the hazard it addresses and the type of mitigation it involves. Table 19-3 shows these classifications. Mitigation types used for this categorization are as follows:

- **Prevention**—Government, administrative or regulatory actions that influence the way land and buildings are developed to reduce hazard losses. Includes planning and zoning, floodplain laws, capital improvement programs, open space preservation, and stormwater management regulations.
- **Property Protection**—Modification of buildings or structures to protect them from a hazard or removal of structures from a hazard area. Includes acquisition, elevation, relocation, structural retrofit, storm shutters, and shatter-resistant glass.
- **Public Education and Awareness**—Actions to inform citizens and elected officials about hazards and ways to mitigate them. Includes outreach projects, real estate disclosure, hazard information centers, and school-age and adult education.
- **Natural Resource Protection**—Actions that minimize hazard loss and preserve or restore the functions of natural systems. Includes sediment and erosion control, stream corridor restoration, watershed management, forest and vegetation management, and wetland restoration and preservation.
- **Emergency Services**—Actions that protect people and property during and immediately after a hazard event. Includes warning systems, emergency response services, and the protection of essential facilities.
- **Structural Projects**—Actions that involve the construction of structures to reduce the impact of a hazard. Includes dams, setback levees, floodwalls, retaining walls, and safe rooms.

Table 19-3. Analysis of Mitigation Actions

Hazard	Actions That Address the Hazard, by Mitigation Type[a]					
	Prevention	Property Protection	Public Education and Awareness	Natural Resource Protection	Emergency Services	Structural Projects
Dam and Levee Failure	3, 5, 6	4	1, 2, 7	—	—	—
Drought	3, 5, 6	4	1, 2, 7	—	—	—
Earthquake	3, 5, 6	4	1, 2, 7	—	—	—
Flood	3, 5, 6	4	1, 2, 7	—	—	—
Landslide	3, 5, 6	4	1, 2, 7	—	—	—
Severe Weather	3, 5, 6	4	1, 2, 7	—	—	—
Wildfire	3, 5, 6	4	1, 2, 7	—	—	—
Non-Natural Hazards	3, 5, 6	4	1, 2, 7	—	—	—

a. See Section 19.1.3 for description of mitigation types

19.2 PLAN ADOPTION

A hazard mitigation plan must document that it has been formally adopted by the governing bodies of the jurisdictions requesting federal approval of the plan (44 CFR Section 201.6(c)(5)). For multi-jurisdictional plans, each jurisdiction requesting approval must document that is has been formally adopted. This plan will be submitted for a pre-adoption review to Cal OES and FEMA Region IX prior to adoption. Once pre-adoption approval has been provided, all planning partners will formally adopt the plan. DMA compliance and its benefits cannot be achieved until the plan is adopted. Copies of the resolutions adopting this plan for all planning partners can be found in Appendix C of this volume.

19.3 PLAN MAINTENANCE STRATEGY

A hazard mitigation plan must present a plan maintenance process that includes the following (44 CFR Section 201.6(c)(4)):

- A section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan over a 5-year cycle
- A process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms, such as comprehensive or capital improvement plans, when appropriate
- A discussion on how the community will continue public participation in the plan maintenance process.

This section details the formal process that will ensure that the Hazard Mitigation Plan remains an active and relevant document and that the planning partners maintain their eligibility for applicable funding sources. The plan maintenance process includes a schedule for monitoring and evaluating the plan annually and producing an updated plan every five years. This chapter also describes how public participation will be integrated throughout the plan maintenance and implementation process. It also explains how the mitigation strategies outlined in this Plan will be incorporated into existing planning mechanisms and programs, such as comprehensive land-use planning processes, capital improvement planning, and building code enforcement and implementation. The Plan’s format allows sections to be reviewed and updated when new data become available, resulting in a plan that will remain current and relevant.

19.3.1 Plan Implementation

The effectiveness of the hazard mitigation plan depends on its implementation and incorporation of its action items into existing local plans, policies and programs. Together, the action items in the Plan provide a framework for activities that the planning partners can implement over the next 5 years. The planning team and the Steering Committee have established goals and objectives and have prioritized mitigation actions that will be implemented through existing plans, policies, and programs.

The plan will be evaluated by how successfully the implementation of identified actions have moved the planning partnership toward reaching the goals and objectives identified in this plan. This will be assessed at the next update by a review of the changes in risk that occurred over the performance period and by the degree to which mitigation goals and objectives were incorporated into existing plans, policies and programs.

Contra Costa County OES and Contra Costa County Department of Conservation and Development will share the lead responsibility for overseeing the plan implementation and maintenance strategy. Plan implementation and evaluation will be a shared responsibility among all planning partnership members and agencies identified as lead agencies in the mitigation action plans (see planning partner annexes in Volume 2 of this plan).

19.3.2 Steering Committee

The Steering Committee is a total volunteer body that oversaw the development of the Plan and made recommendations on key elements of the plan, including the maintenance strategy. It was the Steering Committee's position that an oversight committee with representation similar to the initial Steering Committee should have an active role in the Plan maintenance strategy. Therefore, it is recommended that a steering committee remain a viable body involved in key elements of the Plan maintenance strategy. The new steering committee should strive to include representation from the planning partners, as well as other stakeholders in the planning area, at the discretion of OES.

The principal role of the steering committee in this plan maintenance strategy will be to provide a review forum to be used by Contra Costa County OES and the Department of Conservation and Development for enhancements to be considered at the next update. Future plan updates will be overseen by a steering committee similar to the one that participated in this update process, so keeping a steering committee intact will provide a head start on future updates. Completion of the progress report will be the responsibility of each planning partner, not the steering committee. It will be the steering committee's role to serve as a resource to the planning partnership as needed to review the progress report in an effort to identify issues needing to be addressed by future plan updates.

19.3.3 Annual Progress Report

The minimum task of each planning partner will be the evaluation of the progress of its individual action plan during a 12-month performance period. This review will include the following:

- Summary of any hazard events that occurred during the performance period and the impact these events had on the planning area
- Review of mitigation success stories
- Review of continuing public involvement
- Brief discussion about why targeted strategies were not completed
- Re-evaluation of the action plan to determine if the timeline for identified projects needs to be amended (such as changing a long-term project to a short-term one because of new funding)
- Recommendations for new projects
- Changes in or potential for new funding options (grant opportunities)
- Impact of any other planning programs or actions that involve hazard mitigation.

The planning team has created a template that shows the minimum level of detail that will be sought for preparing a progress report (see Appendix D). The Department of Conservation and Development will oversee progress reporting and will have the discretionary authority on how to capture this information at least annually over the performance period of the plan. This information may be captured by various means available to the planning partnership. This report should be used as follows:

- Posted on the Contra Costa County website page dedicated to the hazard mitigation plan
- Provided to the local media through a press release
- Presented to planning partner governing bodies to inform them of the progress of actions implemented during the reporting period
- Provided as part of the CRS annual re-certification package for planning partners that participate in the CRS. The CRS requires an annual recertification to be submitted by October 1 of every calendar year for which the community has not received a formal audit. To meet this recertification timeline, the planning team will strive to complete progress reports between June and September each year.

Uses of the progress report will be at the discretion of each planning partner. Annual progress reporting is not a requirement specified under 44 CFR. However, it may enhance the planning partners' opportunities for funding. While failure to implement this component of the plan maintenance strategy will not jeopardize a planning partner's compliance under the DMA, it may jeopardize its opportunity to partner and leverage funding opportunities with the other partners. Each planning partner was informed of these protocols at the beginning of this planning process (in the "Planning Partner Expectations" package provided at the start of the process), and each partner acknowledged these expectations with submittal of a letter of intent to participate in this process.

19.3.4 Plan Update

Local hazard mitigation plans must be reviewed, revised if appropriate, and resubmitted for approval in order to remain eligible for benefits under the DMA (44 CFR, Section 201.6(d)(3)). The planning partners intend to update the hazard mitigation plan on a 5-year cycle from the date of initial plan adoption. This cycle may be accelerated to less than 5 years based on the following triggers:

- A Presidential Disaster Declaration that impacts the planning area
- A hazard event that causes loss of life
- A comprehensive update of a planning partner's general plan.

It will not be the intent of future updates to develop a complete new hazard mitigation plan for the planning area. The update will, at a minimum, include the following elements:

- The update process will be convened through a steering committee.
- The hazard risk assessment will be reviewed and, if necessary, updated using best available information and technologies.
- The action plans will be reviewed and revised to account for any actions completed, dropped, or changed and to account for changes in the risk assessment or new policies identified under other planning mechanisms (such as the general plan).
- The draft update will be sent to appropriate agencies and organizations for comment.
- The public will be given an opportunity to comment on the update prior to adoption.
- Planning partner governing bodies will adopt the updated plan.

Contra Costa County OES and Contra Costa County Department of Conservation and Development will share the lead responsibility for initiating the plan update process.

19.3.5 Continuing Public Involvement

The public will continue to be apprised of the plan's progress through the Contra Costa County website and by providing copies of annual progress reports to the media. Each planning partner has agreed to provide links to the hazard mitigation plan website on their individual jurisdictional websites to increase avenues of public access to the plan. The Contra Costa County Public Information Office has agreed to maintain the hazard mitigation plan website, including monitoring the email address where members of the public can submit comments to the steering committee. This site will not only house the final plan, it will become the one-stop shop for information regarding the plan, the partnership and plan implementation. Copies of the plan will be distributed to local libraries. Upon initiation of future update processes, a new public involvement strategy will be initiated based on guidance from a new steering committee. This strategy will be based on the needs and capabilities of the planning partnership at the time of the update. At a minimum, this strategy will include the use of local media outlets within the planning area.

19.3.6 Incorporation into Other Planning Mechanisms

The information on hazard, risk, vulnerability, and mitigation contained in this plan is based on the best science and technology available at the time this plan was prepared. The general plans of the planning partners are considered to be integral parts of this plan. The planning partners, through adoption of general plans and zoning ordinances, have planned for the impact of natural hazards. The plan development process provided them with the opportunity to review and expand on policies contained within these planning mechanisms. The planning partners used their general plans and the hazard mitigation plan as complementary documents that work together to achieve the goal of reducing risk exposure to the citizens of the planning area. An update to a general plan may trigger an update to the hazard mitigation plan.

All municipal planning partners are committed to creating a linkage between the hazard mitigation plan and their individual general plans by identifying a mitigation action as such and giving that action a high priority. Additionally, all planning partners are committed to being in full compliance with California Assembly Bill 2140 and Senate Bill 379, which promote the integration of local hazard mitigation plans and general plans and mandate that these plans address climate change. Other planning processes and programs to be coordinated with the recommendations of the hazard mitigation plan include the following:

- Emergency response plans
- Training and exercise of emergency response plans
- Debris management plans
- Recovery plans
- Capital improvement programs
- Municipal codes
- Community design guidelines
- Water-efficient landscape design guidelines
- Stormwater management programs
- Water system vulnerability assessments
- Community wildfire protection plans
- Comprehensive flood hazard management plans
- Resiliency plans
- Community Development Block Grant-Disaster Recovery action plans
- Public information/education plans.

Some action items do not need to be implemented through regulation. Instead, these items can be implemented through the creation of new educational programs, continued interagency coordination, or improved public participation. As information becomes available from other planning mechanisms that can enhance this plan, that information will be incorporated via the update process.

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GLOSSARY

ACRONYMS

ABAG—Association of Bay Area Governments

CCR—California Code of Regulations

CCWD—Contra Costa Water District

CDBG-DR—Community Development Block Grant Disaster Recovery

CEQA—California Environmental Quality Act

CFR—Code of Federal Regulations

CRS—Community Rating System

DFIRM—Digital Flood Insurance Rate Maps

DHS—Department of Homeland Security

DMA —Disaster Mitigation Act

DTSC—Department of Toxic Substances Control

DWR—Department of Water Resources

EBMUD—East Bay Municipal Utility District

EBRPD—East Bay Regional Park District

EMA—Emergency Management Agency (California state)

EPA—U.S. Environmental Protection Agency

ESA—Endangered Species Act

FCWCD—Flood Control and Water Conservation District

FEMA—Federal Emergency Management Agency

FERC—Federal Energy Regulatory Commission

FHSZ—Fire hazard severity zones

FIRM—Flood Insurance Rate Map

FRA—Federal Responsibility Area

GIS—Geographic Information System

Hazus—Hazards, United States

HMGP—Hazard Mitigation Grant Program

IBC—International Building Code

IRC—International Residential Code

LRA—Local Responsibility Area

MM—Modified Mercalli Scale

NCA—National Climate Assessment

NEHRP—National Earthquake Hazards Reduction Program

NFIP—National Flood Insurance Program

NIMS—National Incident Management System

NOAA—National Oceanic and Atmospheric Administration

NWS—National Weather Service

OES—Office of Emergency Services

PDM—Pre-Disaster Mitigation Grant Program

PGA—Peak Ground Acceleration

PHMSA—Pipeline and Hazardous Materials Safety Administration

SARS—Severe Acute Respiratory Syndrome

SFHA—Special Flood Hazard Area

SHELDUS—Special Hazard Events and Losses Database for the US

SPI—Standardized Precipitation Index

SRA—State Responsibility Area

USGCRP—U.S. Global Change Research Program

USGS—U.S. Geological Survey

WNV—West Nile virus

DEFINITIONS

100-Year Flood: The term "100-year flood" can be misleading. The 100-year flood does not necessarily occur once every 100 years. Rather, it is the flood that has a 1 percent chance of being equaled or exceeded in any given year. Thus, the 100-year flood could occur more than once in a relatively short period of time. The Federal Emergency Management Agency (FEMA) defines it as the 1 percent annual chance flood, which is now the standard definition used by most federal and state agencies and by the National Flood Insurance Program (NFIP).

Acre-Foot: An acre-foot is the amount of water it takes to cover 1 acre to a depth of 1 foot. This measure is used to describe the quantity of storage in a water reservoir. An acre-foot is a unit of volume. One acre foot equals 7,758 barrels; 325,829 gallons; or 43,560 cubic feet. An average household of four will use approximately 1 acre-foot of water per year.

Asset: An asset is any man-made or natural feature that has value, including people; buildings; infrastructure, such as bridges, roads, sewers, and water systems; lifelines, such as electricity and communication resources; and environmental, cultural, or recreational features such as parks, wetlands, and landmarks.

Base Flood: The flood having a 1% chance of being equaled or exceeded in any given year, also known as the "100-year" or "1% chance" flood. The base flood is a statistical concept used to ensure that all properties subject to the National Flood Insurance Program (NFIP) are protected to the same degree against flooding.

Basin: A basin is the area within which all surface water—whether from rainfall, snowmelt, springs, or other sources—flows to a single water body or watercourse. The boundary of a river basin is defined by natural topography, such as hills, mountains, and ridges. Basins are also referred to as "watersheds" and "drainage basins."

Benefit: A benefit is a net project outcome and is usually defined in monetary terms. Benefits may include direct and indirect effects. For the purposes of benefit-cost analysis of proposed mitigation measures, benefits are limited to specific, measurable, risk reduction factors, including reduction in expected property losses (buildings, contents, and functions) and protection of human life.

Benefit/Cost Analysis: A benefit/cost analysis is a systematic, quantitative method of comparing projected benefits to projected costs of a project or policy. It is used as a measure of cost effectiveness.

Building: A building is defined as a structure that is walled and roofed, principally aboveground, and permanently fixed to a site. The term includes manufactured homes on permanent foundations on which the wheels and axles carry no weight.

Capability Assessment: A capability assessment provides a description and analysis of a community's current capacity to address threats associated with hazards. The assessment includes two components: an inventory of an agency's mission, programs, and policies, and an analysis of its capacity to carry them out. A capability assessment is an integral part of the planning process in which a community's actions to reduce losses are identified, reviewed, and analyzed, and the framework for implementation is identified. The following capabilities were reviewed under this assessment:

- Legal and regulatory capability
- Administrative and technical capability
- Fiscal capability

Community Rating System (CRS): The CRS is a voluntary program under the NFIP that rewards participating communities (provides incentives) for exceeding the minimum requirements of the NFIP and completing activities that reduce flood hazard risk by providing flood insurance premium discounts.

Critical Area: An area defined by state or local regulations as deserving special protection because of unique natural features or its value as habitat for a wide range of species of flora and fauna. A sensitive/critical area is usually subject to more restrictive development regulations.

Critical Facility: Facilities and infrastructure that are critical to the health and welfare of the population. These become especially important after any hazard event occurs. For the purposes of this plan, critical facilities include:

- Structures or facilities that produce, use, or store highly volatile, flammable, explosive, toxic and/or water reactive materials;
- Hospitals, nursing homes, and housing likely to contain occupants who may not be sufficiently mobile to avoid death or injury during a hazard event.
- Police stations, fire stations, vehicle and equipment storage facilities, and emergency operations centers that are needed for disaster response before, during, and after hazard events, and
- Public and private utilities, facilities and infrastructure that are vital to maintaining or restoring normal services to areas damaged by hazard events.

- Government facilities.

Dam: Any artificial barrier or controlling mechanism that can or does impound 10 acre-feet or more of water.

Dam Failure: Dam failure refers to a partial or complete breach in a dam (or levee) that impacts its integrity. Dam failures occur for a number of reasons, such as flash flooding, inadequate spillway size, mechanical failure of valves or other equipment, freezing and thawing cycles, earthquakes, and intentional destruction.

Debris Avalanche: Volcanoes are prone to debris and mountain rock avalanches that can approach speeds of 100 mph.

Debris Flow: Dense mixtures of water-saturated debris that move down-valley; looking and behaving much like flowing concrete. They form when loose masses of unconsolidated material are saturated, become unstable, and move down slope. The source of water varies but includes rainfall, melting snow or ice, and glacial outburst floods.

Debris Slide: Debris slides consist of unconsolidated rock or soil that has moved rapidly down slope. They occur on slopes greater than 65 percent.

Disaster Mitigation Act of 2000 (DMA); The DMA is Public Law 106-390 and is the latest federal legislation enacted to encourage and promote proactive, pre-disaster planning as a condition of receiving financial assistance under the Robert T. Stafford Act. The DMA emphasizes planning for disasters before they occur. Under the DMA, a pre-disaster hazard mitigation program and new requirements for the national post-disaster hazard mitigation grant program (HMGP) were established.

Drainage Basin: A basin is the area within which all surface water- whether from rainfall, snowmelt, springs or other sources- flows to a single water body or watercourse. The boundary of a river basin is defined by natural topography, such as hills, mountains and ridges. Drainage basins are also referred to as **watersheds** or **basins**.

Drought: Drought is a period of time without substantial rainfall or snowfall from one year to the next. Drought can also be defined as the cumulative impacts of several dry years or a deficiency of precipitation over an extended period of time, which in turn results in water shortages for some activity, group, or environmental function. A hydrological drought is caused by deficiencies in surface and subsurface water supplies. A socioeconomic drought impacts the health, well being, and quality of life or starts to have an adverse impact on a region. Drought is a normal, recurrent feature of climate and occurs almost everywhere.

Earthquake: An earthquake is defined as a sudden slip on a fault, volcanic or magmatic activity, and sudden stress changes in the earth that result in ground shaking and radiated seismic energy. Earthquakes can last from a few seconds to over 5 minutes, and have been known to occur as a series of tremors over a period of several days. The actual movement of the ground in an earthquake is seldom the direct cause of injury or death. Casualties may result from falling objects and debris as shocks shake, damage, or demolish buildings and other structures.

Exposure: Exposure is defined as the number and dollar value of assets considered to be at risk during the occurrence of a specific hazard.

Extent: The extent is the size of an area affected by a hazard.

Fire Behavior: Fire behavior refers to the physical characteristics of a fire and is a function of the interaction between the fuel characteristics (such as type of vegetation and structures that could burn), topography, and weather. Variables that affect fire behavior include the rate of spread, intensity, fuel consumption, and fire type (such as underbrush versus crown fire).

Fire Frequency: Fire frequency is the broad measure of the rate of fire occurrence in a particular area. An estimate of the areas most likely to burn is based on past fire history or fire rotation in the area, fuel conditions, weather, ignition sources (such as human or lightning), fire suppression response, and other factors.

Flash Flood: A flash flood occurs with little or no warning when water levels rise at an extremely fast rate

Flood Insurance Rate Map (FIRM): FIRMs are the official maps on which the Federal Emergency Management Agency (FEMA) has delineated the Special Flood Hazard Area (SFHA).

Flood Insurance Study: A report published by the Federal Insurance and Mitigation Administration for a community in conjunction with the community's Flood Insurance rate Map. The study contains such background data as the base flood discharges and water surface elevations that were used to prepare the FIRM. In most cases, a community FIRM with detailed mapping will have a corresponding flood insurance study.

Floodplain: Any land area susceptible to being inundated by flood waters from any source. A flood insurance rate map identifies most, but not necessarily all, of a community's floodplain as the Special Flood Hazard Area (SFHA).

Floodway: Floodways are areas within a floodplain that are reserved for the purpose of conveying flood discharge without increasing the base flood elevation more than 1 foot. Generally speaking, no development is allowed in floodways, as any structures located there would block the flow of floodwaters.

Floodway Fringe: Floodway fringe areas are located in the floodplain but outside of the floodway. Some development is generally allowed in these areas, with a variety of restrictions. On maps that have identified and delineated a floodway, this would be the area beyond the floodway boundary that can be subject to different regulations.

Fog: Fog refers to a cloud (or condensed water droplets) near the ground. Fog forms when air close to the ground can no longer hold all the moisture it contains. Fog occurs either when air is cooled to its dew point or the amount of moisture in the air increases. Heavy fog is particularly hazardous because it can restrict surface visibility. Severe fog incidents can close roads, cause vehicle accidents, cause airport delays, and impair the effectiveness of emergency response. Financial losses associated with transportation delays caused by fog have not been calculated in the United States but are known to be substantial.

Freeboard: Freeboard is the margin of safety added to the base flood elevation.

Frequency: For the purposes of this plan, frequency refers to how often a hazard of specific magnitude, duration, and/or extent is expected to occur on average. Statistically, a hazard with a 100-year frequency is expected to occur about once every 100 years on average and has a 1 percent chance of occurring any given year. Frequency reliability varies depending on the type of hazard considered.

Fujita Scale of Tornado Intensity: Tornado wind speeds are sometimes estimated on the basis of wind speed and damage sustained using the Fujita Scale. The scale rates the intensity or severity of tornado events using numeric values from F0 to F5 based on tornado wind speed and damage. An F0 tornado (wind speed less than 73 miles per hour (mph)) indicates minimal damage (such as broken tree limbs), and an F5 tornado (wind speeds of 261 to 318 mph) indicates severe damage.

Goal: A goal is a general guideline that explains what is to be achieved. Goals are usually broad-based, long-term, policy-type statements and represent global visions. Goals help define the benefits that a plan is trying to achieve. The success of a hazard mitigation plan is measured by the degree to which its goals have been met (that is, by the actual benefits in terms of actual hazard mitigation).

Geographic Information System (GIS): GIS is a computer software application that relates data regarding physical and other features on the earth to a database for mapping and analysis.

Hazard: A hazard is a source of potential danger or adverse condition that could harm people and/or cause property damage.

Hazard Mitigation Grant Program (HMGP): Authorized under Section 202 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, the HMGP is administered by FEMA and provides grants to states, tribes, and local governments to implement hazard mitigation actions after a major disaster declaration. The purpose of the program is to reduce the loss of life and property due to disasters and to enable mitigation activities to be implemented as a community recovers from a disaster

Hazards U.S. Multi-Hazard Loss Estimation Program (Hazus): Hazus is a GIS-based program used to support the development of risk assessments as required under the DMA. The Hazus software program assesses risk in a quantitative manner to estimate damage and losses associated with natural hazards. Hazus is FEMA's nationally applicable, standardized methodology and software program and contains modules for estimating potential losses from earthquakes, floods, and wind hazards. Hazus has also been used to assess vulnerability (exposure) for other hazards.

Hydraulics: Hydraulics is the branch of science or engineering that addresses fluids (especially water) in motion in rivers or canals, works and machinery for conducting or raising water, the use of water as a prime mover, and other fluid-related areas.

Hydrology: Hydrology is the analysis of waters of the earth. For example, a flood discharge estimate is developed by conducting a hydrologic study.

Intensity: For the purposes of this plan, intensity refers to the measure of the effects of a hazard.

Inventory: The assets identified in a study region comprise an inventory. Inventories include assets that could be lost when a disaster occurs and community resources are at risk. Assets include people, buildings, transportation, and other valued community resources.

Landslide: Landslides can be described as the sliding movement of masses of loosened rock and soil down a hillside or slope. Fundamentally, slope failures occur when the strength of the soils forming the slope exceeds the pressure, such as weight or saturation, acting upon them.

Lightning: Lightning is an electrical discharge resulting from the buildup of positive and negative charges within a thunderstorm. When the buildup becomes strong enough, lightning appears as a "bolt," usually within or between clouds and the ground. A bolt of lightning instantaneously reaches temperatures approaching 50,000ºF. The rapid heating and cooling of air near lightning causes thunder. Lightning is a major threat during thunderstorms. In the United States, 75 to 100 Americans are struck and killed by lightning each year (see http://www.fema.gov/hazard/thunderstorms/thunder.shtm).

Liquefaction: Liquefaction is the complete failure of soils, occurring when soils lose shear strength and flow horizontally. It is most likely to occur in fine grain sands and silts, which behave like viscous fluids when liquefaction occurs. This situation is extremely hazardous to development on the soils that liquefy, and generally results in extreme property damage and threats to life and safety.

Local Government: Any county, municipality, city, town, township, public authority, school district, special district, intrastate district, council of governments (regardless of whether the council of governments is incorporated as a nonprofit corporation under State law), regional or interstate government entity, or agency or instrumentality of a local government; any Indian tribe or authorized tribal organization, or Alaska Native village or organization; and any rural community, unincorporated town or village, or other public entity.

Magnitude: Magnitude is the measure of the strength of an earthquake, and is typically measured by the Richter scale. As an estimate of energy, each whole number step in the magnitude scale corresponds to the release of about 31 times more energy than the amount associated with the preceding whole number value.

Mass movement: A collective term for landslides, debris flows, and lahars.

Mitigation: A preventive action that can be taken in advance of an event that will reduce or eliminate the risk to life or property.

Mitigation Actions: Mitigation actions are specific actions to achieve goals and objectives that minimize the effects from a disaster and reduce the loss of life and property.

Objective: For the purposes of this plan, an objective is defined as a short-term aim that, when combined with other objectives, forms a strategy or course of action to meet a goal. Unlike goals, objectives are specific and measurable.

Peak Ground Acceleration: Peak Ground Acceleration (PGA) is a measure of the highest amplitude of ground shaking that accompanies an earthquake, based on a percentage of the force of gravity.

Preparedness: Preparedness refers to actions that strengthen the capability of government, citizens, and communities to respond to disasters.

Presidential Disaster Declaration: These declarations are typically made for events that cause more damage than state and local governments and resources can handle without federal government assistance. Generally, no specific dollar loss threshold has been established for such declarations. A Presidential Disaster Declaration puts into motion long-term federal recovery programs, some of which are matched by state programs, designed to help disaster victims, businesses, and public entities.

Probability of Occurrence: The probability of occurrence is a statistical measure or estimate of the likelihood that a hazard will occur. This probability is generally based on past hazard events in the area and a forecast of events that could occur in the future. A probability factor based on yearly values of occurrence is used to estimate probability of occurrence.

Repetitive Loss Property: Any NFIP-insured property that, since 1978 and regardless of any changes of ownership during that period, has experienced:

- Four or more paid flood losses in excess of $1000.00; or
- Two paid flood losses in excess of $1000.00 within any 10-year period since 1978 or
- Three or more paid losses that equal or exceed the current value of the insured property.

Return Period (or Mean Return Period): This term refers to the average period of time in years between occurrences of a particular hazard (equal to the inverse of the annual frequency of occurrence).

Riverine: Of or produced by a river. Riverine floodplains have readily identifiable channels. Floodway maps can only be prepared for riverine floodplains.

Risk: Risk is the estimated impact that a hazard would have on people, services, facilities, and structures in a community. Risk measures the likelihood of a hazard occurring and resulting in an adverse condition that causes injury or damage. Risk is often expressed in relative terms such as a high, moderate, or low likelihood of sustaining damage above a particular threshold due to occurrence of a specific type of hazard. Risk also can be expressed in terms of potential monetary losses associated with the intensity of the hazard.

Risk Assessment: Risk assessment is the process of measuring potential loss of life, personal injury, economic injury, and property damage resulting from hazards. This process assesses the vulnerability of people, buildings, and infrastructure to hazards and focuses on (1) hazard identification; (2) impacts of hazards on physical, social, and economic assets; (3) vulnerability identification; and (4) estimates of the cost of damage or costs that could be avoided through mitigation.

Risk Ranking: This ranking serves two purposes, first to describe the probability that a hazard will occur, and second to describe the impact a hazard will have on people, property, and the economy. Risk estimates are based on the methodology used to prepare the risk assessment for this plan. The following equation shows the risk ranking calculation:

Risk Ranking = Probability + Impact (people + property + economy)

Robert T. Stafford Act: The Robert T. Stafford Disaster Relief and Emergency Assistance Act, Public Law 100-107, was signed into law on November 23, 1988. This law amended the Disaster Relief Act of 1974, Public Law 93-288. The Stafford Act is the statutory authority for most federal disaster response activities, especially as they pertain to FEMA and its programs.

Special Flood Hazard Area: The base floodplain delineated on a Flood Insurance Rate Map. The SFHA is mapped as a Zone A in riverine situations and zone V in coastal situations. The SFHA may or may not encompass all of a community's flood problems

Stakeholder: Business leaders, civic groups, academia, non-profit organizations, major employers, managers of critical facilities, farmers, developers, special purpose districts, and others whose actions could impact hazard mitigation.

Stream Bank Erosion: Stream bank erosion is common along rivers, streams and drains where banks have been eroded, sloughed or undercut. However, it is important to remember that a stream is a dynamic and constantly changing system. It is natural for a stream to want to meander, so not all eroding banks are "bad" and in need of repair. Generally, stream bank erosion becomes a problem where development has limited the meandering nature of streams, where streams have been channelized, or where stream bank structures (like bridges, culverts, etc.) are located in places where they can actually cause damage to downstream areas. Stabilizing these areas can help protect watercourses from continued sedimentation, damage to adjacent land uses, control unwanted meander, and improvement of habitat for fish and wildlife.

Steep Slope: Different communities and agencies define it differently, depending on what it is being applied to, but generally a steep slope is a slope in which the percent slope equals or exceeds 25%. For this study, steep slope is defined as slopes greater than 33%.

Thunderstorm: A thunderstorm is a storm with lightning and thunder produced by cumulonimbus clouds. Thunderstorms usually produce gusty winds, heavy rains, and sometimes hail. Thunderstorms are usually short in duration (seldom more than 2 hours). Heavy rains associated with thunderstorms can lead to flash flooding during the wet or dry seasons.

Tornado: A tornado is a violently rotating column of air extending between and in contact with a cloud and the surface of the earth. Tornadoes are often (but not always) visible as funnel clouds. On a local scale, tornadoes are the most intense of all atmospheric circulations, and winds can reach destructive speeds of more than 300 mph. A tornado's vortex is typically a few hundred meters in diameter, and damage paths can be up to 1 mile wide and 50 miles long.

Vulnerability: Vulnerability describes how exposed or susceptible an asset is to damage. Vulnerability depends on an asset's construction, contents, and the economic value of its functions. Like indirect damage, the vulnerability of one element of the community is often related to the vulnerability of another. For example, many businesses depend on uninterrupted electrical power. Flooding of an electric substation would affect not only the substation itself but businesses as well. Often, indirect effects can be much more widespread and damaging than direct effects.

Watershed: A watershed is an area that drains downgradient from areas of higher land to areas of lower land to the lowest point, a common drainage basin.

Wildfire: These terms refer to any uncontrolled fire occurring on undeveloped land that requires fire suppression. The potential for wildfire is influenced by three factors: the presence of fuel, topography, and air mass. Fuel can include living and dead vegetation on the ground, along the surface as brush and small trees, and in the air such as tree canopies. Topography includes both slope and elevation. Air mass includes temperature, relative humidity, wind speed and direction, cloud cover, precipitation amount, duration, and the stability of the atmosphere at the time of the fire. Wildfires can be ignited by lightning and, most frequently, by human activity including smoking, campfires, equipment use, and arson.

Windstorm: Windstorms are generally short-duration events involving straight-line winds or gusts exceeding 50 mph. These gusts can produce winds of sufficient strength to cause property damage. Windstorms are especially dangerous in areas with significant tree stands, exposed property, poorly constructed buildings, mobile homes (manufactured housing units), major infrastructure, and aboveground utility lines. A windstorm can topple trees and power lines; cause damage to residential, commercial, critical facilities; and leave tons of debris in its wake.

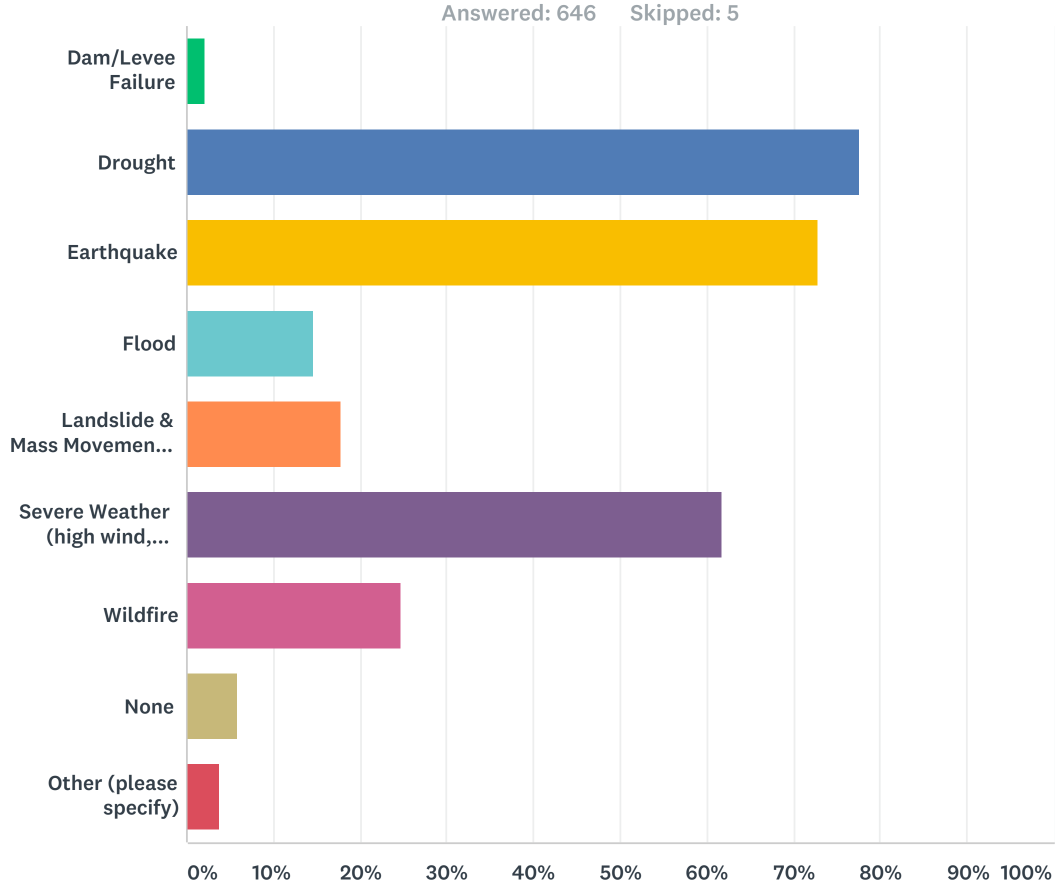
Zoning Ordinance: The zoning ordinance designates allowable land use and intensities for a local jurisdiction. Zoning ordinances consist of two components: a zoning text and a zoning map.

Contra Costa County Hazard Mitigation Plan

Appendix A. Public Outreach Materials

Q1 Which of the following natural hazard events have you experienced in Contra Costa? (Check all that apply)

Answered: 646   Skipped: 5



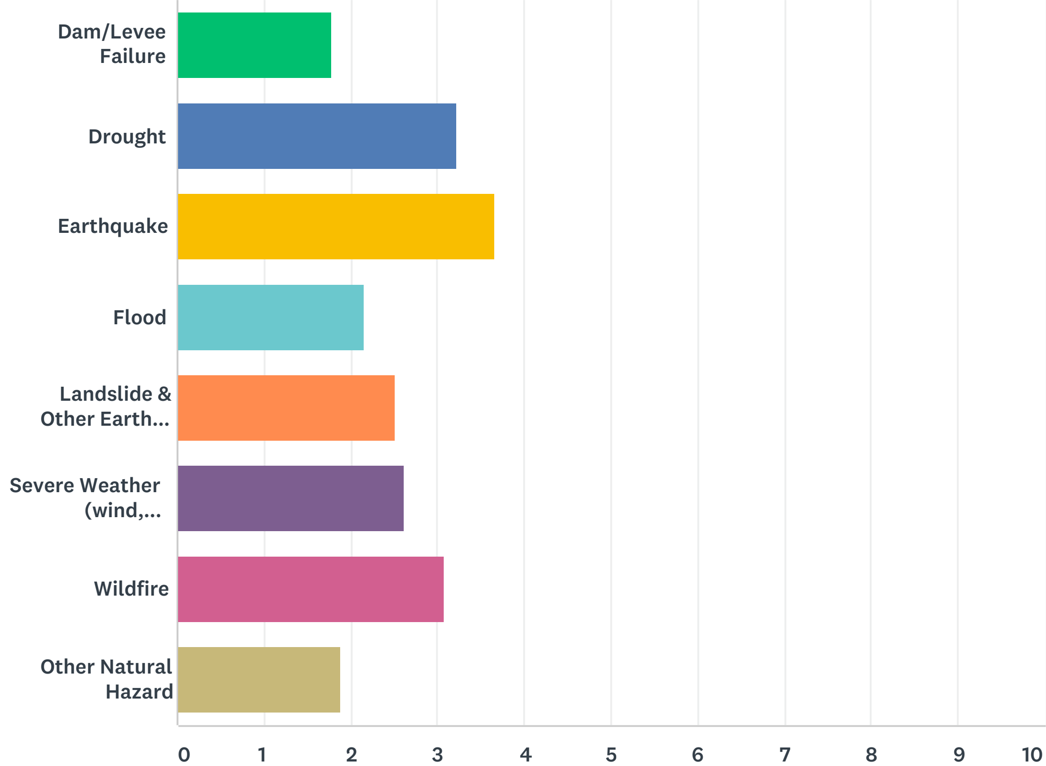
Answer Choices	Responses	
Dam/Levee Failure	2.17%	14
Drought	77.71%	502
Earthquake	72.76%	470
Flood	14.71%	95
Landslide & Mass Movements (sinkholes, geologic hazards)	17.80%	115
Severe Weather (high wind, heavy rain, lightning, etc.)	61.76%	399
Wildfire	24.77%	160
None	5.88%	38
Other (please specify)	3.72%	24
Total Respondents: 646		

#	Other (please specify)	Date
1	Just moved here	7/18/2017 12:26 AM
2	Bomb threats; legionaire's disease form water tank	7/7/2017 3:46 PM
3	martinez refinery related incidents	6/15/2017 5:23 PM

4	angry wild turkeys and goose poop	6/15/2017 1:49 PM
5	I live downtown Martinez and Alhambra Creek breeched the banks on Estuddillo and downtown below Main St. Roads were closed but I would consider it an emergency or disaster	6/14/2017 1:19 PM
6	*minor flooding	6/14/2017 3:17 AM
7	Falling trees	6/13/2017 8:13 PM
8	Chevron fire, explosion, release, shelter in place	6/13/2017 6:12 PM
9	Natural gas line breaks (in San Bruno, San Francisco and EB.	6/12/2017 8:22 PM
10	theft	6/12/2017 6:55 PM
11	Gas Leak	6/12/2017 3:35 PM
12	major highway shutdown due to violence	6/12/2017 2:53 PM
13	Oak tree fell down, taking utility pole with it.	6/8/2017 5:22 PM
14	None	6/8/2017 2:45 PM
15	Mosquitoes	6/8/2017 1:19 PM
16	Fallen tree	6/8/2017 12:18 AM
17	Falling old large trees (Oaks)	6/7/2017 10:29 PM
18	Crime	6/7/2017 7:38 PM
19	I	6/7/2017 7:36 PM
20	Tree collapse	6/7/2017 7:07 PM
21	Extreme heat	6/6/2017 1:11 PM
22	Hazardous materials release from refineries	6/6/2017 10:56 AM
23	Too	6/4/2017 10:51 AM
24	Cyber, power outage, failure of communication systems, refinery incidents, Haz Mat Spills,	6/2/2017 2:47 PM

Q2 How concerned are you about the following natural hazards in Contra Costa? (Please check one for each hazard)

Answered: 646 Skipped: 5



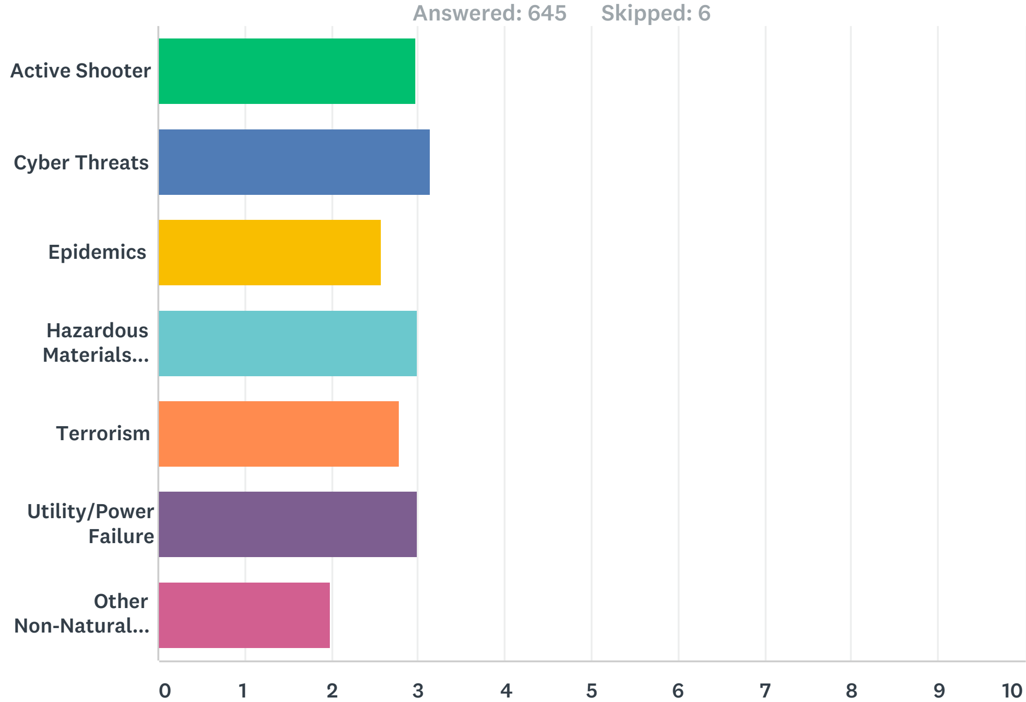
	Not concerned	Somewhat concerned	Concerned	Very concerned	Extremely concerned	Total	Weighted Average
Dam/Levee Failure	54.68% 339	23.23% 144	14.35% 89	5.16% 32	2.58% 16	620	1.78
Drought	6.45% 41	19.50% 124	32.55% 207	27.20% 173	14.31% 91	636	3.23
Earthquake	1.41% 9	12.56% 80	29.83% 190	30.61% 195	25.59% 163	637	3.66
Flood	33.55% 208	33.23% 206	22.26% 138	6.29% 39	4.68% 29	620	2.15
Landslide & Other Earth Movements (sinkholes,geologic hazard)	17.80% 113	36.85% 234	27.09% 172	13.23% 84	5.04% 32	635	2.51
Severe Weather (wind, lightning, fog, heavy rains, solar flare, etc.)	17.32% 111	30.73% 197	30.58% 196	15.76% 101	5.62% 36	641	2.62
Wildfire	10.58% 67	24.01% 152	28.28% 179	21.17% 134	15.96% 101	633	3.08
Other Natural Hazard	47.64% 212	25.84% 115	19.78% 88	4.49% 20	2.25% 10	445	1.88

#	If you are concerned about a natural hazard not listed above, please specify.	Date
1	Lots of open space subject to wildfire. Earth movement issues impact transportation.	7/21/2017 1:16 PM
2	Environmental disasters	7/12/2017 6:55 PM
3	rise in sealevel due to global warming	7/7/2017 3:46 PM

4	Water shortage and the impact on agriculture and water supply for people and wildlife	6/22/2017 12:39 AM
5	I assume tree falls are included with landslides etc	6/20/2017 5:53 PM
6	bridge collaspe to solano county	6/18/2017 7:06 PM
7	Sea level rise and higher tide levels	6/17/2017 12:24 AM
8	goose poop	6/15/2017 1:49 PM
9	Earthquake causing disaster at the refineries	6/14/2017 1:19 PM
10	Natural Gas line break/explosion	6/13/2017 11:28 PM
11	Tornado high winds	6/13/2017 6:29 PM
12	Extremely concerned about Chevron fire, explosion, release, shelter in place	6/13/2017 6:12 PM
13	climate change	6/13/2017 5:21 PM
14	Tornado	6/13/2017 1:01 PM
15	The effect of future sea level rise on our shoreline.	6/13/2017 12:17 PM
16	tsunami	6/13/2017 10:18 AM
17	Anything that would affect our water	6/13/2017 7:53 AM
18	The Yellowstone Caldera blowing and what kind of situation that would be that we would have to deal with or live through.	6/13/2017 12:51 AM
19	Tsunami	6/12/2017 11:57 PM
20	Environmental contamination from the nearby factories/refineries	6/12/2017 8:37 PM
21	Gas line and electric emergencies (retired PG&E)	6/12/2017 8:22 PM
22	Dam/Levee failure is not a natural hazard.	6/12/2017 7:40 PM
23	do potholes count?	6/12/2017 5:47 PM
24	Gas Leak/Explosion	6/12/2017 3:35 PM
25		6/12/2017 12:32 PM
26	Hazardous waste spill/terrorism	6/12/2017 11:04 AM
27	Tornado (East County)	6/9/2017 2:57 PM
28	Mosquitoes are a hazard not mentioned here.	6/8/2017 1:19 PM
29	Pipeline explosion or water main breaks due to infrastructure being very old	6/8/2017 11:51 AM
30	Liquifaction	6/8/2017 12:10 AM
31	tornados	6/7/2017 11:52 PM
32	EBMUD gas line exploding	6/7/2017 8:28 PM
33	Crime esp Criminals coming to our area from other areas due to easy access to freeways and BART, also Terrorism	6/7/2017 7:38 PM
34	Hazard material release from refineries	6/6/2017 10:56 AM
35	Terrorist attacks	6/5/2017 8:56 PM
36	Drought/heat-related side effects, primarily structure related, cracking, shifting	6/2/2017 3:16 PM
37	Listed above	6/2/2017 2:47 PM

Q3 How concerned are you about the following non-natural hazards in Contra Costa? (Please check one for each hazard)

Answered: 645 Skipped: 6



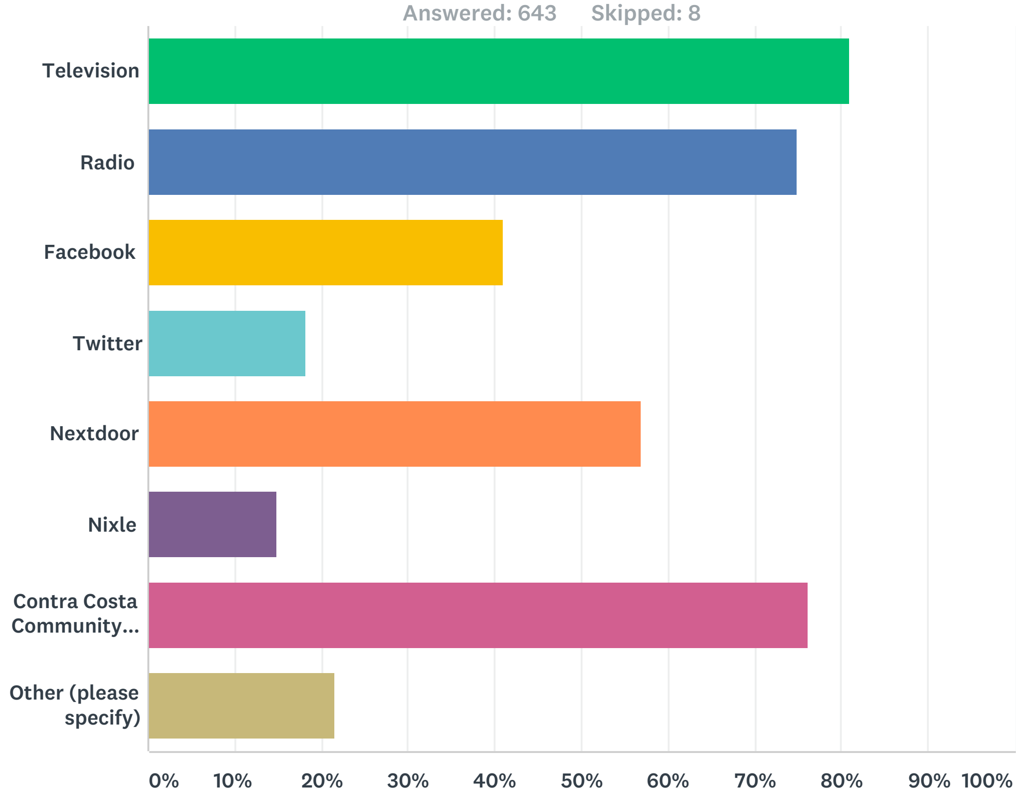
	Not concerned	Somewhat concerned	Concerned	Very concerned	Extremely concerned	Total	Weighted Average
Active Shooter	**11.84%** 76	**26.64%** 171	**27.88%** 179	**19.78%** 127	**13.86%** 89	642	2.97
Cyber Threats	**8.28%** 53	**23.75%** 152	**28.59%** 183	**25.31%** 162	**14.06%** 90	640	3.13
Epidemics	**18.15%** 116	**30.99%** 198	**31.77%** 203	**12.83%** 82	**6.26%** 40	639	2.58
Hazardous Materials Release	**9.80%** 63	**26.28%** 169	**31.42%** 202	**18.66%** 120	**13.84%** 89	643	3.00
Terrorism	**15.23%** 97	**31.08%** 198	**24.49%** 156	**17.43%** 111	**11.77%** 75	637	2.79
Utility/Power Failure	**6.92%** 44	**27.36%** 174	**35.22%** 224	**21.23%** 135	**9.28%** 59	636	2.99
Other Non-Natural Hazard	**46.39%** 212	**22.54%** 103	**19.26%** 88	**8.97%** 41	**2.84%** 13	457	1.99

#	If you are concerned about a natural hazard not listed above, please specify.	Date
1	child abduction, child molester	7/20/2017 11:46 AM
2	Toxic chemicals in water, air, soil (and therefore, drinking water and the food supply)	6/22/2017 12:39 AM
3	do you mean a non-natural hazard?	6/21/2017 12:17 AM
4	Urban Decay/section 8/degenerates = Extremely Concerned	6/17/2017 7:30 PM
5	nuclear war, refinery explosion, zombie apocalypse	6/14/2017 4:27 PM
6	natural gas and petroleum pipeline rupture	6/14/2017 2:51 PM

7	Chevron	6/13/2017 6:12 PM
8	civil unrest from progressive groups (antifa, bml, etc.)	6/13/2017 3:54 PM
9	Reifinery fire and gas pipeline failure and explosions.	6/13/2017 12:17 PM
10	contamination of water, and fracking water being used for crops	6/13/2017 7:53 AM
11	Cut-off from mainstream society due to a natural disaster.	6/13/2017 12:51 AM
12	Robbers. Violence. Gangs.	6/13/2017 12:33 AM
13	theft occurring in my apartment complex	6/12/2017 6:55 PM
14	EMP caused by low atmospheric nuclear detonation or solar flare.	6/12/2017 6:32 PM
15	Global Warming being ignored by new Federal Administration	6/12/2017 5:47 PM
16	Multiple refinery burn off due to grid power outages	6/12/2017 12:32 PM
17	Rise of racial violence	6/11/2017 4:40 PM
18	Im extremely concerned about the lack of fire first response in my comminuty (East County)	6/9/2017 3:50 PM
19	Chemical warfare, war in general	6/9/2017 2:20 PM
20	train derailment	6/9/2017 10:22 AM
21	Oil Refinery(ies) Releases; Bridge Infrastructure & Safety; Local Airport Safety; Water Safety in CoCo Canal	6/8/2017 4:29 PM
22	Do you want a non-natural hazard Drugs & Thugs	6/8/2017 3:41 PM
23	Mosquitoes are a major disease vector	6/8/2017 1:19 PM
24	North Korean Nukes	6/8/2017 1:10 PM
25	Not exactly like the active shooter, but the recent daylight robberies of local businesses have me a bit concerned.	6/8/2017 12:53 PM
26	Civil unrest	6/8/2017 12:22 PM
27	I live near Shell Refinery in Martinez. If something happened there it would be catastrophic	6/8/2017 12:08 PM
28	Natural gas Pipeline explosion and ability to evacuate based on experience when line was hit at Danville bl and Stone Valley bl. Cars were stuck in Safeway park lot and couldn't get out. I could not evacuate from my street (Lunada Lane)	6/8/2017 2:37 AM
29	wild land fire caused by inattentive humans	6/8/2017 12:14 AM
30	Crime/ terrorism	6/7/2017 7:38 PM
31	Insurrection - failure of governmental controls	6/7/2017 7:07 PM
32	We live near Diablo CC and they are planning on putting in a sewage reclaimation plant on the golf course near the 12 th fairway. We are all highly concerned about spillage, accidents, fumes, human error, etc.	6/7/2017 7:07 PM
33	Major earth quake	6/7/2017 7:03 PM
34	Non-terrorist attacks on the public	6/6/2017 10:56 AM
35	Active Shooter situation are a real threat because sheriff Livingston is anti citizen self protection via CCW.	6/2/2017 7:40 PM
36	You mean a NON-natural hazard - lots of traffic on my 22 foot wide curvy street and not getting killed standing out front of my house. This is a greater danger to me than the natural and non-natural listed.	6/2/2017 3:27 PM

Q4 How would you expect to be notified in case of an immediate threat caused by a local hazard.Select all that apply.

Answered: 643 Skipped: 8



Answer Choices	Responses	
Television	80.87%	520
Radio	74.96%	482
Facebook	41.06%	264
Twitter	18.20%	117
Nextdoor	56.92%	366
Nixle	14.77%	95
Contra Costa Community Warning System	76.21%	490
Other (please specify)	21.62%	139
Total Respondents: 643		

#	Other (please specify)	Date
1	Police or Fire	7/21/2017 12:22 PM
2	Reverse 911	7/18/2017 12:26 AM
3	Reverse 911	7/14/2017 4:56 PM
4	Reddinet,	7/11/2017 3:16 PM
5	Don't know what Nixie and CCCWS are.	7/9/2017 9:02 PM
6	Internet	7/7/2017 12:02 PM

7	warning sirens?	6/29/2017 6:51 PM
8	Police and fire departments if immediate and local...	6/27/2017 7:41 PM
9	Text	6/27/2017 7:10 AM
10	text	6/26/2017 5:43 PM
11	Cell phone alert (like the Amber Alert system)	6/26/2017 4:43 PM
12	robo call	6/21/2017 9:02 PM
13	phone call on our landline	6/21/2017 12:17 AM
14	texting	6/20/2017 5:53 PM
15	text message	6/20/2017 5:36 PM
16	I work for a city, City Hall is an EOC	6/20/2017 1:55 PM
17	City Alarm	6/17/2017 7:30 PM
18	Claycord	6/17/2017 3:51 PM
19	text	6/16/2017 6:40 PM
20	mobile device	6/16/2017 3:58 PM
21	phone	6/15/2017 8:10 PM
22	text message	6/15/2017 1:49 PM
23	text	6/15/2017 1:45 PM
24	text (like the amber alert) / concord app	6/15/2017 2:31 AM
25	Phone call	6/14/2017 9:36 PM
26	Phone call	6/14/2017 7:01 PM
27	Work or Cellphone?	6/14/2017 3:38 PM
28	text like the Amber Alert	6/14/2017 2:51 PM
29	Text Alert on mobile phone	6/14/2017 2:27 PM
30	Cell Phone	6/14/2017 2:27 PM
31	cell phone	6/14/2017 1:24 PM
32	cell phone alert	6/14/2017 1:19 PM
33	Home phone calls	6/14/2017 12:58 PM
34	text	6/14/2017 12:42 PM
35	Concord Patch	6/14/2017 8:45 AM
36	Automated phone call, like PGE doors for power outages? Or email or text alert	6/14/2017 3:17 AM
37	PulsePoint	6/13/2017 8:13 PM
38	Text from various government institutions; sirens from Chevron	6/13/2017 6:12 PM
39	redi-net	6/13/2017 5:54 PM
40	cell phone / home phone	6/13/2017 5:53 PM
41	text, telephone.	6/13/2017 3:54 PM
42	Ham Radio CARES 146.405 MHz	6/13/2017 1:01 PM
43	text	6/13/2017 11:58 AM
44	IRIS	6/13/2017 8:49 AM
45	By siren or some loud audible noise. We have received phone messages in the past, but now that we are not using a house phone (due to incessant telemarketers), I am not sure how hazard announcements would get through.	6/13/2017 8:13 AM

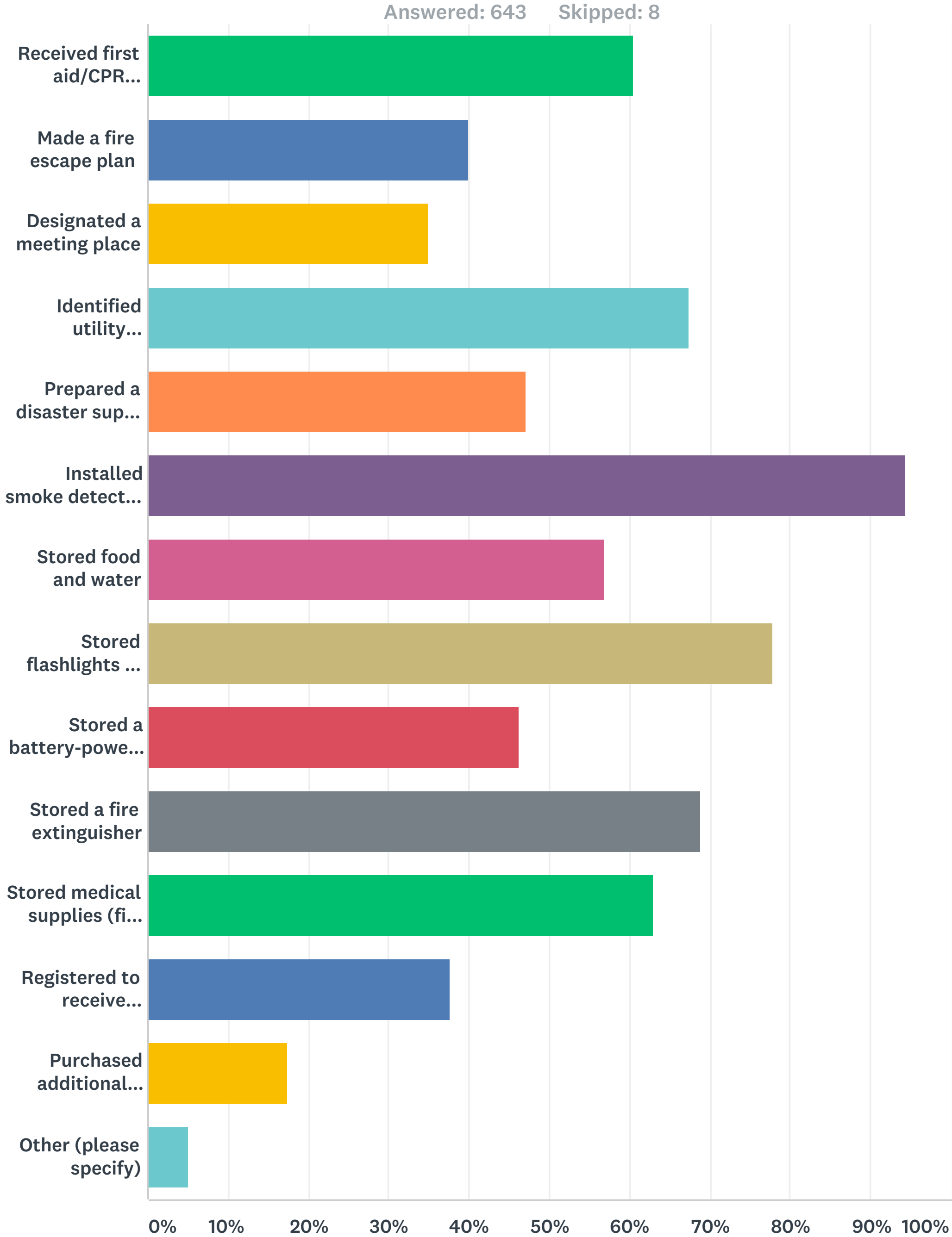
46	claycord.com	6/13/2017 7:53 AM
47	Emergency services broadcasting throughout the streets if safe to do so.	6/13/2017 12:51 AM
48	text message	6/12/2017 10:43 PM
49	Phone call	6/12/2017 10:31 PM
50	Phone call or text	6/12/2017 9:48 PM
51	Ideally text message to my cellphone	6/12/2017 9:47 PM
52	text	6/12/2017 9:09 PM
53	The emergency warning system that alerts your phone	6/12/2017 8:51 PM
54	SMS message	6/12/2017 8:49 PM
55	Word of mouth old school style	6/12/2017 8:27 PM
56	Text alerts	6/12/2017 8:22 PM
57	Text message	6/12/2017 7:40 PM
58	Text alert system (akin to Amber Alerts)	6/12/2017 6:31 PM
59	targeted texts by citizens who sign up for them	6/12/2017 5:47 PM
60	Word of mouth	6/12/2017 5:18 PM
61	Office Manager/Floor Wardens in each department would relay news	6/12/2017 4:54 PM
62	Text message	6/12/2017 3:34 PM
63	text message	6/12/2017 2:53 PM
64	door to door by Sheriffs.	6/12/2017 2:46 PM
65	Text	6/12/2017 12:32 PM
66	TEXT alert	6/12/2017 12:10 PM
67	Internet	6/12/2017 11:56 AM
68	Texts or Nextdoor Neighbor alert	6/12/2017 10:39 AM
69	Text message	6/11/2017 10:02 PM
70	You	6/10/2017 3:27 PM
71	text if it is available	6/10/2017 11:51 AM
72	Text messages	6/10/2017 1:35 AM
73	Text message	6/9/2017 5:44 PM
74	Telephone	6/9/2017 4:03 PM
75	Other social media platforms	6/9/2017 3:50 PM
76	AtHoc	6/9/2017 2:57 PM
77	Text message based alert system	6/9/2017 2:44 PM
78	Text Alert	6/9/2017 2:28 PM
79	Text	6/9/2017 2:01 PM
80	Mass communication system such as everbridge	6/9/2017 2:01 PM
81	internet- all forms of social media	6/9/2017 1:46 PM
82	Text message	6/8/2017 7:05 PM
83	Txt message	6/8/2017 4:12 PM
84	Texting	6/8/2017 3:59 PM
85	local authorities	6/8/2017 3:41 PM
86	text or mobile phone call	6/8/2017 2:44 PM

87	Cell phone announcement on CNN or other news outlet	6/8/2017 2:06 PM
88	Texting	6/8/2017 1:12 PM
89	Public alert broadcast to NOAA weather radios	6/8/2017 12:22 PM
90	Cell phone	6/8/2017 11:56 AM
91	Cell phone	6/8/2017 11:51 AM
92	reverse 9-1-1 call utilizing cell phones registered to home addresses within the area	6/8/2017 11:42 AM
93	EAS	6/8/2017 11:23 AM
94	mobile phone	6/8/2017 10:46 AM
95	Smartphone	6/8/2017 8:42 AM
96	Mobile phone text	6/8/2017 3:10 AM
97	phone	6/8/2017 1:14 AM
98	Landline telephone	6/8/2017 12:55 AM
99	text messaging from county/city	6/8/2017 12:14 AM
100	text messsage	6/8/2017 12:10 AM
101	Amber alert style notification	6/7/2017 11:57 PM
102	Phone alert like we get for Amber alert	6/7/2017 11:37 PM
103	Email	6/7/2017 10:44 PM
104	Text	6/7/2017 10:43 PM
105	Amber alert like system?	6/7/2017 10:18 PM
106	Text	6/7/2017 10:17 PM
107	Texting through cellphones	6/7/2017 9:32 PM
108	Direct Text Message	6/7/2017 9:22 PM
109	cellphone	6/7/2017 9:08 PM
110	Facebook	6/7/2017 8:59 PM
111	Email	6/7/2017 8:49 PM
112	Text notification would be great via Nixle	6/7/2017 8:34 PM
113	Txt message	6/7/2017 7:59 PM
114	electronic signage on Hwy 680	6/7/2017 7:55 PM
115	email. phone	6/7/2017 7:53 PM
116	Txt message like Amber Alerts	6/7/2017 7:43 PM
117	telephone	6/7/2017 7:36 PM
118	Text message	6/7/2017 7:32 PM
119	Text (though I suspect that's complex & expensive to set up)	6/7/2017 7:31 PM
120	Text	6/7/2017 7:20 PM
121	Phone	6/7/2017 7:12 PM
122	911 System in reverse	6/7/2017 7:07 PM
123	text messages	6/7/2017 7:07 PM
124	The County should notify me with a call or text	6/7/2017 5:39 PM
125	Phone	6/7/2017 4:50 PM
126	I get text messages from the Town of Danville about events, emergencies, etc.	6/4/2017 10:12 PM
127	Friends	6/4/2017 6:57 AM

128	Phone	6/4/2017 4:28 AM
129	The	6/4/2017 12:04 AM
130	Text	6/3/2017 11:07 PM
131	phone	6/3/2017 10:33 PM
132	Text message	6/3/2017 4:35 PM
133	Phone	6/3/2017 9:20 AM
134	EAS	6/2/2017 7:40 PM
135	Text	6/2/2017 5:29 PM
136	Text	6/2/2017 3:06 PM
137	Emails, Town halls, WEA, Ipaws, and door to door	6/2/2017 2:47 PM
138	Text	6/2/2017 2:39 PM
139	County website	5/11/2017 6:36 AM

Q5 Which of the following steps has your household taken to prepare for a local hazard event? (Check all that apply)

Answered: 643   Skipped: 8



Answer Choices	Responses	
Received first aid/CPR training	60.50%	389
Made a fire escape plan	39.97%	257
Designated a meeting place	34.99%	225
Identified utility shutoffs	67.34%	433
Prepared a disaster supply kit	46.97%	302

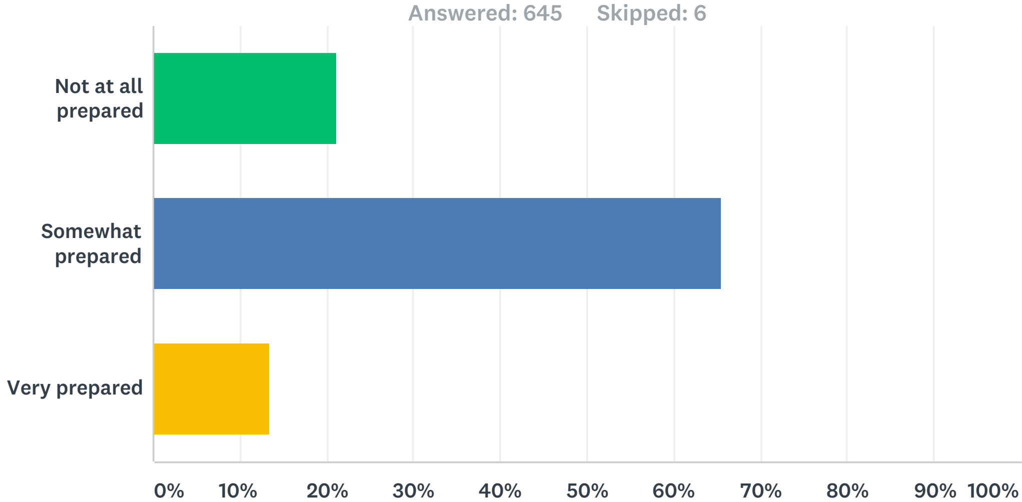
Installed smoke detectors on each level of the house	**94.40%**	607
Stored food and water	**56.92%**	366
Stored flashlights and batteries	**77.76%**	500
Stored a battery-powered radio	**46.19%**	297
Stored a fire extinguisher	**68.90%**	443
Stored medical supplies (first aid kit, medications)	**62.99%**	405
Registered to receive emergency alerts	**37.64%**	242
Purchased additional Insurance	**17.26%**	111
Other (please specify)	**4.98%**	32
Total Respondents: 643		

#	Other (please specify)	Date
1	cell phone	7/12/2017 6:55 PM
2	My camping gear is my emergency survival kit	6/23/2017 12:16 AM
3	This is my workplace (I do not live here)	6/20/2017 1:55 PM
4	we are armed, trained, and equipped with "go-bags" in order to protect and/or defend in the event of an active shooter event	6/14/2017 11:59 AM
5	Retired from Army and CCC Public Health Communicable Disease	6/14/2017 8:45 AM
6	Had additional earthquake retrofitting to home. Strapped furniture to walls.	6/13/2017 7:24 PM
7	have tape and other things we need for the next Chevron Refinery fire or explosions	6/13/2017 6:12 PM
8	gun owner	6/13/2017 3:54 PM
9	Walkie talkies, crank radio	6/13/2017 1:48 PM
10	Ham Radio License	6/13/2017 1:01 PM
11	Purchased camping gear in case we have to bug out. Also purchased a generater and extra fuel, both for the generator and for our vehicle.	6/13/2017 12:51 AM
12	Pet and elderly neighbor plan as well. I am CERT trained through SF Fire department.	6/12/2017 7:35 PM
13	I work but do not live in CCC	6/12/2017 5:12 PM
14	how do I sign up to receive emergency alerts	6/12/2017 4:04 PM
15	our home has a fire sprinkler system	6/12/2017 3:35 PM
16	Im not prepared at all	6/10/2017 8:23 AM
17	Made conscious as to where I bought my house and mitigated gaps found	6/9/2017 10:23 PM
18	cert training	6/8/2017 6:54 PM
19	Ccccc	6/8/2017 4:12 PM
20	growing food	6/8/2017 1:10 PM
21	Home generator for back up power supply	6/8/2017 12:22 PM
22	Generator	6/8/2017 11:56 AM
23	focused on creating defensible space around property	6/8/2017 12:14 AM
24	CERT training	6/8/2017 12:10 AM
25	CERT trained	6/7/2017 10:43 PM
26	Generator	6/7/2017 10:17 PM

27	Pf2100@aol.vom	6/7/2017 9:47 PM
28	CERT Certified	6/4/2017 4:28 AM
29	Alarm/home protection/security	6/4/2017 1:41 AM
30	cert training	6/4/2017 12:57 AM
31	not much - I'll most likely get hit by a car in front of my house before I'm affected by a natural or non- hazard.	6/2/2017 3:27 PM
32	Volunteer	6/2/2017 2:47 PM

Q6 How prepared is your household to get along without electricity or natural gas for one to five days?

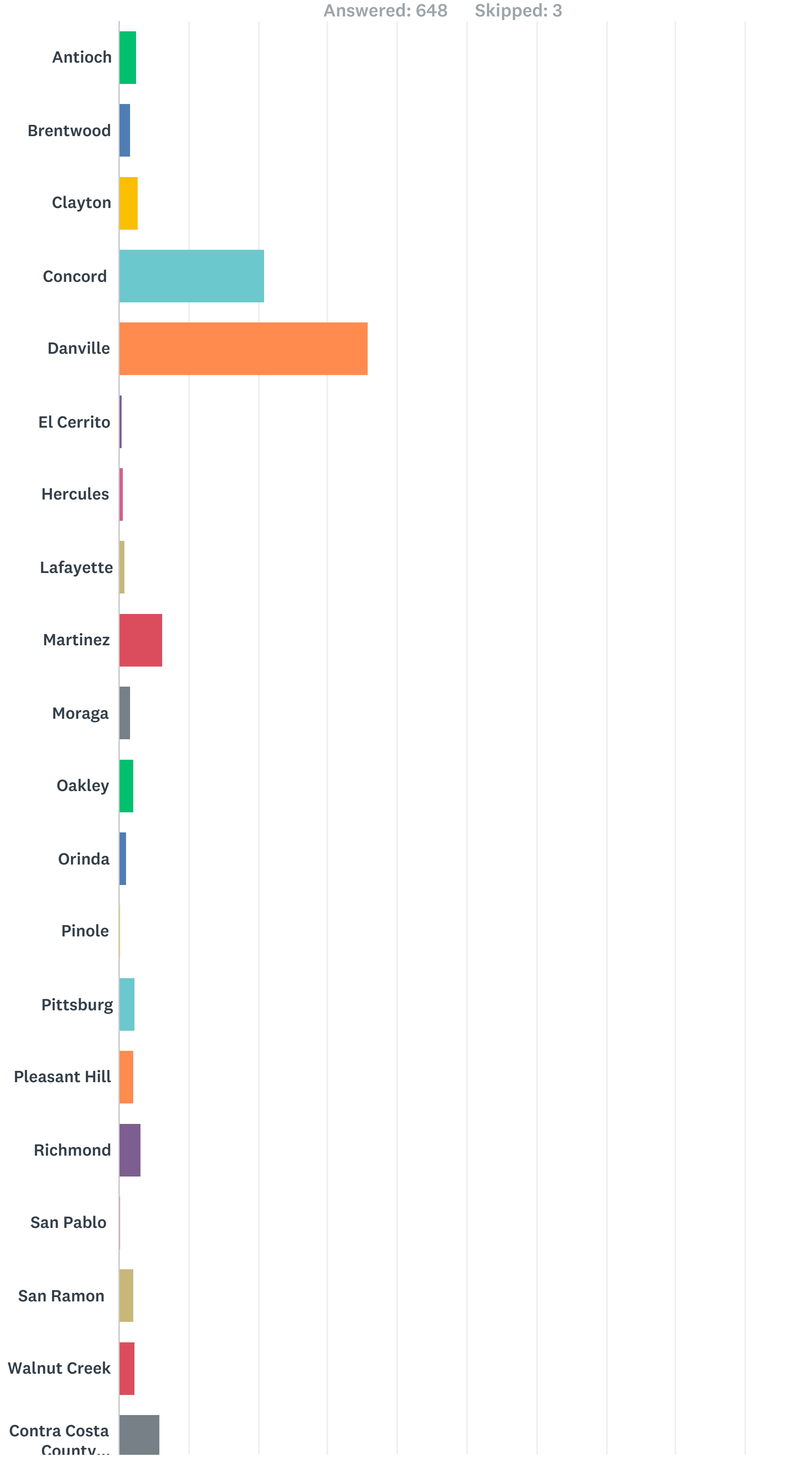
Answered: 645 Skipped: 6

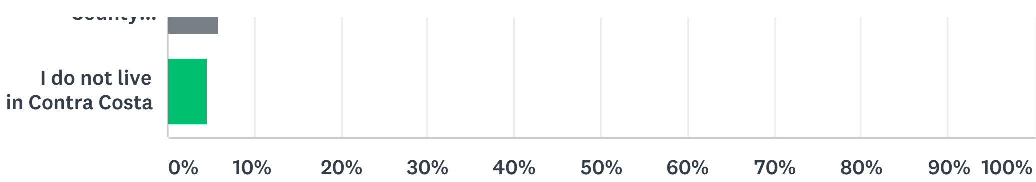


Answer Choices	Responses	
Not at all prepared	21.09%	136
Somewhat prepared	65.43%	422
Very prepared	13.49%	87
Total		645

Q7 Where do you live?

Answered: 648 Skipped: 3





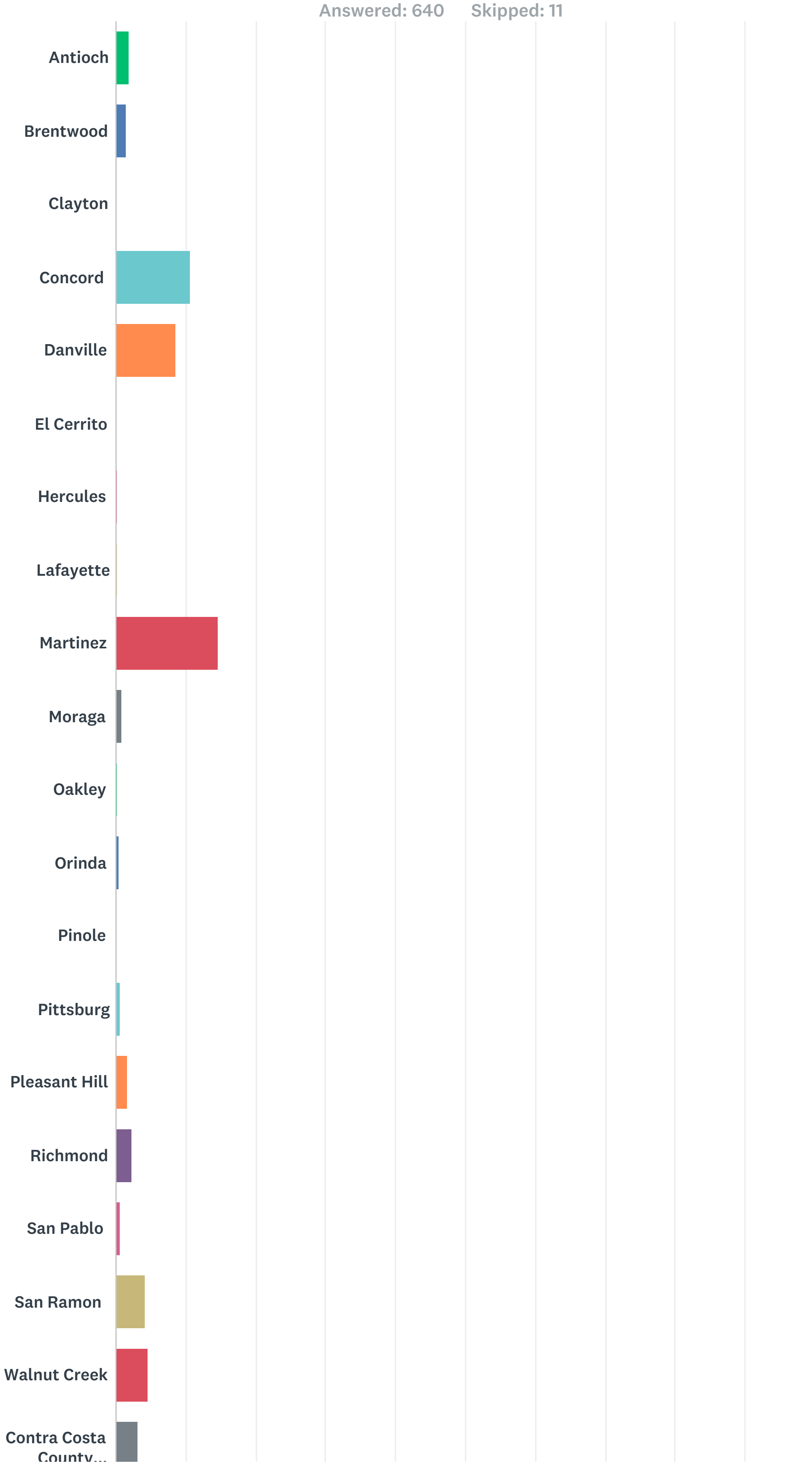
Answer Choices	Responses	
Antioch	2.47%	16
Brentwood	1.70%	11
Clayton	2.78%	18
Concord	20.83%	135
Danville	35.80%	232
El Cerrito	0.46%	3
Hercules	0.62%	4
Lafayette	0.93%	6
Martinez	6.17%	40
Moraga	1.70%	11
Oakley	2.16%	14
Orinda	1.08%	7
Pinole	0.31%	2
Pittsburg	2.31%	15
Pleasant Hill	2.16%	14
Richmond	3.24%	21
San Pablo	0.31%	2
San Ramon	2.16%	14
Walnut Creek	2.31%	15
Contra Costa County (Unincorporated)	5.86%	38
I do not live in Contra Costa	4.63%	30
Total		648

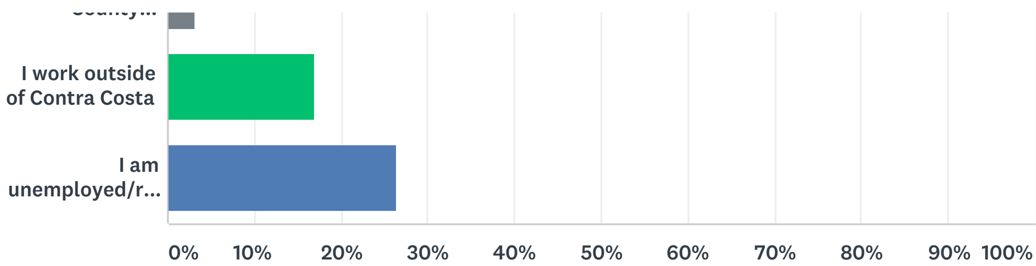
#	If you live in Unincorporated County, please provide the name of your community.	Date
1	I work in North Richmond	7/11/2017 3:20 PM
2	Crockett	7/7/2017 11:22 AM
3	Bay Point	6/29/2017 6:52 PM
4	Kensington	6/22/2017 12:39 AM
5	Canyon	6/14/2017 9:37 PM
6	Bay Point	6/14/2017 5:35 PM
7	Walnut Creek	6/13/2017 11:28 PM
8	Orinda	6/13/2017 9:31 PM

9	orinda???	6/13/2017 12:41 PM
10	Solano	6/12/2017 12:24 PM
11	Alhambra Valley area	6/12/2017 12:06 PM
12	El Sobrante	6/12/2017 11:04 AM
13	Lafayette	6/11/2017 11:56 AM
14	Kensington	6/9/2017 10:43 PM
15	Orinda which is incorporated and not listed	6/9/2017 9:53 PM
16	Mountain View	6/9/2017 4:04 PM
17	Disco Bay	6/9/2017 3:51 PM
18	Baypoint	6/9/2017 2:26 PM
19	Danville	6/9/2017 2:24 PM
20	Canyon	6/9/2017 2:22 PM
21	Rodeo, CA	6/9/2017 2:02 PM
22	Marsh Creek Area	6/9/2017 10:37 AM
23	Bay Point	6/8/2017 10:34 AM
24	Alamo	6/8/2017 2:38 AM
25	Walnut Creek	6/8/2017 1:36 AM
26	Bay Point	6/4/2017 6:42 PM
27	Tassajara	6/4/2017 6:17 PM
28	Bollinger Canyon, San Ramon unincorporated north end.	6/4/2017 1:42 AM
29	Rodeo	6/4/2017 1:00 AM
30	Crockett	6/3/2017 2:17 PM
31	Bay Point	6/3/2017 9:21 AM
32	Rodeo	6/2/2017 5:23 PM
33	Walnut Creek - Cherry Lane & Treat	6/2/2017 3:27 PM
34	Discovery Bay	6/2/2017 2:15 PM

Q8 Where do you work?

Answered: 640 Skipped: 11

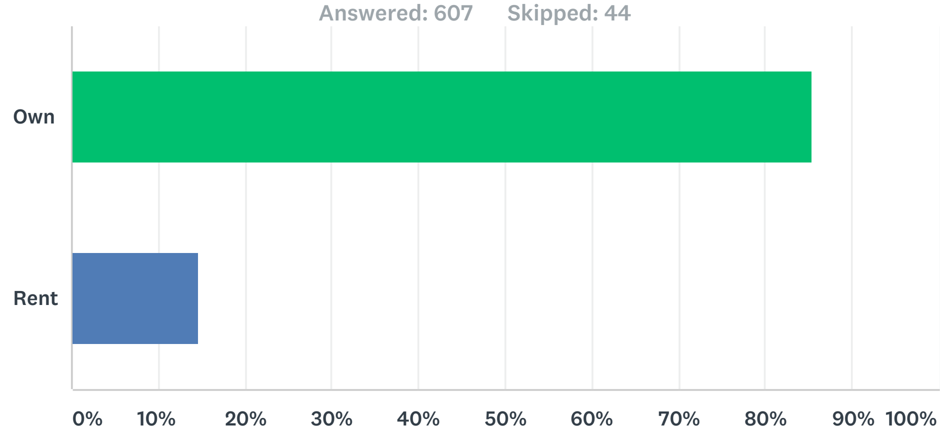




Answer Choices	Responses	
Antioch	1.88%	12
Brentwood	1.41%	9
Clayton	0.00%	0
Concord	10.63%	68
Danville	8.59%	55
El Cerrito	0.00%	0
Hercules	0.16%	1
Lafayette	0.16%	1
Martinez	14.69%	94
Moraga	0.94%	6
Oakley	0.31%	2
Orinda	0.47%	3
Pinole	0.00%	0
Pittsburg	0.63%	4
Pleasant Hill	1.72%	11
Richmond	2.34%	15
San Pablo	0.63%	4
San Ramon	4.22%	27
Walnut Creek	4.69%	30
Contra Costa County (Unincorporated)	3.13%	20
I work outside of Contra Costa	17.03%	109
I am unemployed/retired	26.41%	169
Total		640

Q9 Do you own or rent your place of residence?

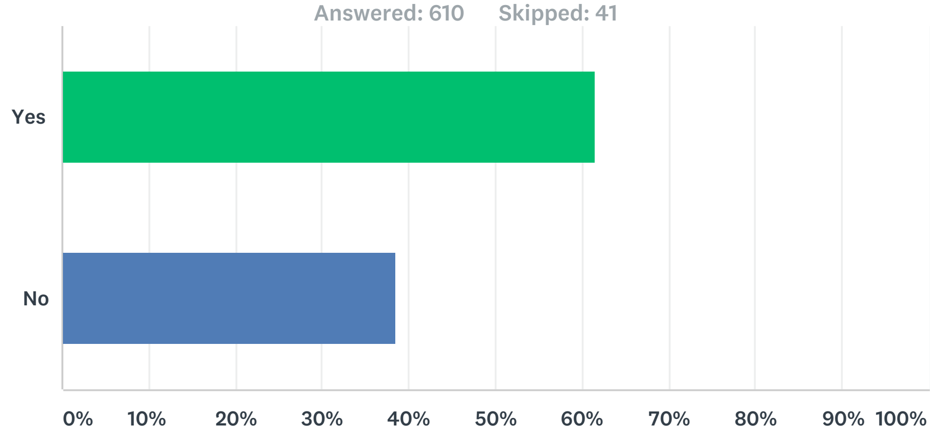
Answered: 607   Skipped: 44



Answer Choices	Responses	
Own	85.34%	518
Rent	14.66%	89
Total		607

Q10 When you moved into your home, did you consider the impact a disaster could have on your home?

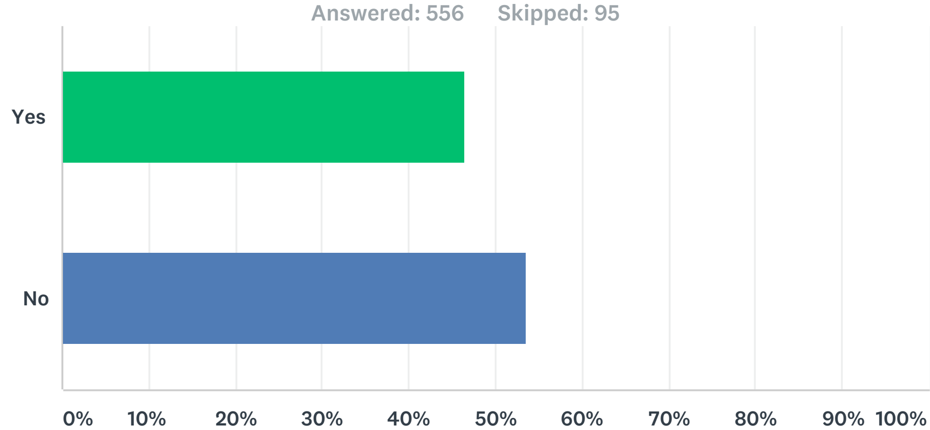
Answered: 610   Skipped: 41



Answer Choices	Responses	
Yes	61.48%	375
No	38.52%	235
Total		610

Q11 If you received real estate disclosure information when you moved into your current residence, did your real estate agent or landlord explain the implications of living in a hazard risk zone and did you understand the information presented?

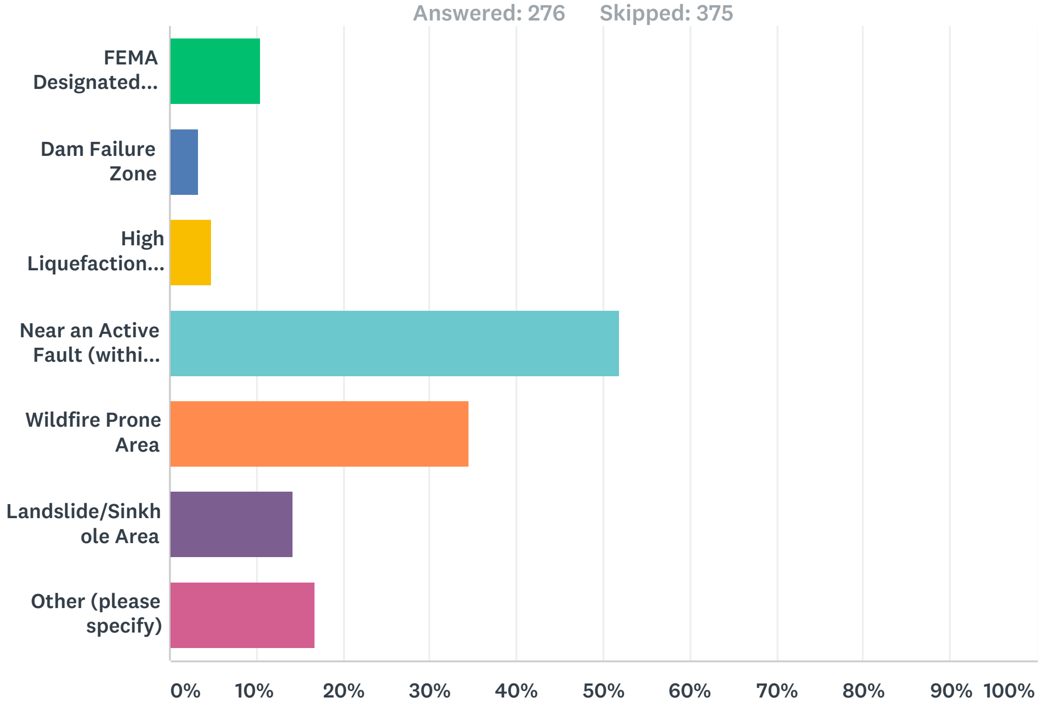
Answered: 556 Skipped: 95



Answer Choices	Responses	
Yes	46.40%	258
No	53.60%	298
Total		556

Q12 Is your home located in any of the following hazard areas (check all that apply):

Answered: 276 Skipped: 375



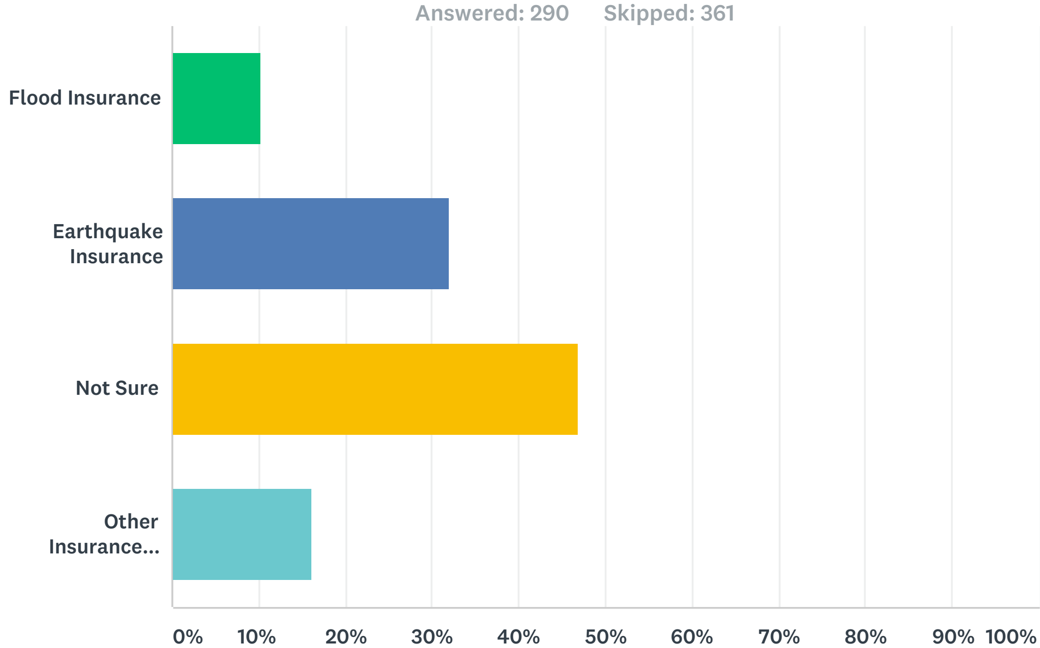
Answer Choices	Responses	
FEMA Designated Floodplain	10.51%	29
Dam Failure Zone	3.26%	9
High Liquefaction Zone	4.71%	13
Near an Active Fault (within 1 mile)	51.81%	143
Wildfire Prone Area	34.42%	95
Landslide/Sinkhole Area	14.13%	39
Other (please specify)	16.67%	46
Total Respondents: 276		

#	Other (please specify)	Date
1	CHEVRON	7/14/2017 2:18 PM
2	Nothing	7/8/2017 10:01 AM
3	gas line	7/1/2017 9:57 AM
4	On a hill with movement	6/27/2017 7:43 PM
5	No	6/27/2017 7:11 AM
6	none	6/23/2017 12:17 AM
7	we had the water pipes burst in the street from an earthquake	6/22/2017 12:22 AM
8	Refinery/Hazardous Materials	6/19/2017 11:09 AM
9	I don't think I am in any of those areas but don't really know	6/14/2017 3:39 PM

10	Tsunami zone	6/14/2017 1:20 PM
11	I recall a potential flood zone if Lafayette dam broke	6/13/2017 11:30 PM
12	Unsure how far we are from Concord fault. Not in floodplain, but we have had minor flooding from creek.	6/13/2017 7:26 PM
13	Chevron Refinery, 880, railyards and other regular polluters	6/13/2017 6:13 PM
14	Don't know	6/13/2017 1:50 PM
15	I don't recall	6/13/2017 8:13 AM
16	Do not know	6/13/2017 12:34 AM
17	I don't know	6/13/2017 12:11 AM
18	I don't know. CCMAP website was not working.	6/12/2017 8:46 PM
19	Alongside year-round flowing creek bed	6/12/2017 5:21 PM
20	I don't know, how can I find out	6/12/2017 4:06 PM
21	Gas storage station located directly behind our home.	6/12/2017 3:37 PM
22	creek, possible flood area	6/12/2017 2:47 PM
23	N/A	6/9/2017 10:25 PM
24	none	6/9/2017 2:22 PM
25	I do not belelive we are in a hazard area	6/9/2017 2:03 PM
26	unsure	6/9/2017 2:02 PM
27	Don't know if it is an active fault location, but a small earthquake was centered in my back yard last year.	6/8/2017 5:24 PM
28	None	6/8/2017 2:47 PM
29	100 year flood plain	6/8/2017 11:53 AM
30	not sure	6/8/2017 10:40 AM
31	None	6/8/2017 4:25 AM
32	on open space so wild fire consideration	6/8/2017 1:16 AM
33	Easement behind house and floods	6/7/2017 11:42 PM
34	Drought	6/7/2017 11:38 PM
35	20 years ago - don't remember	6/7/2017 10:59 PM
36	100 year flood zone	6/7/2017 10:49 PM
37	Earthquake	6/7/2017 10:16 PM
38	Near pipeline	6/7/2017 8:36 PM
39	N/A	6/7/2017 8:23 PM
40	Don't know	6/7/2017 7:13 PM
41	Don't know	6/4/2017 6:58 AM
42	Gas lines are in close enough proximity to affect us as in the explosion a few years ago.	6/4/2017 1:02 AM
43	by refineries	6/3/2017 2:18 PM
44	I don't know	6/3/2017 9:22 AM
45	Refinery	6/2/2017 5:25 PM
46	Buried gas line	6/2/2017 2:16 PM

Q13 Do you have hazard- specific insurance (check all that apply)?

Answered: 290 Skipped: 361



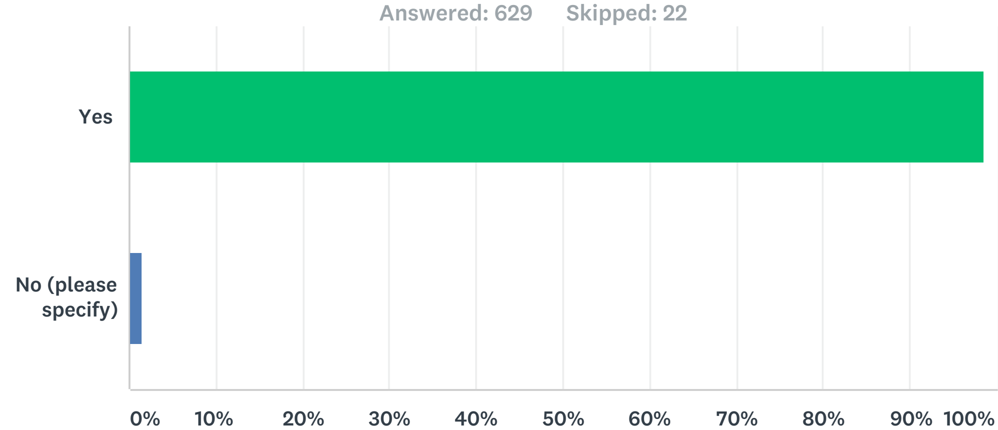
Answer Choices	Responses	
Flood Insurance	10.34%	30
Earthquake Insurance	32.07%	93
Not Sure	46.90%	136
Other Insurance (please specify)	16.21%	47
Total Respondents: 290		

#	Other Insurance (please specify)	Date
1	Nothing	7/8/2017 10:01 AM
2	none	6/23/2017 12:17 AM
3	fire	6/19/2017 11:09 AM
4	Fire, Upgraded Home	6/17/2017 7:31 PM
5	umbrella coverage	6/17/2017 2:20 AM
6	rentors insurance	6/16/2017 4:32 PM
7	umbrella policy	6/15/2017 8:12 PM
8	General home insurance	6/14/2017 9:45 PM
9	Umbrella	6/14/2017 5:44 PM
10	No hazard-specific insurance	6/14/2017 3:39 PM
11	We do not have hazard insurance	6/14/2017 2:53 PM
12	Normal property damage insurance.	6/14/2017 2:30 PM
13	HOME INSURANCE	6/14/2017 12:56 PM
14	No. Earthquake insurance is too expensive.	6/13/2017 6:13 PM

15	Fire	6/13/2017 1:50 PM
16	Homeowners special form	6/13/2017 12:42 PM
17	normal homeowner fire insurance	6/13/2017 12:03 PM
18	AAA regular home policy	6/13/2017 7:55 AM
19	I live in a condominium and I am not sure, but I think we have flood and earthquake insurance.	6/12/2017 8:46 PM
20	Homw	6/12/2017 6:33 PM
21	basic home insurance	6/12/2017 4:06 PM
22	Renters Insurance	6/12/2017 1:58 PM
23	Renter	6/12/2017 12:11 PM
24	no	6/12/2017 12:07 PM
25	Homeowners only	6/9/2017 10:25 PM
26	Fire	6/9/2017 8:12 PM
27	just home owners insurance	6/9/2017 2:48 PM
28	no	6/9/2017 2:22 PM
29	renter's	6/9/2017 2:18 PM
30	Umbrella policy	6/9/2017 1:52 PM
31	Fire insurance	6/8/2017 7:06 PM
32	Standard homeowner's	6/8/2017 5:24 PM
33	home owners	6/8/2017 3:43 PM
34	None	6/8/2017 2:47 PM
35	Too expensive!!! Else I would have earthquake and flood insurance	6/8/2017 11:53 AM
36	General hazard insurance only	6/8/2017 10:47 AM
37	No	6/8/2017 4:25 AM
38	None	6/8/2017 1:37 AM
39	No	6/7/2017 11:23 PM
40	Standard	6/7/2017 8:23 PM
41	REGULAR HOMEOWNERS	6/7/2017 8:14 PM
42	Umbrella policy	6/7/2017 7:44 PM
43	Fire	6/7/2017 7:32 PM
44	Umbrella policy	6/7/2017 7:10 PM
45	None	6/7/2017 7:04 PM
46	Umbrella policy	6/5/2017 7:07 PM
47	renters insurance	6/3/2017 2:18 PM

Q14 Is English the primary language spoken in your home?

Answered: 629 Skipped: 22

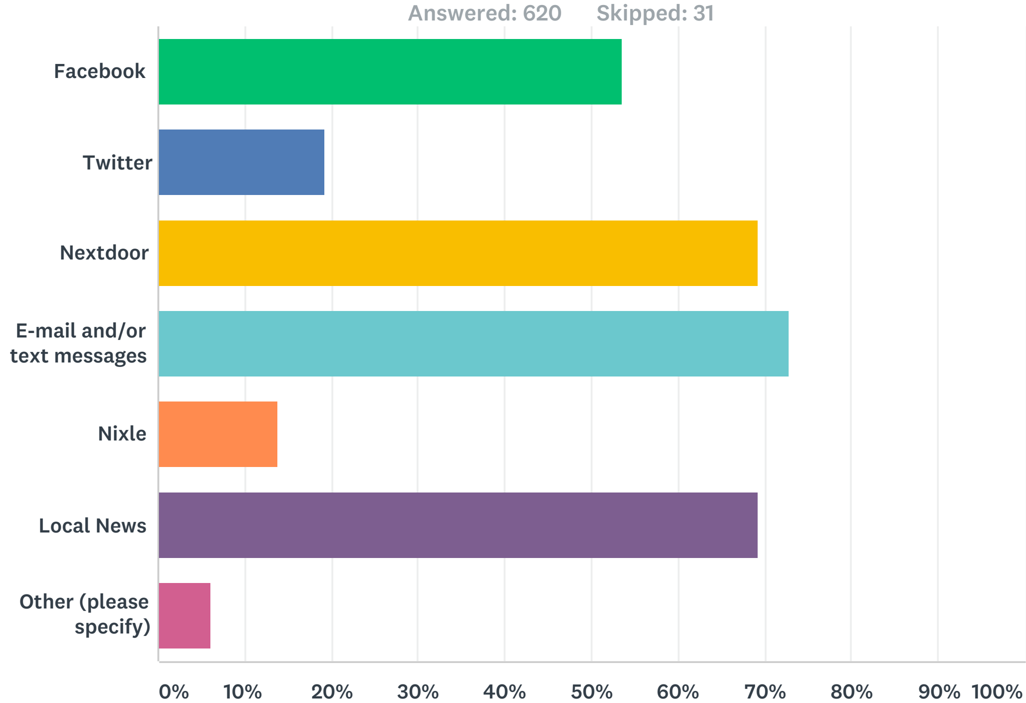


Answer Choices	Responses	
Yes	98.57%	620
No (please specify)	1.43%	9
Total		629

#	No (please specify)	Date
1	Cantonese	7/20/2017 11:49 AM
2	Basic	6/16/2017 3:48 PM
3	spanish	6/14/2017 1:27 PM
4	Cantonese	6/14/2017 12:37 PM
5	Spanish	6/13/2017 12:03 AM
6	polish	6/12/2017 10:19 PM
7	Spanish/English	6/9/2017 2:03 PM
8	Spanish	6/7/2017 9:06 PM
9	Chinese	6/7/2017 7:38 PM

Q15 Which of the following digital media outlets do you use and/or subscribe to receive news and information about Contra Costa?Select all that apply.

Answered: 620 Skipped: 31



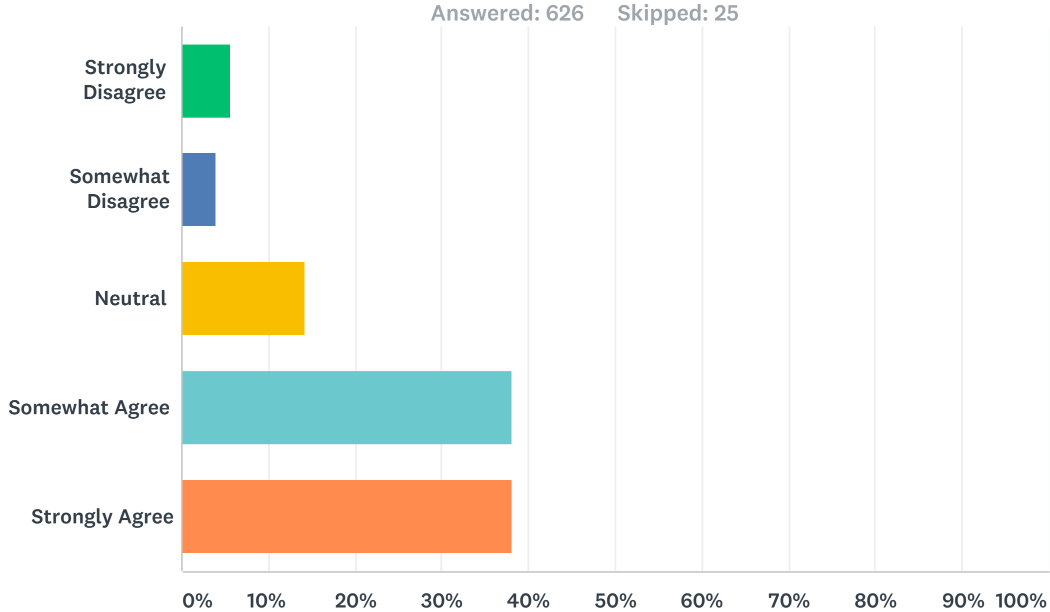
Answer Choices	Responses	
Facebook	53.55%	332
Twitter	19.19%	119
Nextdoor	69.19%	429
E-mail and/or text messages	72.74%	451
Nixle	13.87%	86
Local News	69.19%	429
Other (please specify)	6.13%	38
Total Respondents: 620		

#	Other (please specify)	Date
1	New York Times; East Bay Times	7/7/2017 5:59 PM
2	24/680 news	6/27/2017 7:59 PM
3	eastcountytoday.net	6/26/2017 4:50 PM
4	National news feeds (Flipboard et al)	6/20/2017 5:59 PM
5	City's weekly newsletter	6/20/2017 1:56 PM
6	am radio	6/18/2017 7:08 PM
7	Online Regional Google News	6/17/2017 7:54 PM
8	claycord.com	6/17/2017 3:52 PM

9	News 24-680	6/14/2017 9:38 PM
10	None	6/14/2017 3:40 PM
11	Patch	6/14/2017 2:31 PM
12	I work for the County Public Works	6/14/2017 1:23 PM
13	claycord.com	6/14/2017 12:38 PM
14	radio	6/14/2017 12:37 PM
15	Concord Patch, Red Cross Earthquake Notifications, above 2.5	6/14/2017 8:49 AM
16	Tv, newspaper	6/13/2017 12:48 PM
17	Claycord.com and eastbaytimes.net	6/13/2017 12:24 PM
18	East Bay Times (newspaper)	6/13/2017 8:14 AM
19	claycord.com	6/13/2017 8:01 AM
20	Drudge/breitbart	6/13/2017 1:12 AM
21	E-edition East Bay Times newspaper	6/13/2017 12:57 AM
22	NYTimes.com	6/12/2017 10:23 PM
23	Cable news	6/12/2017 5:30 PM
24	All not checked are not allowed in the workplace	6/12/2017 4:56 PM
25	reddinet	6/9/2017 4:35 PM
26	AtHoc	6/9/2017 3:00 PM
27	community warning system	6/8/2017 2:55 PM
28	East Bay Times	6/8/2017 2:48 PM
29	Internet	6/8/2017 11:59 AM
30	EAS	6/8/2017 11:52 AM
31	News websites - sfgate.com , etc.	6/8/2017 8:57 AM
32	None	6/7/2017 10:18 PM
33	Newspapers, local paper	6/7/2017 8:53 PM
34	Newspaper	6/7/2017 8:06 PM
35	Text	6/7/2017 7:41 PM
36	Newspaper	6/7/2017 7:26 PM
37	Reading a newspaper	6/2/2017 5:32 PM
38	CoCoAlert	6/2/2017 2:50 PM

Q16 Please indicate how you feel about the following statement:It is the responsibility of government (local, state and federal) to provide education and programs that promote citizen actions that will reduce exposure to the risks associated with natural hazards.

Answered: 626 Skipped: 25



Answer Choices	Responses	
Strongly Disagree	5.75%	36
Somewhat Disagree	3.99%	25
Neutral	14.22%	89
Somewhat Agree	38.02%	238
Strongly Agree	38.02%	238
Total		626

Contra Costa County Hazard Mitigation Plan

Appendix B. Risk Assessment Mapping Methodology

B. RISK ASSESSMENT MAPPING METHODOLOGY

DAM INUNDATION MAPPING

The dam inundation areas data are provided by the Contra Costa County Department of Conservation and Development. These data originate from the California Office of Emergency Services. The inundation areas for the various dams were created from different source documents with varying map scales and dates. The spatial accuracy of the boundaries is undetermined and has a large degree of variation between individual dams.

EARTHQUAKE MAPPING

Liquefaction Susceptibility

Liquefaction susceptibility data are provided by the Association of Bay Area Governments and originate from the U.S. Geological Survey as Open-File Report 2006-1037. The report presents a map and database of Quaternary deposits and liquefaction susceptibility for the urban core of the San Francisco Bay region. Much of the land adjacent to the Bay and the major rivers and streams is underlain by unconsolidated deposits that are particularly vulnerable to earthquake shaking and liquefaction of water-saturated granular sediment. The mapping uses geomorphic expression, pedogenic soils, inferred depositional environments, and geologic age to define and distinguish the map units. The report is the product of cooperative work by the National Earthquake Hazards Reduction Program and National Cooperative Geologic Mapping Program of the U.S. Geological Survey, William Lettis and & Associates, Inc., and the California Geological Survey. (USGS, 2006)

National Earthquake Hazard Reduction Program Soils

Soil classification data provided by the California Department of Conservation. The data is based on surficial geology published at a scale of 1:250,000. The surficial geologic units were grouped into composite units with similar average shear wave velocity to 30 meters depth (Vs30) values. This data was prepared as part of the Probabilistic Seismic Hazard Map of California (Petersen et. al., 1999)

Susceptibility to Deep-Seated Landslides

Landslide susceptibility data provided by the California Geological Survey.

The map, and associated data, show the relative likelihood of deep-seated landsliding based on regional estimates of rock strength and steepness of slopes. On the most basic level, weak rocks and steep slopes are most likely to generate landslides. The map uses detailed information on the location of past landslides, the location and relative strength of rock units, and steepness of slope to estimate susceptibility to deep-seated landsliding (0 to X, low to high). The USGS 2009 National Elevation Dataset (NED) with 10-m grid size was used as the base map. This landslide susceptibility map is intended to provide infrastructure owners, emergency planners and the public with a general overview of where landslides are more likely to occur. (Wills, et. al., 2011)

Shake Maps

A shake map is designed as a rapid response tool to portray the extent and variation of ground shaking throughout the affected region immediately following significant earthquakes. Ground motion and intensity maps are derived from peak ground motion amplitudes recorded on seismic sensors (accelerometers), with interpolation based on both estimated amplitudes where data are lacking, and site amplification corrections. Color-coded instrumental intensity maps are derived from empirical relations between peak ground motions and Modified Mercalli intensity. For this plan, shake maps were prepared for five earthquake scenarios:

- An earthquake on the Calaveras (North Central) fault with the following characteristics:
  - Magnitude: 7.0
  - Epicenter: N37.76 W121.97
- An earthquake on the Concord-Green Valley fault with the following characteristics:
  - Magnitude: 6.8
  - Epicenter: N38.31 W122..16
- An earthquake on the Greenville fault with the following characteristics:
  - Magnitude: 7.0
  - Epicenter: N37.51 W121.55
- An earthquake on the Hayward fault with the following characteristics:
  - Magnitude: 7.05
  - Epicenter: N37.81 W122.18
- An earthquake on the Mount Diablo fault with the following characteristics:
  - Magnitude: 6.7
  - Epicenter: N37.82 W121.81

FLOOD MAPPING

Flood hazard areas are mapped as depicted on the effective FEMA Digital Flood Insurance Rate Maps dated September 30, 2015 with last Letter of Map Revision incorporated January 21, 2016. Repetitive flood loss data was provided by FEMA as of March 31, 2017. Property addresses were geocoded and then mapped.

LANDSLIDE MAPPING

See Susceptibility to Deep-Seated Landslides data description under earthquake mapping.

SEA LEVEL RISE MAPPING

Adapting to Rising Tides sea level rise data provided by the San Francisco Bay Conservation and Development Commission. The Contra Costa County Adapting to Rising Tides Program, led by the San Francisco Bay Conservation and Development Commission, provides support, guidance, tools, and information to help agencies and organizations understand, communicate, and begin to address complex climate change issues. The program helps to identify and assess the community assets and natural resources that are most at risk to climate impacts, in particular, sea level rise and storm surge. This data is a broad assessment of Contra Costa County’s shoreline exposure to flooding or inundation from sea level rise scenarios of 0 to 66 inches and extreme tide events from the 1-year to the 500-year extreme tide event. Shoreline exposure to oceanic climate change stressors (e.g., sea level rise and storm surge) can be characterized by the magnitude and frequency of inundation. The data sets and the information provided in the accompanying report can inform design and operational strategies, assist in managing climate-change-related risks, and help identify trigger points for implementing adaptation strategies to increase the likelihood that a consistent level of flood protection can be provided over the coming decades and into the next century. (San Francisco Bay Development Commission, 2016)

TSUNAMI INUNDATION MAPPING

Tsunami inundation areas data provided by the California Governor's Office of Emergency Services. Data was published in 2009.

Initial tsunami modeling was performed by the University of Southern California Tsunami Research Center funded through the California Emergency Management Agency by the National Tsunami Hazard Mitigation Program. The tsunami modeling process utilized the MOST (Method of Splitting Tsunamis) computational program (Version 0), which allows for wave evolution over a variable bathymetry and topography used for the inundation mapping (Titov and Gonzalez, 1997; Titov and Synolakis, 1998). The bathymetric/topographic data that were used in the tsunami models consist of a series of nested grids. Near-shore grids with a 3 arc-second (75- to 90-meters) resolution or higher, were adjusted to "Mean High Water" sea-level conditions, representing a conservative sea level for the intended use of the tsunami modeling and mapping. A suite of tsunami source events was selected for modeling, representing realistic local and distant earthquakes and hypothetical extreme undersea, near-shore landslides. Local tsunami sources that were considered include offshore reverse-thrust faults, restraining bends on strike-slip fault zones and large submarine landslides capable of significant seafloor displacement and tsunami generation. Distant tsunami sources that were considered include great subduction zone events that are known to have occurred historically (1960 Chile and 1964 Alaska earthquakes) and others which can occur around the Pacific Ocean "Ring of Fire." In order to enhance the result from the 75- to 90-meter inundation grid data, a method was developed utilizing higher-resolution digital topographic data (3- to 10-meters resolution) that better defines the location of the maximum inundation line (U.S. Geological Survey, 1993; Intermap, 2003; NOAA, 2004). The location of the enhanced inundation line was determined by using digital imagery and terrain data on a GIS platform with consideration given to historic inundation information (Lander, et al., 1993). This information was verified, where possible, by field work coordinated with local county personnel. The accuracy of the inundation line shown on these maps is subject to limitations in the accuracy and completeness of available terrain and tsunami source information, and the current understanding of tsunami generation and propagation phenomena as expressed in the models. Thus, although an attempt has been made to identify a credible upper bound to inundation at any location along the coastline, it remains possible that actual inundation could be greater in a major tsunami event. This map does not represent inundation from a single scenario event. It was created by combining inundation results for an ensemble of source events affecting a given region. For this reason, all of the inundation region in a particular area will not likely be inundated during a single tsunami event. (State of California, 2009)

WILDFIRE MAPPING

Fire Hazard Severity Zones in State Responsibility Areas data were provided by the California Department of Forestry and Fire Protection. Public Resources Code 4201-4204 direct the CAL FIRE to map fire hazard within State Responsibility Areas, based on relevant factors such as fuels, terrain, and weather. These statutes were passed after significant wildland-urban interface fires; consequently these hazards are described according to their potential for causing ignitions to buildings. These zones referred to as Fire Hazard Severity Zones (FHSZ), provide the basis for application of various mitigation strategies to reduce risks to buildings associated with wildland fires. The zones also relate to the requirements for building codes designed to reduce the ignition potential to buildings in the wildland-urban interface zones. These maps have been created by CAL FIRE's Fire and Resource Assessment Program (FRAP) using data and models describing development patterns, estimated fire behavior characteristics based on potential fuels over a 30-50 year time horizon, and expected burn probabilities to quantify the likelihood and nature of vegetation fire exposure to new construction. The zones were adopted by CAL FIRE on November 7, 2007.

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Contra Costa County Hazard Mitigation Plan

Appendix C. Plan Adoption Resolutions from Planning Partners

C. Plan Adoption Resolutions from Planning Partners

Contra Costa County Hazard Mitigation Plan

Appendix D. Progress Report Template

D. PROGRESS REPORT TEMPLATE

Reporting Period: *(Insert reporting period)*

Background: Contra Costa County and participating local cities and special districts developed a hazard mitigation plan to reduce risk from all hazards by identifying resources, information, and strategies for risk reduction. The federal Disaster Mitigation Act of 2000 requires state and local governments to develop hazard mitigation plans as a condition for federal disaster grant assistance. To prepare the plan, the participating planning partners organized resources, assessed risks from natural hazards, developed planning goals and objectives, reviewed mitigation alternatives, and developed an action plan to address probable impacts from natural hazards. By completing this process, these jurisdictions maintained compliance with the Disaster Mitigation Act, achieving eligibility for mitigation grant funding opportunities afforded under the Robert T. Stafford Act. The plan can be viewed on-line at:

INSERT LINK

Summary Overview of the Plan's Progress: The performance period for the Hazard Mitigation Plan became effective on ____, 2017, with the final approval of the plan by FEMA. The initial performance period for this plan will be 5 years, with an anticipated update to the plan to occur before ______, 2022. As of this reporting period, the performance period for this plan is considered to be __% complete. The Hazard Mitigation Plan has targeted __ hazard mitigation actions to be pursued during the 5-year performance period. As of the reporting period, the following overall progress can be reported:

- __ out of __ actions (__%) reported ongoing action toward completion.
- __ out of __ actions (__%) were reported as being complete.
- __ out of __ actions (___%) reported no action taken.

Purpose: The purpose of this report is to provide an annual update on the implementation of the action plan identified in the Hazard Mitigation Plan. The objective is to ensure that there is a continuing and responsive planning process that will keep the Hazard Mitigation Plan dynamic and responsive to the needs and capabilities of the planning partners. This report discusses the following:

- Natural hazard events that have occurred within the last year
- Changes in risk exposure within the planning area
- Mitigation success stories
- Review of the action plan
- Changes in capabilities that could impact plan implementation
- Recommendations for changes/enhancement.

The Hazard Mitigation Plan Steering Committee: The Hazard Mitigation Plan Steering Committee, made up of planning partners and other stakeholders within the planning area, reviewed and approved this progress report at its annual meeting held on _____, 2018. It was determined through the plan's development process that a steering committee would remain in service to oversee maintenance of the plan. At a minimum, the Steering Committee will provide technical review and oversight on the development of the annual progress report.

It is anticipated that there will be turnover in the membership annually, which will be documented in the progress reports. For this reporting period, the Steering Committee membership is as indicated in Table 1.

Table 1. Steering Committee Members

Name	Title	Jurisdiction/Agency

Natural Hazard Events within the Planning Area: During the reporting period, there were __ natural hazard events in the planning area that had a measurable impact on people or property. A summary of these events is as follows:

- ______________________________
- ______________________________

Changes in Risk Exposure in the Planning Area: *(Insert brief overview of any natural hazard event in the planning area that changed the probability of occurrence or ranking of risk for the hazards addressed in the hazard mitigation plan)*

Mitigation Success Stories: *(Insert brief overview of mitigation accomplishments during the reporting period)*

Review of the Action Plan: Table 2 reviews the action plan, reporting the status of each action. Reviewers of this report should refer to the Hazard Mitigation Plan for more detailed descriptions of each action and the prioritization process.

Address the following in the "status" column of the following table:

- Was any element of the action carried out during the reporting period?
- If no action was completed, why?
- Is the timeline for implementation for the action still appropriate?
- If the action was completed, does it need to be changed or removed from the action plan?

Table 2. Action Plan Matrix

Action Taken? (Yes or No)	Time Line	Priority	Status	Status (X, O,✓)
Action #__—____________________[description]				
Action #__—____________________[description]				
Action #__—____________________[description]				
Action #__—____________________[description]				
Action #__—____________________[description]				
Action #__—____________________[description]				
Action #__—____________________[description]				
Action #__—____________________[description]				
Action #__—____________________[description]				
Action #__—____________________[description]				
Action #__—____________________[description]				
Action #__—____________________[description]				
Action #__—____________________[description]				
Action #__—____________________[description]				
Action #__—____________________[description]				
Action #__—____________________[description]				
Action #__—____________________[description]				
Action #__—____________________[description]				
Action #__—____________________[description]				

Completion status legend:
✓= Project Completed
O = Action ongoing toward completion
X = No progress at this time

Changes That May Impact Implementation of the Plan: *(Insert brief overview of any significant changes in the planning area that would have a profound impact on the implementation of the plan. Specify any changes in technical, regulatory and financial capabilities identified during the plan's development)*

Recommendations for Changes or Enhancements: Based on the review of this report by the Hazard Mitigation Plan Steering Committee, the following recommendations will be noted for future updates or revisions to the plan:

- ________________________________
- ________________________________
- ________________________________
- ________________________________
- ________________________________
- ________________________________

Public review notice: *The contents of this report are considered to be public knowledge and have been prepared for total public disclosure. Copies of the report have been provided to the governing boards of all planning partners and to local media outlets. The report is posted on the Contra Costa County Hazard Mitigation Plan website. Any questions or comments regarding the contents of this report should be directed to:*

Insert Contact Info Here

19. CONTRA COSTA COUNTY FIRE PROTECTION DISTRICT

19.1 HAZARD MITIGATION PLAN POINT OF CONTACT

Primary Point of Contact
Robert Marshall
Fire Marshal
2010 Geary Rd
Pleasant Hill, CA 94523
Telephone: 925-941-3300
e-mail Address: rmars@cccfpd.org

Alternate Point of Contact
Lewis Broschard
Deputy Fire Chief
2010 Geary Rd
Pleasant Hill, CA 94523
Telephone: 925-941-3300
e-mail Address: lbros@cccfpd.org

19.2 JURISDICTION PROFILE

19.2.1 Overview

Contra Costa County Fire Protection District (CCCFPD) provides fire prevention, suppression, and emergency medical response for advanced and basic life support to nine cities and much of the unincorporated area in the central and western portions of Contra Costa County. CCCFPD was formed on December 29, 1964 as a county-dependent district governed by the Contra Costa County Board of Supervisors. The principal act that governs the District is the Fire Protection District Law of 1987 (California). Since its inception, CCCFPD has consolidated with several other fire districts with the most recent significant consolidation occurring in 1994. There were some subsequent detachments of portions of CCCFPD between 1997 and 2001, but since 2001 CCCFPD's service area has remained the same.

The District currently serves a population of approximately 600,000 covering a land area of approximately 300 square miles. The Fire District boundaries encompass the western, central and northern portions of Contra Costa County, extending from the City of Antioch in the east to the eastern boundary of the City of Richmond in the west, and as far south as the northern boundary of the City of Moraga and the City of Danville.

As of 2016, the fire district experienced a 14 percent increase in call volume since 2010, and this trend is expected to continue. Approximately 66 percent of the calls are for Emergency Medical Services (EMS). According to the Association of Bay Area Governments (ABAG) the projected growth rate from 2008 to 2030 is 16 percent. The largest area (approximately 5,000 acres) of future growth will be in the central portion of the county that was once part of the Concord Naval Weapons Station (CNWS). The planned development of the CNWS site will result in a significant increase in population density that will require an expansion of fire and emergency medical service resources to accommodate the increase in call volume. Other planned developments in the eastern portion of the fire district will necessitate additional fire and emergency medical resources to handle population growth, as well as mitigate emergency response times.

The District participates in the Public Protection Class Rating System and currently has a rating of 3 in the urbanized areas, and an 8 in the more rural portions of the district.

The Fire District Board of Directors assumes responsibility for the adoption of this plan; Deputy Fire Chief will oversee its implementation.

19.2.2 Assets

Table 19-1 summarizes the critical assets of the district and their value.

Table 19-1. Special Purpose District Assets

Asset	Value
Property	
Vacant Land- 48 acres	$6,500,000
Critical Infrastructure and Equipment	
Fire Apparatus	$43,936,592
Response Equipment	$8,594,400
Total:	$52,530,992
Critical Facilities	
Fire Stations	$44,127,655
Dispatch Center	$2,288,667
Administration offices	$3,261,553
Total:	$49,677,875

19.3 CAPABILITY ASSESSMENT

19.3.1 Planning and Regulatory Capabilities

Jurisdictions develop plans and programs and implement rules and regulations to protect and serve residents. When effectively prepared and administered, these plans, programs and regulations can support the implementation of mitigation actions. The following existing codes, ordinances, policies, programs or plans are applicable to this hazard mitigation plan:

- **California and US Environmental Protection Agencies—**Develops regulations relative to pollution, and hazardous waste
- **California Code of Regulations—**Contains the regulations giving authority for the enforcement of State Fire Marshal (SFM) Regulations to the Fire District. The District enforces regulations from Title 19, division 1, and all parts of Title 24 as adopted by the SFM.
- **California Environmental Quality Act (CEQA)**—The District participates in the CEQA process as a reviewer of all development projects
- **California Building Code, Chapter 7a**—The regulation governing the building of structures in the Wildland-Urban Interface. Adopted as part of the State adoption of Title 24 CCR by the SFM and the California Building Standards Commission
- **Contra Costa County Ordinance 2016-23 (adopting of Fire Code)**—Adopted in October 2016 for the enforcement starting January 1, 2017.

19.3.2 Fiscal, Administrative and Technical Capabilities

Fiscal capability is an indicator of a jurisdiction's ability to fulfill the financial needs associated with hazard mitigation projects. An assessment of fiscal capabilities is presented in Table 19-2. Administrative and technical capabilities represent a jurisdiction's staffing resources for carrying out the mitigation strategy. An assessment of administrative and technical capabilities is presented in Table 19-3.

Table 19-2. Fiscal Capability

Financial Resource	Accessible or Eligible to Use?
Capital Improvements Project Funding	Yes
Authority to Levy Taxes for Specific Purposes	Yes
User Fees for Water, Sewer, Gas or Electric Service	No
Incur Debt through General Obligation Bonds	Yes
Incur Debt through Special Tax Bonds	No
Incur Debt through Private Activity Bonds	No
State-Sponsored Grant Programs	Yes
Development Impact Fees for Homebuyers or Developers	Yes
Federal Grant Programs	Yes
Other	Yes (Community Facilities Districts, Mitigation Fees)

Table 19-3. Administrative and Technical Capability

Staff/Personnel Resource	Available?	Department/Agency/Position
Planners or engineers with knowledge of land development and land management practices	Yes	Fire Prevention, Engineering Division
Engineers or professionals trained in building or infrastructure construction practices	Yes	Fire Prevention, Engineering Division
Planners or engineers with an understanding of natural hazards	Yes	Fire Prevention, Engineering and Code Enforcement Divisions
Staff with training in benefit/cost analysis	Yes	Fire Administration
Surveyors	No	
Personnel skilled or trained in GIS applications	Yes	IT
Scientist familiar with natural hazards in local area	No	
Emergency manager	Yes	Fire Operations
Grant writers	Yes	Fire Operations
Other	No	

19.3.3 Education and Outreach Capabilities

Outreach and education capability identifies the connection between government and community members, which opens a dialogue needed for a more resilient community. An assessment of education and outreach capabilities is presented in Table 19-4.

Table 19-4. Education and Outreach

Criterion	Response
Do you have a Public Information Officer or Communications Office?	Yes
Do you have personnel skilled or trained in website development?	Yes
Do you have hazard mitigation information available on your website? • If yes, please briefly describe	Yes Wildfire Mitigation, Fire Prevention
Do you utilize social media for hazard mitigation education and outreach? • If yes, please briefly describe	Yes Posting information about risk reduction to several social media platforms
Do you have any citizen boards or commissions that address issues related to hazard mitigation? • If yes, please briefly specify	No N/A
Do you have any other programs already in place that could be used to communicate hazard-related information? • If yes, please briefly describe	Yes CCCFPD participates in the Diablo Fire Safe Council planning and outreach efforts primarily in the central and western portions of the fire district.
Do you have any established warning systems for hazard events? • If yes, please briefly describe	Yes Contra Costa County Community Warning System, Social Media, and Website

19.3.4 Adaptive Capacity for Climate Change

Given the uncertainties associated with how hazard risk may change with a changing climate, a jurisdiction's ability to track such changes and adapt as needed is an important component of the mitigation strategy. Table 19-5 summarizes the District's adaptive capacity for climate change.

19.4 INTEGRATION WITH OTHER PLANNING INITIATIVES

The information on hazards, risk, vulnerability and mitigation contained in this hazard mitigation plan is based on the best available data. Plan integration is the incorporation of this information into other relevant planning mechanisms, such as general planning and capital facilities planning. It includes the integration of natural hazard information and mitigation policies, principles and actions into local planning mechanisms and vice versa. Additionally, plan integration is achieved though the involvement of key staff and community officials in collaboratively planning for hazard mitigation.

19.4.1 Existing Integration

In the performance period since adoption of the previous hazard mitigation plan, the District made progress on integrating hazard mitigation goals, objectives and actions into other planning initiatives. The following plans and programs currently integrate components of the hazard mitigation strategy:

- **California Building Code, Chapter 7a**—Standards intended to prevent ignition of structures from wildland fire exposure. These building standards relate to roof assemblies and materials, windows, siding, decks and eave vents all of which are prone to ignition from burning embers.
- **Contra Costa County Ordinance 2016-23**—Under Chapter 3 (General Precautions Against Fires), it provides for landscaping/vegetation management requirements to reduce and/or prevent the spread of wildland fires.
- **CCCFPD Capital Improvement Plan**—Provides the plan for improvement and construction of stations and other district facilities.

Resources listed in Section 19.10 were used to provide information on hazards and the jurisdiction's capabilities.

Table 19-5. Adaptive Capacity for Climate Change

Criterion	Jurisdiction Rating[a]
Technical Capacity	
Jurisdiction-level understanding of potential climate change impacts	High
Comments/Additional Information: Specifically related to drought impacts, and resulting wildfire hazards	
Jurisdiction-level monitoring of climate change impacts	Medium
Comments/Additional Information: By utilization of National, State and Local resources for drought and wildfire hazards	
Technical resources to assess proposed strategies for feasibility and externalities	High
Comments/Additional Information: Wildfire Prevention is a well-established program within the district	
Jurisdiction-level capacity for development of greenhouse gas emissions inventory	Low
Comments/Additional Information: No regulatory ability to affect carbon emissions.	
Capital planning and land use decisions informed by potential climate impacts	Low
Comments/Additional Information: Generally handled by cities, not the district	
Participation in regional groups addressing climate risks	Low
Comments/Additional Information: Indirectly through groups dealing with drought and wildfire issues	
Implementation Capacity	
Clear authority/mandate to consider climate change impacts during public decision-making processes	Low
Comments/Additional Information: No authority	
Identified strategies for greenhouse gas mitigation efforts	Low
Comments/Additional Information: No authority	
Identified strategies for adaptation to impacts	Medium
Comments/Additional Information: Response changes based on potential impacts for specific hazard increases	
Champions for climate action in local government departments	Low
Comments/Additional Information: Little ability exists for response agencies	
Political support for implementing climate change adaptation strategies	Medium
Comments/Additional Information: None provided	
Financial resources devoted to climate change adaptation	Low
Comments/Additional Information: Impacts are to response and fire prevention, no funding is specifically allocated for climate change adaptation as those are already existing programs	
Local authority over sectors likely to be negative impacted	Medium
Comments/Additional Information: Authority over building in areas subject to climate impacts	
Public Capacity	
Local residents knowledge of and understanding of climate risk	Low
Comments/Additional Information: None provided	
Local residents support of adaptation efforts	Low
Comments/Additional Information: None provided	
Local residents' capacity to adapt to climate impacts	Low
Comments/Additional Information: None provided	
Local economy current capacity to adapt to climate impacts	Low
Comments/Additional Information: None provided	
Local ecosystems capacity to adapt to climate impacts	Low
Comments/Additional Information: None provided	

a. High = The capacity exists and is in use; Medium = The capacity may exist, but is not used or could use some improvement; Low = Capacity does not exist or could use substantial improvement; Unsure= Not enough information is known to assign a rating.

19.4.2 Opportunities for Future Integration

As this hazard mitigation plan is implemented, the Contra Costa County Fire Protection District will use information from the plan as the best available science and data on natural hazards. The capability assessment presented in this annex identifies codes, plans and programs that provide opportunities for integration. The area-wide and local action plans developed for this hazard mitigation plan include actions related to plan integration, and progress on these actions will be reported through the progress reporting process described in Volume 1. New opportunities for integration also will be identified as part of the annual progress report. The capability assessment identified the following plans and programs that do not currently integrate goals or recommendations of the hazard mitigation plan but provide opportunities to do so in the future:

- **Hazardous Materials Response Team—**The district has received a grant to fund equipment and response capability/education to staff a hazardous materials response team. This will address needs related to hazardous materials releases, as well as terrorism response.

19.5 JURISDICTION-SPECIFIC NATURAL HAZARD EVENT HISTORY

Table 19-6 lists past occurrences of natural hazards for which specific damage was recorded in the Contra Costa County Fire Protection District. Other hazard events that broadly affected the entire planning area, including the Contra Costa County Fire Protection District, are listed in the risk assessments in Volume 1 of this hazard mitigation plan.

19.6 JURISDICTION-SPECIFIC VULNERABILITIES

Volume 1 of this hazard mitigation plan provides complete risk assessments for each identified hazard of concern. Noted vulnerabilities within the district include the following:

- All fire stations and urbanized areas are within an active seismic zone. Because of the size of the district, a severe earthquake may prolong response times from other areas within the district due to transportation infrastructure disruptions.
- The hills throughout the district are subject to severe wildfire risk, particularly on the west side of the central part of the district. Drought has exacerbated the problem, and will continue to do so with the effects of climate change.
- Several hilly areas within the district are subject to landslides.

19.7 HAZARD RISK RANKING

Table 19-7 presents a local ranking for the Contra Costa County Fire Protection District of all hazards of concern for which Volume 1 of this hazard mitigation plan provides complete risk assessments. This ranking summarizes how hazards vary for this jurisdiction. As described in detail in Volume 1, the ranking process involves an assessment of the likelihood of occurrence for each hazard, along with its potential impacts on people, property and the economy.

19.8 STATUS OF PREVIOUS PLAN ACTIONS

Table 19-8 summarizes the actions that were recommended in the previous version of the hazard mitigation plan and their implementation status at the time this update was prepared.

Table 19-6. Natural Hazard Events

Type of Event	FEMA Disaster # (if applicable)	Date	Damage Assessment
Wildfire	NA	6/9/16	$300,000
Wildfire	NA	3/20/14	200,000
Wildfire	NA	7/7/15	100,000
Wildfire	NA	6/24/15	$400,000
Wildfire	NA	7/1/13	$350,000
Wildfire	NA	7/12/16	$200,000
Wildfire	NA	6/25/16	600,000
Wildfire	NA	6/11/2010	$100,000
Wildfire	NA	9/14/2011	$15,000
Wildfire	NA	6/27/2012	$40,000
Wildfire	NA	8/16/12	$60,000
Wildfire	NA	8/5/2009	$10,000
Wind	NA	12/25/2008	$13,500
Wind	NA	12/15/2008	$3,000
Flood	NA	1/1/2006	$22,000,000
Flood	FEMA-1628	12/31/2005	$22,000,000
Wildfire	NA	6/20/2004	$500,000
Wind	NA	11/7/2002	$200,000
Wind	NA	12/18/2000	$550,000
Wind	NA	11/24/2000	$700,000
Flood	NA	2/14/2000	$100,000
Wind	NA	12/22/1999	$62,500
Wind	NA	2/9/1999	$200,000
Severe Weather	NA	12/12/1995	$6,000,000
Wind	NA	11/14/1993	$62,500
Wind	NA	2/19/1993	$50,000
Severe Weather	NA	12/25/1990	$86,206
Flood	NA	5/28/1990	$500,000
Severe Weather	NA	12/3/1983	$312,500
Wind	NA	12/22/1982	$1,041,666
Flood, Severe Weather	NA	1/3/1982	$7,142,857

Note: CCCFPD responds to an average of approximately 285 wildland fires per year and many of those threaten residential structures

Table 19-7. Hazard Risk Ranking

Rank	Hazard Type	Risk Rating Score (Probability x Impact)	Category
1	Earthquake	54	High
2	Severe weather	18	Medium
3	Wildfire	6	Low
3	Flood	6	Low
3	Drought	6	Low
4	Landslide	2	Low
5	Dam and levee failure	1	Low
6	Sea level rise	0	None
6	Tsunami	0	None

Table 19-8. Status of Previous Plan Actions

Action Item	Completed	Removed; No Longer Feasible	Carried Over to Plan Update: Check if Yes	Carried Over to Plan Update: Enter Action #
CCCFPD-1—Continue with installation of emergency generators at fire stations			X	CCCFPD-8
Comment: Most stations have been outfitted. There are new stations that will be constructed in the next 5years that will likely be outfitted with generators				
CCCFPD-2—Structural seismic retrofit of fire facilities			X	CCCFPD-9
Comment: Retrofit will occur as stations are remodeled as per Title 24 CCR. All new facilities will meet current standards.				
CCCFPD—Adoption of Fire Hazard Maps – "Very High Fire Hazard Severity Zone" (VHFHSZ) maps currently under development	X			
Comment: Maps adopted for Lafayette. The State maps have not been updated since the original plan. If those maps are updated, we may pursue adoption of those maps for areas served by CCCFPD.				
CCCFPD-4—Enhance/Improve County Code language and enforcement including: County Building Codes to increase compliance with SB 1369 Defensible Space and Other Fire Safe Requirements in the unincorporated county areas	X			
Comment: Adopted by reference in ordinance 2016-23, and are contained in Title 24 parts 2, 2.5, and 9.				
CCCFPD-5—Improve, expand and develop new programs that increase awareness of and reduce risk to wildfires including: Support of Diablo Fire Safe Council vegetation management workshops and chipper program	X		X	CCCFPD-3
Comment: Ongoing support of DFSC and their initiatives				
CCCFPD-6—Implementation of projects listed in the Community Wildfire Protection Plan (CWFPP)			X	CCCFPD-4
Comment: As projects come up within the jurisdictional boundaries, or in adjacent jurisdictions with an impact to CCCFPD jurisdiction, CCCFPD supports them.				
CCCFPD-7—Participate in annual multi-agency Wildland Fire Training	X		X	CCCFPD-5
Comment: Training held annually in June. The current location is being developed, and attempts are being made to find a new location				
CCCFPD-8—Pursue implementation of projects listed in CCCFPD Capital Improvement Plan			X	CCCFPD-6
Comment: The plan is in the process of being revised.				
CCCFPD-9—Educate the public on the risks associated with natural hazards and methods to prepare for and mitigate those risks	X		X	CCCFPD-7
Comment: CCCFPD has maintained an all risk public educator position, and continues to support prevention of all risks faced in the county through these programs.				
CCCFPD-10—Support County-wide initiatives identified in the 2011 Hazard Mitigation Plan.	X		X	CCCFPD-1
Comment: We will continue to support the initiatives in the new plan				
CCCFPD-11—Continue to support the implementation, monitoring, maintenance, and updating of this Plan, as defined in the 2011 Hazard Mitigation Plan.	X		X	CCCFPD-2
Comment: Ongoing support				

19.9 HAZARD MITIGATION ACTION PLAN AND EVALUATION OF RECOMMENDED ACTIONS

Table 19-9 lists the actions that make up the Contra Costa County Fire Protection District hazard mitigation action plan. Table 19-10 identifies the priority for each action. Table 19-11 summarizes the mitigation actions by hazard of concern and mitigation type.

Table 19-9. Hazard Mitigation Action Plan Matrix

Applies to new or existing assets	Hazards Mitigated	Objectives Met	Responsible Agency[a]	Estimated Cost	Sources of Funding	Timeline
CCCFPD-1— Where appropriate, support retrofitting or relocation of structures in high hazard areas, prioritizing structures that have experienced repetitive losses.						
Existing	All Hazards	1, 4, 7, 9, 12, 14, 15, 17	CCCFPD	High	HMGP, PDM, FMA	Short-term
CCCFPD-2— Actively participate in the plan maintenance protocols outlined in Volume 1 of this hazard mitigation plan.						
New and Existing	All Hazards	3, 8, 16	CCC OES*, Fire Marshall	Low	Staff Time, General Funds	Short-term
CCCFPD-3—Improve, expand and develop new programs that increase awareness of and reduce risk to wildfires including: Support of Diablo Fire Safe Council vegetation management workshops and chipper program						
New and Existing	Wildfire	2, 3, 11, 16,	DFSC*, CCCFPD	Low	Staff Time, General Funds	Short Term
CCCFPD-4—Implementation of projects listed in the Community Wildfire Protection Plan (CWFPP)						
New and existing	Wildfire	2, 3, 17	DFSC-CCCFPD	Low	Staff Time, Federal Grants	Ongoing
CCCFPD-5—Participate in annual multi-agency Wildland Fire Training						
New and Existing	Wildfire	2, 16	CCCFPD	Low	Staff Time, General Funds	Short-term
CCCFPD-6—Pursue implementation of projects listed in CCCFPD Capital Improvement Plan						
New and Existing	All Hazards	1, 2	CCCFPD	Medium	Staff Time, General Funds, Mitigation Fees	Ongoing
CCCFPD-7—Educate the public on the risks associated with natural hazards and methods to prepare for and mitigate those risks through ongoing public education campaigns						
New and Existing	All Hazards	3, 5	CCCFPD	Low	Staff Time, General Funds, AFG Funds	Ongoing
CCCFPD-8—Continue with installation of emergency generators at fire stations						
New	All Hazards	1, 2, 13	CCCFPD	Medium	General Funds	Long-term
CCCFPD-9—Structural seismic retrofit of fire facilities						
New and Existing	Earthquake	1, 2	CCCFPD	Medium	General funds	Ongoing

a. Where multiple responsible agencies are listed, an asterisk (*) identifies the lead agency.

Table 19-10. Mitigation Action Priority

Action #	# of Objectives Met	Benefits	Costs	Do Benefits Equal or Exceed Costs?	Is Project Grant-Eligible?	Can Project Be Funded Under Existing Programs/ Budgets?	Implementation Priority[a]	Grant Pursuit Priority[a]
CCCFPD-1	8	High	High	Yes	Yes	No	Medium	High
CCCFPD-2	3	Low	Low	Yes	No	Yes	High	Low
CCCFPD-3	2	High	Low	Yes	No	Yes	High	Low
CCCFPD-4	2	High	Low	Yes	No	Yes	High	Low
CCCFPD-5	2	High	Low	Yes	No	Yes	High	Low
CCCFPD-6	2	High	High	Yes	No	Yes	Medium	Medium
CCCFPD-7	8	High	Low	Yes	Yes	Yes	High	Medium
CCCFPD-8	3	High	Low	Yes	No	Yes	High	Low
CCCFPD-9	2	High	Low	Yes	No	Yes	High	Low

a. See the introduction to this volume for explanation of priorities.

Table 19-11. Analysis of Mitigation Actions

Hazard Type	Action Addressing Hazard, by Mitigation Type[a]							
	Prevention	Property Protection	Public Education and Awareness	Natural Resource Protection	Emergency Services	Structural Projects	Climate Resilient	Community Capacity Building
All hazards	CCCFPD-3, 4, 5, 7, 8, 9		CCCFPD-7		CCCFPD-1, 2, 3, 4, 5, 6, 7, 8, 9			CCFPD-2
Dam and Levee failure			CCCFPD-7					
Drought			CCCFPD-7	CCCFPD-7				
Earthquake	CCCFPD-7, 8, 9	CCCFPD-8, 9	CCCFPD-7			CCCFPD-8, 9		
Flood			CCCFPD-7					
Landslide			CCCFPD-7					
Severe weather			CCCFPD-7					
Tsunami			CCCFPD-7					
Wildfire	CCCFPD-3, 4, 5		CCCFPD-7	CCCFPD-7				CCCFPD-3

a. See the introduction to this volume for explanation of mitigation types.

19.10 REVIEW AND INCORPORATION OF RESOURCES FOR THIS ANNEX

The following technical reports, plans, and regulatory mechanisms were reviewed for this annex.

- **Title 24 CCR**—Utilized in the development of all fire code and building code adoptions
- **Fire Data (FireRMS)**—Used in the determination of previous incidents
- **Hazard Mitigation Plan Annex Development Tool-kit**—The tool-kit was used to support the development of this annex including past hazard events, noted vulnerabilities, risk ranking and action development.

Contra
Costa
County

To: Contra Costa County Fire Protection District Board of Directors

From: Jeff Carman, Chief, Contra Costa County Fire Protection District

Date: June 12, 2018

Subject: Discussion regarding Fire Prevention Bureau inspection activity

RECOMMENDATION(S):

ACCEPT a verbal update from the Fire Chief of Fire Prevention Bureau inspection performance and mandated inspections.

FISCAL IMPACT:

No fiscal impact.

BACKGROUND:

The Fire District performs a variety of mandated inspections on existing commercial, institutional, educational, and multi-family residential buildings. An article published by the Bay Area News Group on Sunday, June 3, 2018 called into question the fire inspection performance of several large Bay Area fire departments, including the Contra Costa County Fire Protection District, specifically with regards to apartment buildings and school facilities.

☑ APPROVE ☐ OTHER

☑ RECOMMENDATION OF CNTY ADMINISTRATOR ☐ RECOMMENDATION OF BOARD COMMITTEE

Action of Board On: **06/12/2018** ☐ APPROVED AS RECOMMENDED ☐ OTHER

Clerks Notes:

VOTE OF SUPERVISORS

I hereby certify that this is a true and correct copy of an action taken and entered on the minutes of the Board of Supervisors on the date shown.

ATTESTED: June 12, 2018

David J. Twa, County Administrator and Clerk of the Board of Supervisors

By: , Deputy

Contact: Jeff Carman, Fire Chief (925) 941-3300 x1100

cc:

Contra Costa County

To: Contra Costa County Fire Protection District Board of Directors

From: Jeff Carman, Chief, Contra Costa County Fire Protection District

Date: June 12, 2018

Subject: Fire Chief's Report - June 12, 2018

RECOMMENDATION(S):

ACCEPT a report from the Fire Chief providing a status summary for ongoing Fire District activities and initiatives.

FISCAL IMPACT:

No fiscal impact.

BACKGROUND:

At the request of the Contra Costa County Fire Board of Directors, the Fire Chief is providing a report on the status and progress of the various District initiatives.

☑ APPROVE ☐ OTHER

☑ RECOMMENDATION OF CNTY ADMINISTRATOR ☐ RECOMMENDATION OF BOARD COMMITTEE

Action of Board On: **06/12/2018** ☐ APPROVED AS RECOMMENDED ☐ OTHER

Clerks Notes:

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ATTESTED: June 12, 2018

, County Administrator and Clerk of the Board of Supervisors

By: , Deputy

Contact: Jeff Carman, Fire Chief
925-941-3300

cc:

ATTACHMENTS

Fire Chief's Report May 2018

May 22, 2018

TO: Board of Directors

FROM: Jeff Carman, Fire Chief

RE: Fire Chief's Report

- Fire Station 16 (Lafayette): Construction is in progress. We encountered some challenges with 2 large oak trees that were going to effect the building. We sought and received permission from the City of Lafayette to remove the trees. We will be planting additional trees on site as mitigation for the removed trees. Earthwork, retaining walls and the new fence line should be complete by June 28th. Significant efforts have gone into communicating and coordinating directly with our neighbors affected by the project.

- Fire Station 70 (San Pablo): The architectural drawings are 99% complete. The final geotechnical reports have been received. The phase 2 environmental analysis should be completed in June. We will be submitting for a building permit soon and we anticipate bidding the project later this summer.

- The wildland fire season is upon us. Unfortunately the addition of wildland fires to our existing work load stretches our resources thinner and thinner. We have had several major incidents already occur in our district as well as neighboring districts. The lack of resources will need to be carefully watched as the wildland season progresses.

- Earlier this month three of our firefighters were providing emergency medical care on Highway 4 when an out-of-control motorist entered the accident scene at a high rate of speed, striking one of the vehicles involved in the previous accident which then struck our firefighters. Fortunately there were no life threatening injuries sustained, however this is the 3rd significant secondary crash involving fire district equipment and personnel in the last four years. We have again met with our local CHP commander and area assistant chief and are working together to provide for better safety of our personnel.

- The ambulance transport program continues to operate at very high levels of performance. Our county contract requires ambulances to be on-scene within 11 minutes/ 45 seconds 90% of the time in all areas except the City of Richmond where our requirement is 90% of the time in 10 minutes. Countywide we are arriving within our time frames 96% of the time. Our average response time county wide is 4 minutes/ 30 seconds, except in Richmond where our average is 4 minutes/ 7 seconds.

- For the last several years our fleet shop has been severely understaffed which has led to back-ups in apparatus repairs, significant overtime expenditures, and increased repair costs due to having to utilize outside repair shops. The remaining mechanics and shop staff have worked very hard to keep our fleet on the road despite the vacancies. The difficulty in recruiting new fire mechanics is the combination of low comparable salaries and very few fire mechanics looking for work. Our Support Services Chief has worked very hard over the last year to reorganize the shop into a two-tiered system, and secure a salary increase for the fire mechanics. As a result of these efforts, our recruitment efforts have produced several candidates who meet the minimum requirements and we will interview those candidates next week.

- Our Asst. Chief of Training and his staff have been working for over a year to get our training campus approved as an Accredited Local Academy with the California State Fire Training. This has been a very arduous process including professional development training for our staff, aligning our training processes with national standards, and a lengthy written application. We will be the only fire district in the county to achieve this accreditation and one of 20 in the state. We have certified over 25 fire district personnel as state fire instructors which will allow us to teach fire related courses in-house and can certify our own fire academies. Final inspection is this coming Tuesday.

Contra Costa County

To: Contra Costa County Fire Protection District Board of Directors

From: Jeff Carman, Chief, Contra Costa County Fire Protection District

Date: June 12, 2018

Subject: California Fire Foundation Grant

RECOMMENDATION(S):

APPROVE and AUTHORIZE the Fire Chief, or designee, to apply for and accept grant funding from the California Fire Foundation, in an amount not to exceed $15,000, for the purchase of helicopter equipment.

FISCAL IMPACT:

100% Grant funded

BACKGROUND:

The California Fire Foundation is a non-profit organization that provides emotional and financial assistance to families of fallen firefighters, firefighters, and the communities they protect. The California Fire Foundation is partnering with Pacific Gas & Electric Company to provide funding to fire departments and firefighter associations to address issues such as wildfires, floods, and climate-caused disasters.

The Contra Costa County Fire Protection District (District) partners with the Office of the Sheriff to provide helicopter rescue and firefighting support. This funding will allow the District to purchase helicopter equipment (a Bambi Bucket) to support the program. The Bambi Bucket is a water carrying and dropping device that attaches to the bottom of the helicopter. It is used

☑ APPROVE ☐ OTHER

☑ RECOMMENDATION OF CNTY ADMINISTRATOR ☐ RECOMMENDATION OF BOARD COMMITTEE

Action of Board On: **06/12/2018** ☐ APPROVED AS RECOMMENDED ☐ OTHER

Clerks Notes:

VOTE OF SUPERVISORS

I hereby certify that this is a true and correct copy of an action taken and entered on the minutes of the Board of Supervisors on the date shown.

ATTESTED: June 12, 2018

David J. Twa, County Administrator and Clerk of the Board of Supervisors

By: , Deputy

Contact: Lewis Broschard, Deputy Chief
925-941-3300 x1101

cc:

BACKGROUND: (CONT'D)

to collect water from remote waterways, rivers, or lakes and drop it on wildland fires. This device allows the Sheriff's helicopter to become a force multiplier to the fire crews on the ground. The Office of the Sheriff has their pilot and helicopters carded for aerial firefighting by CALFire and the U.S. Forest Service. The County Air Unit currently has only one Bambi Bucket for one helicopter for aerial firefighting. We would like to obtain a second Bambi Bucket for the second helicopter to increase the mission profile of the Air Unit and allow both helicopters to perform aerial water drops on wildland fires.

CONSEQUENCE OF NEGATIVE ACTION:

The District will not be able to take advantage of this funding opportunity.

Contra Costa County

To: Contra Costa County Fire Protection District Board of Directors

From: Jeff Carman, Chief, Contra Costa County Fire Protection District

Date: June 12, 2018

Subject: Hazard Mitigation Grant

RECOMMENDATION(S):

APPROVE and AUTHORIZE the Fire Chief, or designee, to apply for and accept grant funding from the U.S. Department of Homeland Security, Federal Emergency Management Agency and the California Governor's Office of Emergency Services, Hazard Mitigation Grant Program, in an amount not to exceed $2,000,000, for the purchase and installation of nine emergency generators.

FISCAL IMPACT:

There is a 25% local agency match requirement for this grant. 75% Federal: not to exceed $1,500,000; 25% District: not to exceed $500,000.

BACKGROUND:

The Hazard Mitigation Grant Program (HMGP) funds projects that reduce the effects of future natural disasters. The program aims to reduce community vulnerability to disasters and their effects, promote individual and community safety and resilience, and promote community vitality after an incident. In California, these funds are administered by the California Governor's Office of Emergency Services HMGP Unit.

The Contra Costa County Fire Protection District (District) is seeking funds to replace

☑ APPROVE ☐ OTHER

☑ RECOMMENDATION OF CNTY ADMINISTRATOR ☐ RECOMMENDATION OF BOARD COMMITTEE

Action of Board On: **06/12/2018** ☐ APPROVED AS RECOMMENDED ☐ OTHER

Clerks Notes:

VOTE OF SUPERVISORS

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ATTESTED: June 12, 2018

David J. Twa, County Administrator and Clerk of the Board of Supervisors

By: , Deputy

Contact: Lewis Broschard, Deputy Chief 925-941-3300 x1101

cc:

BACKGROUND: (CONT'D)

emergency generators in eight fire stations and the communications center. All of the generators scheduled for replacement are at a minimum age of 20 years and have reached their end of service life. Replacing the generators will ensure that the District's locations will be able to continue to function in the event of power interruptions or outages.

CONSEQUENCE OF NEGATIVE ACTION:

The District will not be able to take advantage of this funding opportunity to replace aging and outdated emergency generators. Eventually the generators would need to be replaced out of general operating funds.

Contra Costa County

To: Contra Costa County Fire Protection District Board of Directors

From: Jeff Carman, Chief, Contra Costa County Fire Protection District

Date: June 12, 2018

Subject: Appropriation and Revenue Adjustment – District Administration Building

RECOMMENDATION(S):

APPROVE Appropriation and Revenue Adjustment No. 5079 authorizing new revenue in the amount of $1,261,500 from the May 2018 residual distribution of the Redevelopment Property Tax Trust Fund and appropriating it for tenant improvements and rent payments during fiscal year 2017-18 for the new Contra Costa County Fire Protection District Administrative Office located at 4005 Port Chicago Highway, Suite 250, in Concord, California.

FISCAL IMPACT:

100% Special District Revenue. Use of new revenue from current secured property taxes.

BACKGROUND:

The Contra Costa County Fire Protection District (District) relocated to a new administrative office in February 2018. The new office is leased and requires monthly rent payments. Prior to occupying the property, a number of tenant improvements were necessary. Specific costs for both rent and tenant improvements were not known at the time the District prepared its 2017-18 recommended budget.

The District received approximately $3.6 million more in current secured property taxes than was budgeted for

- [x] APPROVE
- [ ] OTHER
- [x] RECOMMENDATION OF CNTY ADMINISTRATOR
- [ ] RECOMMENDATION OF BOARD COMMITTEE

Action of Board On: **06/12/2018** [x] APPROVED AS RECOMMENDED [ ] OTHER

Clerks Notes:

VOTE OF SUPERVISORS

I hereby certify that this is a true and correct copy of an action taken and entered on the minutes of the Board of Supervisors on the date shown.

ATTESTED: June 12, 2018

David J. Twa, County Administrator and Clerk of the Board of Supervisors

Contact: Jackie Lorrekovich, Chief Admin Svcs (925) 941-3300 x1300

By: , Deputy

cc:

BACKGROUND: (CONT'D)

in fiscal year 2017-18. This is due to a larger than anticipated residual distribution from the Redevelopment Property Tax Trust Fund (RPTTF). Approximately $1.26 million of that will be used to pay for tenant improvements and rent payments from February through June 2018. Tenant improvements are complete. There should be no additional charges. Rent payments were budgeted for in the District's fiscal year 2018-19 budget.

CONSEQUENCE OF NEGATIVE ACTION:

This revenue and appropriation adjustment is necessary to have adequate budgeted funds in the current fiscal year to pay Public Works for interagency charges for building occupancy costs (rent payments) and other charges (tenant improvements).

ATTACHMENTS

Appropriation and Revenue Adjustment No. 5079

CONTRA COSTA COUNTY
ESTIMATED REVENUE ADJUSTMENT/
ALLOCATION ADJUSTMENT
TC/24

AUDITOR-CONTROLLER USE ONLY:
FINAL APPROVAL NEEDED BY:
☒ BOARD OF SUPERVISORS
☐ COUNTY ADMINISTRATOR
☐ AUDITOR-CONTROLLER

ACCOUNT CODING		DEPARTMENT: Contra Costa County Fire Protection District		
ORGANIZATION	REVENUE ACCOUNT	REVENUE ACCOUNT DESCRIPTION	INCREASE	<DECREASE>
7300	9010	Property Taxes Current Secured	1,261,500.00	
		TOTALS	1,261,500.00	0.00

APPROVED

AUDITOR – CONTROLLER
By: [signature] Date 6/6/18

COUNTY ADMINISTRATOR
By: [signature] Date 6/8/18

BOARD OF SUPERVISORS
YES:
NO:

By: ____________________ Date
____

EXPLANATION OF REQUEST

To recognize and appropriate new revenue from current secured property taxes from the second FY 2017-18 residual distribution of RPTTF.

PREPARED BY: Jackie Lorrekovich [signature]
TITLE: Chief of Administrative Services
DATE: 6/4/2018

REVENUE ADJ. JOURNAL NO. RAOO 5079

(M 129 Rev. 6/09 CAO)

AUDITOR-CONTROLLER USE ONLY:
FINAL APPROVAL NEEDED BY:
☒ BOARD OF SUPERVISORS
☐ COUNTY ADMINISTRATOR
☐ AUDITOR-CONTROLLER

CONTRA COSTA COUNTY
APPROPRIATION ADJUSTMENT/
ALLOCATION ADJUSTMENT
T/C-27

ACCOUNT CODING		DEPARTMENT:		
ORGANIZATION	EXPENDITURE SUB-ACCOUNT	EXPENDITURE ACCOUNT DESCRIPTION	<DECREASE>	INCREASE
7300	3619	Gen Svc - Bldg Occupancy Costs		312,130.00
7300	3622	Gen Svc - Other GS Charges		949,370.00
			0.00	1,261,500.00

APPROVED

AUDITOR – CONTROLLER
By: [signature] Date 6/6/18

COUNTY ADMINISTRATOR
By: [signature] Date 6/8/18

BOARD OF SUPERVISORS
YES:
NO:

By: ____________________ Date
____

EXPLANATION OF REQUEST

To appropriate new revenue for Public Works charges for tenant improvements and rent payments for the months Feb-Jun 2018 for the District's new Administrative Office.

PREPARED BY: [signature]
TITLE:
DATE: 6/4/18

APPROPRIATION APOO 5079
ADJ. JOURNAL NO.

(M 129 Rev. 6/09)

C.4

Contra Costa County

To: Contra Costa County Fire Protection District Board of Directors

From: Jeff Carman, Chief, Contra Costa County Fire Protection District

Date: June 12, 2018

Subject: Tablet Command Software License and Interface Development Agreement

RECOMMENDATION(S):

APPROVE and AUTHORIZE the Fire Chief, or designee, to execute a Software License and Interface Development Agreement with Tablet Command, Inc., in an amount not to exceed $575,000, for the development, use, and support of computer aided dispatch incident command software for the period July 1, 2018, through June 30, 2023.

FISCAL IMPACT:

The total cost of this agreement is estimated at $575,000 over the five-year term. Of that amount, an estimated 92% of the cost will be passed on to dispatch user agencies, ancillary County agencies, and American Medical Response (AMR). The remaining amount (8%) will be budgeted in the District's General Operating Fund (5%) and the EMS Transport Fund (3%).

BACKGROUND:

Tablet Command, Inc. designed its Tablet Command software program to enhance the safety and effectiveness of field command operations and continues to refine this system in collaboration with the Contra Costa County Fire Protection District (District). The District uses

☑ APPROVE ☐ OTHER

☑ RECOMMENDATION OF CNTY ADMINISTRATOR ☐ RECOMMENDATION OF BOARD COMMITTEE

Action of Board On: **06/12/2018** ☐ APPROVED AS RECOMMENDED ☐ OTHER

Clerks Notes:

VOTE OF SUPERVISORS

I hereby certify that this is a true and correct copy of an action taken and entered on the minutes of the Board of Supervisors on the date shown.

ATTESTED: June 12, 2018

David J. Twa, County Administrator and Clerk of the Board of Supervisors

By: , Deputy

Contact: Lewis Broschard, Dep Fire Chief
925-941-3300 x1101

cc:

BACKGROUND: (CONT'D)

the software program in a one-way interface environment -- Computer Aided Dispatch (CAD) data to mobile device -- for its incident command management functionality to improve firefighter safety. The software provides standardized command and control, standardized checklists, time stamping of all actions on a fire ground, and improved after-action reviews and accountability. Battalion Chiefs and Captains using the software on their mobile devices receive redundant CAD data via radios.

With the startup of the District's emergency ambulance service, Tablet Command, Inc. developed a new two-way communication interface between ambulances, fire resources, and the Contra Costa Regional Fire Communications Center (CCRFCC) CAD. This allows ambulance and fire resources to communicate their status electronically using an iPad as the Mobile Data Computer (MDC). The two-way interface allows the CCRFCC and all District resources to communicate location, response status, and important emergency information as required by the contract between the District and the County for providing emergency ambulance service.

This Software License and Interface Development Agreement grants the District the right to continue to use and receive support for the Tablet Command one-way and two-way applications. It also grants the District permission to sub-license limited rights to CAD user group members, which includes neighboring fire departments and fire districts, and other ancillary public agencies that provide emergency response services.

CONSEQUENCE OF NEGATIVE ACTION:

The District and several dispatch user agencies and ancillary County agencies will not have an agreement to use this computer aided dispatch incident command software and will not have the required two-way communication interface for fire and ambulance resources.