Local Hazard Mitigation Plan

2020 Five Year Update

DRAFT

Local Hazard Mitigation Plan
2020 Five Year Update

Prepared by

Acknowledgements

City of Capitola

Jamie Goldstein, City Manager

Steve Jesberg, Public Works Director

Katie Herlihy, Community Development Director

Terry McManus, Chief of Police

Larry Laurent, Assistant to the City Manager

Consulting Team

Kimley-Horn and Associates

Table of Contents

Chapter One - Introduction 1
Purpose of the Plan 2
Authority 2
Plan Adoption 2
Plan Use 2
Mitigation Priorities and Goals 3
Hazard Mitigation Planning Process 5
Chapter Two – Community Profile 9
Physical Setting 9
History 9
Community Profile 10
Economic Trends 12
Existing Land Use 12
Residential Neighborhoods 15
Development Trends 16
Critical Facilities 17
Chapter Three – Hazards Assessment 20
Hazard Identification and Prioritization 20
Climate Change Considerations 26
Vulnerability/Risk Assessment Methodology 26
Hazard Profiles 27
Drought and Water Resources 55
Windstorm 61
Landslide and Mudflow 85
Summary of Vulnerability 90
Significant Hazards 90
Facilities at Most Risk 96
Potential Losses 96
Chapter Four – Mitigation Actions 98
Hazard Mitigation Overview 98
Hazard Mitigation Actions 101
Capabilities Assessment 117

Chapter Five - Plan Maintenance Process 125

5.1 Monitoring, Evaluating and Updating the Plan 125

5.2 Method and Schedule for Updating the Plan within 5 years 126

5.3 Adoption 126

5.4 Implementation through Existing Programs 126

5.5 Incorporation into Existing Planning Mechanisms 127

5.6 Continued Public Involvement 127

5.7 Point of Contact 128

List of Exhibits

Exhibit 1 – Regional Vicinity Map 11
Exhibit 2 – Land Use Map 14
Exhibit 4 – Critical Facilities 19
Exhibit 5 – Active Fault Zones 31
Exhibit 6 – Liquefaction Potential 32
Exhibit 7 – Flood Hazard Zones 43
Exhibit 8 - Future Combined Coastal Climate Change Hazard Zones 54
Exhibit 8 – Sea Level Rise In 54
Exhibit 9 – Water Supply 60
Exhibit 10 – Prevailing Wind Patterns 64
Exhibit 11 – Erosion Risk from Sea Level Rise 72
Exhibit 12 – Tsunami Inundation Risk 75
Exhibit 13 – Hazardous Materials Locations 81
Exhibit 14 – Fire Hazard Areas 84
Exhibit 15 – Topographic Relief 89

List of Figures

Figure 1 – The Esplanade (ca. 1910) 9
Figure 2 - Loma Prieta Earthquake 34
Figure 3 - Dust Generated from the Loma Prieta Earthquake (ca. 1989) 35
Figure 4 - Flooding Along Soquel Creek Northwest of the Capitola Village (ca. 1996) 39
Figure 5 - View of Capitola Wharf looking South (ca. 2012) 40
Figure 6 - Soquel Creek Stage Data 42
Figure 7: Coastal Storm (ca. 1926) 44
Figure 8: Coastal Storm (ca. 1940) 44
Figure 9: Coastal Storm (ca. 1983) 44
Figure 10 - Flooding within the Capitola Village (ca. 2011) 50
Figure 11 - Episodic coastal bluff failure in Capitola 66

Figure 12a - Cliff Erosion Beneath Apartments on Depot Hill (c. 1984) 66
Figure 13 - Capitola Beach Erosion 67
Figure 14 - Bluff Failure along Grand Avenue (associated with 1960 coastal storm) 70
Figure 15 - Debris generated during the Flash Floods (ca. 1955) 85

List of Tables

Table 1: 2020 LHMP Agency and Stakeholder Contact List 6
Table 2: Capitola Population Data 10
Table 3: Capitola Ethnicity 10
Table 4: Capitola Education Levels 10
Table 5: General Plan Land Use Designations 13
Table 6: Capitola Critical Facilities List 17
Table 7: City of Capitola Hazard Identification 20
Table 8: Capitola Hazard Ranking Worksheet 23
Table 9: Capitola Hazard Ranking Worksheet Legend 24
Table 10: Capitola Identified Hazards and Planning Considerations 26
Table 11: Richter Scale 29
Table 12: Modified Mercalli Intensity Scale for Earthquakes 29
Table 13: Historical Earthquake Events 33
Table 14: Ten Most Likely Damaging Earthquake Scenarios 36
Table 15: Capitola Critical Facilities Located in a Liquefaction Potential Zone 37
Table 16: FEMA Flood Zones 41
Table 17: Historical Coastal Storm and High Surf Events 45
Table 18: Historical Flood Events 49
Table 19: Capitola Critical Facilities Located in a FEMA Flood Zone 51
Table 20: Comparison of Sea Level Rise Estimates for Medium-High Risk Aversion for Capitola 52
Table 21: Historical Drought Events 58
Table 22: Windstorms Reported in Santa Cruz County, California 1965-2011 61
Table 23: Historical Wind Events 62
Table 24: Historic Erosion Events 68
Table 25: Capitola Critical Facilities Exposed to Increased Erosion Potential 71
Table 26: Tsunami Events in Northern California 1930-2011 74
Table 27: Historic Tsunami Events 76
Table 28: Tsunami Flow Depth Estimates for Capitola 76
Table 29: Capitola Critical Facilities Exposed to Tsunami Inundation 78
Table 30: RIMS Spill Database for Capitola, CA 79
Table 31: Capitola Critical Facilities Located Close to Hazardous Materials Locations 80
Table 32: Landslides and Mudflows 86
Table 33: Risk Assessment Summary 91
Table 34: Capitola Critical Facilities At Risk 96
Table 35: Most Costly Capitola Critical Facilities 96
Table 36: STAPLE/E Review and Selection Criteria 99
Table 37: Capitola Hazard Mitigation Actions 103
Table 38: Capitola Capabilities Assessment 117

Appendices

Appendix A – Timeline of Capitola Natural Hazard Events
Appendix B – Detailed Critical Facilities Inventory
Appendix C – City of Capitola Coastal Climate Change Vulnerability Report (June 2017)

1 Chapter One - Introduction

Natural hazards and extreme weather events are an ongoing part of the cycle of weather and seasons. However, when natural hazards such as earthquakes, tsunamis or coastal storms are at their height, they pose severe risk to people and property. They can cause death or leave people injured or displaced, cause significant damage to our communities, businesses, public infrastructure and environment, and cost tremendous amounts in terms of response and recovery dollars and can contribute to economic loss.

In March 2011, the City of Capitola experienced significant rain events that caused a catastrophic failure of a storm drain, resulting in flooding of the Capitola Village. Damages associated with this flooding were estimated at approximately $4 million in the City of Capitola and $15 million dollars countywide, damaging many business and City facilities. In response to this event, the City pursued grant funding to prepare their first Local Hazard Mitigation Plan (LHMP or the Plan), which was completed in May of 2013.

The Disaster Mitigation Act of 2000 (DMA, Section 201.6(c)(4)(i) requires a Plan Maintenance Process which includes periodically reviewing and updating hazard mitigation plans. FEMA requires jurisdictions to update their LHMP every five years, subject to approval by the California Office of Emergency Services (CalOES). An approved and adopted LHMP is required to receive future federal and state emergency funding.

This document is the City of Capitola 2020 LHMP Five Year Update. It is the first update undertaken by the City.

The intent of the current Plan, while incorporating much of the prior LHMP versions, is to:

- Include any newly identified hazards
- Update hazards/risk data
- Update development data
- Review and revise as necessary the hazard mitigation goals and actions
- Update demographic data and maps
- Incorporate the City of Capitola Coastal Change Vulnerability Report (June 2017)

A successful hazard mitigation strategy enables the implementation and sustaining of local actions that reduce vulnerability and risk from hazards, or reduce the severity of the effects of hazards on people and property. Historically, in many local jurisdictions, disasters are followed by repairs and reconstruction which simply restore the area to pre-disaster conditions. Capitola has experienced many natural hazard events during its history (Appendix A – Timeline of Capitola Natural Hazard Events). Such efforts expedite a return to normalcy; however, the replication of pre-disaster conditions results in a cycle of damage, reconstruction, and repeated damage. Hazard mitigation ensures that post-disaster repairs and reconstruction result in a true reduction in future hazard vulnerability.

While we cannot prevent disasters from happening, their effects can be reduced or eliminated through a well-organized public education and awareness effort, preparedness activities and mitigation actions. For those hazards which cannot be fully mitigated, the community must be prepared to provide efficient and effective response and recovery. As a coastal community, the City of Capitola has historically experienced extreme wave surges, coastal storms, and flooding on a cyclical basis. In addition, Capitola is near the San Andreas earthquake fault line, and is at risk from tsunami, and a variety of other natural disasters. This Plan outlines opportunities to increase Capitola's resiliency in the face of future natural hazards.

1.1 Purpose of the Plan

As the cost of damages from natural disasters continues to increase, the City of Capitola understands the importance of identifying effective ways to reduce vulnerability to disasters. This Plan assists Capitola in reducing vulnerability to disasters by identifying critical facilities (Appendix B – Detailed Critical Facilities Inventory), resources, information, and strategies for risk reduction, while helping to guide and coordinate mitigation actions.

The Plan provides a set of strategies intended to do the following: reduce risk from natural hazards through education and outreach programs, foster the development of partnerships, and implement risk reduction activities.

The resources and information within the Plan:

- Establish a basis for coordination and collaboration among participating agencies and public entities;
- Identify and prioritize future mitigation projects; and
- Assist in meeting the requirements of federal assistance programs.

The Capitola Hazard Mitigation Plan works in conjunction with other plans, including the General Plan, Local Coastal Plan, and Emergency Operations Plan.

1.2 Authority

The Disaster Mitigation Act of 2000 (DMA 2000), Section 322 (a-d) requires that local governments, as a condition of receiving federal disaster mitigation funds, have a mitigation plan that describes the process for identifying hazards, risks and vulnerabilities, identifies and prioritizes mitigation actions, encourages the development of local mitigation and provides technical support for those efforts. This Plan serves to meet these requirements.

1.3 Plan Adoption

The City of Capitola will use a resolution to adopt the local hazard mitigation plan (see sample below).

1.4 Plan Use

Each section of this Plan provides information and resources to assist people in understanding the hazard-related issues facing residents, businesses, and the environment. The structure of the plan enables people to use a section of interest to them and allows the City of Capitola to review and update sections when new data is available. The ability to update individual sections of the mitigation plan places less of a financial burden on the City. Decision makers can allocate funding and staff resources to selected pieces in need of review, thereby avoiding a full update, which can be costly and time consuming. The ease of incorporating new data will result in a Plan that remains current and relevant to Capitola.

The Plan is comprised of the following chapters:

Chapter 1: Introduction
The Introduction describes the background and purpose of developing the mitigation plan in addition to introducing the mitigation priorities and summarizing the planning process.

Chapter 2: Community Profile
The Community Profile presents the history, geography, demographics, and socioeconomics of Capitola. It serves as a tool to provide a historical perspective of natural hazards in the City.

Chapter 3: Hazards Assessment
This chapter provides information on hazard identification, hazard profiles, vulnerability and risk associated with natural hazards, and a vulnerability assessment of critical facilities in relation to the identified hazards.

Chapter 4: Mitigation Actions
This chapter provides strategies and mitigation actions to reduce potential risks to Capitola's critical facilities, residents, and businesses.

Chapter 5: Plan Maintenance/ Capabilities
This chapter provides information on plan implementation, monitoring and evaluation, discusses the assets and capabilities available to achieve the proposed mitigation actions outlined in Chapter 4, and opportunities for continued public involvement.

1.5 Change in Priorities

Subsequent to adoption of the 2013 LHMP, there has been no change in the hazard rankings. However, several technical studies related to sea level rise have been prepared, including most notably the City of Capitola Coastal Climate Change Vulnerability Report (June 2017). This report provides a detailed assessment of the potential impacts of sea level rise and recommended measures to minimize its impact. These measures have been incorporated into Table 37: Capitola Hazard Mitigation Actions.

With respect to the other mitigation actions identified in Table 37: Capitola Hazard Mitigation Actions, the General Plan was adopted in 2014. It includes a Safety and Noise element, providing further guidance on hazard-related issues and policy direction. The City also made improvements to the Noble Gulch storm drain facilities and completed and evaluation of the likelihood of debris flow impacts to the Stockton Avenue bridge during a catastrophic flooding event.

City staff continue to work in close coordination with other jurisdictions and agency to address local and regional hazards. In particular, the City has been working with the Soquel Creek Water District to construct and implement the Pure Water Soquel, Groundwater Replenishment and Seawater Intrusion Prevention Project. This includes plans to construct a new Seawater Intrusion Prevention Well on Monterey Avenue.

1.6 Mitigation Priorities and Goals

The purpose of the Capitola Local Hazard Mitigation Plan is to promote sound public policy designed to protect citizens, critical facilities, infrastructure, private property, and the environment from natural hazards. This can be achieved by increasing public awareness, documenting the resources for risk reduction and loss-prevention, and identifying activities to guide the City toward building a safer, more sustainable community.

Sample City Council Resolution

RESOLUTION ADOPTING A LOCAL HAZARD MITIGATION PLAN FOR THE City of Capitola:

WHEREAS, the Disaster Mitigation Act of 2000, as amended, requires that state and local governments, tribal nations and other eligible applicants develop and adopt hazard mitigation plans in order to receive certain federal assistance, and

WHEREAS, the City of Capitola having developed a Local Hazard Mitigation Plan Five Year Update meeting the requirements of Section 409 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988, and Section 322 of the Disaster Mitigation Act of 2000 (DMA 2000); and

WHEREAS, the DMA 2000 requires all cities, counties, and special districts to adopt a Local Hazard Mitigation Plan, and to update that plan at lease every five years as a condition of future funding for disaster mitigation from multiple FEM pre- and post-disaster mitigation grant programs; and

WHEREAS the City of Capitola seeks to maintain and enhance both a disaster-resistant and resilient city reducing the potential loss of life, property damage, and environmental degradation from natural disasters, which accelerating economic recovery from those disasters.

NOW THEREFORE, BE IT RESOLVED that the City of Capitola does hereby adopt the City of Capitola 2019-2024 Local Hazard Mitigation Plan Five Year Update as an official plan in accordance with the federal Disaster Mitigation Act of 2000, thereby meeting the continued eligibility requirements for the potential receipt of hazard mitigation grant funds; and

Be if further resolved that the City of Capitola will submit this Adopted Resolution to the Federal Emergency Management Agency Region IX Mitigation Division IX official to enable the plan’s final approval

ADOPTED by the City Council this ___ day of ____________________, 2020.

APPROVED:

____

(Title, Name)

____

(Title, Name)

The four primary goals for reducing disaster risk in Capitola include:

1. Avoid or reduce the potential for loss of life, injury and economic damage to Capitola residents from earthquakes, floods, drought, tsunami, coastal erosion/ bluff failure, and other geological hazards.
2. Increase the ability of the City government to serve the community during and after hazard events.
3. Protect Capitola's unique character, scenic beauty and values from being compromised by hazard events.
4. Encourage mitigation activities to increase the disaster resilience of institutions, private companies and systems essential to a functioning City of Capitola.

1.8 Hazard Mitigation Planning Process

This document is the first update to the Local Hazard Mitigation Plan pursuant to the Disaster Mitigation Act of 2000 for the City of Capitola. The primary City staff developing, maintaining, and implementing this plan comprise the Hazard Mitigation Planning (HMP) Team. Members of this team represent the following City Departments:

- Public Works Department
- City Manager's Office
- Police Department
- Community Development Department
- Kimley-Horn & Associates (Consultants)

1.8.1 2020 Capitola LHMP Update

In 2018, the City initiated the planning effort to update the 2013 LHMP. The LHMP team identified characteristics and potential consequences of natural hazards that are a potential threat to the City of Capitola. With the understanding of the risks posed by the identified hazards, the team determined and reviewed previously listed priorities and assessed various methods to avoid or minimize any undesired effects. Recent historical incidents were noted and assessed. Responsible departments were consulted in the review and development of the goals, objectives and actions. As a result, the mitigation strategy, including goals, objectives and actions, were determined, followed by an implementation and monitoring plan. This monitoring plan included tracking of hazard mitigation projects, changes in day-to-day City operations, and continued hazard mitigation development.

Local Capabilities Assessment and Integration

This assessment of the mitigation goals, programs and capabilities included a review of the following items:

- Human and technical resources
- Financial resources and funding sources
- Local ordinances, zoning and building codes
- On-going plans and projects

Consistency with other City plans, programs and policies were reviewed by consulting with the respective City departments. This included a review of the City's 2014 General Plan, Local Coastal Plan, and Emergency Operations Plan.

Agency and Stakeholder Coordination

On February 28, 2019, the City of Capitola held a meeting inviting agencies and stakeholders that were involved in preparation of the 2013 LHMP to inform them about the 2020 LHMP update process and to seek their input regarding hazards and hazard planning for Capitola. The invitation was sent to the following organizations identified in Table 1: 2020 LHMP Agency and Stakeholder Contact List.

Table 1: **2020 LHMP Agency and Stakeholder Contact List**

Name	Organization	Title
Jamie Goldstein	City of Capitola	City Manager
Susan Westman	City of Capitola	Interim Community Dev. Director
Steve Jesberg	City of Capitola	Public Works Director
Michael Card	City of Capitola	Chief of Police
Tom Held	City of Capitola	Captain
Larry Laurent	City of Capitola	Information Technology
Carolyn Flynn	City of Capitola	LHMP Coordinator
Scotty Douglas	Santa Cruz Regional 911	General Manager
Paul Horvatt	County of Santa Cruz	Emergency Services Manager
Kevin C. Cole	Soquel Creek Water District	Field Crew Supervisor/ Safety
Shelley Flock	Soquel Creek Water District	Staff Analyst
Paul Rucker	Soquel Union Elementary School District	Director of Maintenance and Operations
Jeff Maxwell	Central Fire Protection District of Santa Cruz County	Chief/Battalion Chief
Tom Evans	National Weather Service Forecast Office, NOAA	Warning Coordination Meteorologist
Patsy Hernandez	Red Cross	
Charles Bockman	California State Parks	Parks Superintendent
Don Hill	SC County Public Works & Flood Control & Water Conservation District (Zone 5)	Assistant Director, Public Works
Rachel Lather	Santa Cruz County Sanitation District	Senior Civil Engineer
Wendy Abbott Sarsfield	PG&E	Central Coast Government Relations
Bill Wiseman	Kimley-Horn & Associates	Project Consultant

The meeting was attended by representatives from the City of Capitola, Soquel Union Elementary School District, and PG&E. Comments included general questions about the update process and schedule and subsequent coordination needs. PG&E wanted to confirm that fire hazards would be addressed in the plan, which was confirmed.

The Public Review Draft 2020 LHMP was also emailed to the above listed organizations on April 12, 2020 requesting they review document and send any comments to Steve Jesberg by April 29, 2020. No comments were received.

Public Involvement

When the 2020 Draft LHMP update was completed, a 14-day public comment period was initiated by posting the document to the City's web site on April 15, 2020, and requesting comments be submitted to the Public Works

Director by April 29, 2020. Copies were also made available at City Hall. A copy of the notice posted on the City's website is shown in Appendix D.

The only comment received was a letter from the Surfrider Foundation, dated April 29, 2020. In summary, the letter recommended adapting to sea level rise with modalities that preserve the coast; such as living shorelines, soft armoring techniques, and relocation of development within coastal hazard zones. They recommended against implementing the jetty improvement project, identifying alternative options for beach replenishment, and preparing a comprehensive, long-term proactive management plan to protect Depot Hill in a way that preserves the natural coastline and avoids hard armoring. To address these issues, Mitigation Action 2S was broadened to investigate various opportunities for beach nourishment and replenishment in concert with rebuilding the City's groin located at the east end of the main beach. Additionally, a new Mitigation Action 2Z was added to investigate long-term options to manage sea level rise and coastal erosion, referencing recommendations as identified by the Surfrider Foundation.

2 Chapter Two – Community Profile

2.1 Physical Setting

Capitola is a small coastal community in Santa Cruz County, encompassing approximately two square miles. The city is located north of the Monterey Bay shoreline, south of Highway 1, east of the City of Santa Cruz, and west of the unincorporated towns of Soquel and Aptos. Exhibit 1: Regional Vicinity Map, depicts Capitola's regional location. Capitola has a temperate Mediterranean climate and distinct landforms influenced by the San Andreas Fault system. Figure 1 is a historic photo of Capitola viewed from the Esplanade.

The City of Capitola is a popular tourist destination due to its beaches, historic charm, visitor amenities, and scenic location. Capitola has a population of approximately 10,000 residents; however, the number of tourists visiting the City on a given day can be more than three times this number.

2.2 History

Capitola has always been a popular tourist and resort area. Between 1874 and 1883, "Camp Capitola" was primarily a campground for families vacationing during the summer season. Capitola's owner, Frederick Augustus Hihn, contracted for construction of the resort's first hotel in 1878. He began to subdivide surrounding tracts for the sale of lots for summer homes in 1882. Two years later, Hihn added an annex to the hotel and built a ballroom/skating rink and other amenities. About that time, the railroad through Capitola was broad gauged. Costing between $100 and $300, the lots began to sell rapidly with the added convenience of the improved rail line. Hihn's improvements continued, including construction of the Grand Hotel Capitola from 1894-1897 and the addition of the Union Traction Company streetcar line in 1903-4.

Figure 1 – The Esplanade (ca. 1910)

When Hihn died in 1913, his Capitola resort properties were inherited by his daughter Katherine Henderson. In 1919, she sold to capitalist H. Allen Rispin and a syndicate of San Francisco investors. By 1920, Rispin owned the entire waterfront, the Capitola Hotel, resort concessions, and 30 acres along Soquel Creek. The decade between 1920 and 1930 saw an increase in construction in Capitola; however, during the Depression many buildings burned, including the hotel.

In 1949, the residents of Capitola were successful in their campaign to incorporate. The new city had a population of 2,000 residents. In the late 1960's and early 1970's, Capitola experienced a growth surge with the construction of the Capitola Mall along 41st Avenue. For several decades, Capitola Mall was the regional shopping destination in the County. New retail options countywide beginning in the 1990's meant less growth for Capitola's primary retail mall area.

Today, Capitola remains a popular tourist destination. Shops and restaurants are located throughout the Village while the beach areas offer a variety of opportunities for recreational activities. Throughout the years since Capitola was first developed a myriad of hazard events have occurred that have impacted the City's residents, businesses, and infrastructure. Appendix A – Timeline of Capitola Natural Hazard Events provides a chronology of the natural hazard events that have affected the City, which includes dates and times (where available), pictures, and background information regarding the event.

2.3 Community Profile

The City of Capitola has a population of approximately 10,000 residents within an area of approximately two square miles. Tables 2 through 4 provide an overview of the City's population data, ethnicity, and education levels.

Table 2: **Capitola Population Data**

Population	
Total Population	10,080
Median Resident Age	41.9
Median Household Income	$ 69,016
Per Capita Income	$ 38,229
Median House Value	$ 585,100
Source U. S. Census American Community Survey, July 2018	

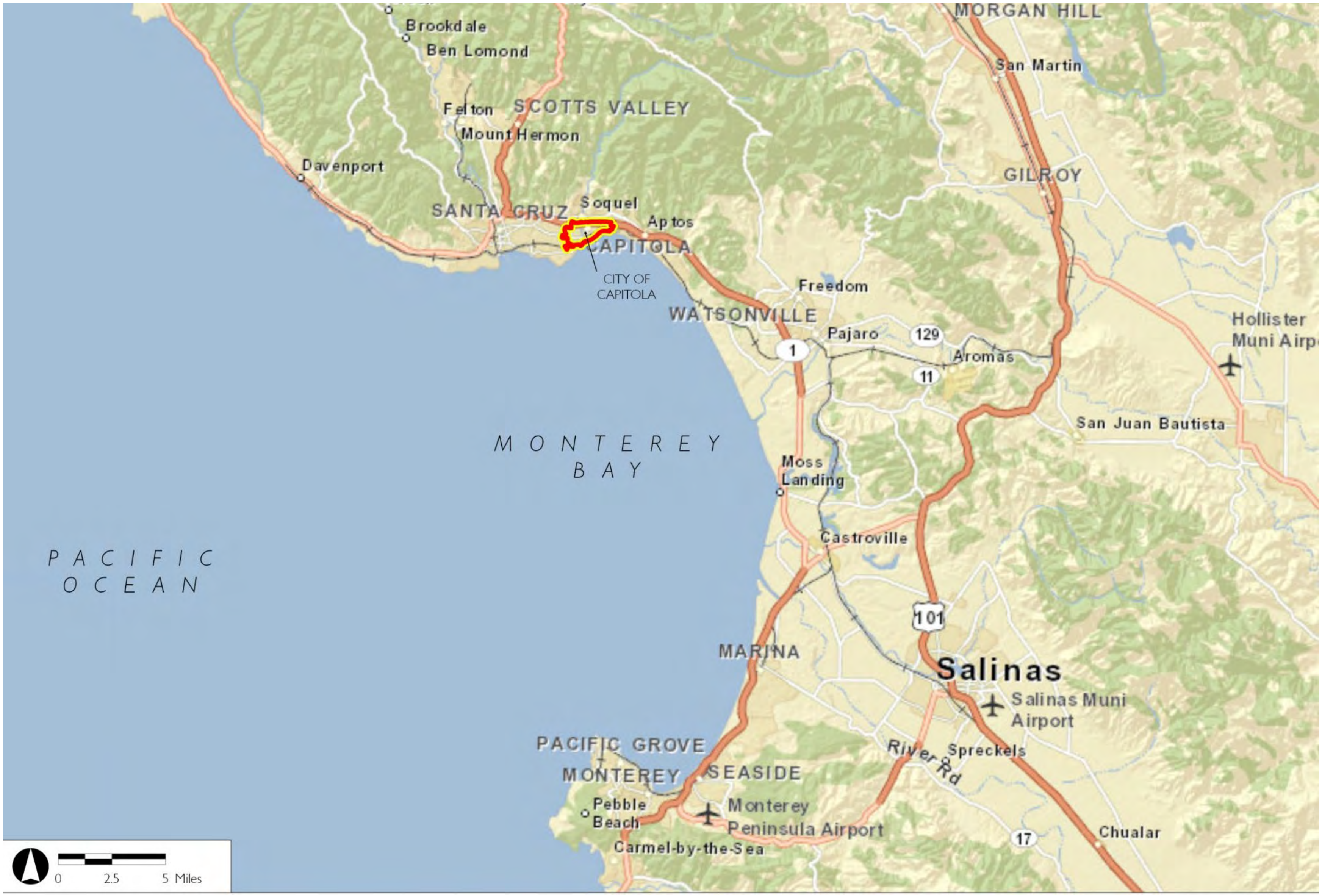
Table 3: **Capitola Ethnicity**

Ethnicity	
White (non-Hispanic)	86.7%
Black	0.5%
American Indian	0.1%
Asian	4.3%
Pacific Islander	0.0%
Two or More Races	5.8%
Hispanic or Latino	26.8%
Source U. S. Census American Community Survey, July 2018	

Table 4: **Capitola Education Levels**

Education Attainment (Age 25 and Over)	
High school graduate or higher	92.7%
Bachelor's degree or higher	36.8%
Source U. S. Census American Community Survey, July 2018	

Exhibit 1: Regional Vicinity Map



2.4 Economic Trends

Capitola City is predominantly occupied by residential uses. The City contains a large retail presence, particularly along 41st Avenue. There is strong demand for visitor accommodations, particularly during the summer months.

Capitola's high rate of workers commuting to jobs outside the City shows that Capitola largely serves as a bedroom community for people working outside the City. However, the City also features more jobs than employed residents, thus indicating a mismatch between the kinds of jobs offered versus the skill levels and occupations of residents.

2.5 Existing Land Use

The General Plan is the principle policy document that regulates land use in Capitola. The Land Use Element contains a Land Use Map (refer to Exhibit 2: Land Use Map), that identifies 12 land use designations. Table 4: General Plan Land Use Designations identifies the General Plan land use designations and description of the typical uses allowed within each designation. The City of Capitola General Plan addresses the use and development of private land, including residential and commercial areas.

Capitola's land use pattern is well established and is unlikely to change in the future. Single-family homes are the most common land use in Capitola, occupying 26 percent of the city. Residential land uses, as a group, occupy more than half of the City area. Retail is the most common commercial land use, occupying 11 percent of the city. A relatively small percentage of Capitola is occupied by office, industrial and mixed uses (1 percent each). A relatively large percentage of the city (14 percent) is occupied by open space and recreational land uses, and approximately 4 percent of City land is vacant.

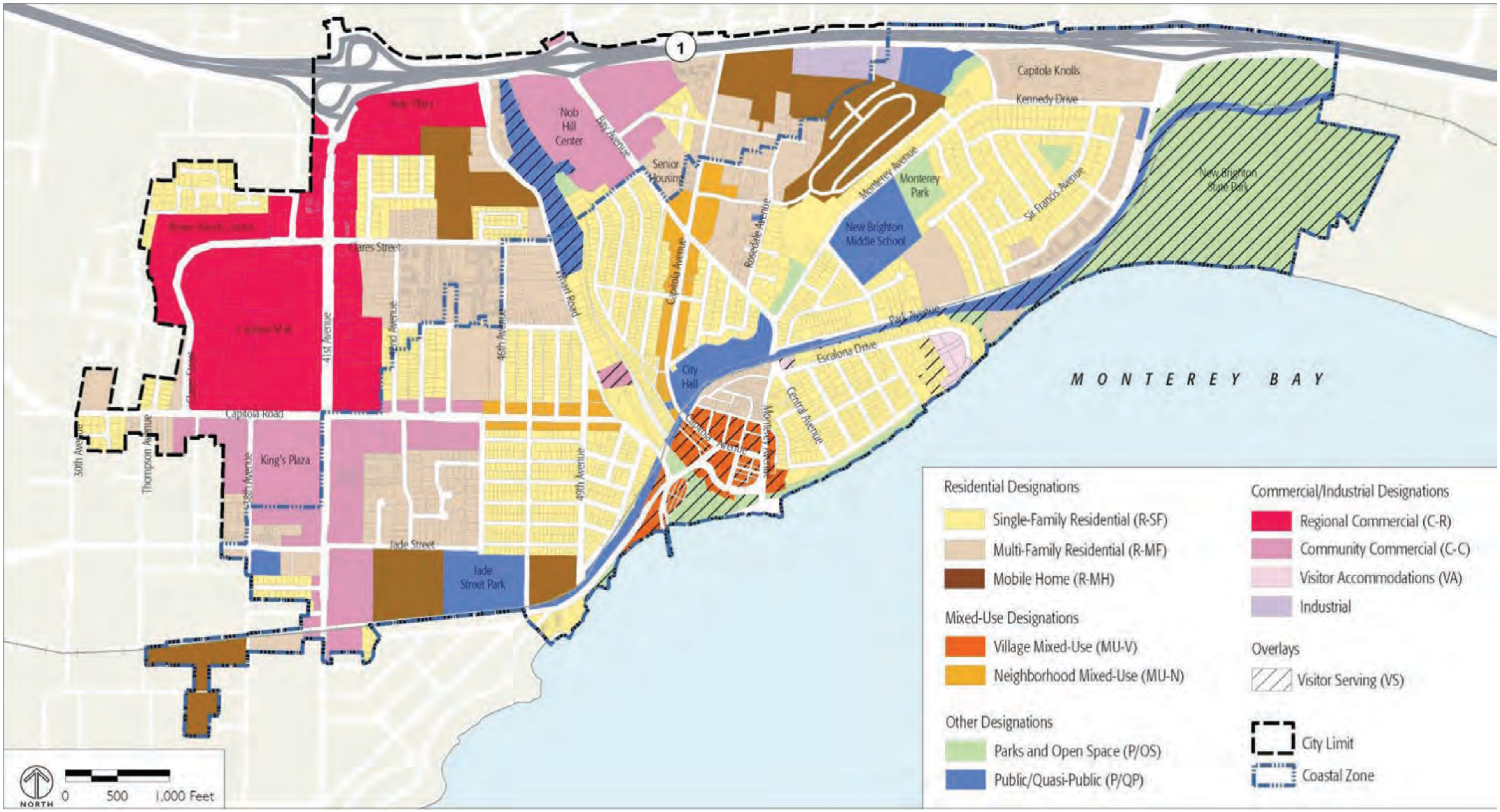
Using these land use designations, the City of Capitola has some capability to reduce risks to lives and property from natural and man-caused hazards. For example, open space land use can be designated in areas of hazard risk to prevent damage to developed property. Similarly, understanding where residential and commercial land uses are in relation to hazard risk is a key component to implementing mitigation strategies.

Table 5: **General Plan Land Use Designations**

	Land Use Designation	Description
RESIDENTIAL	Single-Family Residential (R-1)	Primarily detached single-family homes. Allows residential uses up 10 dwelling units per acre.
	Multi-Family Residential (RM)	Allows residential uses at a density of 5 to 20 units per acre.
	Mobile Home (R-MH)	Allows mobile home development at 20 mobile homes per acre.
COMMERCIAL	Village Mixed-Use (MU-V)	Applies to properties the Capitola Village. Allows for a mix of commercial, residential, visitor-serving, recreational, and public uses.
	Neighborhood Mixed Use (MU-N)	Allows for a mixture of commercial and residential land uses.
	Community Commercial (C-C)	Allows for commercial areas that serve local neighborhoods.
	Regional Shopping (C-R)	Allows for large-scale shopping areas that provide goods and services to the regional population.
	Industrial (I)	Allows for industrial land uses.
VISITOR SERVING		
	Visitor Serving (VS)	Allows for visitor-serving land uses and activities.
OTHER	Parks and Open Space (P/OS)	Applies to open space lands whose primary purpose is recreation.
	Public/Quasi-Public (P/QP)	Applies to areas for public utility facilities.

Source: City of Capitola General Plan, 2019

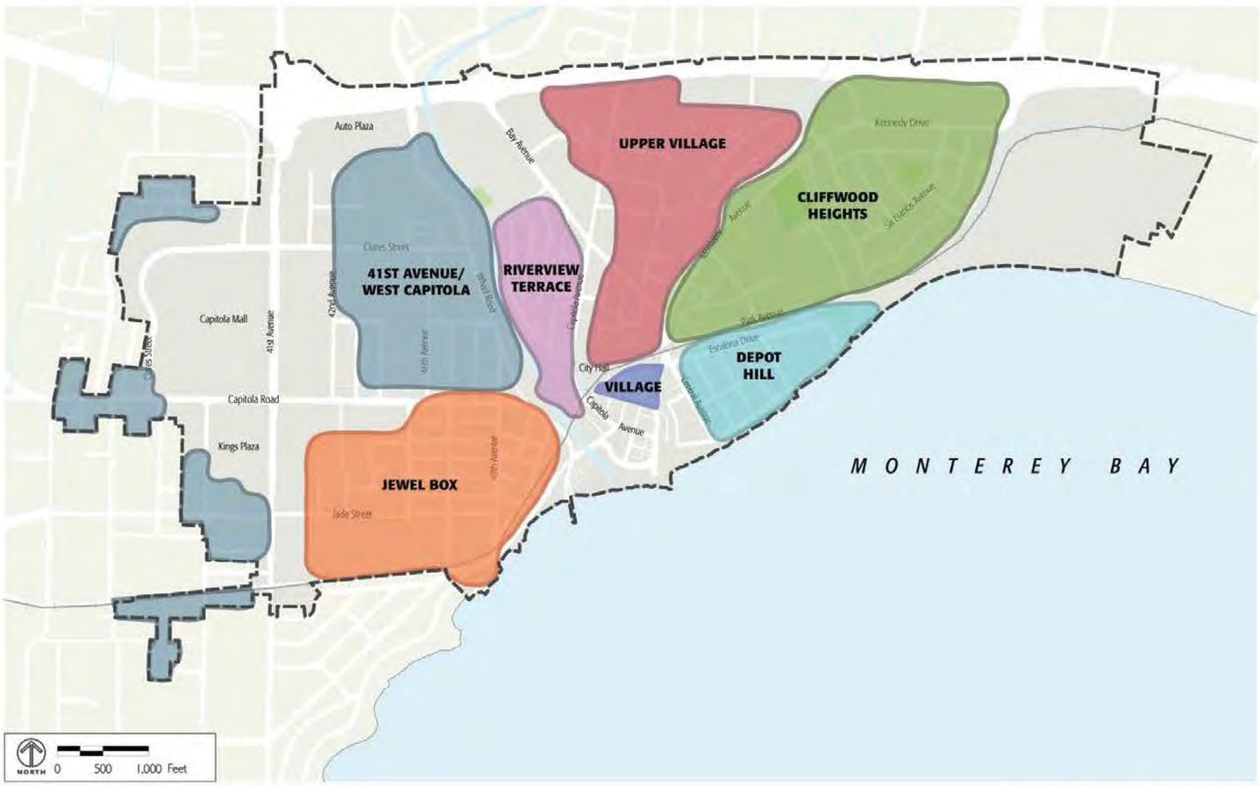
EXHIBIT 2: Land Use Map



2.6 Residential Neighborhoods

Residential uses in Capitola are grouped together in neighborhoods, each with their own special character. The general boundaries of these neighbor-hoods are shown in Exhibit 3 - Capitola Neighborhoods. Each neighborhood has a unique identity defined by its history, design character, land use mix, and natural setting.

EXHIBIT 3: Capitola Neighborhoods



Source: City of Capitola, 2010. *Neighborhood boundaries are approximate.

2.6.1 41st Avenue/West Capitola

The 41st Avenue/ West Capitola neighborhood is comprised of an assortment of detached single-family homes, multi-family housing, and three mobile home parks. The area is known by some as the "North Forties" and includes the Trotter Street area. Housing constructed in the 1970s and 1980s creates a more modern feel to the neighborhood. The Rispin property, the Shadowbrook property, and the Capitola Library are located along the eastern edge of the neighborhood.

2.6.2 Cliffwood Heights

The Cliffwood Heights neighborhood consists primarily of detached single-family homes as well as multi-family housing on Monterey Avenue and Park Avenue. Homes are typically one or two stories occupying relatively large lots. Wider streets with sidewalks and newer homes contribute to a more contemporary feel to the neighborhood. Monterey Park, Cortez Park, and New Brighton Middle School are also located within the Cliffwood Heights neighborhood.

2.6.3 Depot Hill

The Depot Hill neighborhood is nestled along Capitola's shoreline and overlooks Capitola Village. Detached single-family homes on relatively small lots create an intimate feel. A high concentration of historic single-family homes, a variety of architectural styles, and a sidewalk exemption allowance contributes to the neighborhood's coastal village feel. The Inn at Depot Hill and Monarch Cove Inn (formerly El Salto Re-sort) are located in the Depot Hill neighborhood.

2.6.4 Jewel Box

The Jewel Box neighborhood is tucked in the northerly cliff, bounded by the Prospect bluff overlooking the Wharf and Village, located south of Capitola Road and east of 41st Avenue. East of 45th Avenue detached single-family homes occupy quaint lots. Vintage beach cottages and bungalows contribute to a coastal village feel in this community. Multi-family condominiums line the west side of 45th Avenue, with lawns between buildings. The Jewel Box neighborhood includes the West Cliff neighborhood and also contains two mobile home parks, the 10-acre Jade Street Park, Opal Cliffs Elementary School, and the Jade Street Community Center; and a few commercial establishments along Capitola Road.

2.6.5 Riverview Terrace

The Riverview Terrace neighborhood is bordered by Soquel Creek, Capitola Avenue, Bay Avenue, and Center Street. The neighborhood contains a high concentration of historic homes, including many smaller cottages and bungalows. Many homes occupy small lots, with minimal setbacks and structures in close proximity to one another and the street. Narrow streets with on-street parking and no sidewalk contribute to a compact and intimate feel.

2.6.6 Upper Village

The Upper Village neighborhood contains a variety of housing types, including single-family homes, multi-family apartment complexes, and three mobile home parks. In many cases these different land uses are adjacent to or facing one another. Homes located closer to the Village tend to have a more historic and intimate character than those located closer to Highway 1.

2.6.7 Capitola Village

Capitola Village is the "heart" of Capitola and possesses the charm of an inti-mate coastal village. The Village is a true mixed-use district with a diversity of visitor-serving commercial establishments, public amenities, and residential uses. During the summer months, the Village is a popular tourist destination. Visitors are attracted by Capitola Beach, unique accommodations, and the historic village character. Village residents enjoy these amenities year round. The Village is pedestrian friendly, with human-scale architecture and a diversity of public gathering places. Capitola Village contains a high concentration of landmark destinations such as the Esplanade Park, Capitola Beach, the Six Sisters, the Venetian, and the historic Capitola Wharf.

2.7 Development Trends

The City of Capitola is largely built-out, with very little vacant land remaining for new development. The majority of future development in the City is likely to consist of extensive remodeling of existing structures or redevelopment of properties requiring demolition and replacement of existing buildings.

The Capitola City Hall contains the City's administrative departments as well as the Police Department. Across the street is the Central Fire Protection District Station No. 4. Both a portion of City Hall and the fire station are located within the FEMA 100 year flood plain.

Note no changes in development that would result in a decrease or increase in risk to the city…

2.8 Critical Facilities

As shown in Table 5: Capitola Critical Facilities List, there are 25 critical facilities in the City of Capitola. Exhibit 4 – Capitola Critical Facilities identifies their location. These include a police station, fire station, City owned properties, shelters, and other facilities that provide important services to the community. Damage to these facilities during a hazard event has the potential to impair response and recovery from the event and may lead to disruption of critical emergency services. This list includes facilities owned and operated by City or local utilities and districts, but does not include state or federal facilities, which are outside local control.

The LHMP Team identified replacement and contents values for a majority of the facilities. These represent the total potential loss value for each facility. If a facility is destroyed in a hazard event, the replacement and contents values indicate the cost to replace the facility. Typically, the cost to repair a damaged facility will be less than the replacement value. While the replacement and contents values are used throughout this plan to estimate potential losses, it is noted that the actual cost to recover from a hazard event will depend on the type and magnitude of the event.

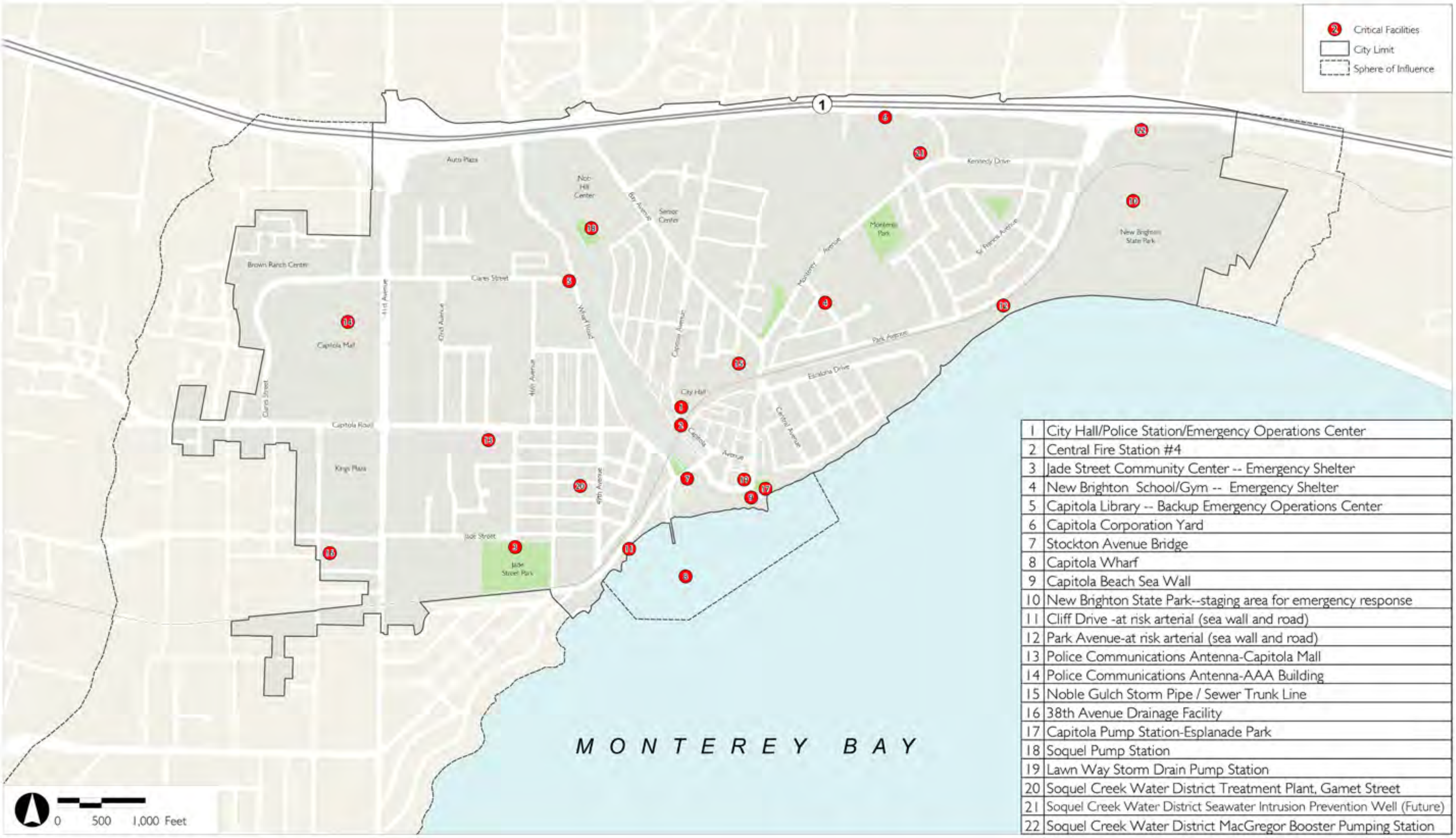
Table 6: **Capitola Critical Facilities List**

Map #	Facility	Notes	Replacement Value	Contents Value
1	City Hall/Emergency Operations Center	Steep hillside on southern portion of site	$8,000,000	$750,000
1	Capitola Police Station	Steep hillside on southern portion of site	$4,000,000	$750,000
2	Central Fire Station #4	Steep slope across Capitola Road	$3,000,000	$100,000
3	Jade Street Community Center - Emergency Shelter and Police Antenna		$3,000,000	$200,000
4	New Brighton Gym and Performing Arts Center-- Emergency Shelter		$2,500,000	$75,000
4	New Brighton School Performing Arts Center-Back-up Emergency Shelter		$4,000,000	$700,000
5	Capitola Library -- Backup Emergency Operations Center	Wharf Road in vicinity of library located adjacent to steep slope hazard area	$10,000,000	$700,000
6	Capitola Corporation Yard	Creek to the east has steep slopes, no risk	$2,000,000	$500,000
7	Stockton Avenue Bridge	Mid-span piers catch mud and debris	$10,000,000	N/A
8	Capitola Wharf		$20,000,000	$300,000
9	Capitola Beach Sea Wall		$5,000,000	N/A
10	New Brighton State Park - staging area for emergency response		N/A	N/A
11	Cliff Drive - at risk arterial (sea wall and road)		$8,000,000	N/A

Table 6: **Capitola Critical Facilities List**

Map #	Facility	Notes	Replacement Value	Contents Value
12	Park Avenue - at risk arterial (sea wall and road)		$4,000,000	N/A
13	Police Communications Antenna - Capitola Mall		$100,000	N/A
14	Police Communications Antenna-AAA Building		$100,000	N/A
15	Noble Gulch Storm Pipe		$10,000,000	N/A
16	38th Avenue Drainage Facility		$2,000,000	$300,000
17	Capitola Sewage Pump Station - Esplanade Park		$10,000,000	$800,000
18	Soquel Sewage Pump Station		$10,000,000	$1,700,000
19	Lawn Way Storm Drain Pump Station		$500,000	N/A
20	Soquel Creek Water District Treatment Plant, Garnet Street	Costs per SCWD.	$2,000,000	$700,000
21	Soquel Creek Water District Seawater Intrusion Prevention Well, Monterey Avenue	To be constructed as part of the Pure Water Soquel project.	$2,000,000	$70,000
22	Soquel Creek Water District MacGregor Booster Pumping Station		$300,000	N/A
23	Capitola Beach Flume		$2,000,000	N/A
24	Capitola Beach Jetty		$3,000,000	N/A
25	Grand Avenue Cliffs		N/A	N/A
Total Potential Losses			**$125,500,000**	**$7,645,000**

CAPITOLA CRITICAL FACILITIES
EXHIBIT 4



Source: City of Capitola, 2010; Santa Cruz County, 2010.

3 Chapter Three – Hazards Assessment

This chapter provides a detailed discussion of the potential hazards and potential risk/ vulnerability to City facilities.

3.1 Hazard Identification and Prioritization

3.1.1 Hazard Identification

Table 7: City of Capitola Hazard Identification summarizes the natural hazards and shows which were identified in the 2013 LHMP and retained in this update. Hazards that have been excluded from further consideration are shaded gray.

Table 7: **City of Capitola Hazard Identification**

Hazard	Risk	Rationale
Agricultural Pests	No	Not enough agriculture in the City to warrant a concern.
Avalanche	No	Not Applicable
Coastal Erosion / Bluff Failure	Yes	This is an event based concern as well as a long term concern, specifically because storm/sewer utility pipelines run through the bluffs.
Coastal Storm	Yes	Concerns include high surf, high tide, storm related coastal flooding from ocean and fluvial (Soquel Creek), wharf protection
Dam Failure	No	There are no levees or dams that failure would impact the City.
Drought	Yes	The City receives about 90% of its water supply from Soquel Creek Water District (SqCWD) while the remaining 10% is supplied by the City of Santa Cruz Water Department (SCWD). Both agencies are solely dependent upon local water supplies as no water is imported from outside of the area. SqCWD obtains 100% of its supply from groundwater sources, whereas the SCWD is primarily supplied by surface water sources. Both water providers are susceptible to drought and water supply shortages. While groundwater sources are generally less susceptible to seasonal drought than surface water sources, coastal groundwater levels in the area are below elevations that protect the local groundwater basin from seawater intrusion, creating a state of overdraft that is exacerbated by drought conditions.
Earthquake (Liquefaction)	Yes	Capitola is located in an area susceptible to earthquake ground shaking and liquefaction.

Hazard	Risk	Rationale
Expansive soils	No	Discussion during TAC Meeting #1 indicated some concern regarding expansive soils along Soquel Creek and other parts of the City. Mapping conducted after the meeting indicated that expansive soils are identified within the City, however no issues as a result of these soils have been reported.
Extreme Temperature	No	During the 2006 heat wave, the City of Capitola did not experience any problems. Extreme cold in the past has caused a few pipe breaks but no significant problems.
Flood	Yes	Flooding within Capitola occurs as a result of surface water runoff from the mountainous areas north and east of the City, changes in tidal elevations (high tide), local coastal storms, and surges from distant storms offshore. These sources can occur separately or in conjunction with one another increasing the magnitude of the effects.
Geological Hazards	N/A	This category may be used to group bluff erosion, earthquake, landslides, etc. in the hazard profiles.
Hailstorm	No	There has been no significant damage from previous storms. The TAC noted that thunderstorms with lightening could damage antennas used for communication, but agreed it was not a significant risk.
Hazardous Materials Spills	Yes	The majority of properties within the City containing hazardous materials are located along 41st Avenue. Additional concerns include Highway 1, railroad, oil spills, and the drinking water treatment facility in the Jewel Box area.
Hurricane	No	Not Applicable
Land Subsidence	No	Not Applicable
Landslide and Mudflow	Yes	Due to steep topography, there is a potential for landslides and mudflows to occur below Wharf Road and above Soquel Creek, which could impact the Stockton Avenue Bridge and Village.
Human Caused Hazards	No	Except for Hazardous Materials Spills, the TAC agreed the intent of this plan is to focus on natural hazard risk.
Severe Winter Storm	No	Not Applicable
Tornado	No	Tornados and water spouts are possible, but very rare. The TAC noted that a tornado occurrence could be devastating, but the probability does not warrant inclusion in this plan.
Tsunami	Yes	Due to its location along the coast, Capitola is susceptible to Tsunami inundation, which could reach as high as 30 feet depending on the location of the source. Evacuations within the City occurred as a result of the most recent tsunami event in March 2011; however, no damage occurred within the City.
Volcano	No	The City is not located within a region of active volcanism.

Hazard	Risk	Rationale
Wildfire	Yes	Concerns include: Wharf Road Corridor, New Brighton area, eucalyptus trees along the bluffs
Wind	No	Regular wind does not cause significant damage
Windstorm	Yes	During severe windstorms trees fall. Severe wind also exacerbates wildfires.
Sea Level Rise	Yes	The City is located adjacent to the Pacific Ocean and is therefore prone to the effects of seal level rise. To address this issue, the City recently participated in a sea level rise study and its potential impacts in and around Capitola, which is included as Appendix C.
Climate Change	N/A	Climate change will be considered as an exacerbation factor for all of the identified hazards.

3.1.2 Hazard Prioritization

City staff and their consultant involved in preparing the 2020 LHMP update assigned each hazard a ranking based on probability of occurrence and potential impact. These rankings were based on group discussion, knowledge of past occurrences, and familiarity with the City's infrastructure vulnerabilities. The results are presented in Table 8: Capitola Hazard Ranking Worksheet.

Table 9: Capitola Hazard Ranking Worksheet Legend provides additional detail regarding how the probability, affected area, and impact categories were weighted and how the total score was calculated.

Table 8: **Capitola Hazard Ranking Worksheet**

Hazard Type	Probability	Impact			Total Score	Hazard Planning Consideration
		Affected Area	Primary Impact	Secondary Impacts		
Earthquake (and Liquefaction)	4	4	4	4	64.00	Significant
Flood (riverine and coastal, including storm surge)	4	4	4	4	64.00	Significant
Sea Level Rise	4	1	4	4	44.80	Significant
Drought	3	4	3	3	40.80	Moderate
Windstorm	3	4	3	2	37.80	Moderate
Coastal Erosion / Bluff Failure	4	1	3	2	31.20	Moderate
Tsunami	2	2	4	4	25.60	Moderate
Hazardous Materials	2	3	3	3	24.00	Moderate
Wildfire	2	2	2	2	16.00	Moderate
Landslide and Mudflow	2	1	2	2	12.80	Moderate
Expansive soils	1	2	2	2	8.00	Limited

Table 9: **Capitola Hazard Ranking Worksheet Legend**

Probability	Importance	2.0		Secondary Impacts	Importance	0.5
Based on estimated likelihood of occurrence from historical data				Based on estimated secondary impacts to community at large		
Probability		Score		Impact		Score
Unlikely (Less than 1% probability in next 100 years or has a recurrence interval of greater than every 100 years.)		1		Negligible - no loss of function, downtime, and/or evacuations		1
Somewhat Likely (Between 1 and 10% probability in next year or has a recurrence interval of 11 to 100 years.)		2		Limited - minimal loss of function, downtime, and/or evacuations		2
Likely (Between 10 and 100% probability in next year or has a recurrence interval of 10 years or less.)		3		Moderate - some loss of function, downtime, and/or evacuations		3
Highly Likely (Near 100% probability in next year or happens every year.)		4		High - major loss of function, downtime, and/or evacuations		4
Affected Area	Importance	0.8		Total Score = Probability x Impact, where:		
Based on size of geographical area of community affected by hazard				Probability = (Probability Score x Importance)		
Affected Area		Score		Impact = (Affected Area + Primary Impact + Secondary Impacts), where:		
Isolated		1		Affected Area = Affected Area Score x Importance		
Small		2		Primary Impact = Primary Impact Score x Importance		
Medium		3		Secondary Impacts = Secondary Impacts Score x Importance		
Large		4				

Table 9: **Capitola Hazard Ranking Worksheet Legend**

Primary Impact	Importance	0.7	Hazard Planning Consideration			
Based on percentage of damage to typical facility in community			Total Score	(Range)	Distribution	Hazard Level
Impact		Score	0.0	12.0	1	Limited
Negligible - less than 10% damage		1	12.1	42.0	7	Moderate
Limited - between 10% and 25% damage		2	42.1	64.0	3	Significant
Critical - between 25% and 50% damage		3				
Catastrophic - more than 50% damage		4				

The probability of each hazard is determined by assigning a level, from unlikely to highly likely, based on the likelihood of occurrence from historical data. The total impact value includes the affected area, primary impact and secondary impact levels of each hazard. Each level's score is reflected in the matrix. The total score for each hazard is the probability score multiplied by its importance factor times the sum of the impact level scores multiplied by their importance factors. Based on this total score, the hazards are separated into three categories based on the hazard level they pose to the communities: Significant, Moderate, and Limited.

Based on this ranking exercise, the City of Capitola confirmed the identified hazards and corresponding planning considerations for this 2020 LHMP update as those listed in Table 10: Capitola Identified Hazards and Planning Considerations.

Table 10: **Capitola Identified Hazards and Planning Considerations**

Identified Hazard	Hazard Planning Consideration
Earthquake (and Liquefaction)	Significant
Coastal Storm / Flooding	Significant
Sea Level Rise	Significant
Drought	Moderate
Windstorm	Moderate
Coastal Erosion / Bluff Failure	Moderate
Tsunami	Moderate
Hazardous Materials	Moderate
Wildfire	Moderate
Landslide and Mudflow	Moderate

3.2 Climate Change Considerations

It should be noted that sea level rise was originally identified as an explicit hazard by the Technical Advisory Committee, however through follow up discussion with the HMP Team, it was determined that sea level rise is an effect associated with climate change. Since climate change also can affect other hazards within the City, the HMP Team determined that it would be best to discuss climate change considerations throughout all applicable hazard profiles.

In June of 2017, the Central Coast Wetlands Group published the City of Capitola Coastal Climate Change Vulnerability Report. This report is incorporated into this 2020 LHMP update by reference and is included as Appendix C. The evaluation provides a predictive chronology of future risks to assist with local coastal planning and foster discussions with state regulatory and funding agencies.

Climate change is a serious issue, as it affects communities in a variety of ways. For the City of Capitola, climate change can result in a multitude of impacts and potentially exacerbate existing natural and human caused hazards or create new hazards. To address potential climate change impacts, the City of Capitola has identified climate change considerations within each hazard profile in this Plan. These considerations deal with issues such as sea level rise, changing weather patterns and precipitation regimes, coastal storms, flooding, and other hazards that could be exacerbated by these changing conditions. Within each hazard profile, the City has provided a discussion of some of the potential impacts that could be a result of climate change. This discussion is intended to supplement, but not replace, the Probability of Future Occurrence discussion.

3.3 Vulnerability/Risk Assessment Methodology[1]

The critical facilities listed in the section above were mapped in GIS and overlaid with mapped hazard areas to determine which assets are located within each hazard area. Hazard area and critical facility overlays were

[1] All GIS data used in the vulnerability analyses profiled in Section 3.3 was provided by the City of Capitola, County of Santa Cruz or applicable State or Federal Agency.

conducted for flood, beach erosion, cliff erosion, liquefaction, landslide/mudslide (slope), and tsunami. For hazardous materials, it was determined which critical assets are located within 500 and 1,000 feet of a hazardous materials site.

Hazard and critical facility overlays were not conducted for wildfire, windstorm, drought, and earthquake. Per Santa Cruz County fire hazard maps, there are no fire hazard areas located in the City of Capitola. Windstorms affect the entire City and therefore all facilities listed in the critical facility inventory could be potentially susceptible to damage from a windstorm. Drought does not inflict physical damage on Capitola's critical assets; however, residents could be impacted by potential restrictions from the two water districts. 90% of the City's water supply is provided by the Soquel Creek Water District, which, although supplied by groundwater and less susceptible to seasonal drought, is susceptible to overdraft. The remaining 10% of the water supply is provided by the City of Santa Cruz Water Department, which is supplied by surface water and is susceptible to seasonal drought. There are no fault zones that fall within the City of Capitola and therefore an overlay was not conducted for earthquake.

Each hazard profile in the section below includes a Vulnerability/Risk Assessment section that presents the results of the methodology described above. Replacement and contents values for the facilities that fall within the hazard areas are tallied in each vulnerability table to estimate the total potential losses to each hazard. It should be noted that the actual losses will depend on the type and extent of the hazard event.

Combined coastal climate change hazards were based on findings as described in the City of Capitola Coastal Change Vulnerability Report, June 2017, which is incorporated in this LHMP update and included as Appendix C.

A comprehensive list of facilities and the hazard areas they fall within can be found in Appendix A – Critical Facilities Inventory.

3.4 Hazard Profiles

The following are profiles of the hazards identified for the City of Capitola. The profiles include a vulnerability analysis and risk assessment using the methodologies described in the Vulnerability/ Risk Assessment Section above.

3.4.1 Geologic Hazards (Earthquake and Liquefaction)

Identifying Earthquake and Liquefaction Hazards

An earthquake is a sudden release of energy in the earth's crust. Caused by movement along fault lines, earthquakes vary in size and severity. The focus of an earthquake is found at the first point of movement along the fault line (which may be beneath the surface), and the epicenter is the corresponding point above the focus at the earth's surface.

Damage from an earthquake varies with the local geological conditions, the quality of construction, the energy released by the earthquake, the distance from the earthquake's focus, and the type of faulting that generates the earthquake. Earthquake related hazards include primary impacts (fault rupture and ground shaking) and secondary impacts (liquefaction). This hazard profile will discuss ground shaking and liquefaction, since these are the two most likely impacts anticipated as a result of an earthquake.

Ground Shaking: Ground motion/shaking is the primary cause of damage and injury during earthquakes and can result in surface rupture, liquefaction, landslides, lateral spreading, differential settlement, tsunamis, building and infrastructure failure, which could lead to fire and other collateral damage. Typically, areas underlain by thick, water-saturated, unconsolidated material will experience greater shaking motion than areas underlain by firm bedrock, but, in some cases, topographic relief may intensify shaking along ridge tops, where landslides may develop.

Fires and structural failure are the most hazardous results of ground shaking. Most earthquake-induced fires start because of ruptured power lines and gas lines or electrically powered stoves and equipment. Structural failure is generally a result of age, quality, and type of building construction.

Liquefaction: Liquefaction is the transformation of loose, water-saturated granular materials (such as sand and silt) from a solid to a liquid state. This results in the loss of soil strength and the soil's ability to support weight. Buildings and their occupants are at risk when the ground can no longer support these buildings and structures.

Profiling Earthquake and Liquefaction Hazards

Location

Capitola is located in one of the most seismically active areas of the country. Significant earthquakes occur along well-defined, active fault zones that trend northwesterly. The regional faults of significance potentially affecting Capitola include the San Andreas, the Zayante, and the Palo Colorado-San Gregorio faults. The most probable seismic hazards to Capitola are from the San Andreas Fault (in the Santa Cruz Mountains) and, further south, the Palo Colorado-San Gregorio fault as shown in Exhibit 5 - Active Fault Zones.

The main trace of the San Andreas Fault is approximately nine miles northeast of Capitola. One of the largest local earthquakes in recent history occurred on October 17, 1989 due to movement on this fault (Loma Prieta Earthquake) and measured 7.1 on the Richter scale.

The Zayante fault is located approximately five miles northeast of Capitola, and the Palo Colorado-San Gregorio is located 14 miles southwest of Capitola. The California Geologic Survey considers the Zayante fault active, although it has not caused any significant earthquakes historically, only some aftershocks after the Loma Prieta earthquake. The Palo Colorado-San Gregorio fault is not well understood, but is considered potentially active with an estimated maximum credible magnitude of 7.7 and a recurrence level of 800+ years (City of Capitola General Plan White Paper #4 Environmental Resources & Hazards, 2011).

Liquefaction can also occur in Capitola. Exhibit 6: Liquefaction Potential shows the liquefaction potential in Capitola. Significant portions of Capitola have either High or Very High potential for liquefaction. These areas are generally located along the alignment of drainage courses like Soquel Creek, Noble Gulch and Tannery Gulch. More specifically, areas determined to have a Very High potential include the northern end of Bay Avenue, including Highway 1/Bay Avenue/Porter Avenue interchange, and a large portion of Capitola Village. Areas determined to have a High potential include the residential and commercial areas along the southern portion of Bay Avenue and along Capitola Avenue.

Extent of Earthquake

The size and magnitude (M) of an earthquake is measured in various ways. The Richter scale determines the amount of ground displacement or shaking that occurs near the epicenter. This scale is shown in Table 11: Richter Scale.

Another scale, the Moment Magnitude scale, measures the magnitude of medium and large sized earthquakes by characterizing the amount of energy released by the earthquake. The magnitude is based on the seismic moment of the earthquake, which is equal to the rigidity of the Earth multiplied by the average amount of slip on the fault and the size of the area that slipped. (USGS, Glossary of Terms on Earthquake Maps) The Modified Mercalli Intensity Scale measures ground shaking intensity in terms of perception and damage and takes into account localized earthquake effects. This scale is shown in Table 12: Modified Mercalli Intensity Scale for Earthquakes.

Table 11: **Richter Scale**

Richter Magnitudes (M)	Earthquake Effects
Less than 3.5	Generally not felt, but recorded.
3.5-5.4	Often felt, but rarely causes damage.
Under 6.0	At most slight damage to well-designed buildings. Can cause major damage to poorly constructed buildings over small regions.
6.1-6.9	Can be destructive in areas up to about 100 kilometers across where people live.
7.0-7.9	Major earthquake. Can cause serious damage over larger areas.
8 or greater	Great earthquake. Can cause serious damage in areas several hundred kilometers across.

Table 12: **Modified Mercalli Intensity Scale for Earthquakes**

Scale	Intensity	Earthquake Effects	Corresponding Richter Scale Magnitude
I	Instrumental	Detected only on seismographs	
II	Feeble	Some people feel it	<4.2
III	Slight	Felt by people resting; like a truck rumbling by	
IV	Moderate	Felt by people walking	
V	Slightly Strong	Sleepers awake; church bells ring	<4.8
VI	Strong	Trees sway; suspended objects swing; objects fall off shelves	<5.4
VII	Very Strong	Mild Alarm; walls crack; plaster falls	<6.1
VIII	Destructive	Moving cars uncontrollable; masonry fractures; poorly constructed buildings damaged	

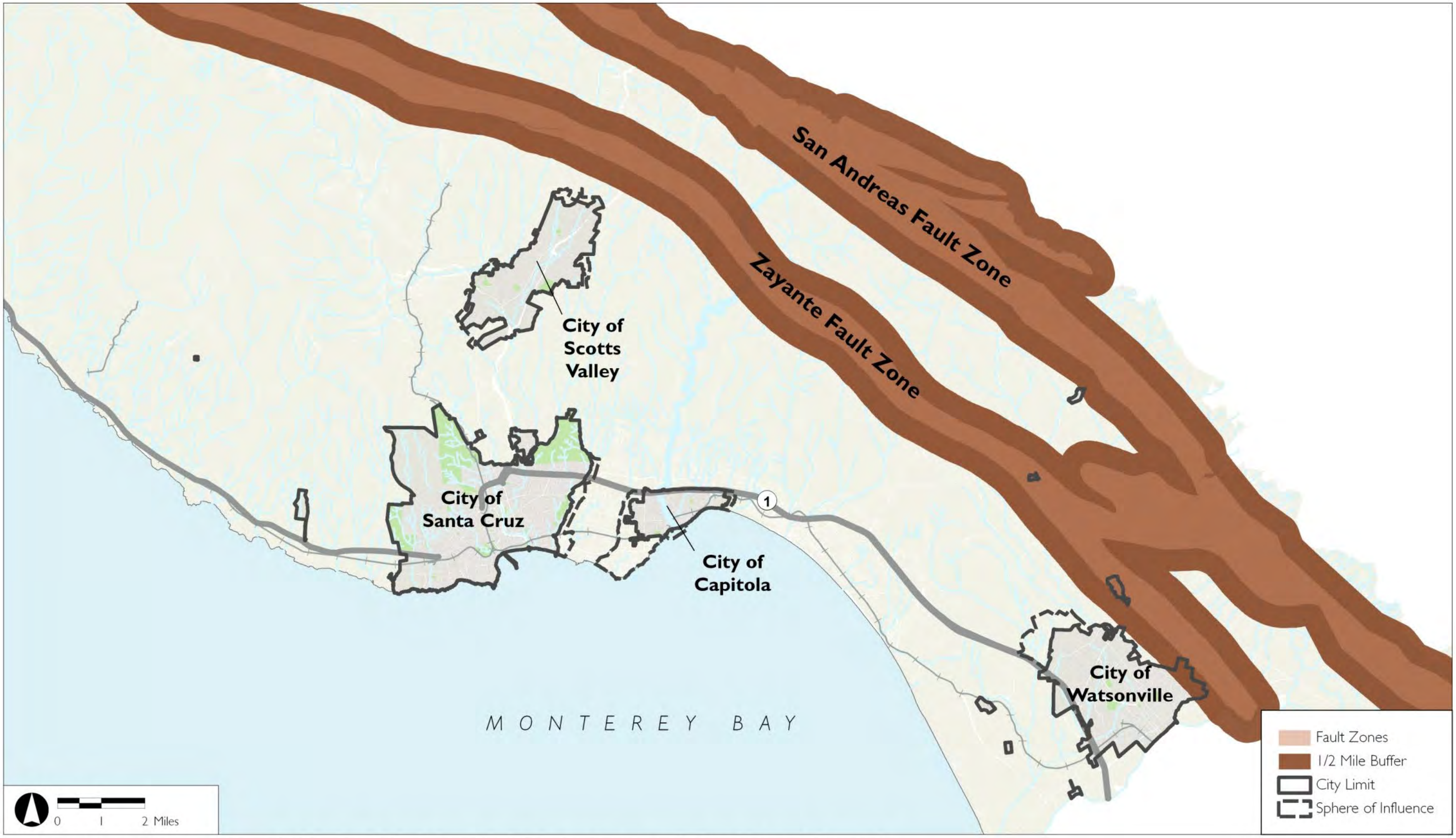
Table 12: **Modified Mercalli Intensity Scale for Earthquakes**

Scale	Intensity	Earthquake Effects	Corresponding Richter Scale Magnitude
IX	Ruinous	Some houses collapse; ground cracks; pipes break open	<6.9
X	Disastrous	Ground cracks profusely; many buildings destroyed; liquefaction and landslides widespread	<7.3
XI	Very Disastrous	Most buildings and bridges collapse; roads, railways, pipes and cables destroyed; general triggering of other hazards	<8.1
XII	Catastrophic	Total destruction; trees fall; ground rises and falls in waves	>8.1

Seismic historical records of Capitola show that earthquakes of 6.5 – 7.0 M occur periodically on the San Andreas Fault (City of Capitola General Plan White Paper #4 Environmental Resources & Hazards, 2011). The San Andreas Fault zone poses the most significant threat to Santa Cruz County and to the City of Capitola. Based on records from the 1906 San Francisco earthquake, it is estimated that the maximum credible earthquake likely to occur on the San Andreas Fault would equal 8.3 M on the Richter scale, which represents more than 30 times the energy released by the 1989 Loma Prieta Earthquake. Santa Cruz County was one of the hardest hit counties during that earthquake.

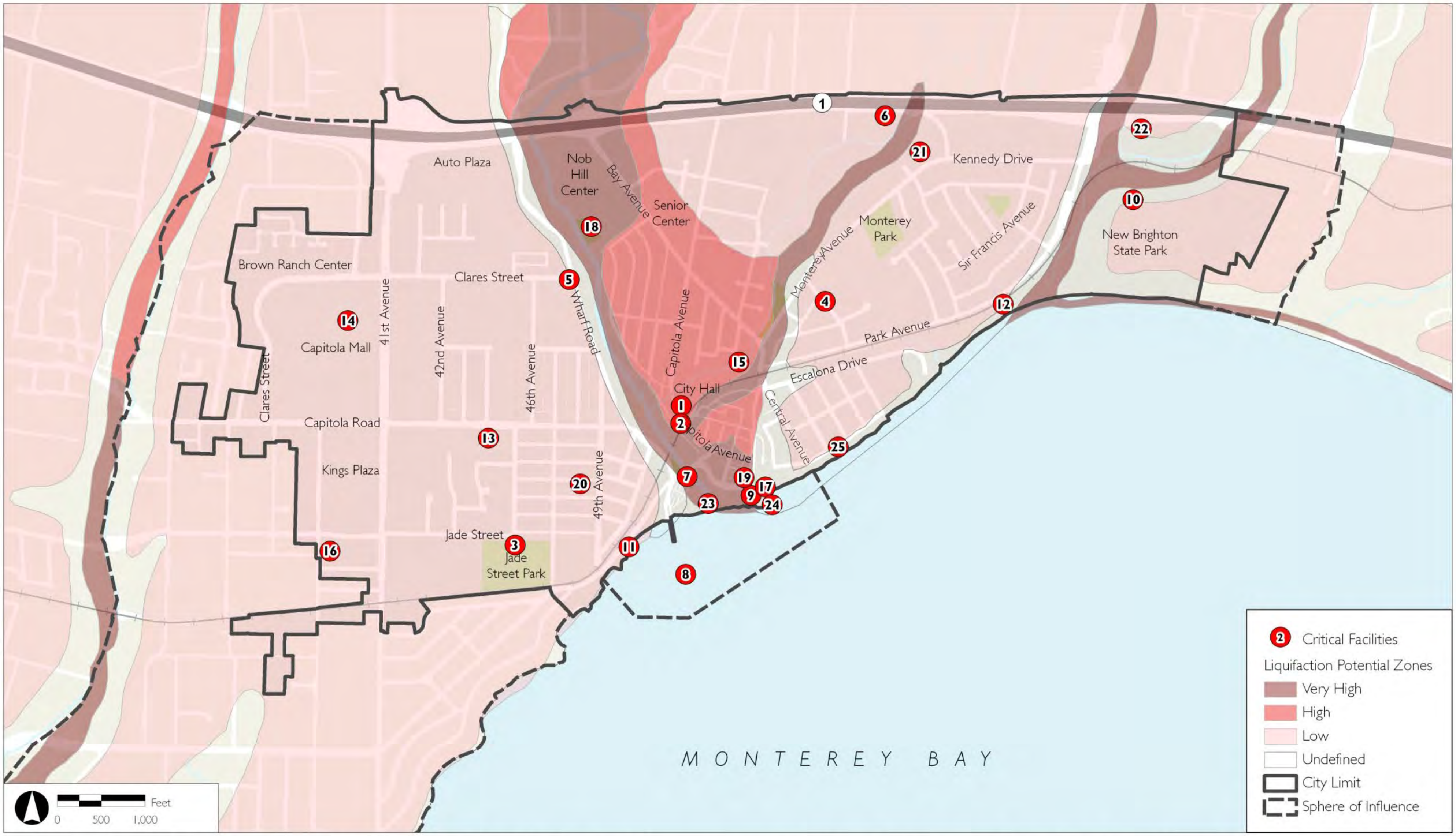
ACTIVE FAULT ZONES

EXHIBIT 5



Source: City of Capitola, 2010; Santa Cruz County, 2010; Hazards. "Fault Zones." [shapefile]. (2012). Santa Cruz County Geographic Information System File Download Site. Available at <http://sccftpmap.co.santa-cruz.ca.us/File%20Download%20Site/Hazards/Shapefiles/Hazards.zip>, Downloaded: February 1, 2012.

LIQUEFACTION POTENTIAL
EXHIBIT 6



Source: City of Capitola, 2010; Santa Cruz County, 2010; Hazards. "Liquifaction." [shapefile]. (2009) Available at <http://sccftpmap.co.santa-cruz.ca.us/File%20Download%20Site/Hazards/Shapefiles/Hazards.zip>, Downloaded: January 29, 2011.

Extent of Liquefaction

Areas within Capitola that have a High and Very High potential for liquefaction (as identified on Exhibit 6) would be the primary areas affected by liquefaction during an earthquake event. In addition, other areas within the City that experience shallow groundwater conditions (less than 50 feet beneath the ground surface [bgs]) may also be susceptible to liquefaction if loose unconsolidated materials are located beneath the surface within these areas.

Past Occurrences - Earthquake

While Santa Cruz County has sustained numerous earthquakes throughout history, the two most destructive incidents were the 1906 San Francisco earthquake and the 1989 Loma Prieta earthquake. Table 13 Historical Earthquake Events summarizes historical records collected by the City of Capitola Historical Museum.

Table 13: **Historical Earthquake Events**

Date	Time	Impact/Property Damage
January 9, 1857		Three earthquakes struck the Santa Cruz vicinity in a series. The tower and a portion of the Santa Cruz Mission Church collapsed.
August 1, 1863		Described as "severe shock"
October 8, 1865		Unknown
October 25, 1868		"Second only to October 1865"
July 1, 1882		Worst since 1868
March 1883		Severe shock with several aftershocks recorded. No damaged listed for Capitola.
September 18, 1888		Described as extremely severe.
1906	5:12am	Nine men killed in mudslide at the Loma Prieta mill above Soquel; surge on local creeks; water pipes broken; chimneys and walls cracked. Splits in the earth. Magnitude 8.3.
October 28, 1926		Damage recorded in Capitola
April 15, 1941		Santa Cruz epicenter. No damage.
June 2, 1941		Sharp jolt
April 15, 1954		Falling plaster, broken chimneys, shattered dishes
January 16, 1980		Epicenter of 3.6 magnitude quake in Corralitos
October 17, 1989	5:04pm, Duration: 15 seconds	6.9 magnitude earthquake, epicenter 3 miles north of Aptos. Comparatively, damage to Capitola homes and businesses was not severe. Within the city, no buildings immediately collapsed and no one was injured physically. Damage countywide ultimately estimated to be about $1 billion.

The events described below were all recorded by a seismic recorder at the Capitola Fire Station.

San Francisco Earthquake: April 18, 1906 - Magnitude 8.3, Intensity Viii-Xiii, occurred 91.1 miles away from City center – The earthquake was felt from southern Oregon to south of Los Angeles and inland as far as central Nevada. There were no recorded deaths in Santa Cruz but the old courthouse partially collapsed and approximately 1/3 of the chimneys within the city of Santa Cruz were destroyed or damaged. Landslides were observed throughout the Santa Cruz Mountains, and fault rupture was nearly continuous along the San Andreas

Fault zone, and nearby fault zones in the county of Santa Cruz. Infrastructure was destroyed and broken water mains and pipes shut off water supply in many areas.

Monterey Bay Earthquake: October 1926 - Magnitude 6.1 – Two large earthquakes caused considerable damage in the Monterey Bay region. The first shock was severe at Santa Cruz, where many chimneys were knocked down, and old brick buildings sustained damage.

Coyote Lake Earthquake: August 6, 1979 - Magnitude 5.9, Intensity VI-VII, occurred 20.7 miles away from City center – Felt from approximately 37 miles north of Bakersfield, north to Sacramento, east to the Pacific Ocean.

Livermore Earthquake: January 24, 1980 - Magnitude 5.9, occurred 52.5 miles from City center – The earthquake injured 44 people and caused an estimated $11.5 million in property damage. The shock was associated with surface rupture along the Greenville fault. It was felt over a large area of central California and a few towns in western Nevada.

Morgan Hill Earthquake: April 24, 1984 - Magnitude 6.2, Intensity VII-IX, occurred 26.5 miles from City center – Damage from the earthquake estimated at 7.5 million dollars. The earthquake was felt from Bakersfield to Sacramento and from San Francisco to Reno.

Unnamed Earthquake: June 27, 1988: Magnitude 5.9, occurred 11.4 miles from City center

Loma Prieta Earthquake: October 17, 1989 - Magnitude 7.1 occurred 5 miles from City Center (see Figure 2) – This major earthquake caused 63 deaths, 3,757 injuries, and an estimated $6 billion in property damage statewide. It was the largest earthquake to occur on the San Andreas Fault since the San Francisco earthquake in April 1906. Communities sustaining heavy damage in the epicentral area included Los Gatos, Santa Cruz, and Watsonville. Liquefaction occurred as far as 110 kilometers from the epicenter and contributed to significant property damage in the Santa Cruz and Monterey Bay area. The severe shaking near Santa Cruz caused heavy damage to the unreinforced masonry buildings in that area. Most of the landslides and rockfalls that occurred as a result of the earthquake occurred in the Santa Cruz Mountains. Shaking from this earthquake was felt throughout Capitola and resulting damage varied from minor structural damage and window and chimney breakage throughout the city. The most extensive damage in the city occurred in mobile home parks where coaches were knocked off their foundations disrupting gas and water services. Figure 3 shows what the City of

Figure 2 - Loma Prieta Earthquake

Capitola looked like just minutes after the earthquake occurred. As seen in the photo a significant amount of dust was generated as a result of the shaking.

Figure 3 - Dust Generated from the Loma Prieta Earthquake (ca. 1989)

San Juan Bautista Earthquake: August 12, 1998 – Magnitude 5.0 – Earthquake occurred on the San Andreas Fault, 12 kilometers southeast of San Juan Bautista.

Gilroy Earthquake: May 13, 2002 – Magnitude 4.9

Parkfield Earthquake: September 28, 2004 – Magnitude 6.0 – Earthquake occurred on the San Andreas Fault. It ruptured roughly the same segment of the fault that broke in 1966. Strong shaking lasted for about 10 seconds.

Alum Rock Area Earthquake: October 30, 2007 – Magnitude 5.6. This was the last significant earthquake before 2020 to occur

Past Occurrences - Liquefaction

Prior instances of liquefaction have not occurred or have been extremely isolated within the City of Capitola.

Probability of Future Occurrence

There are at least six major faults and fault systems within or near Santa Cruz County and the City of Capitola, placing both locations in an area of high seismic risk. Earthquakes can cause severe damage over a long distance and, therefore, Santa Cruz County and Capitola remain at risk from seismic activity along the faults in the greater San Francisco Bay area. The reduction of seismic stresses that occurred in the Loma Prieta earthquake did nothing to relieve, and possibly increased, stresses along other faults, including other sections of the San Andreas Fault.

To clarify the extent of future earthquake risk, a partnership between the United States Geological Survey, California Geologic Survey, and Southern California Earthquake Center was formed in September 2004 to provide a uniform forecast. Known as the Working Group on California Earthquake Probabilities, this group evaluated and systemized currently available historic and paleoseismic information to produce a probabilistic seismic hazards analysis to indicate the type of future earthquakes. One product of this analysis is a method of estimating the probability of ground shaking, which is illustrated in Table 14: Ten Most Likely Damaging Earthquake Scenarios. The 30-year probability of an M ≥ 6.7 earthquake on the northern segment of the San Andreas Fault is 21% and on the San Gregorio Fault is 6%. Other faults within the region can also cause damage in the county, including the Hayward-Rogers Creek Fault that has a 31% probability of having a M ≥ 6.7 earthquake in the next thirty years.

Because the ten most likely future earthquakes in the Bay area occur on faults throughout the region, the impact and potential losses reported here reveal significant risk for the entire San Francisco Bay area region including Santa Cruz County and the City of Capitola.

The probability that liquefaction will occur in the future in Capitola is dependent on many factors including the intensity of ground shaking, location of the earthquake, and subsurface conditions (including groundwater elevation). For those areas of the City identified with a High and Very High liquefaction potential, it should be anticipated that potential damage could occur under anticipated future earthquakes.

Table 14: **Ten Most Likely Damaging Earthquake Scenarios**

Earthquake Fault	30-year probability	Magnitude
Rodgers Creek	15.2%	7.0
Northern Calaveras	12.4%	6.8
Southern Hayward (possible repeat of 1868 EQ)	11.3%	6.7
Northern + Southern Hayward	8.5%	6.9
Mt. Diablo	7.5%	6.7
Green Valley –Concord	6.0%	6.7
San Andreas: Entire N. CA Segment (possible repeat of 1906 EQ)	4.7%	7.9
San Andreas: Peninsula Segment (possible repeat of 1838 EQ)	4.4%	7.2
Northern San Gregorio segment	3.9%	7.2
San Andreas: Peninsula + Santa Cruz segment	3.5%	7.4

Climate Change Considerations

As climate change occurs, it is anticipated that changes to precipitation regimes and hydrological patterns would result. Since liquefaction is dependent on the presence of shallow subsurface water, an increase in groundwater levels could occur due to increased precipitation, as well as sea-level rise, which is anticipated to inundate low lying coastal areas within Capitola. The potential increase in shallow subsurface water conditions could expand the potential liquefiable areas within the City, increasing the risk of future damage to structures within the City.

Vulnerability/Risk Assessment

While Capitola remains a seismically active area, there are no active earthquake faults located within the City limits. Therefore, an overlay analysis between the earthquake faults and the City's critical facilities was not conducted. However, given the proximity to active faults, it is anticipated that a seismic event will produce intense shaking that could impact the entire community's population and systems. Depending on the intensity of shaking and location of the earthquake epicenter, buildings, structures, roadways, and utility systems (i.e. water lines, sewer lines, power lines, and storm drains) could be damaged. It is difficult to identify specific areas within the City that may be more vulnerable than others as a result of this impact. Based on this, it is assumed that all areas are equally vulnerable as a result of seismic impact.

Based on the extent of liquefaction potential zones within the City (Exhibit 6) and the location of critical facilities (depicted on Exhibit 6), Table 15: Capitola Critical Facilities Located in a Liquefaction Potential Zone identifies the critical facilities that fall within each zone of liquefaction potential, ranging from low to very high and the financial implications of their loss. Those areas where liquefaction potential is unknown is determined to be "Undefined".

It is expected that a liquefaction event would most likely impact facilities within the "Very High" potential zone. If all of the facilities in that zone are completely destroyed the loss would amount to $27,500,000. A liquefaction event impacting facilities in the "High" potential zone could result in a total loss of $22,000,000. While it is unlikely that an event would impact facilities in the low liquefaction potential zones and the undefined liquefaction areas, a rare, large, catastrophic event could impact facilities within all liquefaction zones. The total potential losses for an event of this scale are estimated to be a total of $125,500,000.

The extent of the liquefaction potential layer did not allow for the intersection of the Capitola Wharf location. However, given the proximity to water and similar characteristics to other areas of high liquefaction potential within the City, it is assumed that liquefaction could occur in the vicinity of this location.

Table 15: **Capitola Critical Facilities Located in a Liquefaction Potential Zone**

Map #	Facility	Very High (A)	High (B)	Low (D)	Undefined (Unkn)	Replacement Value	Contents Value	Potential Loss
1	City Hall/Emergency Operations Center		X			$8,000,000	$750,000	$8,750,000
1	Capitola Police Station		X			$4,000,000	$750,000	$4,750,000
2	Central Fire Station #4		X			$3,000,000	$100,000	$3,100,000
3	Jade Street Community Center -- Emergency Shelter			X		$3,000,000	$200,000	$3,200,000
4	New Brighton Gym -- Emergency Shelter			X		$2,500,000	$75,000	$2,575,000
4	New Brighton School -- Back-up Emergency Shelter			X		$4,000,000	$700,000	$4,700,000
5	Capitola Library -- Backup Emergency Operations Center			X		$10,000,000	$700,000	$10,700,000
6	Capitola Corporation Yard			X		$2,000,000	$500,000	$2,500,000
7	Stockton Avenue Bridge	X				$10,000,000	N/A	$10,000,000
8	Capitola Wharf	Outside of Hazard layer extent				$20,000,000	$300,000	$20,300,000
9	Capitola Beach Sea Wall	X				$5,000,000	N/A	$5,000,000
10	New Brighton State Park--staging area for emergency response		X	X	X	N/A	N/A	N/A

Table 15: **Capitola Critical Facilities Located in a Liquefaction Potential Zone**

Map #	Facility	Very High (A)	High (B)	Low (D)	Undefined (Unkn)	Replacement Value	Contents Value	Potential Loss
11	Cliff Drive -at risk arterial (sea wall and road)			X		$8,000,000	N/A	$8,000,000
12	Park Avenue-at risk arterial (sea wall and road)			X		$4,000,000	N/A	$4,000,000
13	Police Communications Antenna-Capitola Mall			X		$100,000	N/A	$100,000
14	Police Communications Antenna-AAA Building			X		$100,000	N/A	$100,000
15	Noble Gulch Storm Pipe		X			$10,000,000	N/A	$10,000,000
16	38th Avenue Drainage Facility			X		$2,000,000	$300,000	$2,300,000
17	Capitola Pump Station-Esplanade Park				X	$10,000,000	$800,000	$10,800,000
18	Soquel Pump Station	X				$10,000,000	$1,700,000	$11,700,000
19	Lawn Way Storm Drain Pump Station	X				$500,000	N/A	$500,000
20	Soquel Creek Water District Treatment Plant, Garnet Street			X		$2,000,000	$700,000	$2,700,000
21	Soquel Creek Water District Seawater Intrusion Prevention Well, Monterey Avenue			X		$2,000,000	$70,000	$2,070,000
22	Soquel Creek Water District MacGregor Booster Pumping Station			X		$300,000	N/A	$300,000
23	Capitola Beach Flume	X				$2,000,000	N/A	$2,000,000

Table 15: **Capitola Critical Facilities Located in a Liquefaction Potential Zone**

Map #	Facility	Very High (A)	High (B)	Low (D)	Undefined (Unkn)	Replacement Value	Contents Value	Potential Loss
24	Capitola Beach Jetty				X	$3,000,000	N/A	$3,000,000
25	Grand Avenue Cliffs				X	N/A	N/A	N/A
	Total Potential Losses					$125,500,000	$7,645,000	$133,145,000

3.4.2 Coastal Storm/ Flooding

Identifying Coastal Storm and Flooding Hazards

Flooding and coastal storms present similar risks and are usually related types of hazards in Capitola. Coastal storms can cause increases in tidal elevations (called storm surge), wind speed, coastal erosion, and debris flows, as well as flooding.

Coastal storms are generated in the Pacific Ocean and, as they rise over the mountain and ridges that border the eastern boundaries of Santa Cruz County, the air associated with these storms cools, resulting in large amounts of precipitation. The topography of the County provides fairly steep and well defined watershed areas to funnel the falling rain into runoff tributaries. Periods of heavy rainfall are common during fall and winter months causing Soquel Creek, the major drainage course through Capitola, and its tributaries to rise.

During a flood, excess water from rainfall or storm surge accumulates and overflows onto stream banks, beaches, and adjacent floodplains (as illustrated in Figure 4). Floodplains are lowlands adjacent to rivers, lakes, and oceans that are subject to recurring floods. Several factors determine the severity of floods, including rainfall intensity and duration; creek and storm drain system capacity, and the infiltration rate of the ground.

Figure 4 - Flooding Along Soquel Creek Northwest of the Capitola Village (ca. 1996)

A flood occurs when a waterway receives a discharge greater than its conveyance capacity. Floods may result from intense rainfall, localized drainage problems, tsunamis or failure of flood control or water supply structures such as culverts, levees, dams or reservoirs. Floods usually occur in relation to precipitation. Flood severity is determined by the quantity and rate at which water enters the waterway, increasing volume and velocity of water flow. The rate of surface runoff, the major component of flood severity, is influenced by the topography of the region as well as the extent to which ground soil allows for infiltration in addition to the percent of impervious surfaces.

Floodwaters can carry large objects downstream with a force strong enough to destroy stationary structures such as homes and bridges and break utility lines. Floodwaters also saturate materials and earth resulting in the instability, collapse, and destruction of structures as well as the loss of human life.

3.4.3 Profiling Coastal Storm/ Flood Hazards

Location

Capitola Wharf: The Capitola Wharf is located in Monterey Bay and serves as a tourist attraction within Capitola Village. The wharf has a long history within the City, first founded in 1857. The current Capitola Wharf (Figure 5) was constructed in the 1980's following storm damage. It is an 855 foot long structure that contains a bait shop, restaurant, restroom facilities, and free fishing. This wharf is particularly vulnerable to coastal storms.

Figure 5 - View of Capitola Wharf looking South (ca. 2012)

Soquel Creek Watershed: Capitola is located in the lower reaches of the Soquel Creek Watershed, which is located between the cities of Santa Cruz and Watsonville. The Soquel Creek watershed drains an area of approximately 42 square miles. Major tributaries include the West Branch (Burns, Laurel, Hester Creek, Amaya Creek, Fern Gulch, Ashbury Gulch, and Hinkley Creek) and the Main Branch (Moore's Gulch, Grover Gulch, Love Creek, and Bate's Creek). Other tributaries include Noble Gulch, Porter Gulch, Tannery Gulch and Borregas Creek. Principal land use in the watershed includes urban development, rural residential development, agriculture, parks and recreation, and mining and timber harvesting. The Village, a cultural and business center in Capitola, is located at the terminus of Soquel Creek, where it enters the Pacific Ocean. Storm events can result in a significant amount of vegetation debris, which can get blocked at the Stockton Bridge and further exacerbate flood conditions.

Noble Gulch: Noble Gulch is a significant drainage that flows into Soquel Creek at the Capitola Village. Starting in the 1920's, the last 2,000 feet of the Gulch (west of Bay Avenue) was diverted via a 72-inch drainage pipe that extends under the current Pacific Cove Mobile Home Park. During a heavy storm in March 2011, high storm flows in Noble Gulch broke a 72 inch storm drain resulting in flood waters damaging the mobile home park and downstream properties. More information about this event is provided in the *Past Occurrences* section below.

FEMA Special Flood Hazard Area Map: Exhibit 7 - Flood Hazard Zones identifies the 100 and 500 year floodplains as identified by FEMA. The entire stretch of Soquel Creek (within the City limits) and a portion of Noble Gulch creek are located within the 100-year flood zone, which is generally narrow and follows the flow path of the main channel.

Extent

Exhibit 7 identifies the special flood hazard areas within the City of Capitola. These areas are subject to the 100 year flood (1 percent annual chance flood event), 500 year flood (.2 percent annual chance flood event), and coastal flooding (1 percent annual chance flood event with additional hazards associated with storm-induced waves). The TAC noted that occasionally waves from coastal storms do surpass the seawall built in the 1980s, which can cause localized flooding in the Capitola Village. Table 16: FEMA Flood Zones provides definitions of the FEMA Special Flood Hazard Area Zones delineated on Flood Insurance Rate Maps (FIRMs).

Table 16: **FEMA Flood Zones**

Annual Probability of Flooding of 1% or greater (100 Year Flood Zones)	
A	Subject to 100-year flood. Base flood elevation undetermined.
AE or A1-A30	Both AE and A1-A30 represent areas subject to 100-year flood with base flood elevation determined.
AH	Subject to 100-year shallow flooding (usually areas of ponding) with average depth of 1-3 feet. Base flood elevation determined.
AO	Subject to 100-year shallow flooding (usually sheet flow on sloping terrain) with average depth of 1-3 feet. Base flood elevation undetermined.
V	Subject to 100-year flood and additional velocity hazard (wave action). Base flood elevation undetermined.
VE or V1-V30	Both VE and V1-V30 represent areas subject to 100-year flood and additional velocity hazard (wave action). Base flood elevation determined.
Annual Probability of Flooding of 0.2% to 1% (500 Year Flood Zone)	
B or X500	Both B and X500 represent areas between the limits of the 100-year and 500-year flood; or certain areas subject to 100-year flood with average depths less than 1 foot or where the contributing drainage area is less than 1 square mile; or areas protected by levees from the 100-year flood.
Annual Probability of Flooding of Less than 0.2%	
C or X	Both C and X represent areas outside the 500-year flood plain with less than 0.2% annual probability of flooding.
Annual Probability of Flooding of Less than 1%	
No SFHA	Areas outside a "Special Flood Hazard Area" (or 100-year flood plain). Can include areas inundated by 0.2% annual chance flooding; areas inundated by 1% annual chance flooding with average depths of less than 1 foot or with drainage areas less than 1 square mile; areas protected by levees from 1% annual chance flooding; or areas outside the 1% and 0.2% annual chance floodplains.

The potential extent of flooding from Soquel Creek is quantified using the scale depicted in Figure 6. This scale illustrates stage level (water elevation within the creek) and the corresponding stage category (base flow, watch, monitor, flood warning) on the left hand side and past events (included measured flood depth) on the right hand side. Seven events in the past 30 years have exceeded a five year flood event, triggering a flood warning stage along Soquel Creek. Information regarding historic flooding events, including flood depth, are described in the Past Occurrences section of this hazard profile.

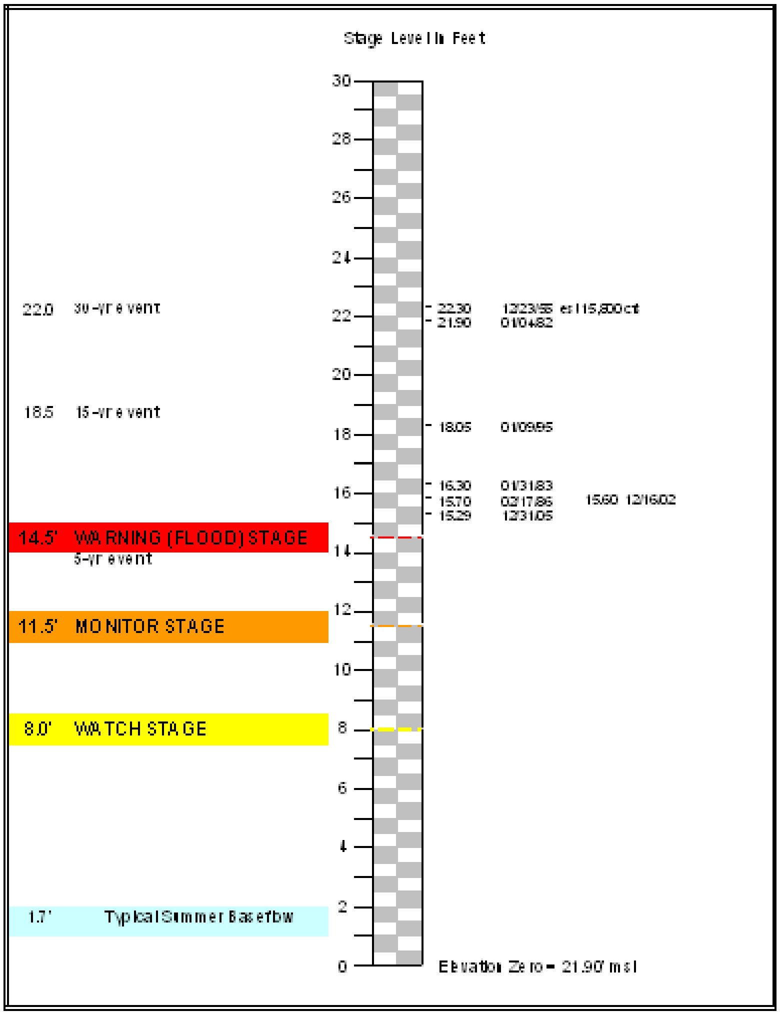
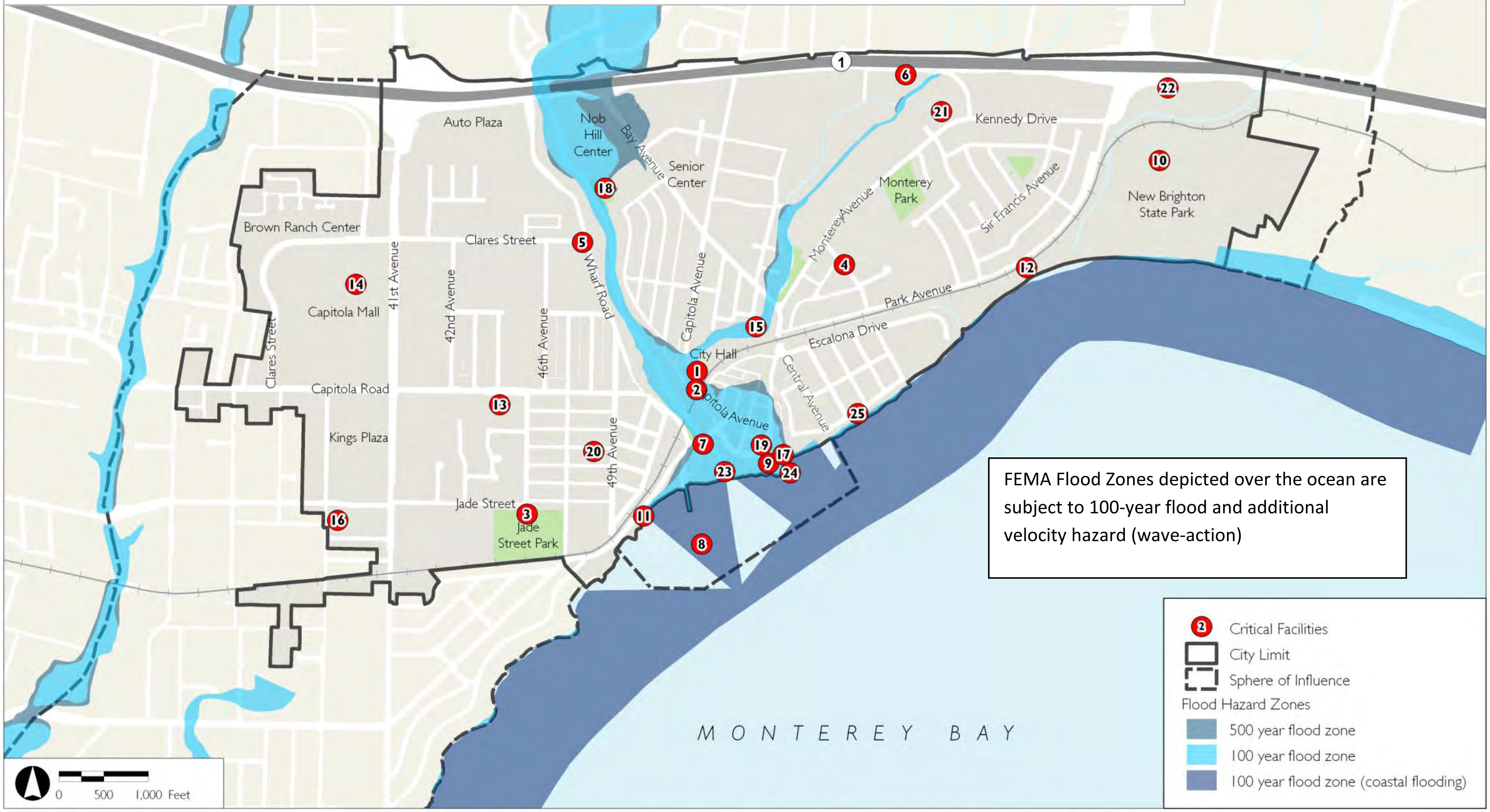


Figure 6 - Soquel Creek Stage Data

(Source: City of Capitola Public Works)

FLOOD HAZARD ZONES
EXHIBIT 7

Note: This map is for planning purposes only and is not intended to be used in lieu of FEMA Flood Insurance Rate Maps.



Source: City of Capitola, 2010; Santa Cruz County, 2011; FEMA DFIRM Santa Cruz County, California, USA. DFIRM Special Flood Hazard Areas (Flood Plains). FIRM and FIS effective date December 1, 2003.

Past Occurrences

Coastal Storm: Past events of storm surge, high surf/tide, flooding, and coastal erosion that have affected the City are identified in Table 17: Historical Coastal Storm and High Surf Events. This information along with the pictures depicting flooding and coastal storm damage in Figures 7 through 9 were provided by the City of Capitola Historical Museum.

Figure 7: Coastal Storm (ca. 1926)

Figure 8: Coastal Storm (ca. 1940)

Figure 9: Coastal Storm (ca. 1983)

Table 17: **Historical Coastal Storm and High Surf Events**

Date	Event	Injury	Impact/Property Damage
January 1862	Storm/Flood		Major event- Soquel village inundated; mills, flumes, school, town hall, houses and barns were destroyed. Massive pile of debris went out to sea and then washed ashore at Soquel Landing.
November 25, 1865	Storm/High Tide		500 feet of the Soquel Landing wharf is lost; the remaining 600 feet are deemed "useless". Nearby barn blown down. Two young whales and a hair cloth sofa washed ashore. Waves described as "mountain high". Wharf damage is $6,000. Pilings are deposited in a potato field beyond the beach.
December 14, 1867	Storm		Wharves damaged in Aptos and Watsonville but no specifics are listed for Soquel Landing.
September 19, 1868	Tidal Wave		High tide described as tidal wave; damage unknown.
February 3, 1869	Storm/ Flood/ Slides/ Washouts		New bridge washed away at Soquel; roads impassable.
December 23, 1871	Southeast gale, food, high tide		Water gauged to be "higher than flood of 1862."
January 24, 1874	Storm		Roaring surf. Rain threatens crops.
January 19, 1878	Storm with Tide		No Capitola impact recorded.
January 30, 1881	Storm		Conflicting reports on damage to Capitola. One report describes the resort as destroyed, while another stated damage was "not as serious"
December 16, 1886	High surf		Capitola impact unknown
December 30, 1886	High surf		High seas; ships prevented from landing.
May 10, 1887	Heaviest surf of the season		No damage reported for Capitola.
January 5, 1889	Storm		Damage to beach areas
December 26, 1889	Storm		Train service stopped; Santa Cruz County becomes isolated.
January 6, 1890	Storm / Mudslides in mountains		Worst winter in 40 years; concern for grain crops
February 8, 1892	High Tides	Swimmers endangered	Yacht "Petrel" washed ashore at Capitola; beachfront concessions damaged.
January 12, 1899	Severe Storm		Duration of several days; damage unknown.
January 2, 1900	Storm		Severe; no damage listed.
March 14, 1905	Storm		Judged to be "worst in 27 years." Capitola impact unknown.
April 27, 1907	Storm		High water and flooding; Capitola damage unknown.
January 21, 1911	Storm		Unknown

Table 17: **Historical Coastal Storm and High Surf Events**

Date	Event	Injury	Impact/Property Damage
March 7, 1911	Storm		Unknown
November 27, 1913	Storm and Tide	Fisherman Alberto Gibelli stranded when mid-section of wharf washed away.	Great groundswells when the tide was highest. Waves ran across the beach to the Esplanade and water spread “clear to the railroad tracks.” Union Traction Company tracks covered with sand. Water reached the Hihn Superintendent’s Building (Capitola and Monterey Avenues), and waves were described as “monster.” About 200 feet washed of wharf washed away. Stranded fisherman rescued and pulled underwater to safety. A huge pile of debris covered the beach and was cut-up for firewood.
November 28, 1919	Storm		Damage high; no Capitola details.
December 27, 1921	Storm		Described as "great".
February 12 and 13, 1926	High Tides		Waves to 20 feet. Wharf damaged. Sea wall promenade broken at Venetian Courts. Apartments flooded. Breakers slammed into Esplanade, destroying boathouse/bathhouse, beach concessions. Tide hits the second floor of Hotel Capitola. Water runs a foot deep through village.
December 26, 1931	Storm		Soquel Creek rises; cleans lagoon at Capitola. Debris and wood deposited on the beach.
December 28 and 29, 1931	Storm and High Tide		Damage to cottages and concessions at New Brighton Beach. Roads fill with “the muck of the sea.” At Seacliff Beach, the concrete ship Palo Alto is shaken loose and moved about three feet as if “impelled by the spirit of the sea to fulfill its destiny and start moving.” Soquel “River” widens to sixty feet, the highest since 1890, damaging property in Soquel and all the way to the mouth at Capitola. Orchards are lost with the rapid rise of water. Hundreds gather to watch the tides batter the concessions at the beach. There is a “vortex of water where the river and sea meet.” The waterfront is piled high with flood debris thrown back up the beach. The creek cuts across the beach and moves sand below the new outlet. Two months later, workers discovered a noticeable settling of the western end of the bathhouse, due to a break in the retaining wall. This left a portion of the bathhouse supported only by its concrete flooring. Repairs required rebuilding the retaining wall and replacing the fill.
March 22 and 23, 1937	Storm		Boats in the streets at Capitola. An estimated $3,000 is spent to repair the sea wall at the Venetian Court Apartments.

Table 17: **Historical Coastal Storm and High Surf Events**

Date	Event	Injury	Impact/Property Damage
January 4, 1939	Wind and Waves		Main damage to Capitola Beach Club at the Esplanade and Monterey Avenue. Water and sand carried into the structure and spread out over the dance floor to the bandstand. While the storm was still raging, thieves jimmied the back door of the club's tap room, and made away with two slot machines, along with the stands on which they had rested. Ocean also swept over the Esplanade during the night, and into town for a block-and-a-half, carrying sand and rocks, some 6-8 inches in diameter. Waves hit the front and sides of the pier. Sand and rocks were swept into lower terraces of the Venetian Court and covered porches of the casino on the waterfront, but did no serious damage.
January 8, 1940 9pm until Noon	Storm		The "old Capitola casino" owned by Capitola Amusement Company was the principal victim of storm. Casino "capsized" shortly after 9 a.m. Plans for new structure announced immediately.
January 12, 1940	Storm		Most rain "since 1890" reported.
January 26, 1940	Storm		"Shatters all records"
March 31, 1940	Storm		"Wettest day in Santa Cruz history."
December 23, 1940	Storm		Flood conditions, winds
February 9, 1941	Storm		Near record storm
April 2, 1941	Severe Storm		Lasting many days. Damage unknown.
August 1, 1949	"Heaviest surf in 20 years"		18 foot waves recorded along the coast. Swimmer drowns in Santa Cruz.
Winter 1953	Giant Swells		Ocean side of building at the end of the Capitola Wharf smashed in by waves 20-30 feet at high tide. Six pilings broken off.
April 3, 1958	High Tide		Esplanade smashed by tides. Andy Antonetti's Merry-go-round damaged; horses are knocked off and washed down San Jose Avenue.
February 9, 1960	Gale winds, heavy seas		Power outages, slides, and winds 35-40 mph. Capitola hardest hit. Damage estimated at $100,000. Ten Venetian Court apartments flooded. "A sign was ripped off the end of the wharf, rolled into a ball, and deposited into an apartment." Heavy waves smashed the beach restaurants, amusement concessions, and the merry-go-round. Rocks and logs strewn across the beach. Water pushed back under the Stockton Bridge, crushing the riverfront fences 100 yards on either side. An estimated $5,000 in damage was done to the wharf building, but not much happened to the wharf itself. Cliffs crumbled on Grand Avenue. Police Chief Marty Bergthold called it "The worst storm in 15 years." A portion of Grand Avenue falls into the ocean.'

Table 17: **Historical Coastal Storm and High Surf Events**

Date	Event	Injury	Impact/Property Damage
December 1965	Storm		The City replaced 21 pilings under the wharf that were weakened by the storm. Capitola officials fear that waves would smash the seawall which protected sewer lines that ran from Capitola's pumping station to the East Cliff Sanitation District plant. That winter, the county public works department offered 500 cubic feet of rock rubble to be placed against the seawall.
January 1967	Storm		Reported as heavy
January 1973	Storm		Beach littered with tons of driftwood after heavy rains.
December 21, 1976	High waves		Waves crash over wharf
January 1978	High waves		Capitola Village streets flooded. Waves crash over wharf.
October 2, 1979	High waves		At least eight sailboats were destroyed at Capitola during the morning. A powerful swell brook 15 boats from their moorings off the Capitola Wharf. The boats were pushed ashore by 12-to-20 foot waves that pounded the shoreline
December 17, 1982	Storm		Restaurant on the newly renovated Capitola Wharf is damaged in storm.
January 27, 1983	High Tide		Capitola Wharf buildings, the Venetian Courts, the former boathouse building (Mr. Toots Downstairs) and all other business of the Esplanade were flooded. Water extends down San Jose Avenue and Lawn Way. Huge logs and debris are scattered through town. The giant surf took out a 30-foot section of the wharf which had been renovated in 1982.
February 10, 1983	High Tide		Surf rolls over the sea wall along the Esplanade. Water and debris extend as far as Capitola Avenue.
March 1, 1983	High Tide/Strong Winds		Waves damaged the restaurant at the end of the wharf, crashed over beach wall and entered restaurants on the Esplanade, "but damage was nothing compared to the million-dollar loss suffered in January," said Capitola City Manager Steve Burrell.
Winter 2008	High Tide		Old bathhouse/boathouse building (Margaritaville/Stockton Bridge Grill) battered by swells. This was the last significant coastal storm/flooding event before 2020 to occur.

Flooding: Table 18: Historical Flood Events identifies notable occasions of flooding as researched by the City of Capitola Historical Museum.

Table 18: **Historical Flood Events**

Date	Injury	Impact/Property Damage
1791-1792		Santa Cruz Mission destroyed.
1847		Sawmill constructed on Soquel Creek (Rancho Soquel) destroyed. It had been built by John Hames and John Daubenbiss, who later obtained lands of the Rancho Rodeo, and became the founders of the town of Soquel (1852).
1852		This was a major flood event but impact not recorded (no newspapers had yet been established).
December 4, 1875		Compared to ferocity of the 1862 flood.
March 10, 1884		Storm lasted five days. No Capitola impact described in newspapers.
January 27, 1890		Judged to be as bad as 1852, 1862, and 1871; Capitola floods, footbridge and span of wagon bridge destroyed. Esplanade flooded—buildings to be replaced in “permanent form.” A huge pile of debris appears along the beach.
January 20, 1906		Buildings from Loma Prieta Lumber Company camp above Soquel are destroyed. Debris at Capitola. Downtown Soquel floods. Landslides in hills.
January 1, 1914		Flood in Soquel and along Soquel Creek.
January 4, 1935		Capitola Village floods; thirty feet of the sea wall is taken out. Beach playground disappears. Venetian Courts hit hard but damage minimal.
February 14, 1937		Soquel Creek floods in Soquel Village due to logjam at the bridge on Soquel Drive. Landslides in watershed.
February 27, 1940		Logs pile against bridge in downtown Soquel and village floods. Landslides in watershed.
February 5, 1945		Local damage unknown.
December 22, 1955		At the Soquel Drive bridge in downtown Soquel, remains of a four-room house and five cabins joined the rubble that wedged against the bridge abutments, causing the bridge to collapse. Overall damage to property in Soquel and Capitola exceeded $1 million. Capitola damage included the Venetian Courts. Noble Creek and Tannery Creek also flooded.
December 20, 1964		Storm and tide alarms City with a disappearing beach.
January 1980		No damage reported.
January 3-5, 1982	Estimated damage to public property: $270,889	Torrential rainfall, floods, mudslides countywide. Soquel Creek overflowed and flooded Soquel. The logjam at the bridge was estimated to be nearly 100 yards wide and 25 feet high. In Capitola, damage was comparatively minimal. The roadway leading to the Stockton Avenue bridge was damaged. The bridge bulkhead was undercut. Several of the Venetian Court units were damaged and a portion of the seawall gave way.
March 1995		The creek rose near the village.
Winter 1996		Yards and basements of homes along both sides of Soquel Creek near the village were flooded.
March 24 and 26, 2011		Noble Creek floods village; Tannery Creek rushes through New Brighton Parking lot and undermines the cliff roadway.

The most recent and damaging event that has occurred in the past 15 years is the 2011 flooding event in Capitola, which is summarized below:

March 2011: Rushing water from a heavy storm overwhelmed an underground pipe drain that sends water from Noble Gulch Creek, which a tributary to Soquel Creek. This event caused a sinkhole at Pacific Cove Mobile Home Park, causing damage to mobile homes and businesses within Capitola Village. Water cascaded down Capitola Avenue into the Village flooding numerous businesses as well as City buildings (Police Station, Fire Station, and City Hall), see Figure 10. The Capitola Public Works Director estimated approximately $500,000 worth of damage to city property, and several million dollars' worth of damage to the city-owned Pacific Cove Mobile Park occurred as a result of this event. According to the National Climactic Data Center (NCDC), property damage county-wide resulting from this flood was estimated at $15.5 million.

Figure 10 - Flooding within the Capitola Village (ca. 2011)

This was the last significant flooding event before 2020 to occur

Sea Level Rise: No considerable events associated with sea level rise have occurred since the 2013 LHMP was approved. However, sea level rise has been an ongoing issue in Capitola due to its location adjacent to the Pacific Ocean and global impacts associated with climate change. As described below in Vulnerability/Risk Assessment, sea level rise is expected to become more severe in future due to projected global increases in sea level.

Probability of Future Occurrence

Coastal Storms: Significant storms, with associated damage, strike the Monterey Bay communities with a frequency of one large storm every 3 to 4 years (Ott Water Engineers, Inc., 1984). This equates to a 25% to 33% chance of a large storm occurring within Capitola in a given year.

Flooding: The FEMA flood zones identified on Exhibit 7 provide the probability of a future occurrence of a flood in Capitola. The probability of occurrence is expressed in a percentage of the change of a flood of a specific extent occurring in any given year. For areas located within the 100 year flood zone, there is a 1% chance in a given year that this area will be inundated by flood waters. For areas located within the 500 year flood zone, this probability decreases to 0.2%. Exhibit 7 also identifies the critical facilities within the City that are located within the 100 and 500 year floodplains.

Climate Change Considerations

Climate change can increase the probability and intensity of both fluvial (river) and coastal storms, which could increase the probability and intensity of flooding in Capitola, particularly in the Village and along the Soquel River.

The City of Capitola Coastal Climate Vulnerability Report (CCWG, 2017) considers flooding and severe coastal storms, which are exacerbated due to sea level rise to be a considerable, potential risk to the City and its residents. Sea level rise has been an on-going progression and due to climate change, this progression has recently and will in the future become more severe.

As shown in Exhibit 8 - Future Combine Coastal Climate Change Hazard Zones (2030, 2060, and 2100), flooding and coastal storm hazard zones were projected and mapped for the years 2030, 2060, and 2100, and quantified in terms of number of damaged or lost facilities and assets and their value (see analysis below). A copy of the report is included as Appendix C and incorporated herein by reference as part of this LHMP update.

Vulnerability/Risk Assessment

Table 19: Capitola Critical Facilities Located in a FEMA Flood Zone identifies the Capitola critical facilities located within the 100 year FEMA floodplain, which have a greater risk to flooding. The potential loss is based on the assumption that all facilities within the 100 year flood zone would be completely destroyed during a coastal storm/flooding event and shows the maximum potential losses. While this is possible, actual losses will vary based on the magnitude of the event. In addition to loss of critical facilities, it is estimated based on 2010 Census Tract data that up to 967 residents located within the City and Sphere of Influence could be impacted by 100 year flood events. This estimate is based on the area of flood impact within each Census Tract multiplied by the population density of the Census Tract. Since the majority of the City's 100 year flood zone is located along Noble Gulch and Soquel Creek, roadways and utility systems (water pump stations, sewer lift stations, storm drains, and overhead electric lines) adjacent to these drainages are most susceptible to flood related hazards.

Table 19: **Capitola Critical Facilities Located in a FEMA Flood Zone**

Map #	Facility	Within 100 Year Flood Zone	Replacement Value	Contents Value	Potential Loss
1	City Hall/Emergency Operations Center	Y	$8,000,000	$750,000	$8,750,000
1	Capitola Police Station	Y	$4,000,000	$750,000	$4,750,000
2	Central Fire Station #4	Y	$3,000,000	$100,000	$3,100,000
7	Stockton Avenue Bridge	Y	$10,000,000	N/A	$10,000,000
8	Capitola Wharf	Y	$20,000,000	$300,000	$20,300,000
9	Capitola Beach Sea Wall	Y	$5,000,000	N/A	$5,000,000
15	Noble Gulch Storm Pipe	Y	$10,000,000	N/A	$10,000,000
17	Capitola Pump Station-Esplanade Park	Y	$10,000,000	$800,000	$10,800,000

Table 19: **Capitola Critical Facilities Located in a FEMA Flood Zone**

Map #	Facility	Within 100 Year Flood Zone	Replacement Value	Contents Value	Potential Loss
18	Soquel Pump Station	Y	$10,000,000	$1,700,000	$11,700,000
19	Lawn Way Storm Drain Pump Station	Y	$500,000	N/A	$500,000
23	Capitola Beach Flume	Y	$2,000,000	N/A	$2,000,000
24	Capitola Beach Jetty	Y	$3,000,000	N/A	$3,000,000
	Total Potential Losses		**$85,500,000**	**$4,400,000**	**$89,900,000**

Combined Impacts of Coastal Climate Change

The California Coastal Commission Sea Level Rise Policy Guidance (November 2018) recommends all communities evaluate the impacts from sea level rise on various land uses. The guidance recommends using a method called "scenario-based analysis". Since sea level rise projections are not exact, but rather presented in ranges, scenario-based planning includes examining the consequences of multiple rates of sea level rise, plus extreme water levels from storms and El Niño events.

In general, the Coastal Commission recommends using best available science (currently the 2018 State of California Ocean Protection Council [OPC] SLR Guidance) to identify a range of sea level rise scenarios, including the low, medium-high, and, as appropriate, extreme risk aversion scenario. These projections are an update from a previous scenario estimate by the National Research Council (NRC) Seal Level Rise study prepared in 2012. A comparison of these two scenarios are shown below in Table 20: Comparison of Sea Level Rise Estimates for Medium-High Risk Aversion for Capitola. The delta between the two methodologies suggests that sea level rise could be greater than previously anticipated, particularly by the year 2100.

Table 20: **Comparison of Sea Level Rise Estimates for Medium-High Risk Aversion for Capitola**

Time Horizon	NRC 2012 Projected SLR	OPC 2018 Projected SLR (Monterey Tide Gauge)	Difference
2030	0.3 ft.	0.8 ft.	0.5 ft.
2060	2.4 ft.	2.6 ft.	0.2 ft.
2100	5.2 ft.	6.9 ft.	1.7 ft.

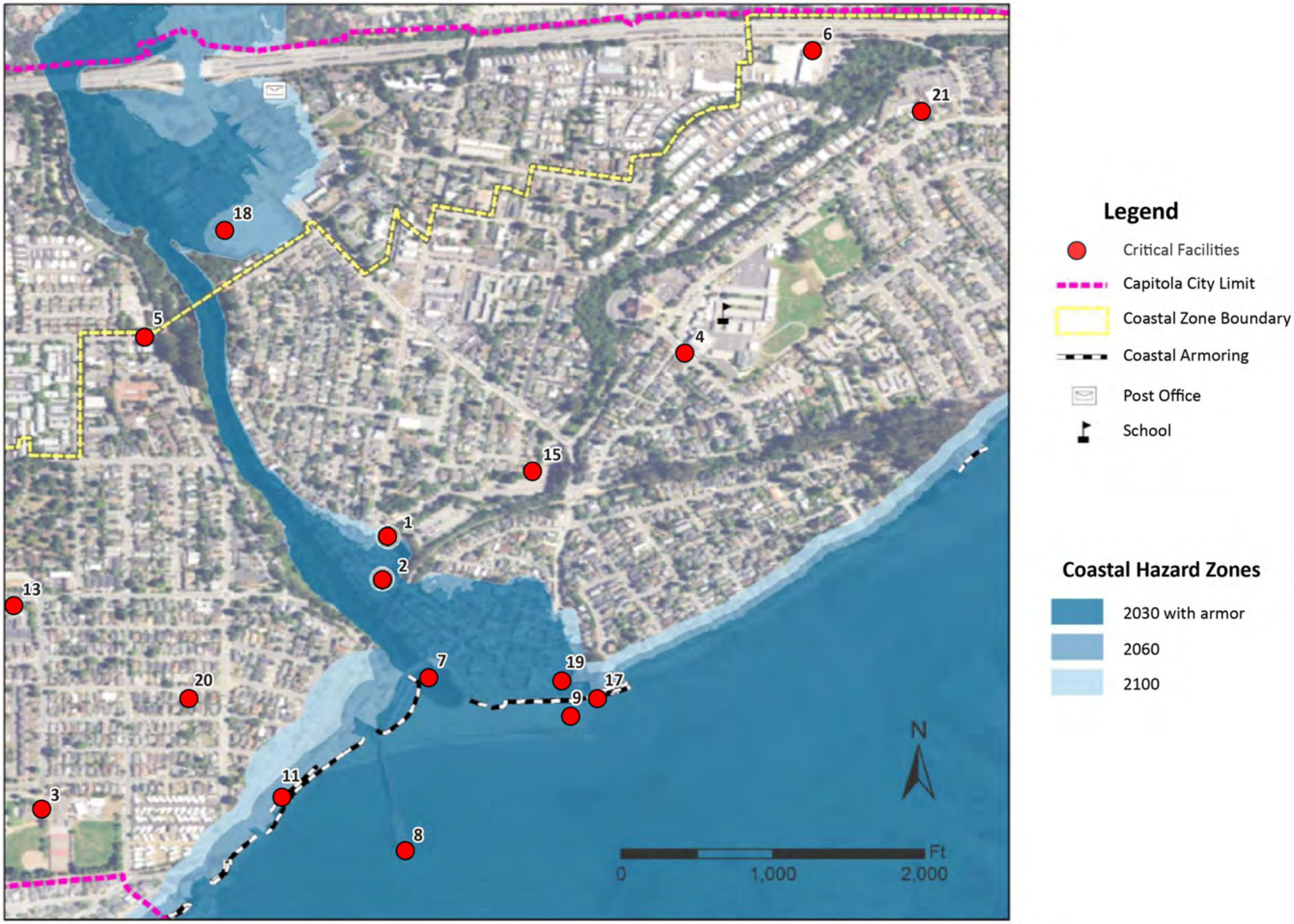
Regardless of the estimates, sea level rise, when combined with coastal storm flooding and rising tides, creates a significant threat to Capitola. For the purposes of assessment of these combined impacts of coastal climate change, the conclusions below are based on the 2017 CCWG City of Capitola Coastal Climate Change Vulnerability

Report (included as part of this LHMP as Appendix C) as it analyzed a comprehensive vulnerability assessment of Capitola's public and private land use and infrastructure assets. Exhibit 8 - Future Combine Coastal Climate Change Hazard Zones (2030, 2060, and 2100) identifies areas of Future Combine Coastal Climate Change Hazard Zones (2030, 2060, and 2100). To the degree these impacts could be greater based on evolving scenario estimates only reinforces the fact that policy planning that addresses the long-range effects of the combined impacts of coastal climate change is an important issue for the City of Capitola.

Key findings from the CCWG report include:

- Infrastructure closest to the beach will continue to be impacted by the force of waves, the deposition of sand, kelp and other flotsam, and by floodwaters that do not drain between waves.
- Infrastructure further inland is most vulnerable to flooding by a combination of ocean and riverine sources.
- Infrastructure identified as vulnerable to coastal flooding by 2030 is similar to that which is currently vulnerable.
- Total property values at risk from the combined hazards of coastal climate change for 2030 were estimated at $200 million.
- Property value at risk may increase to $275 million dollars by 2060. That value is reduced by approximately $50 million dollars if current coastal armoring is replaced or upgraded.
- By 2060 use of all 12 public access ways may be restricted due to various coastal climate vulnerabilities.
- Projected flood water depths along the river walkway are estimated to be as much as 8 feet by 2060.
- Cliff Drive remains a key western access road into the downtown area and is vulnerable to cliff erosion by 2060 if coastal armoring is not replaced.
- By 2100 most of the beach may be lost due to higher sea levels and beach erosion if back beach structures are rebuilt in their current locations.
- As many as 221 properties are within the 2100 bluff erosion zone if protective structures are not maintained or replaced.
- By 2100 SLR and Fluvial models used in this analysis project that much of the downtown area may be periodically flooded during winter storms and high river discharges.
- By 2100 tidal inundation within portions of the downtown area may become a serious challenge, risking 23 residential and 23 commercial buildings to monthly flooding.
- By 2100, portions of Capitola may be too difficult and costly to protect from the combined hazards of Coastal Climate Change.

Exhibit 8 - Future Combined Coastal Climate Change Hazard Zones



3.5 Drought and Water Resources

3.5.1 Identifying Drought Hazards

Drought: A drought is a period of dry weather that persists long enough to cause problems such as crop damage and/or water supply shortages. Droughts can occur in short durations (single year occurrence) or can persist for several years (multi-year) which can impact hydrologic cycles and biologic communities. Droughts may not be predictable, but they should be expected. They occur with some regularity and varying levels of severity. The magnitude and duration of a drought is something that can be predicted based on historical records and should be taken into account in water resource planning.

The City of Capitola receives about 90% of its water supply from the Soquel Creek Water District (SqCWD), while the remaining 10% is supplied by the City of Santa Cruz Water Department (SCWD). In general, SqCWD serves areas of the City that are located east of 41st Avenue and the SCWD serves the portions of the City that are located west of 41st Avenue. Neither agency receives imported water from sources outside of the area, thus both agencies are solely dependent on local water supplies and face a number of critical constraints in their ability to provide enough water to meet current and future demand.

SqCWD obtains 100 percent of its water supply from two groundwater sources within the Soquel-Aptos area. While groundwater sources in general are usually less susceptible to seasonal drought than surface water sources, droughts do impact SqCWD's groundwater supply. Due to cumulative over-pumping for many years, coastal groundwater levels are below elevations that protect the local groundwater basin from seawater intrusion. This condition creates a state of overdraft that is exacerbated by drought conditions to the extent that less rainfall reduces groundwater recharge and generally increases water demand.

The SCWD obtains the majority of its water supply from surface water sources. Approximately 79 percent of its annual water supply needs are met by coastal stream surface diversions, and about 17 percent of its needs are met by Loch Lomond Reservoir. The remaining 4 percent of SCWD's annual supply needs are met by its Live Oak groundwater wells. The SCWD's water supply has limited capacity to serve additional users under normal conditions and has insufficient supply to meet existing demand under drought conditions.

Both water providers have experienced drought periods which resulted in water supply curtailment actions, the most recent occurring from 2007-2009, and both are susceptible to drought conditions in the future. In addition to the 2007-2009 drought, California experienced two other state-wide drought periods within the last forty years: 1976-1977 and 1987-1992.

Groundwater supply: The water supply in Capitola is primarily provided by SqCWD, which has been able to meet historical demand within its service area even though the underlying groundwater basin is overdrafted and at risk from seawater intrusion. In order to recover groundwater levels to protective elevations and eliminate overdraft, SqCWD needs to and is planning on reducing pumping to the Pre-Recovery Pumping Yield of 2,900 acre-feet per year (afy) within approximately 5 years, and maintaining pumping at or below this level for approximately 20 years. For perspective, the SqCWD pumped about 4,000 acre-feet of groundwater in 2011, so an approximate pumping reduction of 30 percent is required to meet the Pre-Recovery Pumping Yield. In response to overdraft conditions and the resulting need to reduce pumping by approximately 30 percent from 2011 levels, SqCWD continues to advocate water conservation and evaluate a desalination project with the SCWD as a supplemental water supply. SqCWD maintains an Urban Water Management Plan[2], which outlines water conservation strategies. SqCWD also completed a Well Master Plan and will be developing up to five new wells over the next five or so years to redistribute pumping inland away from vulnerable coastal areas and to achieve more uniform drawdown of the groundwater basin.

Seawater Intrusion: Seawater intrusion is the movement of ocean water into an area occupied by fresh groundwater, causing chloride contamination of the groundwater. While coastal aquifers naturally experience some seawater intrusion due to the seawater and freshwater interface, freshwater naturally serves as a barrier to seawater moving further inland. However, when coastal groundwater levels are depressed near or below sea level due to over-pumping, seawater can move inland and contaminate groundwater.

The State of California has declared the Santa Cruz Mid-County Groundwater Basin — which supplies water to the SqCWD, Central Water District, City of Santa Cruz, and over a thousand private well users and private mutual systems — as critically overdrafted and mandated that the basin be brought into sustainability by 2040. This mandate affects all basin users, not just the SqCWD.

The SqCWD is solely dependent on groundwater as is most of the Santa Cruz Mid-County area . In addition to the groundwater basin being overdrafted, seawater intrusion is present in Pleasure Point, Aptos, Seascape, and La Selva Beach; data collected in 2017 confirmed the entire coastline is at-risk.

To address this issue, SqCWD is actively working on a groundwater replenishment and seawater intrusion prevention project called Pure Water Soquel. This project will involve taking already treated municipal wastewater from the City of Santa Cruz, purifying it through advanced water purification methods, replenishing the basin through recharge wells, and creating a seawater barrier. One of these recharge wells will be located on Monterey Avenue and replace the existing (now decommissioned) SqCWD Treatment Plant (critical facility # 21). The goal is to have the project operational by 2022.

3.5.2 Profiling Drought Hazards

Location

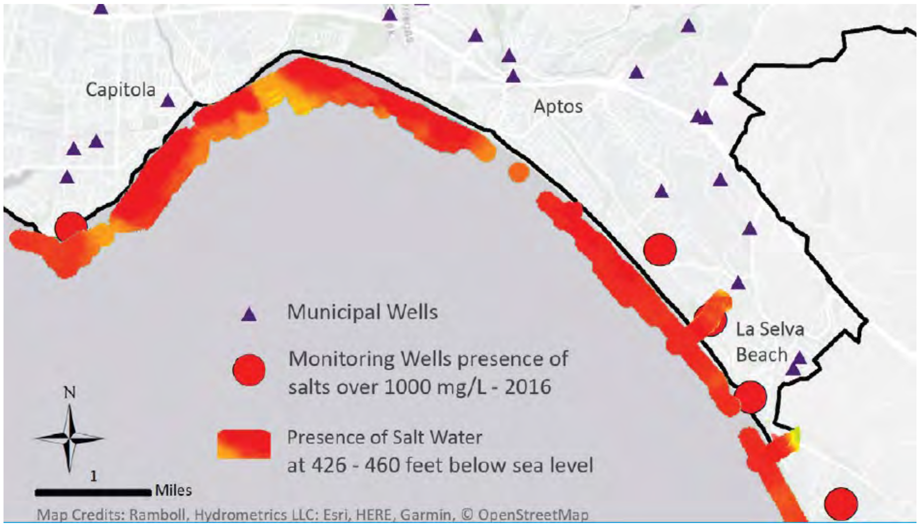
Exhibit 9 - Water Supply illustrates the SqCWD and SCWD boundaries as well as the limits of the local groundwater basin.

Drought: Droughts can occur over large regions (multiple states) or be isolated to small areas such as a City or County. The Santa Cruz County Hazard Mitigation Plan notes the entire county is susceptible to and at risk of drought conditions. Likewise, the City of Capitola is susceptible to drought.

Groundwater Supply: The majority of Capitola is served by the SqCWD, which currently relies solely on groundwater aquifers within the Soquel-Aptos area. The aquifers are located within two geologic formations that underlie the SqCWD service area. The Purisima Formation provides approximately two-thirds of SqCWD's annual production and serves the communities of Capitola, Soquel, Seacliff Beach, and Aptos. The Aromas Red Sands aquifer provides the remaining one-third of SqCWD's annual production and mainly serves the communities of Seascape, Rio Del Mar, and La Selva Beach.

[2] Soquel Creek Water District Urban Water Management Plan

Seawater Intrusion: As shown in the image below, seawater instruction is actively occurring on the Monterey Bay coastline, including Capitola.



Extent

Drought: For a county-wide perspective on the extent of seasonal drought impacts, it is helpful to reference the SCWD since they rely on surface water for water supply. They are able to meet 100% of the existing water demand in about 7 out of every 10 years and at least approximately 90% of existing demand in about 9 out of 10 years. A significant shortage occurs on average about one out of every 10 years.

In addition to water supply shortages, prolonged periods of drought in the Capitola region can exacerbate the potential for wildfires that may affect the City. A decline in water supply can also negatively affect the ability to protect lands from wildfire and/or the City's ability to respond to fire incidents.

Groundwater Supply and Seawater Intrusion:

The Pure Water Soquel project includes facilities in portions of the cities of Santa Cruz and Capitola, and in the Live Oak, Soquel, and Aptos communities of unincorporated Santa Cruz County. The treatment process is planned to be split: tertiary treatment at the Santa Cruz Wastewater Treatment Facility and Advanced Water Purification at the corner of Chanticleer Avenue/Soquel Avenue and the planned three seawater intrusion prevention wells at Monterey Avenue, Willowbrook Lane, and Cabrillo College Drive. The project will; help increase the sustainability of the District's groundwater supply, upon which it currently relies for 100% of its water supply, reduce the degree of overdraft conditions in the District's groundwater basin, protect against and aid in preventing further seawater intrusion of the groundwater basin, and promote beneficial reuse by reducing discharge of treated wastewater to the Monterey Bay National Marine Sanctuary by 25%.

Past Occurrences

Drought: In recent history, Santa Cruz County was impacted by 3 statewide drought occurrences: 1976-77, 1987-1992, and 2007-09. Table 21: Historical Drought Events presents the impacts of drought researched by the City of Capitola Historical Museum.

Table 21: **Historical Drought Events**

Date	Impact/Property Damage
1863-1864	Unknown.
1877	Capitola's founder, S.A. Hall, was boarding 300 horses at his stable during the summer. The price of hay went to $20.00 a ton due to the drought, and he lost money. When landowner F.A. Hihn increased the rent two years later, Hall couldn't afford the increase, and left
1928-1937	Reported as one of longest and most severe in state's history. Capitola is bordered by bulb ranches and floral nurseries, as well as poultry ranches and rabbit farms.
December 14, 1936	Long drought ended by rain.
1947-1949	Statewide.
1976-1977	Water conservation ordered.
1987-1992	Severe drought, water conservation ordered.
2007-2009	Water waste regulations strictly enforced; voluntary 15% conservation savings requested by local water providers.
2013 - 2017	On-going drought conditions resulted in water use restrictions throughout California. This was the last significant drought event before 2020 to occur

Groundwater Supply: The Soquel Creek Water District is currently experiencing a water supply shortfall due to overdraft of the groundwater basin.

Probability of Future Occurrence

Drought: As noted in the Santa Cruz County Hazard Mitigation Plan, one approach to evaluating probability of future events focuses on the magnitude of the worst case drought, because it is the degree of shortfall that determines what actions the community would have to take and the resulting hardships the public would face. It should also take into account, though, the chance of that event occurring before a solution is achieved. The amount of time that elapses before new supply can be developed is an important consideration because it also has a bearing on the degree of risk faced by water customers; the longer the delay, the greater the risk. As with the threat of other natural hazards like a flood or an earthquake, the probability of a severe drought in any one-year may be comfortably low.

For instance, the drought on record of 1977 has a recurrence interval of 1 in 59 years. This means the probability of such an event is 1/59 or 0.017, which is the same as a 1.7% chance of occurrence in any one year. But the percent probability of occurrence, or chance, of a shortage occurring over a longer time frame is considerably higher, which changes the perception of the significance of risk.

Groundwater Supply: The SqCWD Urban Water Management Plan addresses the fact that without incorporating additional conservation methods and a supplemental supply of water to their existing groundwater water supply, the District will be unable to service all water demands in the future without exacerbating overdraft conditions in the basin or imposing significant water use restrictions.

Seawater Intrusion: As discussed above, seawater intrusion in and around Capitola is being addressed by the Pure Water Soquel project.

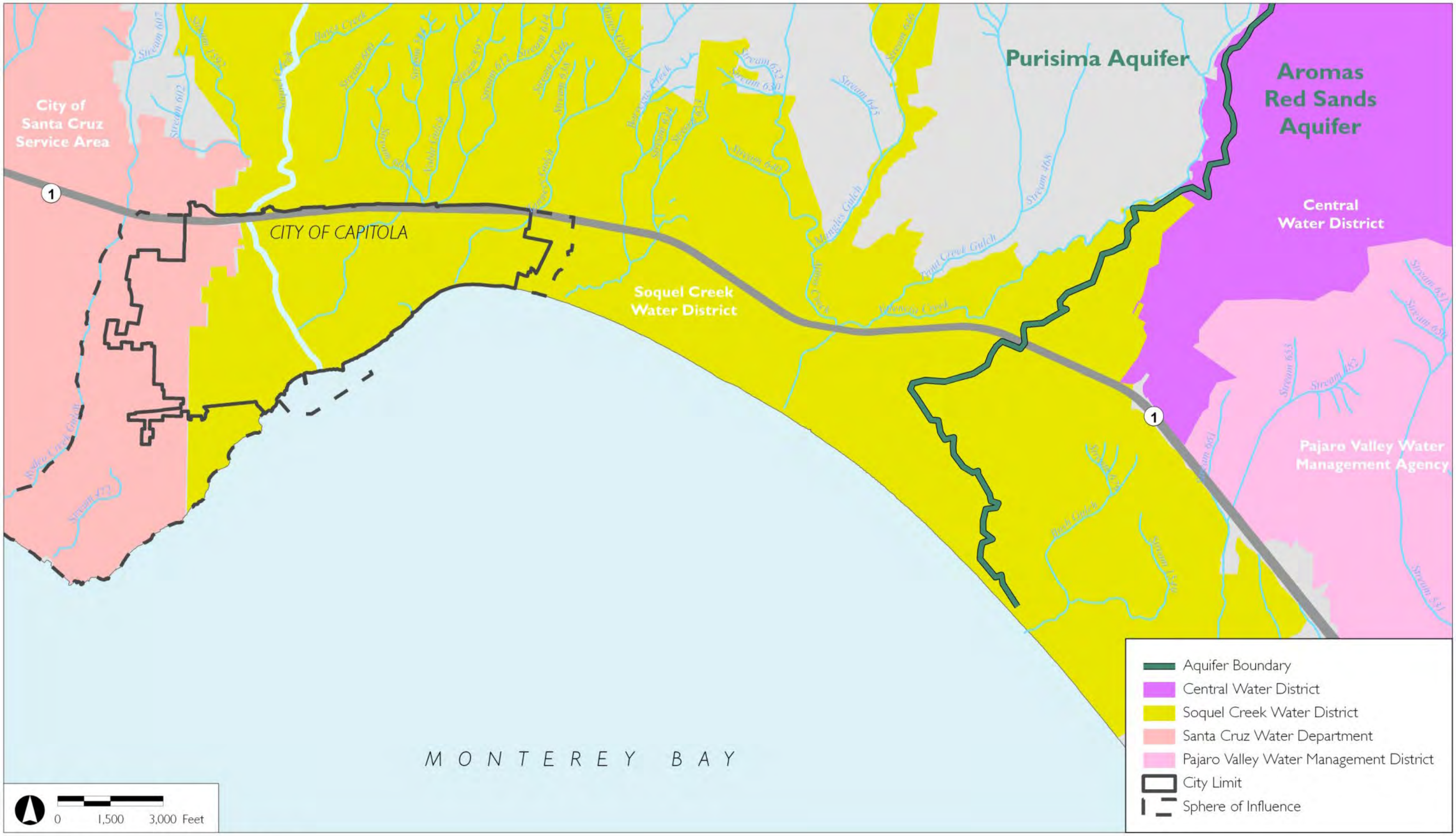
3.5.3 Climate Change Considerations

Per the SqCWD Urban Water Management Plan, consistent future use of the Aromas and Purisima groundwater sources may be affected by climate change. Climate change forecasts indicate a potentially significant decrease (e.g., 30%) in recharge of groundwater basins. Additionally, projected rises in sea level may increase the risk and extent of seawater intrusion. Due to climate change, the City of Capitola may expect more severe droughts of longer duration.

Vulnerability/Risk Assessment

Drought does not inflict physical damage on Capitola's critical assets; however, residents and businesses could be impacted by the water district they are provided by. 90% of the City's water supply is provided by the Soquel Creek Water District, which, although supplied by groundwater and less susceptible to seasonal drought, is susceptible to overdraft. The remaining 10% of the water supply is provided by the City of Santa Cruz Water Department, which is supplied by surface water and is susceptible to seasonal drought. Exhibit 9: Water Supply shows the water district boundaries.

WATER SUPPLY
EXHIBIT 9



Source: City of Capitola, 2010; Santa Cruz County, 2012.

3.6 Windstorm

3.6.1 Identifying Windstorm Hazards

Winds are horizontal flows of air that blow from areas of high pressure to areas of low pressure. Wind strength depends on the difference between the high- and low-pressure systems and the distance between them. A steep pressure gradient results from a large pressure difference or short distance between these systems and causes high winds. High winds are defined as those that last longer than 1 hour at greater than 39 miles per hour (mph) or for any length of time at greater than 57 mph.

3.6.2 Profiling Windstorm Hazards

Location

As illustrated in Exhibit 10 - Prevailing Wind Patterns, Capitola experiences prevailing wind conditions that are generated from the north and northwest, following the California coast. Due to its proximity to the ocean, Capitola also experiences ocean breezes that average between 1-2 miles per hour.

Extent

Since 2004 the highest recorded wind speed in Capitola has reached 46 mph. [3] Wind damage in Capitola may not always be associated with wind, but with tree falls that occur during windy conditions. If soil is saturated due to rain, the trees are more susceptible to falling in the wind.

Past Occurrences

Table 22: Windstorms Reported in Santa Cruz County, California 1965-2011 identifies past high wind, strong wind, and tornado events in Santa Cruz County from 1965 through 2011.

Table 22: **Windstorms Reported in Santa Cruz County, California 1965-2011**

Date	Type of Event	Magnitude	Countywide Property Damage
4/1/1965	Tornado	F1 (73-112 mph)	$0
12/05/1998	Tornado	F0 (40-72 mph)	$50,000
4/3/1999	High Winds	85 MPH	$0
4/4/2001	High Winds	71 MPH	$2,700,000
11/24/2001	High Winds	85 MPH	$7,100,000
12/21/2001	Tornado	F1 (73-112 mph)	$250,000
1/7/2005	High Winds	58 MPH	$0
2/27/2006	High Winds	70 MPH	1 Fatality
12/27/2006	High Winds	40 MPH	$100,000
10/12/2008	Strong Winds	47 MPH	$150,000
1/25/2009	Strong Winds	39 MPH	$25,000
2/15/2009	High Winds	64 MPH	$25,000
4/14/2009	Strong Winds	48 MPH	$70,000
10/13/2009	High Winds	61 MPH	$0
11/28/2009	Strong Winds	43 MPH	$50,000
1/18/2010	Strong Winds	39 MPH	$150,000
1/19/2010	Strong Winds	44 MPH	$200,000

[3] Capitola Weather Net, accessed February 24, 2012. http://www.capitolaweather.net/climate.php

Table 22: **Windstorms Reported in Santa Cruz County, California 1965-2011**

Date	Type of Event	Magnitude	Countywide Property Damage
4/11/2010	Strong Winds	45 MPH	$25,000
10/24/2010	Strong Winds	47 MPH	$15,000
11/20/2010	Strong Wind	48 MPH	$500,000
12/19/2010	Strong Winds	45 MPH	$15,000
12/28/2010	High Winds	50 MPH	$15,000
2/25/2011	Strong Winds	39 MPH	$35,000
11/30/2011	High Winds	56 MPH	$8,000

National Climatic Data Center

http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

Since 2011, NOAA has recorded 11 events with wind speeds 60 knots and higher in Santa Cruz County. The last strong wind event occurred on February 9, 2020.

The City of Capitola Historical Museum researched the historical impacts from wind events as presented in Table 23: Historical Wind Events.

Table 23: **Historical Wind Events**

Date	Injury	Impact/Property Damage
February 10, 1938		Winds up to 70 mph; 500 trees uprooted throughout county.
December 9, 1943		60-mile-an-hour winds create damage in county
1975		40 knot winds downed trees and power lines.
1976 February 9, 2020		Winds downed power lines Winds over 70 mph downed trees and power lines.

In addition to the historical wind events listed above, historical coastal storm events, listed in the flood profile, may also produce wind damage.

Probability of Future Occurrence

Due to its location, it is anticipated that Capitola will experience windstorms in the future. The predominant wind pattern throughout this area is from north to south, however strong winds have been known to occur from other directions as well. It is difficult to predict the amount of damage that could occur from a windstorm with great precision. Based on current modeling and information it is anticipated that most windstorms will follow the general patterns that have historically affected the City. However, what is difficult to predict far into the future is the intensity and duration of a storm. Understanding that windstorm will occur within the City, it is better for the City to determine what potential vulnerabilities exist associated with a windstorm and mitigate these vulnerabilities effectively.

Climate Change Considerations

It is anticipated that wind patterns and windstorm development may be altered due to climate change. The resulting change could increase future storm intensity and duration and potentially change the location of where these storms are generated. With this in mind it will be important for the City to consider how anticipated changes in weather patterns may change future events and how they respond and mitigate hazards associated with windstorms.

Vulnerability/Risk Assessment

The entire City of Capitola and all critical facilities are susceptible to windstorm damage. A majority of windstorm damage that occurs is associated with fallen trees/ tree limbs. Facilities located in close proximity to large trees may be more susceptible to windstorm damage as a result. It is highly unlikely that a windstorm would completely destroy any of the identified critical facilities. However, the replacement values for these facilities may be referenced in Table 7: Capitola Critical Facilities List.

PREVAILING WIND PATTERNS
EXHIBIT 10

Source: City of Capitola, 2010; Santa Cruz County, 2010; ESRI, 2011.

3.6.3 Coastal Erosion/Bluff Failure

Identifying Coastal Erosion/Bluff Failure Hazards

Coastal erosion is the wearing away of coastal land. It is commonly used to describe the horizontal retreat of the shoreline along the ocean. Erosion can be measured as a rate, with respect to either a linear retreat (feet of shoreline recession per year) or volumetric loss (cubic yards of eroded sediment per linear foot of shoreline frontage per year).

Erosion rates are not uniform and vary over time at any single location. Annual variations are the result of seasonal changes in wave action and water levels. Erosion is caused by coastal storms and flood events, changes in the geometry of tidal inlets and bays and man-made structures and human activities such as shore protection structures and dredging.

Coastal erosion includes both cliff and bluff erosion and beach erosion, and is a result of both winter wave attack as well as constant wave action. Beaches change seasonally in response to changes in wave conditions. Winter storm waves are larger, steeper, and contain more energy, typically moving significant amounts of sand from the beaches to offshore sandbars, creating steep, narrow beaches. In the summer, lower, less energetic waves return the sand, widening beaches, and creating gentle slopes. During the winter months when beaches are narrow, or absent altogether, the storm waves attack the cliffs and bluffs more frequently. There are many factors involved in coastal erosion, including human activity, sea-level elevation, seasonal fluctuations and climate change, and sand movement from year to year in the same location.

Wind, waves, and the long-shore currents are some of the driving forces behind coastal erosion. The removal and deposition of sand creates long-term changes to beach shape and structure. Sand may be transported to landside dunes, deep ocean trenches, other beaches, and deep ocean bottoms.

Coastal erosion such as cliff and bluff erosion is also a result of processes related to the land such as rainfall and runoff, weathering, uplift, and earthquakes.

3.6.4 Profiling Coastal Erosion/Bluff Failure Hazards

Location

Capitola is a coastal city, residing within the Monterey Bay area of the Pacific Ocean. The entire coastal edge of the City is affected by coastal erosion. Areas of particular concern include:

Capitola Beach**:** Capitola Beach is a gently rising beach. A jetty located at the eastern edge of the beach has allowed the beach to remain relatively stable. Seasonal changes cause the amount of sand to change whereby winter storms deplete the sand supply, which is then replenished in summer months.

Capitola Cliffs**:** Located along Cliff Drive and the Depot Hill neighborhood. These areas have experienced high levels of coastal erosion (see Figure 11). The cliffs are characterized by gently dipping, late Tertiary sedimentary rocks that are generally overlain by nearly horizontal, quaternary terrace deposits. The local shoreline is nearly parallel to the dominant direction of approach for refracted waves. As a result, littoral drift is rapid, inhibiting formation of a continuous protective beach. Instead, a series of pocket beaches, which are sensitive to seasonal changes and human intervention, have formed. Cliff Drive within this portion of the City has been armored with a rip rap toe and concrete walls along the bluff, which provides erosion protection, however the Depot Hill neighborhood portion is unprotected.

The sanitation district is interested in seeing where the coastal erosion and bluff failure risks are the highest so they can evaluate if it will affect their infrastructure. They are actively planning to relocate sewers based on risk. They use the Capital Improvement Program to budget for these projects.

Extent

Coastal Bluff Failure**:** The historic rate of bluff retreat in Capitola is approximately 0.9 feet per year. If this rate continues, the pedestrian pathway along the cliff area in the Depot Hill neighborhood would be unusable within 10-15 years and the Grand Avenue right-of-way almost entirely gone within 25 years. Assuming this constant rate of retreat, the first houses would be threatened or damaged in approximately 50 years, and most would be damaged or destroyed within approximately 75 years. After 100 years, some of the second-line houses could be threatened.

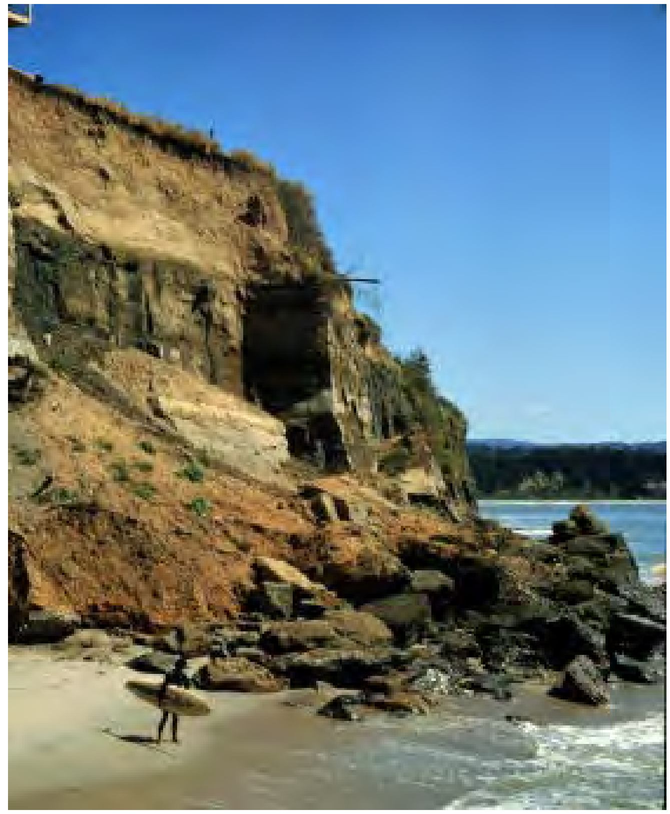


Figure 11 - Episodic coastal bluff failure in Capitola

.

Figure 12a - Cliff Erosion Beneath Apartments on Depot Hill (c. 1984)

An example of coastal bluff failure are illustrated in Figures 12a and b. Both sewer and sanitary infrastructure run through the bluffs in Capitola and have the potential to be impacted by bluff failure. In addition, sewer treatment plants are commonly located along the coast of California and are at risk to bluff failure and beach erosion in many locations. In addition, development that has been placed on top of bluffs within Capitola is vulnerable to erosion, as illustrated in Figure 13.

In 2018, the City closed a portion of the Grand Avenue pedestrian pathway between Sacramento Avenue and Oakland Avenue due to concern for bluff failure. On December 2, 2019, a portion of the bluff failed taking with it a portion of the pathway with it.

Figure 12b – Grand Avenue Pedestrian Pathway Erosion

Beach Erosion**:** Beach erosion (as shown in Figure 13) is a seasonal occurrence during the winter months within Capitola. In a 2009 study prepared by the USGS[4], the highest long-term shoreline erosion rates along the California coast were found in the Monterey Bay region, where the average rate of erosion was -0.6 meters/year. The short-

Figure 13 - Capitola Beach Erosion

[4] Rates and Trends of Coastal Change in California and the Regional Behavior of the Beach and Cliff system (http://allenpress.com/pdf/COAS_25.3_603_615.pdf)

term erosion rate was also high, at -0.8 meters/year. These erosion rates not only contribute to the loss of beach sand along the Capitola coast, but also contribute to erosion along the cliffs within this part of the State as well.

Past Occurrences

Although coastal erosion is a continuous process, the rate of erosion is accelerated during times of severe storm activity. The NCDC database captures ocean surf events, which include high tides and surf, rip currents, and storm surge on a county-wide basis. The events noted in the NCDC database that may have contributed to increased coastal erosion in Capitola include:

October 28-29, 1999: A 15 foot swell in association with a relatively high tide produced waves as high as 40 feet which broke through the seawall in Capitola and flooded low lying streets and businesses. The Capitola Wharf was closed because the waves were breaking up through the decking of the wharf. The event caused $1 million in property damage.

February 25, 2004: A strong winter storm brought ocean water onto the Capitola Wharf producing damage on the wharf and adjacent restaurant.

Additional coastal erosion in Capitola's history as researched by the City of Capitola Historical Museum is presented in Table 24: Historic Erosion Events.

Table 24: **Historic Erosion Events**

Date	Impact/Property Damage
1911	Incidents of cliff erosion along Grand Avenue prompt Lewis B. Hanchett, the owner of El Salto Resort, to begin chopping down trees along what is left of "Lover's Lane" along the bluff of Depot Hill. Hanchett believed that when the trees fell, they further hastened the cliff erosion.
January 24, 1930	About 130 residents appear before Santa Cruz County Supervisors to protest announced firing of 12-inch guns at Camp McQuaide, Capitola. Among petitioners claims are that "the terrific jar of the guns loosens the rim of the cliffs, and the earth is sloughing off to a dangerous degree."
January 9, 1935	Near the seawall cave-in by the site of the old hotel, a tree fell sixty feet from Grand Avenue. The "new favorite outdoor sport" for onlookers is to walk behind the sewer plant to see the fallen tree and debris of the broken sea wall.
May 2, 1955	Sentinel: Capitola City Council Asks Cleanup Help "Believe it or not, a few people still occasionally throw garbage over the cliff, particularly along Grand Avenue. This not only creates health hazards, but also attracts rodents which burrow into and weaken the cliff, increasing the rate of cliff erosion…."
1963	Capitola City Council votes to start condemnation proceedings against Harry Hooper to obtain 320 feet of Hooper Beach for erosion control to protect Cliff Drive, where a high rise development was planned.
1963	Capitola City Council considers construction of seawall to control erosion from Grand Avenue to New Brighton Beach. The filled in area would also provide parking for approximately 400 cars.
December 20, 1964	Construction begins on controversial Crest "prestige" 24-unit apartment house on the bay side of Grand Avenue on Depot Hill. Robert Lamberson, architect. Grand Avenue residents eventually sue the City over a disputed 10-foot setback for the project, which was built on a former park site at the top of the bluff. In the 1980s, several units facing the bay were removed due to cliff erosion. $500,000

Table 24: **Historic Erosion Events**

Date	Impact/Property Damage
January 13, 1965	Capitola considers feasibility study to build 370-foot seawall along Grand Avenue. Backfilling below Grand Avenue would be used for a 1,000-car parking lot. Developers expressed desire to lease portion of the parking lot for a three-story, 20 unit convention hotel with restaurant and cocktail bar, to be built along the Grand Avenue bluff. First step was to have the beach deeded to the city by the state. $1,228,000 estimated cost for parking lot $275,000 estimated cost for hotel.
Summer 1965	Capitola requests help from the State Department of Water Resources to solve the problem of disappearing sand, due to “failure of Santa Cruz harbor officials to install a recommended sand by-pass at the harbor jetty.
Summer 1965	Off-Shore parking lot plan revised. Parking lot to extend 430 feet out into the way from the cliffs south of Capitola beach for about 1,500 feet. A breakwater is planned to extend 600 feet south to the end of the high cliff area, to prevent cliff erosion. The parking lot would also be used as an “overnight parking unit” with commercial concessions for tourists. Project to cover ten acres reclaimed from the bay.
1966	Lifelong resident Violet Gooch hired Granite Construction to build a rip-rap wall at the base of the cliff at the end of the row of homes west of the wharf. (Hooper Beach)
1968	Army Corps of Engineers begins work to construct a groin, completed the following spring. $160,000.
February 15, 1984 1984 – present	Even though planner Susan Tupper warned the plan might not be a lasting solution, Capitola City Council approved a plan to stabilize its crumbling cliffs by installing artificial seaweed—a series of floating plastic fronds anchored to a sand-filled tube. The intent was to capture sand that drifts down the coast each year, thereby building a sandy beach in front of the cliffs below Grand Avenue. The “ersatz” seaweed lasted until the next major storm and then drifted to sea. The cliff continues to erode at a rate of 12-18 feet per year. $120,000. Ongoing isolated slope failures have occurred along the Grand Avenue Bluff.

In addition to the past erosion events listed above, coastal storms and high tides can also contribute to erosion and bluff failure. Figure 14 depicts a bluff failure along Grand Avenue that occurred in conjunction with the coastal storm that occurred in 1960. Additional detail of these past events can be found in the flood profile.

Figure 14 - Bluff Failure along Grand Avenue (associated with 1960 coastal storm)

Probability of Future Occurrence

Based on its coastal location, bluff and shoreline erosion will continue to occur in Capitola in the future. The amount of erosion will be dependent on the intensity of future storms and whether or not corrective actions are taken by the City or County to protect shoreline areas by reducing erosion rates. With regard to beach erosion/ bluff failure, it is less a matter of whether or not the hazard will occur and more a matter of the rate in which the hazard will cause additional damage (i.e. structural failure).

Climate Change Considerations

As a coastal community, the potential for sea level rise could increase Capitola's vulnerability to flooding and coastal erosion. The cliffs and sandy beaches that line sections of the Capitola coastline are already susceptible to erosion due to wave attack. It is anticipated that this susceptibility will increase in the event of sea-level rise. In areas not lined with vertical cliffs and bluffs, the depletion of sandy beaches may expose previously protected areas to additional flood hazards.

Exhibit 11 - Erosion Risk from Sea Level Rise, shows the location of future erosion hazard areas in the Year 2100, assuming a 1.4 meter rise in Mean Sea Level. The hazard area is a swath of land approximately 250 feet wide that extends the length of nearly all of Capitola's shoreline, with the exception of a .2 mile gap along the low-lying area at the mouth of Soquel Creek in the Village. Assuming a rise in MSL of 1.4 meters, a total of 40 additional acres of land in Capitola will be vulnerable to bluff erosion hazards. Future vulnerable areas include Cliff Drive and surrounding open space and residential areas in the City's Jewel Box neighborhood, between the Village and New Brighton State Park. In addition, the coastal edge of New Brighton State Park on the east side of the City would be vulnerable to bluff erosion. An estimated 19 acres of land in Capitola would be susceptible to beach erosion in the year 2100, most likely in the low-lying area where Soquel Creek meets the Monterey Bay. At-risk areas include most of Capitola Village on both the south and north side of Soquel Creek.

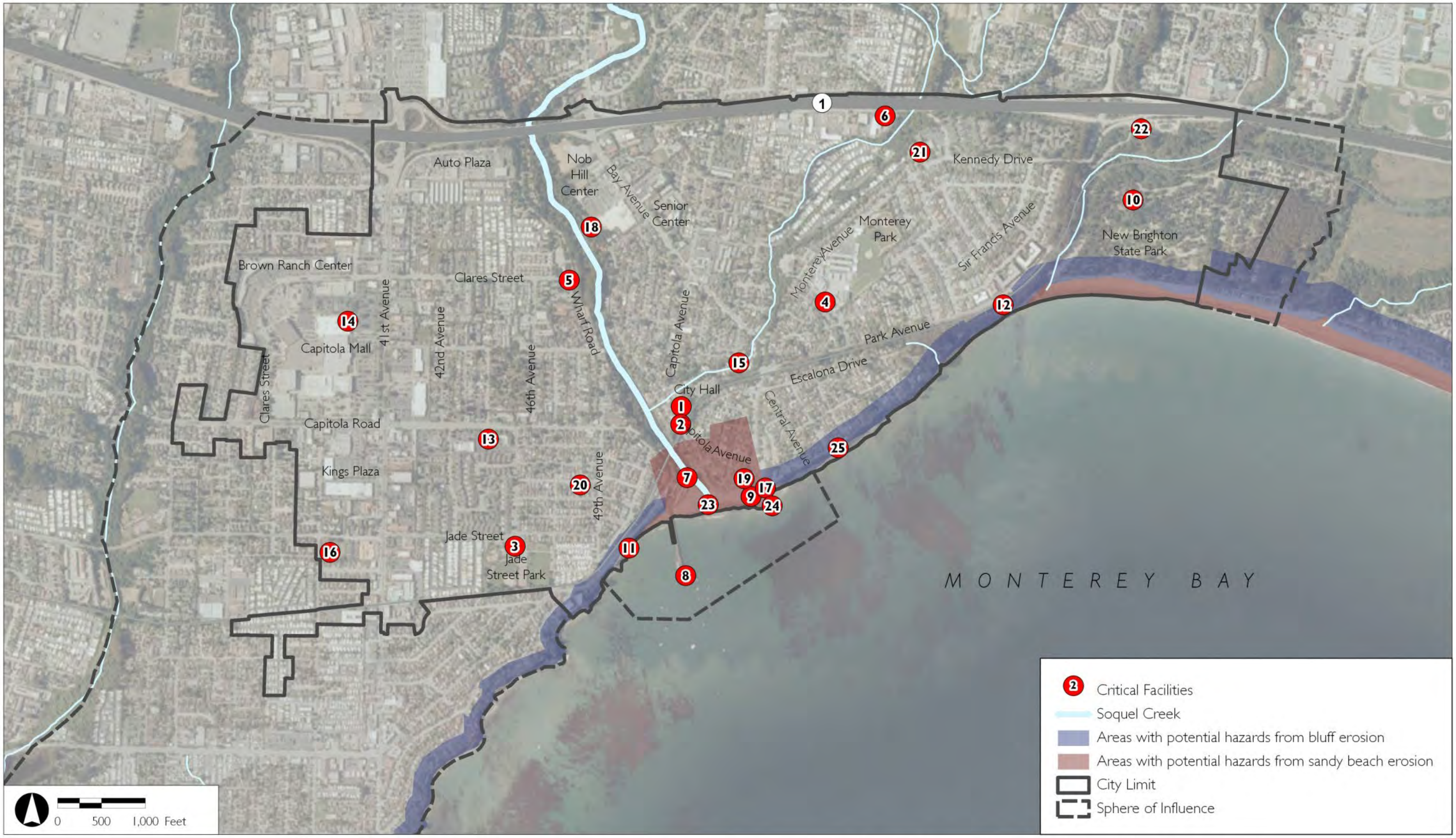
Vulnerability/Risk Assessment

Intersections between critical facilities and areas of beach erosion and cliff erosion were conducted to determine which facilities are at risk to erosion. Based on this analysis, Table 25: Capitola Critical Facilities Exposed to Increased Erosion Potential identifies the facilities that could be impacted by increased beach and/ or cliff erosion in the future. The total potential loss shown in the table below is based on the assumption that all facilities within the beach and cliff erosion potential areas would be completely destroyed during an erosion event and shows the maximum potential losses. While this is possible, actual losses will vary based on the type and magnitude of the event.

Table 25: **Capitola Critical Facilities Exposed to Increased Erosion Potential**

Map #	Facility	Within Area of Beach Erosion Potential	Within Area of Cliff Erosion Potential	Replacement Value	Contents Value	Potential Loss
7	Stockton Avenue Bridge	X		$10,000,000	N/A	$7,000,000
11	Cliff Drive -at risk arterial (sea wall and road)		X	$8,000,000	N/A	$5,000,000
12	Park Avenue-at risk arterial (sea wall and road)		X	$4,000,000	N/A	$3,000,000
17	Capitola Pump Station-Esplanade Park		X	$10,000,000	800,000	$2,800,000
19	Lawn Way Storm Drain Pump Station	X		$500,000	N/A	$200,000
25	Grand Avenue Pathway		X	N/A	N/A	N/A
	Total Potential Losses			$17,200,000	$800,000	$18,000,000

EROSION RISK FROM SEA LEVEL RISE
EXHIBIT 11



Source: City of Capitola, 2010; Santa Cruz County, 2010; Pacific Institute, 2012;The Impacts of Sea-Level Rise on the California Coast. "Bluff erosion hazard with a 1.4 meter sea-level rise, 2100." [shapefile]. (2009). Oakland, CA: Pacific Institute. Available at <http://www.pacinst.org/reports/sea_level_rise/files/Bluff_hz_yr2100.zip>, Downloaded: March 14, 2012.
Discalimer: This map is for planning purposes only. It is not to be used in lieu of site-specific studies of erosion.

3.6.5 Tsunami

3.6.6 Identifying Tsunami Hazards

A tsunami is a series of traveling ocean waves of extremely long length generated primarily by earthquakes occurring below or near the ocean floor. Underwater volcanic eruptions and landslides can also generate tsunamis. In the deep ocean, the tsunami waves propagate across the deep ocean with a speed exceeding 500 miles per hour and a wave height of only one foot or less. Tsunami waves are distinguished from ordinary ocean waves by their great length between wave crests, often exceeding 60 miles or more in the deep ocean, and by the time between these crests, ranging from ten minutes to an hour.

As tsunamis reach the shallow waters of the coast, the waves slow down and the water can pile up into a wall of destruction 30 feet or more in height. The effect can be amplified where a bay, harbor or lagoon is present, funneling the wave as it moves inland. Large tsunamis have been known to rise over 100 feet. Even a tsunami 10 to 20 feet high can be very destructive and cause many deaths and injuries.

Tsunamis can be categorized as "local" and Pacific-wide. Typically, a Pacific-wide tsunami is generated by major vertical ocean bottom movement in offshore deep trenches. A "local" tsunami can be a component of the Pacific-wide tsunami in the area of the earthquake or a wave that is confined to the area of generation within a bay or harbor and caused by movement of the bay itself or landslides. The local tsunami may be the most serious threat as it strikes suddenly, sometimes before the earthquake shaking stops.

3.6.7 Profiling Tsunami Hazards

Location and Extent

The City of Capitola is located on the Monterey Bay. Several active and potentially active earthquake faults are located near Capitola. Even a moderate earthquake occurring on any of the nearby faults could result in local source tsunamis from submarine landsliding in Monterey Bay. Additionally, distinct source tsunamis from the Cascadia Subduction Zone to the north, or Teletsunamis from elsewhere in the Pacific Ocean are also capable of causing tsunamis, which could result in inundation and damage in Capitola.

According to the Cal EMA Tsunami Inundation Maps of the Soquel and Santa Cruz Quadrangles, prepared on July 1, 2009, the entire Capitola coastline is susceptible to inundation by a tsunami. Properties located along Capitola Beach could experience significant damage from tsunami run up. In addition, inland areas of the City along Soquel Creek could experience flooding as far north as California State Route 1 (SR1) following a tsunami.

Exhibit 12 – Tsunami Inundation Risk, identifies the tsunami hazard areas within Capitola based on the Cal EMA Tsunami Inundation Mapping. This mapping is based on a theoretical worst case earthquake causing theoretical worst case inundations that could extend approximately 100 feet inland from the coast, encompassing the Capitola Village up to Cherry Avenue, the Lower Riverview neighborhood, and the Venetian Court area adjacent to Wharf Road. Along Soquel Creek, tsunami inundation could extend north to SR 1, essentially dividing the City in two and potentially limiting access between the eastern and western portions of the City.

Past Occurrences

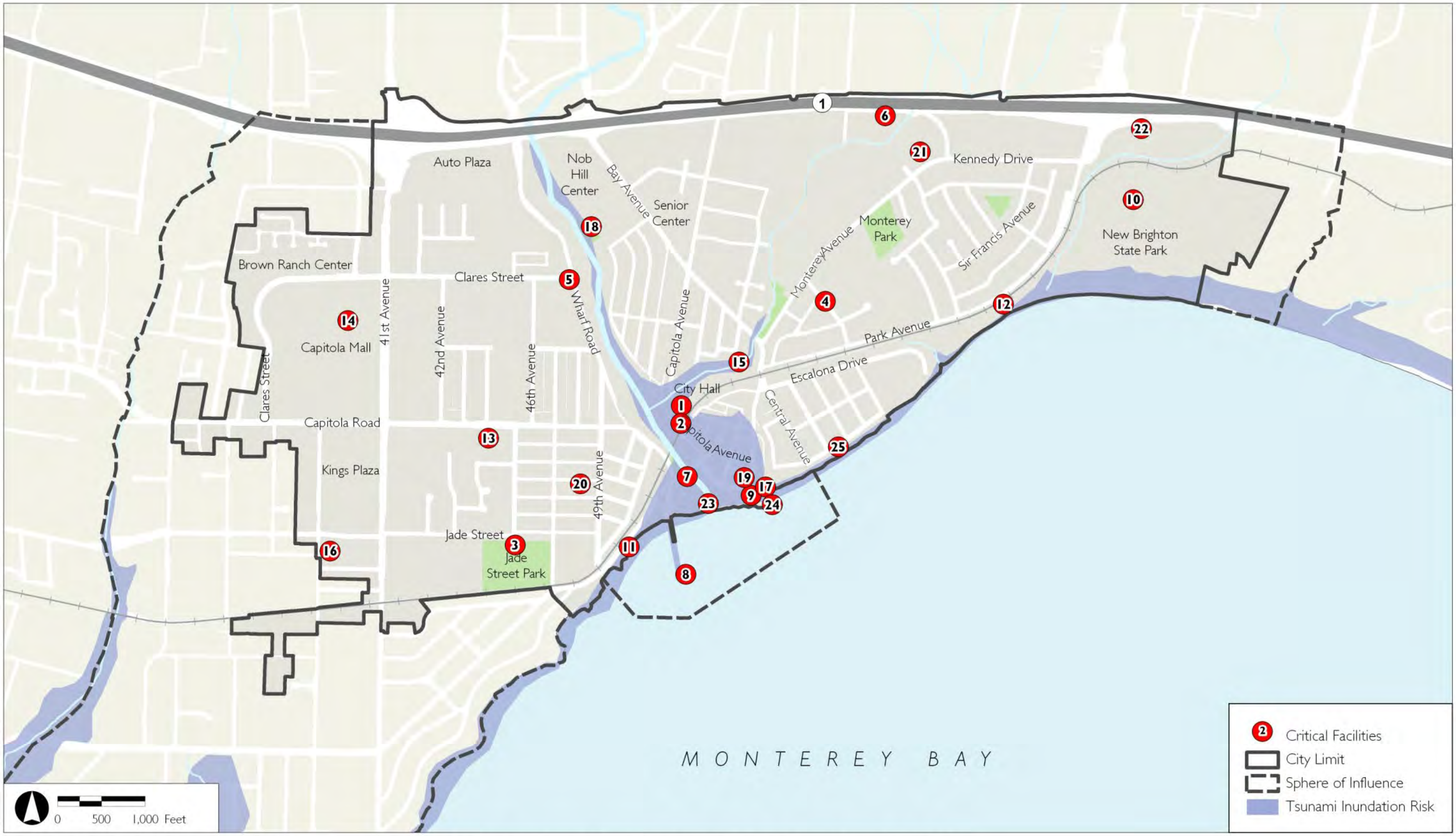
Tsunamis have been documented extensively in California since 1806. Table 26: Tsunami Events in Northern California 1930-2011, contains a list of tsunamis that have impacted Northern California.

Table 26: **Tsunami Events in Northern California 1930-2011**

Date	Tsunami Location	Maximum Water Height*(m)	Earthquake Magnitude	Tsunami Source Location
10/3/1931	San Francisco	0.03	7.9	Solomon Islands
3/2/1933	San Francisco	0.07	8.4	Sanriku, Japan
11/10/1938	Crescent City	0.18	8.2	Alaska
4/6/1943	San Francisco	0.03	8.2	Chile
12/7/1944	San Francisco	0.02	8.1	Japan
4/1/1946	Santa Cruz	3.5	8.1	Unimak Island, Alaska
12/20/1946	San Francisco	0.05	8.1	Honshu, Japan
3/4/1952	San Francisco	0.02	8.1	Hokkaido, Japan
11/4/1952	San Francisco	0.54	9	Kamchatka Peninsula, Russia
3/9/1957	Monterey	0.61	8.6	Alaska
11/6/1958	San Francisco	0.2	8.3	Kuril Islands, Russia
5/22/1960	Santa Cruz	0.91	9.5	Chile
10/13/1963	San Francisco	0.1	8.5	Kuril Islands, Russia
3/28/1964	Capitola	2.13	9.2	Alaska
2/4/1965	Santa Cruz	0.61	8.7	Aleutian Islands, Alaska
10/17/1966	San Francisco	0.1	8.1	Lima, Peru
5/16/1968	San Francisco	0.1	8.2	Japan
7/26/1971	Crescent City	0.06	7.9	Papua New Guinea
10/3/1974	Crescent City	0.08	8.1	Lima, Peru
11/29/1975	San Francisco	0.06	7.1	Hawaii
5/7/1986	Crescent City	0.06	8	Aleutian Islands, Alaska
11/30/1987	San Francisco	0.05	7.9	Yakutat, Alaska
3/6/1988	San Francisco	0.01	7.7	Alaska
10/19/1989	Monterey	0.2	6.9	California
4/25/1992	Monterey	0.03	7.2	Cape Mendocino, CA
9/1/1994	Crescent City	0.07	7	California
10/4/1994	Crescent City	0.5	8.3	Kuril Islands, Russia
7/30/1995	Monterey	0.04	8	Chile
12/3/1995	Monterey	0.1	7.9	Kuril Islands, Russia
2/17/1996	Monterey	0.05	8.2	Indonesia
6/10/1996	San Francisco	0.02	7.9	Andreanof Islands, AK
6/23/2001	Monterey	0.08	8.4	Peru
9/25/2003	Monterey	0.05	8.3	Hokkaido Island, Japan
12/26/2004	Monterey	0.1	9.1	Indonesia
6/15/2005	Crescent City	0.1	7.2	California
5/3/2006	San Francisco	0.05	8	Tonga
1/13/2007	San Francisco	0.05	8.1	Kuril Islands, Russia
8/15/2007	Crescent City	0.16	8	Peru
9/29/2009	Monterey	0.15	8	Samoa Islands
10/7/2009	Monterey	0.05	7.6	Vanuatu Islands
2/27/2010	Monterey	0.28	8.8	Chile
3/11/2011	Santa Cruz	1.9	9	Honshu Island, Japan

* The maximum water height above sea level in meters NOAA/WDC Tsunami Runup Database
http://www.ngdc.noaa.gov/nndc/struts/form?t=101650&s=167&d=166

TSUNAMI INUNDATION RISK
EXHIBIT 12



Source: City of Capitola, 2010; Santa Cruz County, 2012; Tsunami Inundation Risk of Caliofornia, USC Tsunami Research Center, 2009 via California Resources Agency ArcGIS Map Server.

Table 27: Historic Tsunami Events highlights the tsunami occurrences which impacted the City of Capitola, as researched by the City of Capitola Historical Museum.

Table 27: **Historic Tsunami Events**

Date	Impact/Property Damage*
April 1946	Earthquake in Aleutians produced 115-foot wave. Tsunami observed along the West Coast. A man was swept to sea in Santa Cruz. Ten-foot waves hit the coastline.
March 11, 2011	Capitola Village received warnings, but no damage

* Historical information provided by City of Capitola Historical Museum, 2012.

The March 2011 Tsunami event closed roads in Capitola Village. As a precaution, the City of Capitola issued a voluntary evacuation, notifying individuals through reverse 911, for the hotels on the wharf and a significant portion of the village. They used reverse 911 to issue the voluntary evacuation. Fortunately, it was low tide at the time the tsunami reached the California coast. The water receded past the end of the wharf, which is a very rare occurrence. If the tide was higher, the tsunami could have been large enough to overtop the seawall. No significant damage occurred from the tsunami event. This was the last Tsunami event before 2020 to occur.

Probability of Future Occurrence

Since scientists cannot predict when earthquakes will occur, they cannot determine exactly when a tsunami will be generated. Tsunamis are caused by large offshore earthquakes and ocean landslides. Dangerous tsunamis would most likely originate in the Aleutian and Chilean trenches, or the eastern coast of Japan or the Pacific Islands.

Based on modeling prepared by the California Geologic Survey, Tsunami Flow Depth Estimates for Capitola are provided in Table 28: Tsunami Flow Depth Estimates for Capitola. This table identifies the modeled source location of the earthquake event, magnitude of the modeled earthquake, approximate travel time and maximum flow depth values of the waves generated by the event. As indicated in this table Capitola is most susceptible to Tsunamis generated in the Alaska/ Aleutian Islands area as well as a local tsunami generated by a landslide within the Monterey Canyon.

Table 28: **Tsunami Flow Depth Estimates for Capitola**

Tsunami Source Location	Magnitude (Mw)	Approximate Travel Time	Tsunami Flow Depth (in feet above MSL)
Cascadia Subduction Zone	9.0	1 hour	5
Alaska/ Aleutian Islands	8.9-9.3	5 hours	7 - 30
Kuril Islands	8.8	9 hours	4 - 5
Japan	8.8	10 hours	4
Marianas Subduction Zone	8.6	11 hours	3
Chile	9.3-9.4	13-14 hours	4-6
Monterey Canyon Landslide*	N/A	7-15 minutes	16

*A Monterey Canyon Landslide could be triggered by an average earthquake.

Capitola is participating in the Tsunami Ready Program in order to mitigate the effects of future tsunamis. The Tsunami Ready Program is designed to help cities, towns, counties, universities, and other large sites in coastal areas reduce the potential for disastrous tsunami-related c consequences. Tsunami Ready status is achieved through a vigorous certification program that includes planning, communication, and education specifically addressing tsunami hazards. As part of this program, tsunami inundation maps, evacuation maps, and a tsunami ready signage plan, indicating the perimeter of an inundation zone and the appropriate action to be taken by individuals on the beach when an earthquake occurs, were created.

Climate Change Considerations

As a coastal community, the threat of inundation from a Tsunami is always there. Given the anticipated changes in sea level elevation associated with climate change, it is likely that the City's risk to tsunami inundation would increase. With a sea level increase, larger portions of the Capitola coast would be inundated by the rising sea, allowing for greater tsunami run up into the interior portions of the City. The main areas that would experience inundation due to sea level rise are the lower reaches of Soquel Creek and coastal areas of New Brighton State Park. Since these same areas are also susceptible to tsunami inundation, it is likely that additional areas along the periphery of the zone identified on Exhibit 12 would experience run up as sea level increases.

Vulnerability/Risk Assessment

Table 29: Capitola Critical Facilities Exposed to Tsunami Inundation identifies the critical facilities that are potentially at risk during a tsunami event. Depending on the location or origination, severity of movement, and time of year when the event occurs, these facilities could be impacted by tsunami inundation. The total potential loss shown in the table below is based on the assumption that all facilities within the tsunami inundation zone would be completely destroyed during a tsunami event and shows the maximum potential losses. In addition to loss of critical facilities, it is estimated based on 2010 Census Tract data that up to 1,694 residents located within the City and Sphere of Influence could be impacted by tsunami inundation. This estimate is based on the area of flood impact within each Census Tract multiplied by the population density of the Census Tract. A majority of the impact would occur along the shoreline and within the Capitola Village area of the City. Roadways and utility systems (water pump stations, sewer lift stations, storm drains, and overhead electric lines) within these areas are most susceptible to tsunami hazards. While this is possible, actual losses will vary based on the magnitude of the event.

Table 29: **Capitola Critical Facilities Exposed to Tsunami Inundation**

Map #	Facility	Within Tsunami Inundation Zone	Replacement Value	Contents Value	Potential Loss
1	City Hall/Emergency Operations Center	Y	$8,000,000	$750,000	$4,750,000
1	Capitola Police Station	Y	$4,000,000	$750,000	$2,750,000
2	Central Fire Station #4	Y	$3,000,000	$100,000	$1,100,000
7	Stockton Avenue Bridge	Y	$10,000,000	N/A	$7,000,000
8	Capitola Wharf	Y	$20,000,000	$300,000	$7,300,000
9	Capitola Beach Sea Wall	Y	$5,000,000	N/A	$3,000,000
11	Cliff Drive -at risk arterial (sea wall and road)	Y	$8,000,000	N/A	$5,000,000
15	Noble Gulch Storm Pipe	Y	$10,000,000	N/A	$5,500,000
17	Capitola Pump Station-Esplanade Park	Y	$10,000,000	$8,000,000	$10,000,000
19	Lawn Way Storm Drain Pump Station	Y	$500,000	N/A	$200,000
23	Capitola Beach Flume	Y	$2,000,000	N/A	$2,000,000
24	Capitola Beach Jetty	Y	$3,000,000	N/A	$3,000,000
	Total Potential Losses		**$83,500,000**	**$9,900,000**	**$51,600,000**

3.6.8 Hazardous Materials

Identifying Hazardous Material Release Hazards

"Hazardous materials" covers a large number of substances that are a danger to the public. These include toxic metals, chemicals, and gases; flammable and/or explosive liquids and solids; corrosive materials; infectious substances; and radioactive materials. The City of Capitola has adopted a Hazardous Materials Ordinance which requires that the City be notified of all use, storage, and transport of hazardous materials.

In addition to the immediate risk to life safety, public health, and air quality, the potential for water source contamination and the potential environmental impacts of accidental hazardous materials releases and toxic substances, there is also concern over the long-term public health and environmental impacts that may result from the sustained use of or exposure to certain substances. An incident could result in the evacuation of a few people, a section of a facility, or an entire neighborhood.

Profiling Hazardous Material Release Hazards

Location and Extent

Hazardous materials are everywhere and are accidentally released or spilled many times during any given day. On average, the California State Warning Center receives eight to ten thousand hazardous material spill reports on hazardous material incidents and potential hazardous material incidents. Of these incidents, most are minor but some do cause significant impacts such as injuries, evacuation, and the need for cleanup. As illustrated in *Exhibit 13 - Hazardous Materials Locations*, the western portion of Capitola contains the majority of City's hazardous materials locations, with a significant number of locations located along 41st Avenue.

One area of special concern regarding toxic spills is the close proximity of the Capitola Auto Plaza Mall and Highway One, to Soquel Creek. In case of a hazardous materials spill from either location, the discharge could migrate into Soquel Creek. Another concern regarding hazardous materials spills is the potential for chemicals and substances to migrate into the groundwater table. Since a majority of the City is served by Soquel Creek Water District which relies on groundwater, any potential contaminants entering the groundwater aquifer could impact the District's ability to serve its customers.

Past Occurrences

Table 30: RIMS Spill Database for Capitola, CA contains a list of spills documented on the CalOES's (CalEMA) Regional Information Management System (RIMS) between 2006 and the beginning of 2012. Since 2006 there have been 14 cases documented within Capitola, which equates to an average of approximately 2.7 spills per year. One historic event documented by the Capitola Historical Museum includes birds known as Sooty Shearwaters falling from the sky in the summer of 1961 due to toxins from red algae. The birds covered the streets, wharf, and beach.

Probability of Future Occurrence

Although past occurrences can be an indicator of future impacts, in the case of hazardous materials spills, the City is constantly improving the mechanisms by which they approve and regulate businesses that use hazardous materials. In addition, technological advances and increases in industry standards are also improving safety and further preventing/ minimizing potential releases of hazardous materials. As a result, it is anticipated that future incidents will decrease over time as newer technologies, standards, and regulations are put in place.

Table 30: **RIMS Spill Database for Capitola, CA**

Date	Spill Site	Substance
2/6/2006	Storm Drain	Raw Sewage
4/24/2006	Railroad	Unknown
5/12/2006	Road	Raw Sewage
7/4/2006	Waterways	Unspecified
8/13/2006	Merchant/Business	Raw Sewage
4/3/2007	Residence	Raw Sewage
4/26/2007	Railroad	Unspecified
2/22/2009	Merchant/Business	Raw Sewage
3/23/2009	Other	Raw Sewage
4/27/2011	Residence	Other
7/9/2011	Ship/Harbor/Port	Petroleum
7/9/2011	Waterways	Petroleum
8/1/2011	Waterways	Petroleum
1/20/2012	Merchant/Business	Chemical

Hazardous Materials Spill Report http://www.oes.ca.gov/operational/malhaz.nsf

The chemical spill on January 20, 2012 is the last known significant hazard event before 2020 to occur in Capitola.

Climate Change Considerations

Anticipating that precipitation regimes may change in the future as a result of climate change, there may be greater opportunity for the release of hazardous materials to enter local waterways and the groundwater aquifer.

It is anticipated that if this concern increases that the City and other regulating agencies would re-visit procedures and practices in place to ensure that the greatest amount of protection occurs.

Vulnerability/Risk Assessment

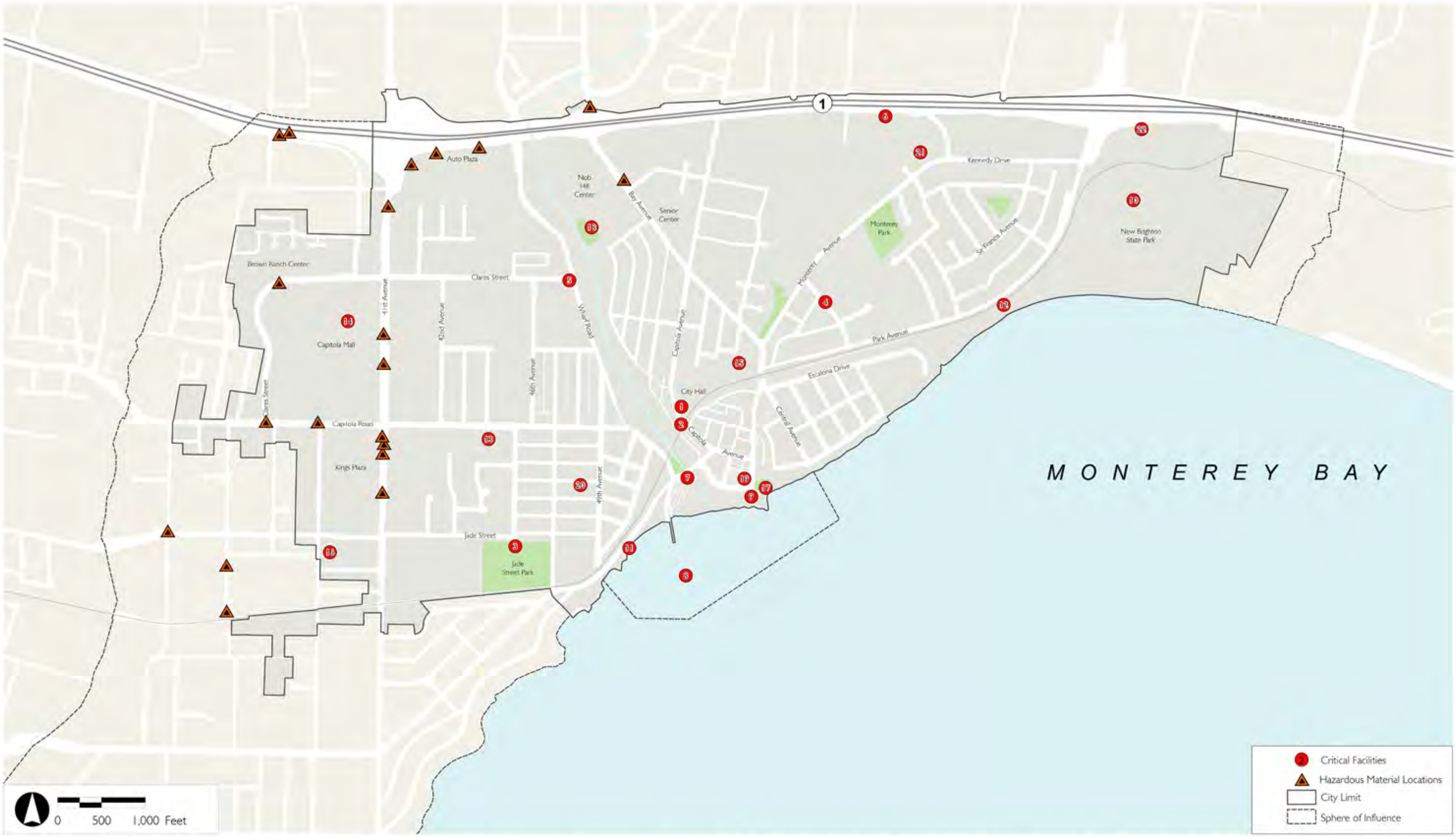
Table 31: Capitola Critical Facilities Located Close to Hazardous Materials Locations identifies locations that could be exposed to hazardous materials releases during a disaster event. These locations only take into consideration the proximity to existing hazardous materials facilities and do not include potential exposure associated with the movement/ transport of hazardous materials. The total potential loss shown in the table below is based on the assumption that all facilities within 1,000 feet of a hazardous materials facility would be completely destroyed during a hazardous materials release/event and shows the maximum potential losses. While this is possible, actual losses will vary based on the location and magnitude of the event.

Table 31: **Capitola Critical Facilities Located Close to Hazardous Materials Locations**

Map #	Facilities	Hazardous Materials within 500'	Hazardous Materials within 1000'	Replacement Value	Contents Value	Potential Loss
14	Police Communications Antenna-AAA Building	X	X	$100,000	N/A	$100,000
16	38th Avenue Drainage Facility		X	$2,000,000	$300,000	$2,300,000
18	Soquel Pump Station		X	$10,000,000	$1,700,000	$11,700,000
17	Capitola Pump Station – Esplanade Park		X	$10,000,000	$800,000	$10,800,000
	Total Potential Losses			**$22,100,000**	**$2,800,000**	**$24,900,000**

HAZARDOUS MATERIALS LOCATIONS

EXHIBIT 13



Source: City of Capitola, 2010; Santa Cruz County, 2011; Environmental Protection Agency (EPA) Resource Conservation and Recovery Act (RCRA) Information System, "Facilities Regulated by EPA" (April 17, 2009). Washington D.C, U.S. Environmental Protection Agency, Headquarters. Available at <http://www.epa.gov/emefdata/em4ef.home>, Downloaded February 3, 2012.

3.6.9 Wildfire

Identifying Wildfire Hazards
Fire hazards threaten lives, property, and natural resources, and also present a considerable risk to vegetation and wildlife habitat. Fires occur in wildland and urban areas.

A wildfire is an uncontrolled fire spreading through vegetative fuels. Wildfires can be caused by human error (such as campfires), intentionally by arson, by mechanical sources of ignition (such as heaters and generators), and by natural events (such as lightning). Wildfires often occur in forests or other areas with ample vegetation. In areas where structures and other human development meets or intermingles with wildland or vegetative fuels (referred to as the "wildland urban interface"), wildfires can cause significant property damage and present extreme threats to public health and safety.

Urban fires usually result from sources within structures themselves and are generally related to specific sites and structures. The availability of firefighting services is essential to minimizing losses that result from a fire. Effective fire protection in urban areas is based upon several factors, such as the age of structures, efficiency of circulation routes (ultimately affects response times), and availability of water resources to combat fires.

3.6.10 Profiling Wildfire Hazards

Location and Extent
As indicated in Exhibit 14 - Fire Hazard Areas, there are no fire hazard areas located in the City of Capitola based on the available fire mapping for Santa Cruz County. However, fire hazard areas do exist two miles north of the city limits along the foothills of the Santa Cruz Mountains.

In addition to the mapped fire hazard areas within the County, the areas that are most susceptible to fire hazards are drainage courses that have a significant amount of vegetation within them such as Soquel Creek. It is likely that these areas within the City would experience fires due to natural or man-made causes. The wildland threat for Capitola is increased due to localized invasive species such as Eucalyptus groves.

Past Occurrences
There are no significant wildfire events that have impacted the City of Capitola.

Probability of Future Occurrence
Despite the fact that there has not been a recent wildland fire within the city limits, residential development continues to spread into wildland/urban interface areas increasing the danger to life and property should a fire occur. Areas of concern associated with wildland fire are those adjacent to natural areas that are heavily vegetated (i.e. Soquel Creek). These areas are even more susceptible if human activities are allowed within, as these activities can introduce new ignition sources into these areas.

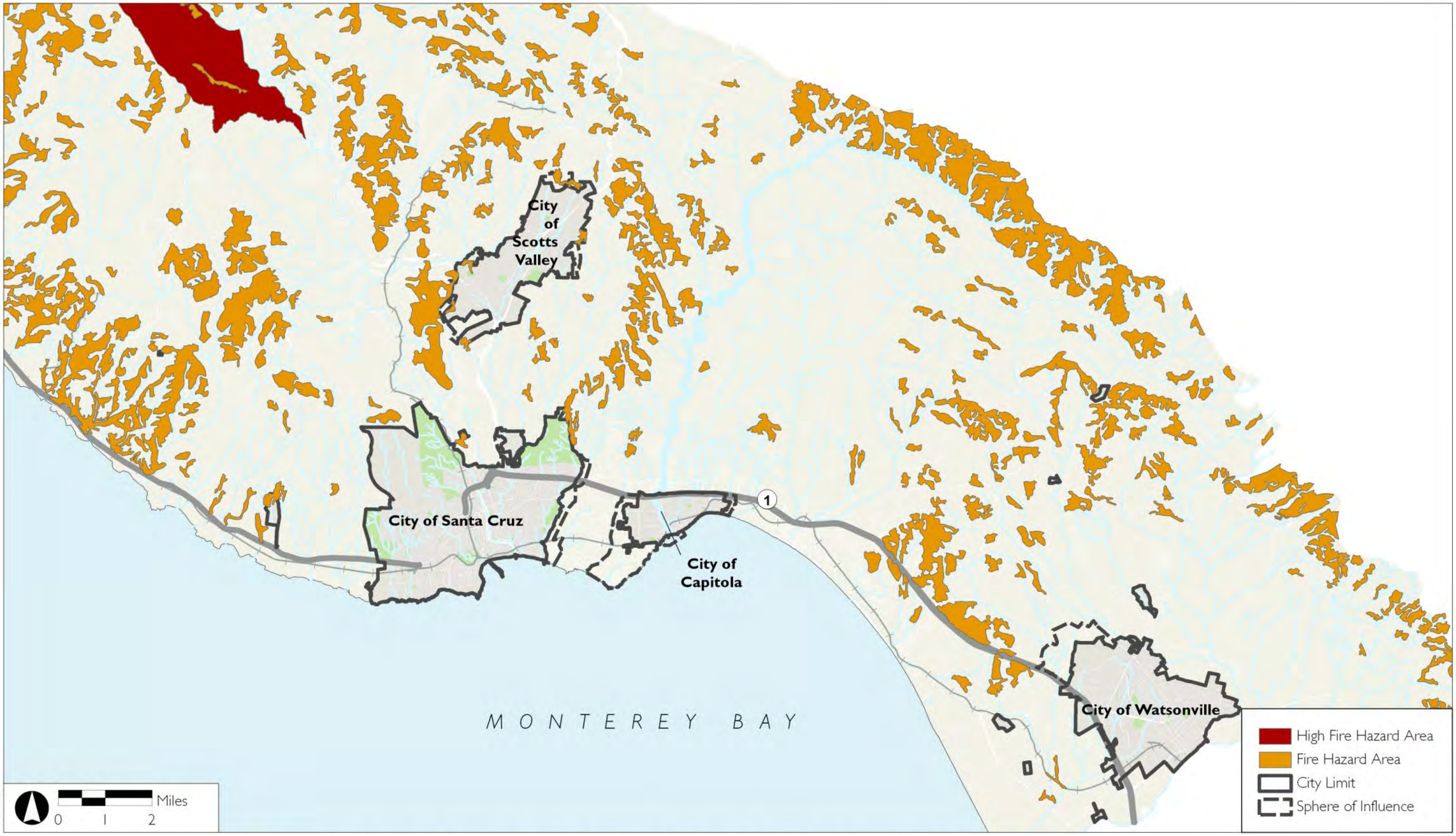
Cal FIRE has not identified fire hazard areas within the City of Capitola. Based on this, threats to populations and systems associated with wildland fires are anticipated to be minimal. However, a fire threat will always exist in a wildland/urban interface area as long as vegetation, trees, down and dead fuels, structures and humans co-exist. There is a high probability that fires will occur in one or more of these areas.

Climate Change Considerations
Anticipating that precipitation regimes may change in the future as a result of climate change, there may be greater opportunity for wildfire hazards throughout the State of California. Increases future droughts and hotter temperatures could increase fuel loads within wildland areas increase the risk associated with wildland fires.

Vulnerability/Risk Assessment

As indicated in Exhibit 14 - Fire Hazard Areas, there are no fire hazard areas located in the City of Capitola based on the available fire mapping for Santa Cruz County. Intersections between critical facilities and fire hazard areas were not conducted since these areas are not within the City.

FIRE HAZARD AREAS
EXHIBIT 14



Source: City of Capitola, 2010; Santa Cruz County, 2010; Emergency Management. "Fire Hazard Areas." [shapefile]. (2010). Santa Cruz County Geographic Information System File Download Site. Available at <http://sccftpmap.co.santa-cruz.ca.us/File%20Download%20Site/Emergency%20Management/Shapefiles/EmergencyMgmt.zip>, Downloaded: January 29, 2011.

3.7 Landslide and Mudflow

3.7.1 Identifying Landslide and Mudflow Hazards

General slope stability is determined by a number of factors such as the angle of the slope, vegetative cover, wildland fire, bedrock, soil, seismic activity, precipitation, groundwater, erosion, and human alterations to land such as hillside grading activities. Slopes may be in temporary equilibrium until one of the aforementioned factors is modified by natural or human activity resulting in an unstable condition and potential slope failure.

Figure 15 - Debris generated during the Flash Floods (ca. 1955)

A landslide is defined as a downward and outward movement of soil and rock. Such a movement occurs when steep slopes are destabilized by excess water accumulation in the soil, the addition of excess weight to the top of a slope, the removal of support from the bottom of a slope, or a combination of the above. The force of rocks, soils, or other debris moving down a slope can devastate anything in its path as illustrated in Figure 15.

Mudflows, often referred to as "debris flows" or "mudslides" are caused by sustained and intense rain fall that is accompanied by rocks, vegetation and other debris. These are fast moving down slope flows and can cause severe damage. The rapid movement and sudden arrival of debris flows pose a hazard to life and property during and immediately following the triggering rainfall. In order to trigger "debris flows" a storm must have a critical combination of rainfall intensity and duration leading to saturation of the hill slope soils, generation of positive pore fluid pressures within the soil and ultimately, slope failure.

Examples of common impacts can include death and injuries, damage to structures and infrastructure, environmental damages (such as destruction of plant life and habitat), economic impacts, impacts to continuity of business and/or government, etc. They can be general statements as they apply to the City.

3.7.2 Profiling Landslide and Mudflow Hazards

Location and Extent

Landslides are a common occurrence in the Santa Cruz Mountains. Intense winter storms, high rainfall amounts, and steep terrain are all conducive to land sliding. Earthquake activity can exacerbate this hazard. The 1906 San Francisco earthquake set off dozens of large landslides in the Santa Cruz Mountains, some of which claimed human lives.

Capitola's topography ranges in steepness from 0 percent slope (flat) to more than 50 percent slope. The majority of the City falls into a relatively flat category. The primary area of concern for the City of Capitola with regard to landslides is the land above Soquel Creek and below Wharf Road. Exhibit 15 - *Topographic Relief* categorizes the City of Capitola and surrounding areas based on the percentage of slope. Areas on the map most susceptible to landslides and mudflows have slopes greater than 50% and are colored red. The majority of these areas are coastal bluffs, escarpments of decomposed rock or soil resulting from erosion or faulting, with a vertical elevation of at least ten feet. In addition to the coastal bluffs, there are areas along Soquel Creek, Nobel Gulch, and Tannery Gulch that have steep slopes that could be susceptible to landslides and mudflows.

Coastal bluff areas within Capitola that have steep topography include Cliff Drive and surrounding open space, residential areas in the City's Jewel Box neighborhood, as well as shoreline residences and open space areas of the Depot Hill neighborhood, between the Village and New Brighton State Park.

Past Occurrences

Table 32: Landslides and Mudflows identifies past landslide and mudflow events in Santa Cruz County from 2005 through 2011. No major landslides or mudflows have occurred in Capitola.

Table 32: **Landslides and Mudflows**

Date	Location	Magnitude	County-wide Property Damage
3/22/2005	Valencia Road in Aptos	Mudflow	$150,000
3/22/2005	Scotts Valley	Landslide	$375,000
3/22/2005	Santa Cruz County	Landslide	$1,000,000
10/13/2009	Highway 84	Landslide	$10,000
12/19/2010	Old San Jose Road	Mudflow	$4,000

National Climatic Data Center http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

In addition to the past landslide and mudflow events listed above, coastal storms can contribute to landslide and mudflow. Historical events describing coastal storms of this nature can be found in the flood profile.

Probability of Future Occurrence

Although nature caused landslides are beyond control, most recent landslides in the Santa Cruz Mountains have been caused by a combination of human activity and natural factors. Human activities that may destabilize slopes include logging, woodland conversion, road building, housing construction and any activity which alters normal drainage patterns. Whether or not any of these activities will trigger landslides depends on the existing natural conditions. Some soil and rock types are more prone to land sliding than others. In Capitola, areas of greatest concern are located within drainage courses like Soquel Creek, Noble Gulch, and Tannery Gulch. Landslides within these drainages could occur in areas of steep topography, if conditions allow.

Climate Change Considerations

Anticipating that precipitation regimes may change in the future as a result of climate change, there may be greater opportunity for landslides and mudflows. Current climate change science indicates that storms may become less frequent and more intense, which could result in greater amounts of runoff at higher velocities within the various drainages in Capitola. With greater amounts of precipitation underlying soils and rock units could become saturated quicker increasing the risk for landslides. In addition, if water runoff is occurring at greater velocities, there is greater potential for erosion, which could induce landslides and mudflows within Capitola.

Vulnerability/Risk Assessment

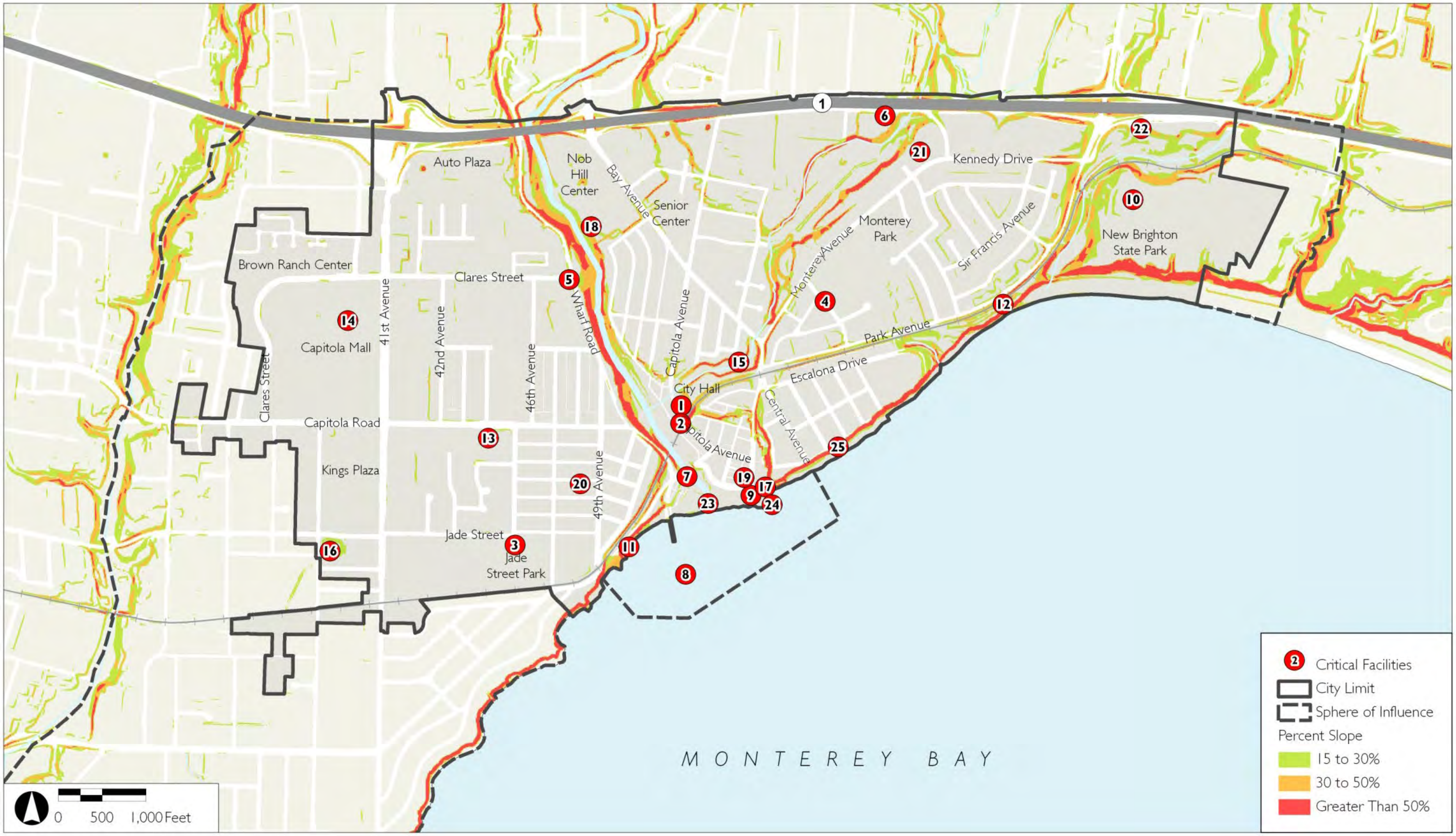
Table 33: Topographic Relief Associated with Capitola Critical Facilities identifies the critical facilities located within the increasing slope categories identified on Exhibit 15: Topographic Relief. The greater the slope, the more

susceptible the area is to a landslide or mudflow. The replacement, contents, and potential loss values have been calculated for each facility located in a sloped area. As stated above, the greater the slope, the more susceptible the area is to a landslide or mudflow.

Map #	Facility	Topographic Relief (Slope)				Replacement Value	Contents Value
		0-15%(no color)	15-30% (green)	30-50% (orange)	>50% (red)		
1	City Hall/Emergency Operations Center	X	X	X	X	$8,000,000	$750,000
1	Capitola Police Station	X	X	X	X	$4,000,000	$750,000
2	Central Fire Station #4	X				$3,000,000	$100,000
3	Jade Street Community Center -- Emergency Shelter	X				$3,000,000	$200,000
4	New Brighton Gym -- Emergency Shelter	X				$2,500,000	$75,000
4	New Brighton School -- Back-up Emergency Shelter	X				$4,000,000	$700,000
5	Capitola Library -- Backup Emergency Operations Center	X				$10,000,000	$700,000
6	Capitola Corporation Yard	X				$2,000,000	$500,000
7	Stockton Avenue Bridge	X	X	X	X	$10,000,000	N/A
9	Capitola Beach Sea Wall	X				$5,000,000	N/A
10	New Brighton State Park--staging area for emergency response	X				N/A	N/A
11	Cliff Drive -at risk arterial (sea wall and road)	X	X	X	X	$8,000,000	N/A
12	Park Avenue-at risk arterial (sea wall and road)	X	X	X	X	$4,000,000	N/A
13	Police Communications Antenna-Capitola Mall	X				$100,000	N/A
14	Police Communications Antenna-AAA Building	X				$100,000	
15	Noble Gulch Storm Pipe	X	X	X	X	$10,000,000	N/A
16	38th Avenue Drainage Facility	X	X			$2,000,000	$300,000

Map #	Facility	Topographic Relief (Slope)				Replacement Value	Contents Value
		0-15%(no color)	15-30% (green)	30-50% (orange)	>50% (red)		
17	Capitola Pump Station-Esplanade Park	X	X	X	X	$10,000,000	$800,000
18	Soquel Pump Station	X	X	X		$10,000,000	$1,700,000
19	Lawn Way Storm Drain Pump Station	X				$500,000	N/A
20	Soquel Creek Water District Treatment Plant, Garnet Street	X				$2,000,000	$700,000
21	Soquel Creek Water District Seawater Intrusion Prevention Well, Monterey Avenue	X				$2,000,000	$70,000
22	SCWD MacGregor Booster Pumping Station	X	X	X		$300,000	N/A
23	Capitola Beach Flume	X				$2,000,000	N/A
24	Capitola Beach Jetty	X				$3,000,000	N/A
25	Grand Avenue Cliffs	X				N/A	N/A
	Total Potential Losses					$115,500,000	$7,345,000

TOPOGRAPHIC RELIEF
EXHIBIT 15



Source: City of Capitola, 2010; Santa Cruz County, 2012.

3.7.3 Expansive Soils

The Technical Advisory Committee initially identified expansive soils as a hazard of risk to the City of Capitola with limited hazard planning consideration. Based on the lack of past occurrences and minimal risk of future impacts from expansive soils, the Hazard Mitigation Planning Team decided not to include a profile for expansive soils. This hazard may be re-visited in future updates to this Plan.

3.8 Summary of Vulnerability

Table 33: Risk Assessment Summary shows a summary of critical facilities that intersect with hazard areas in the City of Capitola. Those facilities that intersect with a hazard area are indicated with a "Y" and a red shaded cell. Facilities that do not fall within the hazard area are designated by an "N" and a green shaded cell. The Capitola Beach Sea Wall and New Brighton State Park were not intersected ("NA") with the liquefaction potential hazard area because they fall outside the hazard area boundary.

As stated above, hazard and critical facility overlays were not conducted for wildfire, windstorm, drought, and earthquake. Overlays were conducted for erosion, flood, hazardous materials, liquefaction, landslide/mudslide, and tsunami. More detailed findings from this analysis can be found in the sections below.

3.9 Significant Hazards

The vulnerability assessments within each hazard profile are used to understand the varying levels of risk to the City of Capitola. Based on these assessments, the planning team concluded the two hazards of greatest concern to the City of Capitola are **coastal storm/flooding** and **tsunami**. For both of these hazards, 12 of the City's 25 critical facilities fall within the 100 year flood zone and the tsunami inundation zone. **Liquefaction** also poses a significant threat to the City. Nine critical facilities fall within the Very High and High liquefaction potential zones, 13 facilities fall within the low liquefaction potential zone, meaning that 22 of the City's 25 critical facilities are at risk to damage caused by liquefaction. **Landslide and mudslide** also pose a risk to the City, with 12 facilities falling within the 30% to greater than 50% slope range.

Table 33: **Risk Assessment Summary**

Facility				Flood	Hazardous Materials			Liquefaction Potential				Topo (Slope)				
		Beach Erosion	Cliff Erosion	100 yr.	intersect	within 500'	within 1000'	Very High (A)	High (B)	Low (D)	Undefined (Unkn)	0-15%(no color)	15-30% (green)	30-50% (orange)	>50% (red)	Tsunami
1	City Hall/Emergency Operations Center	N	N	Y	N	N	N	N	Y	N	N	N	N	N	Y	Y
1	Capitola Police Station	N	N	Y	N	N	N	N	Y	N	N	N	N	N	Y	Y
2	Central Fire Station #4	N	N	Y	N	N	N	N	Y	N	N	Y	N	N	N	Y
3	Jade Street Community Center -- Emergency Shelter	N	N	N	N	N	N	N	N	Y	N	Y	N	N	N	N
4	New Brighton Gym Emergency Shelter	N	N	N	N	N	N	N	N	Y	N	Y	N	N	N	N
4	New Brighton School Backup Emergency Shelter	N	N	N	N	N	N	N	N	Y	N	Y	N	N	N	N

Table 33: **Risk Assessment Summary**

Facility		Beach Erosion	Cliff Erosion	Flood	Hazardous Materials			Liquefaction Potential				Topo (Slope)				Tsunami
				100 yr.	intersect	within 500'	within 1000'	Very High (A)	High (B)	Low (D)	Undefined (Unkn)	0-15%(no color)	15-30% (green)	30-50% (orange)	>50% (red)	
5	Capitola Library Backup Emergency Operations Center	N	N	N	N	N	N	N	N	Y	N	Y	N	N	N	N
6	Capitola Corporation Yard	N	N	N	N	N	N	N	N	Y	N	Y	N	N	N	N
7	Stockton Avenue Bridge	Y	N	Y	N	N	N	Y	N	N	N	Y	Y	Y	Y	Y
8	Capitola Wharf	N	N	Y	N	N	N	NA	NA	NA	NA	N	N	N	N	Y
9	Capitola Beach Sea Wall	N	N	Y	N	N	N	Y	N	N	N	Y	N	N	N	Y
10	New Brighton State Park--staging area for emergency response	N	N	N	N	N	N	NA	NA	NA	NA	Y	N	N	N	N
11	Cliff Drive -at risk arterial (sea wall and road)	N	Y	N	N	N	N	N	N	Y	N	Y	Y	Y	Y	Y

Table 33: **Risk Assessment Summary**

Facility				Flood	Hazardous Materials			Liquefaction Potential				Topo (Slope)				
		Beach Erosion	Cliff Erosion	100 yr.	intersect	within 500'	within 1000'	Very High (A)	High (B)	Low (D)	Undefined (Unkn)	0-15%(no color)	15-30% (green)	30-50% (orange)	>50% (red)	Tsunami
12	Park Avenue-at risk arterial (sea wall and road)	N	Y	N	N	N	N	N	N	Y	N	Y	Y	Y	Y	N
13	Police Communications Antenna-Capitola Mall	N	N	N	N	N	N	N	N	Y	N	Y	N	N	N	N
14	Police Communications Antenna-AAA Building	N	N	N	N	Y	Y	N	N	Y	N	Y	N	N	N	N
15	Noble Gulch Storm Pipe	N	N	Y	N	N	N	N	Y	N	N	Y	Y	Y	Y	Y
16	38th Avenue Drainage Facility	N	N	N	N	N	Y	N	N	Y	N	Y	Y	N	N	N
17	Capitola Pump Station-Esplanade Park	N	Y	Y	Y	N	N	YY	N	N	Y	Y	Y	Y	Y	Y
18	Soquel Pump Station	N	N	Y	N	N	Y	Y	N	N	N	Y	Y	Y	N	N

Table 33: **Risk Assessment Summary**

Facility		Beach Erosion	Cliff Erosion	Flood	Hazardous Materials			Liquefaction Potential				Topo (Slope)				Tsunami
				100 yr.	intersect	within 500'	within 1000'	Very High (A)	High (B)	Low (D)	Undefined (Unkn)	0-15%(no color)	15-30% (green)	30-50% (orange)	>50% (red)	
19	Lawn Way Storm Drain Pump Station	Y	N	Y	N	N	N	Y	N	N	N	Y	N	N	N	Y
20	Soquel Creek Water District Treatment Plant, Garnet Street	N	N	N	N	N	N	N	N	Y	N	Y	N	N	N	N
21	Soquel Creek Water District Seawater Intrusion Prevention Well, Monterey Avenue	N	N	N	N	N	N	N	N	Y	N	Y	N	N	N	N
22	Soquel Creek Water District MacGregor Booster Pumping Station	N	N	N	N	N	N	N	N	Y	N	Y	Y	Y	N	N
23	Capitola Beach Flume	N	N	Y	N	N	N	Y	N	N	N	Y	N	N	N	Y

Table 33: **Risk Assessment Summary**

Facility		Beach Erosion	Cliff Erosion	Flood	Hazardous Materials			Liquefaction Potential				Topo (Slope)				Tsunami
				100 yr.	intersect	within 500'	within 1000'	Very High (A)	High (B)	Low (D)	Undefined (Unkn)	0-15%(no color)	15-30% (green)	30-50% (orange)	>50% (red)	
24	Capitola Beach Jetty	N	N	Y	N	N	N	N	N	N	Y	Y	N	N	N	Y
25	Grand Avenue Cliffs	N	Y	N	N	N	N	N	N	N	Y	Y	N	N	N	N

Y denotes that the critical facility intersects the hazard layer	N denotes that the critical facility does not intersect the hazard layer	NA denotes that the hazard layer is not available within the geographic extent of the analysis

3.10 Facilities at Most Risk

The critical facilities listed in Table 35: Capitola Critical Facilities At Risk are the most at risk to hazard events in the City of Capitola. They fall within multiple hazard zones making them susceptible to future damage from a variety of potential events.

Table 34: **Capitola Critical Facilities At Risk**

Facility	Erosion	Flood	HAZMAT	Liquefaction	Slope	Tsunami
Stockton Avenue Bridge	Y	Y	N	Y	Y	Y
Capitola Pump Station- Esplanade Park	Y	Y	Y	Y	Y	Y
Cliff Drive	Y	N	N	Y	Y	Y
Noble Gulch Storm Pipe	N	Y	N	Y	Y	Y
Park Avenue	Y	N	N	Y	Y	N
Soquel Pump Station	N	Y	Y	Y	Y	N

3.11 Potential Losses

Table 36: Most Costly Capitola Critical Facilities identifies the critical facilities with the greatest replacement value (combination of building replacement and contents value), in the City of Capitola. Should these facilities be completely destroyed by a hazard event, their replacement will be the most costly compared to other identified critical facilities.

Table 35: **Most Costly Capitola Critical Facilities**

Map #	Facility	Replacement Value
8	Capitola Wharf	$20,000,000
5	Capitola Library -- Backup Emergency Operations Center	$10,000,000
7	Stockton Avenue Bridge	$10,000,000
15	Noble Gulch Storm Pipe	$10,000,000
17	Capitola Sewage Pump Station - Esplanade Park	$10,000,000
18	Soquel Sewage Pump Station	$10,000,000
1	City Hall/Emergency Operations Center	$8,000,000
11	Cliff Drive - at risk arterial (sea wall and road)	$8,000,000
9	Capitola Beach Sea Wall	$5,000,000

Of these facilities, the Stockton Avenue Bridge, Cliff Drive, the Noble Gulch Storm Pipe, and the Soquel Sewage Pump Station are also facilities that are most susceptible to hazard events in the City of Capitola.

4 Chapter Four – Mitigation Actions

Hazard mitigation strategies are used to reduce the hazard impacts on large employment and industrial centers, public infrastructure, and critical facilities. This section of the City of Capitola Hazard Mitigation Plan is derived from an in-depth review of the vulnerabilities and capabilities described in this Plan. Mitigation actions from the Santa Cruz County Hazard Mitigation Plan and City of Santa Cruz Hazard Mitigation Plan were also reviewed so that the City of Capitola can support these actions. Overall, the actions represent Capitola's risk-based approach for reducing and/or eliminating the potential losses as identified in the Vulnerability Assessment section of each Hazard Profile.

4.1 Hazard Mitigation Overview

4.1.1 FEMA'S National Flood Insurance Program

In 1968, the US Congress created the National Flood Insurance Program (NFIP). Participation in the NFIP by a Community is voluntary; however, in order to receive funding from FEMA, a Community is required to participate in the program.

The City of Capitola participates in the NFIP and development in the floodplain is permitted according to Title 15.20 Floodplain District of the Municipal Code. Ordinance No. 970 adopted on May 10, 2012 amended the Title 15.20 floodplain management regulations per FEMA guidance and for consistency with the 2010 updated digital flood insurance rate maps. The ordinance is administered, implemented, and enforced by the City's Building Official as the designated floodplain administrator. The Building Official grants or denies building permits in accord with Title 15.20 Floodplain District of the Municipal Code.

The Community Rating System (CRS) is a voluntary part of the National Flood Insurance Program that seeks to coordinate all flood-related activities, reduce flood losses, facilitate accurate insurance rating, and promote public awareness of flood insurance by creating incentives for a community to go beyond minimum discounts. CRS ratings are on a 10-point scale (from 10 to 1, with 1 being the best rating), with residents of the community who live within FEMA's Special Flood Hazard Areas (SFHA) receiving a 5% reduction in flood insurance rates for every Class improvement in the community's CRS rating. The City of Capitola does not currently participate in the Community Rating System.

Repetitive Loss Properties: According to FEMA, in Capitola there are nine properties with a total of 28-repetitive loss incidents which total $615,891.00 dollars (avg. $21,996 per incident).

4.1.2 Hazard Mitigation Goals

The plan goals, presented in the Mitigation Priorities and Goals section of Chapter 1, serve as basis for direction to promote sound public policy designed to protect citizens, critical facilities, infrastructure, private property, and the environment from hazards. The Plan goals guide the direction of future activities aimed at reducing risk and preventing loss from natural hazards. The goals also serve as checkpoints as agencies and organizations begin implementing mitigation action items.

The hazard mitigation actions identified below list those activities which the City of Capitola will utilize to reduce their risk to potential hazards. These mitigation actions were identified through data collection and research, collaboration with the Technical Advisory Committee, and public input. Mitigation actions as related to coastal climate change vulnerability as derived in part from the Coastal Climate Change Vulnerability Report, June 2017, which is included as part of this LHMP update and included as Appendix C.

Some of these actions may be eligible for funding through Federal and State grant programs, and other funding sources as made available to the City. The mitigation actions are intended to address the comprehensive range of identified hazards. Some actions may address risk reduction from multiple hazards.

4.1.3 Hazard Mitigation Prioritization

Through discussion and self-analysis, the TAC used the STAPLE/E (Social, Technical, Administrative, Political, Legal, Economic, and Environmental) criteria, as described in Table 36: STAPLE/E Review and Selection Criteria, when considering and prioritizing the most appropriate mitigation alternatives for the City. This methodology (as endorsed by FEMA) requires that social, technical, administrative, political, legal, economic, and environmental considerations be taken into account when reviewing potential actions to undertake. This process was used to help ensure that the most equitable and feasible actions would be undertaken based on the City's unique capabilities.

To develop a consensus priority ranking for the mitigation actions, each representative at the third milestone meeting was given ten votes to identify their highest priority mitigation actions. The votes were tallied to identify the highest priority mitigation actions and results incorporated into the final mitigation action priority rankings.

Table 36: **STAPLE/E Review and Selection Criteria**

Social
• Is the proposed action socially acceptable to the jurisdiction and surrounding community? • Are there equity issues involved that would mean that one segment of the jurisdiction and/or community is treated unfairly? • Will the action cause social disruption?
Technical
• Will the proposed action work? • Will it create more problems than it solves? • Does it solve a problem or only a symptom? • Is it the most useful action in light of other jurisdiction goals?
Administrative
• Can the jurisdiction implement the action? • Is there someone to coordinate and lead the effort? • Is there sufficient funding, staff, and technical support available? • Are there ongoing administrative requirements that need to be met?
Political
• Is the action politically acceptable? • Is there public support both to implement and to maintain the project?

Table 36: **STAPLE/E Review and Selection Criteria**

Legal
• Is the jurisdiction authorized to implement the proposed action? • Are there legal side effects? Could the activity be construed as a taking? • Will the jurisdiction be liable for action or lack of action? • Will the activity be challenged?
Economic
• What are the costs and benefits of this action? • Do the benefits exceed the costs? • Are initial, maintenance, and administrative costs taken into account? • Has funding been secured for the proposed action? If not, what are the potential funding sources (public, non-profit, and private)? • How will this action affect the fiscal capability of the jurisdiction? • What burden will this action place on the tax base or local economy? • What are the budget and revenue effects of this activity? • Does the action contribute to other jurisdiction goals? • What benefits will the action provide?
Environmental
• How will the action affect the environment? • Will the action need environmental regulatory approvals? • Will it meet local and state regulatory requirements? • Are endangered or threatened species likely to be affected?

4.1.4 Hazard Mitigation Benefit-Cost Review

FEMA requires local governments to analyze the benefits and costs of a range of mitigation actions that can reduce the effects of each hazard within their community. Benefit-cost analysis is used in hazard mitigation to show if the benefits to life and property protected through mitigation efforts exceed the cost of the mitigation activity. Conducting benefit/cost analysis for a mitigation activity can assist communities in determining whether a project is worth undertaking now, in order to avoid disaster related damages later. The analysis is based on calculating the frequency and severity of a hazard, avoided future damages, and risk.

A hazard mitigation plan must demonstrate that a process was employed that emphasized a review of benefits and costs when prioritizing the mitigation actions. The benefit-cost review must be comprehensive to the extent that it can evaluate the monetary as well as the non-monetary benefits and costs associated with each action. The benefit-cost review should at least consider the following questions:

- How many people will benefit from the action?
- How large an area is impacted?

- How critical are the facilities that benefit from the action (which is more beneficial to protect, the fire station or the administrative building)?
- Environmentally, does it make sense to do this project for the overall community?

For the Capitola LHMP, the Technical Advisory Committee used these questions to determine the appropriateness of mitigation actions. Those actions that did not have adequate benefits were excluded from the preliminary list of mitigation actions.

4.2 Hazard Mitigation Actions

The process used to identify hazard mitigation actions for this Plan included the following:

- Review of the Risk Assessment presented in Chapter 3 of this plan;
- Review of the Capabilities Assessment presented in Chapter 5 of this plan;
- Review of the Santa Cruz County and City of Santa Cruz Hazard Mitigation Plan mitigation actions;
- Review of new concerns/ issues that need to be addressed to reduce hazards to critical facilities.

Table 37: Capitola Hazard Mitigation Actions identifies the primary hazard, mitigation action priority, proposed mitigation action, City department responsible for implementation, the anticipated funding source(s), and the target completion date.

Potential Funding Source(s) identified in the table include the following:

PDM	Pre-Disaster Mitigation (FEMA)
HMGP	Hazard Mitigation Grant Program (FEMA)
CDBG	Community Development Block Grant (CA Department of Housing & Community Development)
FMA	Flood Mitigation Assistance (FEMA)
FHA	Federal Highway Administration
CalEMA	CalOES
Caltrans	California Department of Transportation

Table 37: **Capitola Hazard Mitigation Actions**

Mitigation Action	Responsible Department	Potential Funding Source(s)	Target Completion Date	Priority	Status Since 2013 LHMP
1. Earthquake / Liquefaction Hazard Related Actions					
A. Continue to enforce the requirements of the Geologic Hazards District (Chapter 17.48) of the Capitola Municipal Code which requires the assessment of geologic hazards by a registered geologist or professional engineer for all new development projects. The geologic hazards identified through this assessment process are then mitigated by avoidance or through measures designed by civil engineers using the California Building Code.	Community Development, Public Works, and Building	Staff budget, Review Fees, Development Impact Fees	Ongoing	Low	Unchanged
B. Continue to enforce the most current versions of both the California Building Code (CBC) and the California Building Standards with regards to seismicity, including requiring engineering and liquefaction studies for all potentially affected development.	Public Works and Building	Staff budget	Ongoing	Low	Unchanged

Table 37: **Capitola Hazard Mitigation Actions**

Mitigation Action	Responsible Department	Potential Funding Source(s)	Target Completion Date	Priority	Status Since 2013 LHMP
C. In cooperation with other agencies, conduct seismic evaluations of all City owned critical facilities (including roadways, water, sewer, storm drains and emergency use facilities) and coordinate with other agencies to evaluate non-city owned critical facilities. Seek funding sources to assist in necessary upgrades of these critical facilities.	Public Works and Other Agencies	PDM, HMGP, Staff budget, and General Fund	2025	Low	Unchanged
D. Work with Caltrans and other relevant agencies to evaluate and retrofit the structural integrity of all bridges to ensure their safety during a seismic event.	Public Works	PDM, HMGP, Staff budget	2030	Low	Unchanged
E. Continue training appropriate plan check staff on seismic requirements for new and existing structures.	Building	Staff budget	Ongoing	Low	Unchanged
2. Coastal Storm / Flooding Hazard Related Actions					
A. Evaluate the likelihood of debris flow impacts to the Stockton Avenue bridge during a catastrophic flooding event.	Public Works	FHA, FMA, Staff budget	2017	High	Completed
B. Improve the Noble Gulch storm drain facilities to protect against flooding within the Capitola Village.	Public Works and Community Development	PDM, HMGP, General Fund	2025	High	Unchanged

Table 37: **Capitola Hazard Mitigation Actions**

Mitigation Action	Responsible Department	Potential Funding Source(s)	Target Completion Date	Priority	Status Since 2013 LHMP
C. Relocate or elevate critical facilities (e.g. City hall, police, fire, etc.) above the level of the 100-year flood elevation.	Public Works and Community Development	PDM, HMGP, General Fund	2035	High	Unchanged
D. Continue to implement the Soquel Creek Lagoon Management Plan.	Public Works and Community Development	PDM, HMGP, FMA, Staff budget	Ongoing	Medium	Unchanged
E. Participate in the National Weather Service (NWS) Storm Ready Program	Community Development and Public Works	Staff budget, General Fund	Ongoing	Medium	Unchanged
F. Assist in the planning and/or improvement of infrastructure (e.g. sewers) and facilities to help minimize flooding impacts, particularly in critical flood-prone areas (e.g. Capitola Village).	Public Works and Community Development in coordination with the County Sanitation District	FHA, PDM	Ongoing	Low	Unchanged
G. Continually monitor and review CA State Water Resources Control Board regulations and permit requirements to ensure consistency with city policies and regulations. This includes on-site retention of stormwater runoff from impervious surfaces and the implementation of Low Impact Development (LIDs) standards on new development.	Public Works and Community Development	Staff budget	Ongoing	Low	Unchanged

Table 37: **Capitola Hazard Mitigation Actions**

Mitigation Action	Responsible Department	Potential Funding Source(s)	Target Completion Date	Priority	Status Since 2013 LHMP
H. Limit development and monitor conditions of development and grading permits to prevent sedimentation in natural channels and wetlands.	Community Development	Staff budget	Ongoing	Low	Unchanged
I. Develop more accurate GIS maps of the City's drainage system in coordination with future updates of the Capitola Stormwater Management Program.	Public Works and Community Development	CalEMA, General Fund, Staff budget	2025	Low	Unchanged
J. In coordination with the Santa Cruz County Public Works & Flood Control & Water Conservation District (Zone 5), evaluate the effectiveness of current policies and ordinances to ensure that storm water runoff from impervious surfaces does not contribute to flooding.	Public Works and Community Development	Staff budget	2025	Low	Unchanged
K. Continually monitor and review FEMA's National Flood Insurance Program (NFIP) requirements to ensure the City's floodplain management regulations are in compliance.	Public Works and Community Development	Staff budget	Ongoing	Low	Unchanged
L. Participate in the FEMA NFIP Community Rating System (CRS).	Community Development	Staff budget	2025	Low	Unchanged

Table 37: **Capitola Hazard Mitigation Actions**

Mitigation Action	Responsible Department	Potential Funding Source(s)	Target Completion Date	Priority	Status Since 2013 LHMP
M. Work in coordination with the Santa Cruz County Public Works & Flood Control & Water Conservation District (Zone 5) to develop and disseminate public education materials on flood protection and mitigation by working collaboratively with community groups, non-governmental organizations and the local media.	Community Development	General Fund	Ongoing	Low	Unchanged
N. Review and update the city's existing ordinances as they relate to storm / flooding hazards, consistent with the risks identified in this LHMP.	Community Development	Staff budget, PDM, HMGP, General Fund	2025	Low	Unchanged
O. Adopt policies to limit municipal capital improvements that would be at risk.	Public Works and Community Development	Staff budget, General Fund	2030	Low	Unchanged
P. Improve resiliency to flooding along Soquel Creek and Coast such as the construction of flood walls and improved building guidelines (increase free board and first floor parking).	Public Works and Community Development	PDM, HMGP, CDBG, CalEMA, FMA	2050	Low	New
Q. Investigate natural habitat buffering to reduce coastal flooding such as beach and kelp management.	Public Works and Community Development	HMGP	2030	Low	New

Table 37: **Capitola Hazard Mitigation Actions**

Mitigation Action	Responsible Department	Potential Funding Source(s)	Target Completion Date	Priority	Status Since 2013 LHMP
R. Upgrade vulnerable storm drains with tidal flap gates and pumps, as appropriate.	Public Works	PDM, HMGP, FMA, CalEMA, General Fund	2030	Low	New
S. Investigate various opportunities for beach nourishment and replenishment in concert with rebuilding the City's groin located at the east end of the main beach.	Public Works	PDM, HMGP	2020	Medium	New
T. Prepare a coastal bluff and beach management plan for Capitola that outlines short- and long-term coastal bluff management strategies that will help to establish local protection and adaptation priorities.	Public Works and Community Development	PDM, HMGP, CDBG, General Fund	2030	Medium	New
U. Prioritize coastal protection structures for upgrade and replacement including the sea wall along The Esplanade and coastal revetments.	Public Works	PDM, HMGP, CDBG, General Fund	2040	Low	New
V. Consider resiliency improvements to protect and maintain critical vehicular and non-vehicular coastal access ways.	Public Works and Community Development	PDM, HMGP, CDBG, General Fund	2030	Medium	New
W. Adopt policies to limit municipal capital improvements that would be at risk.	Public Works and Community Development	Staff budget, General Fund	2025	Medium	New

Table 37: **Capitola Hazard Mitigation Actions**

Mitigation Action	Responsible Department	Potential Funding Source(s)	Target Completion Date	Priority	Status Since 2013 LHMP
X. Improve resiliency to flooding along Soquel Creek including the possibility of a temporary or permanent flood wall along the Soquel Creek walking path may help to reduce flooding within high risk areas.	Public Works and Community Development	PDM, HMGP, FMA, CalEMA	2050	Low	New
Y. Identify priority areas for future protection accounting for costs, structural feasibility and secondary implications (flood wall, seawall or revetment).	Public Works and Community Development	PDM, HMGP, FMA, CalEMA; Staff budget; General Fund	2060	Low	New
Z. Investigate long-term options to manage sea level rise and coastal erosion such as living shorelines, soft armoring techniques, and relocation of development within coastal hazard zones. As part of this investigation, consider the preparation of a comprehensive, long-term proactive management plan to protect Depot Hill in a way that preserves the natural coastline and avoids hard armoring.	Public Works and Community Development	PDM, HMGP, FMA, CalEMA; Staff budget; General Fund	2060	Low	New
3. Drought Hazard Related Actions					
A. Work in coordination with the City of Santa Cruz and the Soquel Creek Water District to implement water conservation strategies that maximize the use of existing water resources.	Community Development	Staff budget	Ongoing	Low	Unchanged

Table 37: **Capitola Hazard Mitigation Actions**

Mitigation Action	Responsible Department	Potential Funding Source(s)	Target Completion Date	Priority	Status Since 2013 LHMP
B. Work in coordination with the Soquel Creek Water District to construct and implement the Pure Water Soquel, Groundwater Replenishment and Seawater Intrusion Prevention Project	Public Works	Staff budget, Prop 84 – IRWMP	2022	High	Unchanged
C. Coordinate with the Soquel Creek Water District and City of Santa Cruz to inform public of water conservation restrictions and drought conditions.	Community Development	Staff budget	Ongoing	Low	Unchanged
4. Windstorm Hazard Related Actions					
A. Coordinate with Pacific Gas & Electric to implement an ongoing tree trimming program for trees located in close proximity to overhead power lines.	Public Works	Staff budget, PG&E	Ongoing	Low	Unchanged
B. Establish a working relationship with the NWS Decision Support program to be advised of upcoming weather conditions in a manner that enables smart decisions.	Police Department	Staff budget	2025	Low	Unchanged

Table 37: **Capitola Hazard Mitigation Actions**

Mitigation Action	Responsible Department	Potential Funding Source(s)	Target Completion Date	Priority	Status Since 2013 LHMP
5. Coastal Erosion/ Bluff Failure Hazard Related Actions					
A. Work in close coordination with state and local agencies and organizations to protect and preserve the coastline and its coastal bluffs through restoration efforts to help ensure safe coastal access and the protection of adjacent infrastructure and facilities. These efforts may include beach replenishment, coastal bluff protection, seawall construction, and other appropriate measures.	Public Works, Community Development, County Sanitation District	Staff budget	Ongoing	Medium	Unchanged
6. Tsunami Hazard Related Actions					
A. Continue implementation of Tsunami Ready Program	Community Development, Public Works, Police	Staff budget	Ongoing	Medium	Unchanged
B. Maintain a public communication system to warn the public of a potential tsunami threat.	Community Development, Public Works, Police	Staff budget	Ongoing	Medium	Unchanged
C. Support the timely and accurate update of tsunami inundation maps within the Monterey Bay area. Then integrate the new tsunami inundation maps into the risk assessment of this Local Hazard Mitigation Plan	Community Development, Public Works, Police	Staff budget	Ongoing	Low	Unchanged

Table 37: **Capitola Hazard Mitigation Actions**

Mitigation Action	Responsible Department	Potential Funding Source(s)	Target Completion Date	Priority	Status Since 2013 LHMP
D. Continue to work collaboratively with relevant agencies and organizations to investigate tsunami threat to the City based on the best available information.	Community Development, Public Works, Police	Staff budget	Ongoing	Low	Unchanged
7. Hazardous Materials Related Actions					
A. Continue to coordinate with the Santa Cruz County Department of Environmental Health Services, on enforcement of State and local statutes and regulations pertaining to hazardous materials/ waste storage, use, and disposal.	Community Development, Public Works, Police, Fire	Staff budget	Ongoing	Low	Unchanged
B. Support staff training and education requirements regarding emergency response procedures associated with transportation-based hazardous materials releases.	Community Development, Public Works, Police, Fire	Staff budget	Ongoing	Low	Unchanged
C. Continue to coordinate the Urban Area Security Initiative to enhance preparedness efforts.	Police	UASI, Homeland Security Grant	Ongoing	Not Ranked*	Unchanged

Table 37: **Capitola Hazard Mitigation Actions**

Mitigation Action	Responsible Department	Potential Funding Source(s)	Target Completion Date	Priority	Status Since 2013 LHMP
8. Fire Hazard Related Actions					
A. Coordinate with the Fire District and Department of Corrections to create fuel reduction zones near properties at risk, shaded fuel breaks, and clean up areas prone to ground fuel litter common with invasive species habitat (i.e. Eucalyptus)	Fire, Public Works	Staff Budget	Ongoing	Not Ranked*	Unchanged
B. Continue to maintain cooperative fire protection and fire prevention agreements with the Central Fire Protection District and other relevant agencies.	Community Development, Public Works, Police, Fire	Staff budget	Ongoing	Low	Unchanged
C. Identify inadequate access roadways. Develop a program to address inadequacies.	Community Development, Public Works, Fire, Police	PDM, HMGP, General Fund	Ongoing2025	Low	Unchanged
D. Promote land use planning and implement building codes to reduce incidence of human-caused wildfires especially in very high fire hazard areas.	Community Development, Building, Fire	Staff budget	Ongoing	Low	Unchanged
E. Implement building codes relevant to fire protection in new development or major renovations. (i.e. built-in fire extinguishing and fire alarm systems)	Community Development, Building, Fire	Staff budget	Ongoing	Low	Unchanged

Table 37: **Capitola Hazard Mitigation Actions**

Mitigation Action	Responsible Department	Potential Funding Source(s)	Target Completion Date	Priority	Status Since 2013 LHMP
F. Work cooperatively with Central Fire Protection District, CalFire, and other relevant agencies to promote the implementation and awareness of fire prevention programs.	Community Development, Fire	Staff budget	Ongoing	Low	Unchanged
9. Landslide/ Mudflow Hazard Related Actions					
A. Continue to require that geologic/engineering reports be prepared for any proposed construction near landsliding and require mitigation of landslide hazards before issuing any building or grading permits.	Community Development, Building, Public Works	Staff budget	Ongoing	Low	Unchanged
10. Multi-Hazard Related Actions					
B. Coordinate hazard mitigation progress/efforts with the Santa Cruz County Office of Emergency Services and other agencies and cities within Santa Cruz County.	Community Development, Public Works, Police, Fire, City Manager	Staff budget	Ongoing	Medium	Unchanged
C. Continue to work with Santa Cruz 911 and other relevant agencies to maintain a coordinated and effective emergency communication system.	Community Development, Public Works, Police, Fire	Staff budget	Ongoing	Low	Unchanged

Table 37: **Capitola Hazard Mitigation Actions**

Mitigation Action	Responsible Department	Potential Funding Source(s)	Target Completion Date	Priority	Status Since 2013 LHMP
D. Continue to update and enhance mapping data and the City's GIS for all hazards.	Information Technology	General Fund	Ongoing	Low	Unchanged
E. Verify the replacement value of City-owned critical facilities and coordinate with other agencies for non city-owned facilities to improve the risk assessment within this plan.	Public Works, Community Development, Finance	General Fund	2019	Low	Completed
F. Work with the appropriate cellular phone service providers to ensure there is always adequate cellular services to critical facilities within the City.	Police, Information Technology	Staff budget	Ongoing	Low	Unchanged
G. Reference and integrate the City's Local Hazard Mitigation Plan into the Safety Element of the General Plan.	Community Development	General Fund, DRI	2015	Low	Completed
H. Integrate the results of the Monterey Bay Sea Level Rise Study into the Local Hazard Mitigation Plan risk assessment and the General Plan Safety Element.	Community Development	DRI	2025	Low	New
I. As part of the General Plan Update process, develop a plan to address climate change/ climate adaptation issues within the City and its surroundings.	Community Development	Staff budget	2014	Low	Completed

Table 37: **Capitola Hazard Mitigation Actions**

Mitigation Action	Responsible Department	Potential Funding Source(s)	Target Completion Date	Priority	Status Since 2013 LHMP
J. Protect and preserve the coastline through permit review and continue to review coastal development for conformance with applicable City regulations (e.g. geologic, flood).	Community Development, Public Works	Staff budget	Ongoing	Low	Unchanged
K. Review and update the city's existing ordinances as they relate to hazards and risks identified in this LHMP.	Community Development	Staff budget	2025	Low	Unchanged

*These mitigation actions were added after mitigation action ranking was conducted.

4.3 Capabilities Assessment

This capability assessment is designed to identify existing local agencies, personnel, planning tools, public policy and programs, technology, and funds that have the capability to support hazard mitigation activities and strategies outlined in this LHMP. To create this capability assessment, the Technical Advisory Committee collaborated to identify current local capabilities and mechanisms available to the City of Capitola for reducing damage from future natural hazard events. These plans and resources were reviewed while developing the Local Hazard Mitigation Plan and summarized below.

4.3.1 Key Resources

The City of Capitola and the County of Santa Cruz have several key departments with resources to support the implementation of mitigation actions. These departments offer a variety of planning, technical, policy, and staffing resources as summarized in Table 38: Capitola Capabilities Assessment.

Table 38: **Capitola Capabilities Assessment**

Type of Resource	Resource Name	Ability to Support Mitigation
Community Development Department		
Personnel Resource	Community Development Director	Leads the development and implementation of this Local Hazard Mitigation Plan. Can use personnel resources to include outreach to the public.
Policy Resource	Zoning Ordinance	The Zoning Ordinance is the main tool to implement the City's General Plan. It sets land use regulations and the zoning map for the City. Hazard mitigation related zones include the floodplain district and the geologic hazards district. Mitigation actions outlined in this Plan can be adopted in the form of land use/development regulations.
Policy Resource	Building Code/Fire Code	International Building Code, International Fire Code.
Policy Resource	Code Enforcement	Each zoning district has specific zoning codes and guidelines that were developed to enhance and protect each district. The Community Development Department enforces and carries out these guidelines.
Technical and Personnel Resources	GIS Program	GIS creates an updated zoning map and General Plan map and also maintains an interactive parcel map that residents can use to determine if they are located in a floodplain, floodway, or redevelopment district.

Table 38: **Capitola Capabilities Assessment**

Type of Resource	Resource Name	Ability to Support Mitigation
Plan Resource	General Plan	Principal policy document that guides conservation, development, and change in the City. Identifies City programs and policies as they pertain to land use, public services, housing, natural resources, and safety. Hazard data and mitigation actions described in this Plan have been incorporated into the General Plan. Capitola's General Plan was adopted 2014. The City can adopt the 2020 LHMP into the Safety Element of the General Plan
Policy Resource	Housing Program	The City offers numerous programs to help residents maintain safe housing.
Plan Resource	Flood Management Plan	The City manages floodplain per Chapter 17.50 Floodplain Management of the Capitola Municipal Code.
Personnel Resource	Planning Commission	The Planning Commission meets once per month to discuss planning capabilities in Capitola. They review and comment on the LHMP.
Plan Resource	2007 Economic Development Strategic Plan	The underlying belief of the Economic Development Strategy is that the local economy interlinks with many other aspects of a community, including housing, transportation, recreation, and safety. This document helps understand economic development trends in Capitola.
Plan Resource	Existing Conditions White Papers	Provide background information on City of Capitola.
Plan and Technical Resource	Local Coastal Program Land Use Plan	Land Use maps will be revised as part of the LCP update which is currently underway. Planning and IT departments may update the General Plan maps, as relevant, to address mitigation identified in this LHMP.
Plan Resource	2005 Historic Structures List	Provides a list of historic structures in Capitola.
Plan Resource	Climate Action Plan	Completed 2015.
Building Department		
Personnel Resource	Building Official	Enforces building codes and development ordinances including the floodplain management ordinance. New and updated building codes can address hazards as addressed in this LHMP.
Policy Resource	Inspections & Permit	Building permits ensure that zoning requirements as well as fire and structural safety standards are met.
City Council		
Policy Resource	Policy Approval	Policy legislation and implementation

Table 38: **Capitola Capabilities Assessment**

Type of Resource	Resource Name	Ability to Support Mitigation
City Administration		
Administrative / Personnel Resource	City Manager	Supports the development and implementation of this Local Hazard Mitigation Plan by allocating the appropriate personnel and resources.
Financial Resource	Finance	Budgeting and Risk Management for City owned facilities. Money for the local match for FEMA mitigation funding are available from the City of Capitola General Fund.
Public Works Department		
Personnel Resource	Public Works Director	Participates in the development and implementation of this Hazard Mitigation Plan.
Technical and Policy Resource	Streets Program	Provides maintenance and improvement of the City's streets and highways. Also provides maintenance of Soquel Creek, Capitola Lagoon, City owned buildings, and the municipal wharf.
Policy and Plan Resource	Storm Water Management Program	The Depot Hill Drainage Study was conducted in 2008 and the Storm Water Management Program is updated annually.
Policy and Plan Resource	Capital Improvement Program	The Capital Improvement Program should be informed by the strategies identified and prioritized in this plan.
Personnel Resource	Grant writing	Part of the Engineering Department
Police Department		
Training and Personnel Resource	Police Chief	Coordinates preparedness training, public outreach on safety and emergency preparedness, and emergency response.
Policy and Plan Resource	Emergency Preparedness	Includes emergency preparedness guides for the elderly, physically challenged, and children.
Special Districts		
Central Fire Protection District of Santa Cruz County		
Personnel Resource	Fire Chief	Coordinates emergency response, fire prevention education, CERT training, and wildfire education and prevention.
Plan Resource	Wildland Fire Structure Protection Plan	A western portion of the City limits (where there is a large stand of Eucalyptus trees) is located in the Central Fire Districts Wildland Protection Zone CTL 11.
Plan Resource	Central Fire District Master and Strategic Plan	This Plan can assist the City in identifying future improvements and prioritize mitigation activities.

Table 38: **Capitola Capabilities Assessment**

Type of Resource	Resource Name	Ability to Support Mitigation
Personnel Resource	Emergency Services	Coordinates with City staff on emergency preparedness, response, and mitigation activities.
Policy Resource	Public Education Program and CERT Training	Educates City employees and residents on hazards awareness, prevention, and preparedness.
Policy Resource	Commercial Building Inspections and Permits	The Fire District provides reoccurring fire prevention inspections of all commercial buildings in the City. The District also provides plan check and permit functions for commercial development addressing Fire Code Standards.
Soquel Creek Water District		
Plan Resource	Urban Water Management Plan and Pure Water Soquel Project	Identifies adequate water supplies and proper planning, funding, and construction of future water infrastructure improvements.
Plan Resource	Emergency Response Plan (ERP)	The goals of the ERP are to rapidly restore water service after an emergency, ensure adequate water supply for fire suppression, minimize water system damage, minimize impact and loss to customers, minimize negative impacts on public health and employee safety, and provide emergency public information concerning customer service.
Plan Resource	Groundwater Management Plan	Enhances existing water supplies and identifies future opportunities for planning and funding of groundwater management activities.
Soquel Union Elementary School District		
Personnel and Technical Resource	New Brighton School	The School District owns and manages the New Brighton Middle School which is the City's back-up Emergency shelter location, which is co-located with the New Brighton Gym (the city-owned primary emergency shelter.)
911 Communications Center		
Technical Resource	Santa Cruz Regional 911	Provides a means of notification to residents and listed phone numbers during an emergency situation allowing resident and businesses to relocate out of a potentially vulnerable area.
City of Santa Cruz Water District		
Plan and Personnel Resource	Wildfire Preparedness	Links to various wildfire educational websites. Personnel can develop and outreach program to inform the public that these website exist.

Table 38: **Capitola Capabilities Assessment**

Type of Resource	Resource Name	Ability to Support Mitigation
Plan Resource	Urban Water Management Plan	A long range planning document to aid in updating city and county General Plans and for preparation of environmental documents under the California Environmental Quality Act. Serves as a detailed source of information to coordinate local water supply availability and certain land use decisions made by cities and counties.
Plan Resource	Water Supply Assessment	Assesses the adequacy of the water supply to meet the demand of proposed projects over the next 20 years in addition to the public water system's existing and planned future uses.
Plan Resource	Adequacy of Municipal Water Supplies to Support Future Development	Provides information on the ability of the system to deliver water and offers possible approaches that could be used by policy makers to integrate local land use decisions with long-term water supply availability.
Plan Resource	Water Shortage Contingency Plan	Establishes procedures and actions that can be taken to respond to a large, long term shortage in the water supply.
Plan Resource	City of Santa Cruz/Soquel Creek Water District Evaluation of Regional Water Supply Alternative	Provides an evaluation of "regional" desalination and wastewater reclamation facilities to augment water supplies for both the City and the District.
Santa Cruz County		
Technical Resource	County Flood Control and Water Conservation District (5)	Provides flood protection and regulation and stormwater services for Zone 5 facilities.
Technical Resource	County Sanitation District	Operates water and wastewater services.
Technical Resource	County Public Works	Assist the City in protecting the public's health, safety, and welfare through superior engineering, maintenance, operations, and administrative services that incorporate customer service and integrity with competence and productivity for a sustained commitment to excellence.
Plan Resource	San Mateo-Santa Cruz Community Wildfire Protection Plan	Identifies wildfire hazard areas and methods for reduction/ elimination of fire hazards.

Table 38: **Capitola Capabilities Assessment**

Type of Resource	Resource Name	Ability to Support Mitigation
Plan Resource	Hazard Mitigation Plan	Identifies mitigation actions for County of Santa Cruz critical facilities.
Plan Resource	Coastal Incident Response Plan	Establishes response framework and protocols for incidents along the Santa Cruz County coastline, including the City of Capitola.
Plan Resource	Operational Area Emergency Management Plan (2005)	Overall emergency management plan for the Santa Cruz County Operational Area.
Plan Resource	Tsunami Response Plan Annex (2010)	The City of Capitola relies on the Tsunami Response Plan Annex developed to accompany the Operational Area Emergency Management Plan.
Plan Resource	General Plan	Provides policies within Santa Cruz County intended to reduce hazards and disasters.
Plan Resource	Emergency Preparedness Guide	Provides a resource for residents/ businesses to better prepare for future disaster/ emergency situations.
Policy Resource	Growth Management	Reduces development potential within hazard prone areas.
Technical Resource	Rain and Stream Gauging	Allow the City to better monitor rainfall and stream flow totals to gauge the adequacy of storm drain infrastructure capacity.
Technical and Staffing Resource	NIMS Training	On an ongoing basis, County OES conducts training for all department heads on their role in an emergency based on the National Incident Management Systems (NIMS). This training proved to be successful in the response to the severe floods in March 2011.
Technical Resource	National Weather Service	Decision Support Program (improved forecast interpretations for making informed decisions)
Technical Resource	CalOES	Hazard Mitigation Web Portal provides guidance and examples of hazard mitigation planning as well as notifications regarding available funding.
Technical Resource	Federal Emergency Management Agency	Guidance for hazard mitigation planning processes and resources.

4.3.2 Fiscal Capability

City of Capitola Budget Department Overview

The following summarizes Capitola's fiscal capabilities in terms of the City's financial resources and allocated spending. Sales tax and property tax are the primary sources of Capitola's financial resources. The City has allocated the majority of these financial resources to Public Safety, Community Development, Public Works, and City Manager/City Clerk/Human Resources departments which are all relevant for implementing hazard mitigation actions.

The City Council, City Manager, Community Development, Police, and Public Works departments all have a general fund that could be used toward mitigation activities. These departments also have budgets used to employ City staff that are an integral part of the mitigation planning process. These staff members include:

- The City Manager's department employs an Information Systems Specialist.
- The Community Development Department staff includes a community development director, one planner, and a building inspector and official.
- Public Works Department staff includes a public works director and a ten person maintenance crew.
- The Police Department employees a chief, captain, sergeant, and 16 police officers. This department is also responsible for the City's Emergency Preparedness.

Capital Improvement Projects: 2020-2022

Capital improvements projects scheduled for the 2020-21 fiscal year include several projects that include hazard mitigation elements. Three specific projects to rehabilitate the Capitola wharf, beach jetty and flume address sea level rise, costal storm damage, and climate change. The flume and jetty project, scheduled for Fall of 2020, will rehabilitate these structures to their designed specifications. The wharf project, currently in environmental review and permitting, will increase the storm resiliency of the structure while providing for future raising of the wharf deck to further address sea level rise. The water project is currently on schedule to begin construction in 2021.

5 Chapter Five - Plan Maintenance Process

This Chapter identifies the formal process that will ensure that the Capitola LHMP (the Plan) remains an active and relevant document. The Plan maintenance process includes a schedule for monitoring and evaluating the Plan annually and producing an update every five years.

This chapter describes how Capitola will integrate public participation throughout the plan maintenance and implementation process. It also describes how the City intends to incorporate the mitigation actions outlined in this Plan into existing planning mechanisms and programs. These include the Capitola General Plan, the City's Capital Improvement Program, as well as building code enforcement and implementation. The Plan's format allows the City to readily update sections when new data becomes available, resulting in a Plan that will remain current and relevant to the City of Capitola.

5.1 Monitoring, Evaluating and Updating the Plan

5.1.1 Coordinating Body

The Capitola Hazard Mitigation Planning Team will be responsible for the maintenance of this LHMP. The City of Capitola Community Development Department will take the lead in LHMP maintenance issues, by coordinating maintenance of this Plan and undertaking the formal review process and the rewrite of the LHMP.

5.1.2 Convener

The City of Capitola Community Development Department will facilitate the Hazard Mitigation Planning Team meetings, and will assign tasks such as updating and presenting the Plan to other Departments, Stakeholder Groups, and/or elected officials. Plan implementation and evaluation will be a shared responsibility among all of the Hazard Planning Team.

5.1.3 Evaluation

The minimum task of the ongoing annual hazard mitigation planning team meeting will be the evaluation of the progress of the Plan and incorporating the actions into other planning documents. This review will include the following:

- Summary of any hazard events that occurred during the prior year and their impact on the community.
- Review of successful mitigation initiatives identified in the Plan.
- Brief discussion about why targeted mitigation strategies were not completed.
- Re-evaluation of the mitigation actions plan to determine if the timeline for identified projects needs to be amended (such as changing a long-term project to a short-term project due to funding availability).
- Recommendations for new mitigation actions.
- Changes in, or potential for, new funding options/grant opportunities.
- Integration of new GIS data and maps that can be used to inform the Plan.
- Evaluation of any other planning programs or initiatives within the City that involve hazard mitigation.

The City will create a template to guide the LHMP team in preparing a progress report. The City will also prepare a formal annual report on the progress of the LHMP. This report will be used as follows:

- Distributed to City department heads for review.
- Provided to the local media through a press release.
- Presented in the form of a council report to the City Council.

5.2 Method and Schedule for Updating the Plan within 5 years

Section 201.6.(d)(3) of Title 44 of the Code of Federal Regulations requires that local hazard mitigation plans be reviewed, revised if appropriate, and resubmitted for approval in order to remain eligible for benefits awarded under the Disaster Mitigation Act (DMA). The City intends to update the Plan on a five-year cycle from the date of initial plan adoption. It is anticipated that this update process will occur one year prior to expiration of the existing plan. This cycle may be accelerated to less than five years based on the following triggers:

- A Presidential Disaster Declaration that impacts the City of Capitola.
- A hazard event that causes loss of life.

The intent of the update process will be to add new planning process methods, community profile data, hazard data and events, vulnerability analyses, mitigation actions and goals to the adopted plan so that the Plan will always be current and up to date. Based on the needs identified by the planning team, the update will, at a minimum, include the elements below:

1. The update process will be convened through a committee appointed by the Community Development Director and will consist of at least one member of the General Plan Update Advisory Committee or staff to ensure consistency between Plans.
2. The hazard risk assessment will be reviewed and updated using best available information and technologies on an annual basis.
3. The evaluation of critical structures and mapping will be updated and improved as funding becomes available.
4. The mitigation actions will be reviewed and revised to account for any actions completed, deferred, or changed to account for changes in the risk assessment or new City policies identified under other planning mechanisms, as appropriate (such as the General Plan).
5. The draft update will be sent to appropriate agencies for comment.
6. The public will be given an opportunity to comment prior to adoption.
7. The Capitola City Council will adopt the updated Plan.

5.3 Adoption

The Capitola City Council is responsible for adopting the Plan. This formal adoption should take place every five years. Once the Plan has been adopted, the City of Capitola Community Development Department will be responsible for final submission to the Governor’s Office of Emergency Services (CalOES). CalOES will then submit the Plan to the Federal Emergency Management Agency (FEMA) for final review and approval.

5.4 Implementation through Existing Programs

The effectiveness of the City’s non-regulatory LHMP depends on the implementation of the Plan and incorporation of the outlined mitigation action items into existing City plans, policies, and programs. The Plan includes a range of action items that, if implemented, would reduce loss from hazard events in the City. Together, the mitigation action items in the Plan provide the framework for activities that the City can choose to implement over the next five years. The City has prioritized the plan’s goals and identified actions that will be implemented (resources permitting) through existing plans, policies, and programs.

The Community Development Department has taken on the responsibility for overseeing the Plan's implementation and maintenance through the City's existing programs. The Community Development Director, or designated appointee, will assume lead responsibility for facilitating LHMP implementation and maintenance meetings. Although the Community Development Department will have primary responsibility for review, coordination, and promotion, plan implementation and evaluation will be a shared responsibility among all departments identified as lead departments in the mitigation action plan. The Community Development Department will continue to work closely with the Santa Cruz County Emergency Operations Manager to insure consistency with all relevant plans.

5.5 Incorporation into Existing Planning Mechanisms

The following planning mechanisms from the 2013 LHMP were implemented:

- Capitola Building Codes
- Monterey Bay Sea Level Rise studies (various)

The following planning mechanisms were not implemented:

- Santa Cruz County Emergency Management Plan
- Capitola Capital Improvement Program
- Capitola Storm Water Management Program
- Capitola Emergency Operations Plan

The information on hazards, risk, vulnerability, and mitigation contained in this Plan is based on the best information and technology available at the time the LHMP was prepared. As previously stated, the City's General Plan is considered to be an integral part of this plan. The City, through adoption of its 1994 General Plan (Safety Element) goals, has planned for the impact of natural hazards. The City's General Plan is currently being updated and the LHMP process has allowed the City to review and expand upon the policies contained within the General Plan Safety Element. The City views the General Plan and the LHMP as complimentary planning documents that work together to achieve the ultimate goal of the reduction of risk exposure to the citizens of Capitola. Many of the ongoing recommendations identified in the mitigation strategy are programs recommended by the General Plan and other adopted plans. The City will coordinate the recommendations of the LHMP with other planning processes and programs including the following:

5.6 Continued Public Involvement

The public will continue to be apprised of the LHMP actions through the City website and by providing copies of the annual progress report to the media. Copies of the Plan will be distributed to the Santa Cruz Library System. Upon initiation of the LHMP update process, a new public involvement strategy will be developed based on guidance from the planning team. This strategy will be based on the needs and capabilities of the City at the time of the update. At a minimum, this strategy will include the use of local media outlets within the planning area and the City's website.

5.7 Point of Contact

Steve Jesberg
City of Capitola
City of Capitola Public Works Director
831/475-7300

Local Hazard Mitigation Plan

Appendices

2020

Appendix A – **Timeline of Capitola Natural Hazard Events**

Prepared by Carolyn Swift, Former Museum Director, City of Capitola

Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
1791-1792	Flood	Santa Cruz Mission destroyed	
1847	Flood	Sawmill constructed on Soquel Creek (Rancho Soquel) destroyed. It had been built by John Hames and John Daubenbiss, who later obtained lands of the Rancho Rodeo, and became the founders of the town of Soquel (1852).	
1852	Flood	This was a major flood event but impact not recorded (no newspapers had yet been established).	
1/9/1857	Earthquake	Three earthquakes struck the Santa Cruz vicinity in a series. The tower and a portion of the Santa Cruz Mission Church collapsed.	
Jan. 1862	Storm/Flood	Major event—Soquel village inundated; mills, flumes, school, town hall, houses and barns were destroyed. Massive pile of debris went out to sea and then washed ashore at Soquel Landing.	
8/01/1863	Earthquake	Described as “severe shock.”	
1863-64	Drought	Unknown	
10/08/1865	Earthquake	Unknown	
11/25/1865	Storm/High Tide	500 feet of the Soquel Landing wharf is lost; the remaining 600 feet are deemed “useless.” Nearby barn blown down. Two young whales and a hair cloth sofa washed ashore. Waves described as “mountain high.” Wharf damage is $6,000. Pilings are deposited in a potato field beyond the beach.	

Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
12/14/1867	Storm	Wharves damaged in Aptos and Watsonville but no specifics are listed for Soquel Landing.	
9/19/1868	"Tidal Wave"	High tide described as tidal wave; damage unknown	
10/24/1868	Earthquake	"Second only to October 1865"	
2/03/1869	Storm, flood, slides, washouts	New bridge washed away at Soquel; roads impassable.	
12/23/1871	Southeast gale, flood, high tide	Water gauged to be "higher than flood of 1862."	
1/24/1874	Storm	Roaring surf. Rain threatens crops.	
12/04/1875	Flood	Compared to ferocity of the 1862 flood	
1877	Severe drought	Capitola's founder, S.A. Hall, was boarding 300 horses at his stable during the summer. The price of hay went to $20.00 a ton due to the drought, and he lost money. When landowner F.A. Hihn increased the rent two years later, Hall couldn't afford the increase, and left.	

Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
1/19/1878	Storm with tide	No Capitola impact recorded.	
7/01/1882	Earthquake	Worst since 1868	
1/30/1881	Storm	Conflicting reports on damage to Capitola. One report describes the resort as destroyed, while another stated damage was "not as serious."	
March 1883	Earthquake	Severe shock with several aftershocks recorded. No damage listed for Capitola.	
3/10/1884	Flooding and Washouts	Storm lasted five days. No Capitola impact described in newspapers	
12/16/1886	High surf	Capitola impact unknown	
12/30/1886	High surf	High seas; ships prevented from landing	
5/10/1887	Heaviest surf of the season	No damage reported for Capitola.	
9/18/1888	Earthquake	Described as extremely severe.	
1/05/1889	Storm	Damage to beach areas	
12/26/1889	Storm	Train service stopped; Santa Cruz County becomes isolated.	
1/06/1890	Storm/ Mudslides in mountains	Worst winter in 40 years; concern for grain crops	

Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
1/27/1890	Floods	Judged to be as bad as 1852, 1862, and 1871; Capitola floods, footbridge and span of wagon bridge destroyed. Esplanade flooded—buildings to be replaced in "permanent form." A huge pile of debris appears along the beach.	
2/08/1892	High tides	Yacht "Petrel" washed ashore at Capitola; beachfront concessions damaged. Swimmers endangered.	
1/12/1899	Severe storm	Several days duration; damage unknown	
1/02/1900	Storm	Severe; no damage listed.	
3/14/1905	Storm	Judged to be "worst in 27 years." Capitola impact unknown.	
1/20/1906	Flood	Buildings from Loma Prieta Lumber Company camp above Soquel are destroyed. Debris at Capitola. Downtown Soquel floods. Landslides in hills.	

Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
1906, 5:12am	Earthquake	Nine men killed in mudslide at the Loma Prieta mill above Soquel; surge on local creeks; water pipes broken, chimneys and walls cracked. Splits in the earth. Magnitude 8.3.	
4/27/1907	Storm	High water and flooding; Capitola damage unknown	
1/21/1911	Storm	Unknown	
3/07/1911	Storm	Unknown	
1911	Erosion	Incidents of cliff erosion along Grand Avenue prompt Lewis B. Hanchett, the owner of El Salto Resort, to begin chopping down trees on what is left of "Lover's Lane" along the bluff of Depot Hill. Hanchett believed that when the trees fell, they further hastened the cliff erosion.	 

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
11/27/1913	Storm and tide	Great groundswells when the tide was highest. Waves ran across the beach to the Esplanade and water spread "clear to the railroad tracks." Union Traction Company tracks covered with sand. Water reached the Hihn Superintendent's Building (Capitola and Monterey Avenues), and waves were described as "monster." About 200 feet of wharf washed away. Stranded fisherman rescued and pulled underwater to safety. A huge pile of debris covered the beach and was cut-up for firewood. Fisherman Alberto Gibelli stranded when mid-section of wharf washed away.	 
1/01/1914	Flood	Flood in Soquel and along Soquel Creek.	
11/28/1919	Storm	Damage high; no Capitola details	
12/27/1921	Storm	Described as "great."	

Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
2/12 and 2/13/1926	High tides	Waves to 20 feet. Wharf damaged. Sea wall promenade broken at Venetian Courts. Apartments flooded. Breakers slammed into Esplanade, destroying boathouse/bathhouse, beach concessions. Tide hits the second floor of Hotel Capitola. Water runs a foot deep through village.	  

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
		Top photo courtesy of Homer Berry	  

Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
10/28/1926	Earthquake	Damage recorded in Capitola	
1/24/1930	Erosion	About 130 residents appear before Santa Cruz County Supervisors to protest announced firing of 12-inch guns at Camp McQuaide, Capitola. Among petitioners claims are that "the terrific jar of the guns loosens the rim of the cliffs, and the earth is sloughing off to a dangerous degree."	
1928-1937	Drought	Reported as one of longest and most severe in state's history. Capitola is bordered by bulb ranches and floral nurseries, as well as poultry ranches and rabbit farms.	
12/26/1931	Storm	Soquel Creek rises; cleans lagoon at Capitola. Debris and wood deposited on the beach.	
12/28 and 12/29/1931	Storm and high tide	Damage to cottages and concessions at New Brighton Beach. Roads fill with "the muck of the sea." At Seacliff Beach, the concrete ship Palo Alto is shaken loose and moved about three feet as if "impelled by the spirit of the sea to fulfill its destiny and start moving." Soquel "River" widens to sixty feet, the highest since 1890, damaging property in Soquel and all the way to the mouth at Capitola. Orchards are lost with the rapid rise of water. Hundreds gather to watch the tides batter the concessions at the beach. There is a "vortex of water where the river and sea meet." The waterfront is piled high with flood debris thrown back up the beach.	*Photo courtesy of Lee Lester* 

Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
		The creek cuts across the beach and moves sand below the new outlet. Two months later, workers discovered a noticeable settling of the western end of the bathhouse, due to a break in the retaining wall. This left a portion of the bathhouse supported only by its concrete flooring. Repairs required rebuilding the retaining wall and replacing the fill.	
1/04/1935	Flood	Capitola Village floods; thirty feet of the sea wall is taken out. Beach playground disappears. Venetian Courts hit hard but damage minimal.	*Photo courtesy of Lee Lester*
1/09/1935	Erosion	Near the seawall cave-in by the site of the old hotel, a tree fell sixty feet from Grand Avenue. The "new favorite outdoor sport" for onlookers is to walk behind the sewer plant to see the fallen tree and debris of the broken sea wall.	
12/14/1936	Drought	Long drought ended by rain.	
2/14/1937	Flood	Soquel Creek floods in Soquel Village due to logjam at the bridge on Soquel Drive. Landslides in watershed.	
3/22-23/1937	Storm	Boats in the streets at Capitola. An estimated $3,000 is spent to repair the sea wall at the Venetian Court Apartments.	
2/10/1938	Storm winds	Winds up to 70 mph; 500 trees uprooted throughout county. Thunderous seas lashed the waterfront from Aptos to Capitola.	

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
1/04/1939, 10:30pm	Wind and waves	Main damage to Capitola Beach Club at the Esplanade and Monterey Avenue. Water and sand carried into the structure and spread out over the dance floor to the bandstand. While the storm was still raging, thieves jimmied the back door of the club's tap room, and made away with two slot machines, along with the stands on which they had rested. Ocean also swept over the Esplanade during the night, and into town for a block-and-a-half, carrying sand and rocks, some 6-8 inches in diameter. Waves hit the front and sides of the pier. Sand and rocks were swept into lower terraces of the Venetian Court and covered porches of the casino on the waterfront, but did no serious damage.	
1/8/1940, 9pm-Noon	Storm	The "old Capitola casino" owned by Capitola Amusement Company was the principal victim of storm. Casino "capsized" shortly after 9 a.m. Plans for new structure announced immediately.	

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
		Photo courtesy of Homer Berry	 
1/12/1940	Storm	Most rain "since 1890" reported.	
1/26/1940	Storm	"Shatters all records."	
2/27/1940	Severe Flood	Logs pile against bridge in downtown Soquel and village floods. Landslides in watershed.	

Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
3/31/1940	Storm	"Wettest day in Santa Cruz history."	
12/23/1940	Storm	Flood conditions, winds	
2/09/1941	Near record storm		
4/2/1941	Severe Storm	Lasting many days Damage unknown	
4/15/1941	Earthquake	Santa Cruz is epicenter. No damage.	
6/02/1941	Earthquake	Sharp jolt	
6/18/1941		Capitola announces plans to lengthen flume	
12/09/1943	Gale winds	60-mile-an-hour winds create damage in county	
2/5/1945	Flood conditions	Local damage unknown	
April 1946	Tsunami	Earthquake in Aleutians produced 115-foot wave. Tsunami observed along the West Coast. A man was swept to sea in Santa Cruz. Ten-foot waves hit the coastline.	
1947-1949	Drought	Statewide	
8/01/1949	"Heaviest surf in 20 years"	18-foot waves recorded along the coast. Swimmer drowns in Santa Cruz.	

Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
Winter 1953	Giant swells	Ocean side of building at the end of the Capitola Wharf smashed in by waves 20-30 feet at high tide. Six pilings broken off.	 

Prov of Capitola Historical

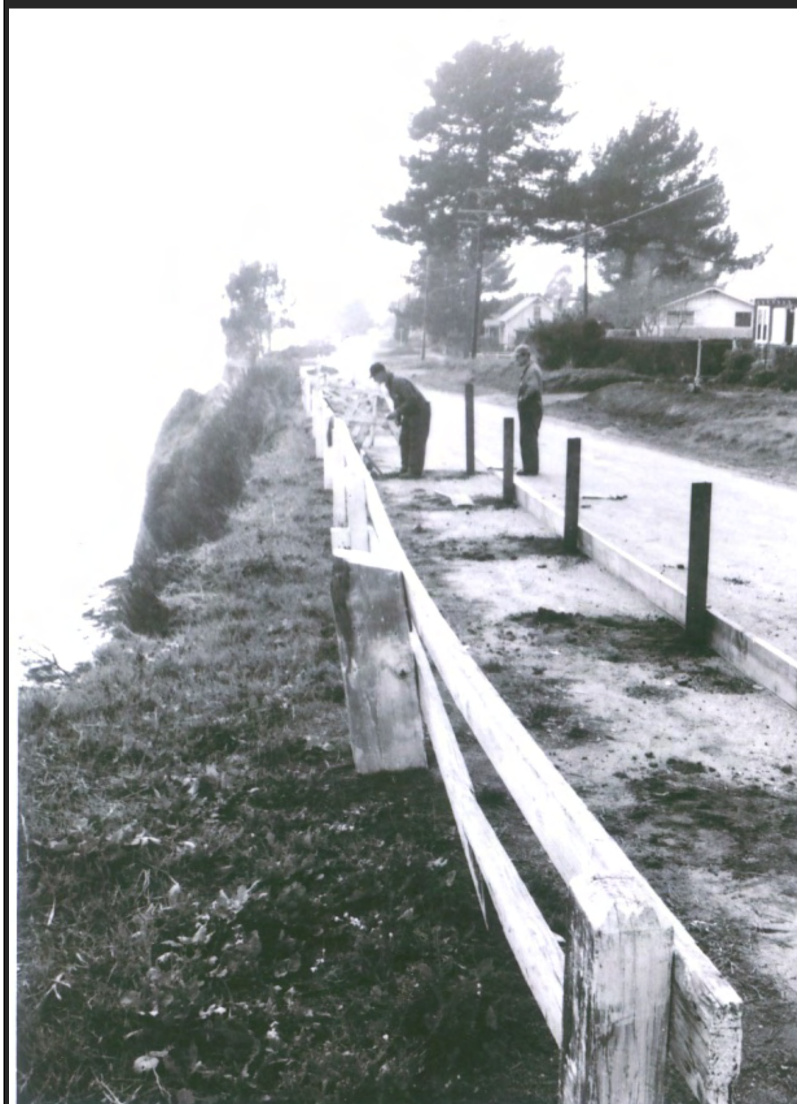
Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
4/15/1954	Earthquake	Falling plaster, broken chimneys, shattered dishes	
12/22/1955	Highest Flood	At the Soquel Drive bridge in downtown Soquel, remains of a four-room house and five cabins joined the rubble that wedged against the bridge abutments, causing the bridge to collapse. Overall damage to property in Soquel and Capitola exceeded $1 million. Capitola damage included the Venetian Courts. Noble Creek and Tannery Creek also flooded. *Photos courtesy of Carolyn Swift*	 

Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
5/2/1955	Erosion	Sentinel: Capitola City Council Asks Cleanup Help “Believe it or not, a few people still occasionally throw garbage over the cliff, particularly along Grand Avenue. This not only creates health hazards, but also attracts rodents which burrow into and weaken the cliff, increasing the rate of cliff erosion….” *Photos courtesy of Covello and Covello Photography.*	 
4/3/1958	High Tide	Esplanade smashed by tides. Andy Antonetti’s Merry-go-round damaged; horses are knocked off and washed down San Jose Avenue. *Photo courtesy of Covello and Covello Photography.*	

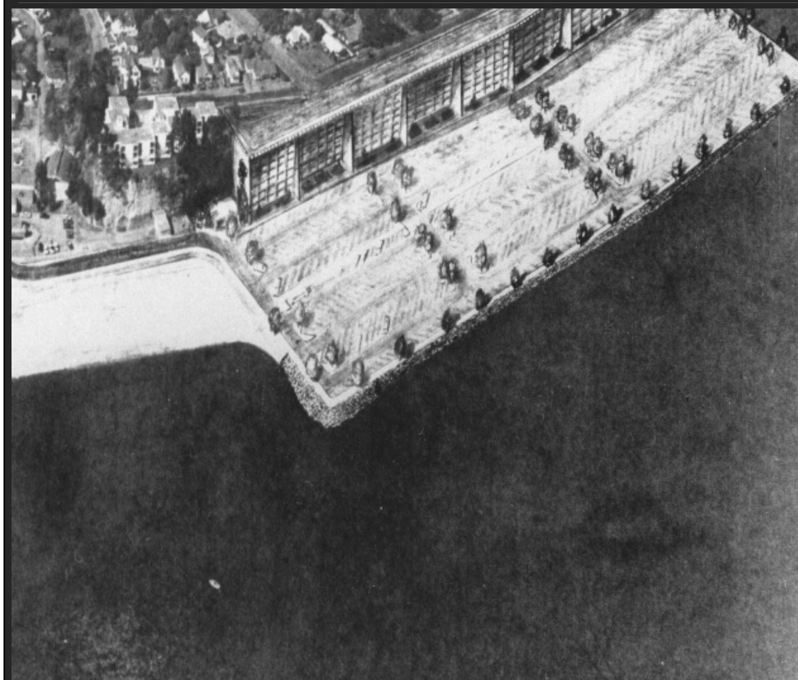
Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
2/09/1960	Gale winds, heavy seas	Power outages, slides, and winds 35-40 mph. Capitola hardest hit. Damage estimated at $100,000. Ten Venetian Court apartments flooded. "A sign was ripped off the end of the wharf, rolled into a ball, and deposited into an apartment." Heavy waves smashed the beach restaurants, amusement concessions, and the merry-go-round. Rocks and logs strewn across the beach. Water pushed back under the Stockton Bridge, crushing the riverfront fences 100 yards on either side. An estimated $5,000 in damage was done to the wharf building, but not much happened to the wharf itself. Cliffs crumbled on Grand Avenue. Police Chief Marty Bergthold called it "The worst storm in 15 years." A portion of Grand Avenue falls into the ocean.' *15 people knocked to the ground by breakers. One woman injured.*	
Summer 1961	Birds fall from sky	Sooty Shearwaters fall from the sky; they are affected by toxins from red algae. Birds cover streets, wharf, and beach. Alfred Hitchcock inspired to move ahead with filming "The Birds."	

Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
1963	Erosion	Capitola City Council votes to start condemnation proceedings against Harry Hooper to obtain 320 feet of Hooper Beach for erosion control to protect Cliff Drive, where a high rise development was planned.	
1963	Erosion	Capitola City Council considers construction of seawall to control erosion from Grand Avenue to New Brighton Beach. The filled in area would also provide parking for approximately 400 cars.	
Dec. 20, 1964	Erosion	Construction begins on controversial Crest "prestige" 24-unit apartment house on the bay side of Grand Avenue on Depot Hill. Robert Lamberson, architect. Grand Avenue residents eventually sue the City over a disputed 10-foot setback for the project, which was built on a former park site at the top of the bluff. *Cost $500,000.* In the 1980s, several units facing the bay were removed due to cliff erosion. *Photo courtesy of Minna Hertel.*	
12/20/1964	Flood threat	Storm and tide alarms City with a disappearing beach	

Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
1/13/1965	Erosion	Capitola considers feasibility study to build 370-foot seawall along Grand Avenue. Backfilling below Grand Avenue would be used for a 1,000-car parking lot. Developers expressed desire to lease portion of the parking lot for a three-story, 20 unit convention hotel with restaurant and cocktail bar, to be built along the Grand Avenue bluff. First step was to have the beach deeded to the city by the state. *$1,228,000 estimated cost for parking lot* *$275,000 estimated cost for hotel.* *Photo courtesy of Covello and Covello Photography.*	
Summer 1965	Erosion	Capitola requests help from the State Department of Water Resources to solve the problem of disappearing sand, due to "failure of Santa Cruz harbor officials to install a recommended sand by-pass at the harbor jetty. *Photo courtesy of Al Lowry.*	

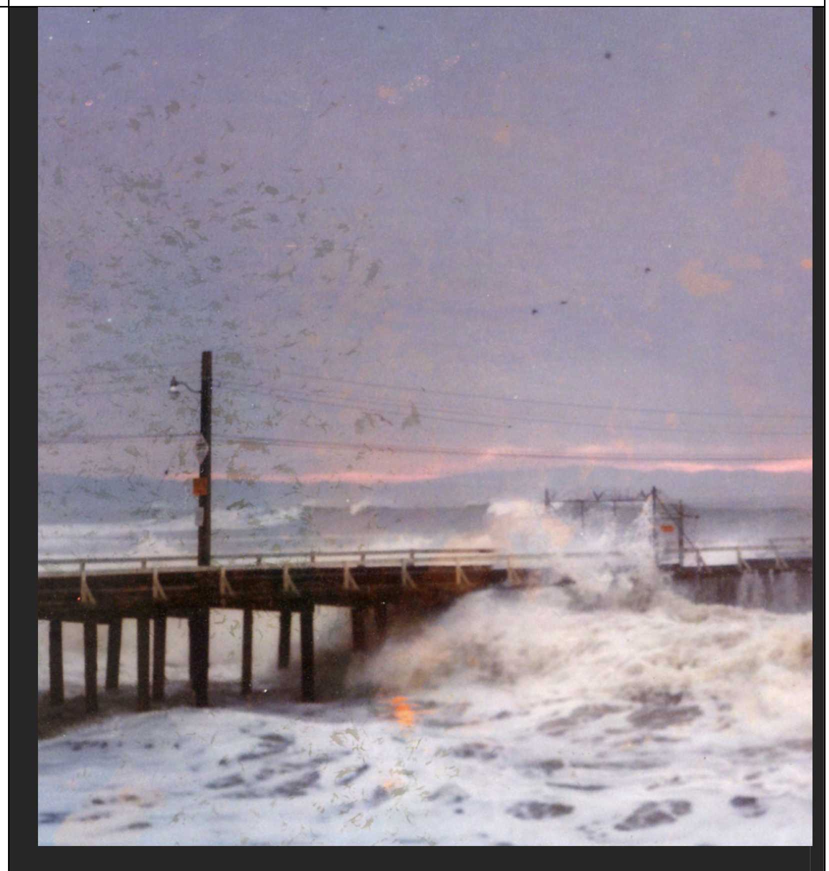
Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
Summer of 1965	Erosion	Off-Shore parking lot plan revised. Parking lot to extend 430 feet out into the way from the cliffs south of Capitola beach for about 1,500 feet. A breakwater is planned to extend 600 feet south to the end of the high cliff area, to prevent cliff erosion. The parking lot would also be used as an "overnight parking unit" with commercial concessions for tourists. Project to cover ten acres reclaimed from the bay. *Photo courtesy of Covello and Covello Photography.*	
December 1965	Storm	The City replaced 21 pilings under the wharf that were weakened by the storm. Capitola officials fear that waves would smash the seawall which protected sewer lines that ran from Capitola's pumping station to the East Cliff Sanitation District plant. That winter, the county public works department offered 500 cubic feet of rock rubble to be placed against the seawall.	

Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
1966	Erosion	Lifelong resident Violet Gooch hired Granite Construction to build a rip-rap wall at the base of the cliff at the end of the row of homes west of the wharf. (Hooper Beach) *Photo courtesy of Covello and Covello Photography.*	
January 1967	Storm	Reported as heavy	
1968	Erosion	Army Corps of Engineers begins work to construct a groin, completed the following spring. *Cost $160,000.*	
January 1973	Storm	Beach littered with tons of driftwood after heavy rains.	
1975	Wind storm	40 knot winds downed trees and power lines.	
1976-77	Severe drought	Water conservation ordered	

Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
1976	Strong winds	Winds downed power lines	
12/21/1976	High waves	Waves crash over wharf	
10/2/1979	High waves	At least eight sailboats were destroyed at Capitola during the morning. A powerful swell broke 15 boats from their moorings off the Capitola Wharf. The boats were pushed ashore by 12-to-20 foot waves that pounded the shoreline.	
Jan 1980	Flood	No damage reported	

Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
1/16/1980	Earthquake	Epicenter of 3.6 magnitude quake in Corralitos	

Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
January 3-5, 1982	Flood	Torrential rainfall, floods, mudslides countywide. Soquel Creek overflowed and flooded Soquel. The logjam at the bridge was estimated to be nearly 100 yards wide and 25 feet high. In Capitola, damage was comparatively minimal. The roadway leading to the Stockton Avenue bridge was damaged. The bridge bulkhead was undercut. Several of the Venetian Court units were damaged and a portion of the seawall gave way. *City officials estimated damage to public property at $270,889.*	  

Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
12/17/1982	Storm	Restaurant on the newly renovated Capitola Wharf is damaged in storm.	
1/27/1983	High Tide	Capitola Wharf buildings, the Venetian Courts, the former boathouse building (Mr. Toots Downstairs) and all other business of the Esplanade were flooded. Water extends down San Jose Avenue and Lawn Way. Huge logs and debris are scattered through town. The giant surf took out a 30-foot section of the wharf which had been renovated in 1982. *Photos courtesy of Minna Hertel.*	 

Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
		Top photo courtesy of Minna Hertel; middle photo courtesy of Sandy Lydon.	 
2/10/1983	High Tide	Surf rolls over the sea wall along the Esplanade. Water and debris extend as far as Capitola Avenue. *(Photo courtesy of Minna Hertel)*	

Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
			
3/1/1983	High Tide/strong winds	Waves damaged the restaurant at the end of the wharf, crashed over beach wall and entered restaurants on the Esplanade, "but damage was nothing compared to the million-dollar loss suffered in January," said Capitola City Manager Steve Burrell.	
2/15/1984	Erosion	Even though planner Susan Tupper warned the plan might not be a lasting solution, Capitola City Council approved a plan to stabilize its crumbling cliffs by installing artificial seaweed—a series of floating plastic fronds anchored to a sand-filled tube. The intent was to capture sand that drifts down the coast each year, thereby building a sandy beach in front of the cliffs below Grand Avenue. The "ersatz" seaweed lasted until the next major storm and then drifted to sea. *Cost $120,000.* The cliff continues to erode at a rate of 12-18 feet per year.	

Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
1987-1992	Drought	Severe drought, water conservation ordered.	
10/17/1989, 5:04pm, Duration of 15 Seconds	Earthquake	Loma Prieta 6.9 mag earthquake with epicenter 3 miles north of Aptos. Comparatively, damage to Capitola homes and businesses was not as severe. Within the city, no buildings damaged and no one was injured physically. *Damage countywide ultimately estimated to be about $1 billion.* *(Top photo courtesy of Karen Nevis)*	 
March 1995	Flood	The creek rose near the village.	

Timeline of Natural Hazard Events Impacting the City of Capitola

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
Winter 1996	Flood	Yards and basements of homes along both sides of Soquel Creek near the village were flooded.	
2007-2009	Drought	Water waste regulations strictly enforced; voluntary 15% conservation savings requested by local water providers.	
Winter 2008	High tide	Old bathhouse/boathouse building (Margaritaville/Stockton Bridge Grill) battered by swells. *(Photo courtesy of Karen Nevis)*	

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
3/11/2011	Tsunami	Capitola Village received warnings, but no damage	
March 24 and 26, 2011	Noble Creek and Tannery Creek Floods	Noble Creek floods village; Tannery Creek rushes through New Brighton Parking lot and undermines the cliff roadway.	 

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
			 

DATE	TYPE	IMPACT/PROPERTY DAMAGE	IMAGES
			 

Appendix B – **Detailed Critical Facilities Inventory**

Critical Facilities Inventory

Facility ID	Facility	Year Built	Type of Structure	Replacement Value	Contents Value	Occupancy	Facility Address
1	City Hall/Emergency Operations Center	1975	Government	$8,000,000	$750,000	30	420 Capitola Ave
1	Capitola Police Station	1975	Government	$4,000,000	$750,000	30	422 Capitola Ave
2	Central Fire Station #4		Government	$3,000,000	$100,000	20	405 Capitola Ave
3	Jade Street Community Center - Emergency Shelter and Police Antenna	1978	Government	$3,000,000	$200,000	varies	4500 Jade Street
4	New Brighton Gym and Performing Arts Center-- Emergency Shelter	1980	Government	$2,500,000	$75,000	varies	300 Washburn Ave
4	New Brighton School Performing Arts Center- Back-up Emergency Shelter	2010	Education	$4,000,000	$700,000	varies	300 Washburn Ave
5	Capitola Library -- Backup Emergency Operations Center	1990	Government	$10,000,000	$700,000	20	2005 Wharf Road
6	Capitola Corporation Yard	1980	Government	$2,000,000	$500,000		430 Kennedy Dr
7	Stockton Avenue Bridge	1934	Government	$10,000,000	N/A	N/A	N/A
8	Capitola Wharf	1986	Government	$20,000,000	$300,000	N/A	1400 Wharf Rd
9	Capitola Beach Sea Wall	late 80's	Government	$5,000,000	N/A	N/A	Capitola Beach
10	New Brighton State Park - staging area for emergency response	N/A	Government	N/A	N/A	N/A	McGregor Drive
11	Cliff Drive - at risk arterial (sea wall and road)	N/A	Government	$8,000,000	N/A	N/A	Cliff Drive (Wharf Rd to Opal Cliff Dr)
12	Park Avenue - at risk arterial (sea wall and road)	N/A	Government	$4,000,000	N/A	N/A	Park Ave (Weslely St to Coronado Ave)
13	Police Communications Antenna - Capitola Mall		Government	$100,000	N/A	N/A	4400 Capitola Road
14	Police Communications Antenna-AAA Building		Government	$100,000	N/A	N/A	1855 41st Ave
15	Noble Gulch Storm Pipe	1963	Utilities	$10,000,000	N/A	N/A	426 Capitola Ave
16	38th Avenue Drainage Facility		Utilities	$2,000,000	$300,000	N/A	Brommer & 38th
17	Capitola Sewage Pump Station - Esplanade Park	1978	Utilities	$10,000,000	$800,000	N/A	104 Monterey Ave
18	Soquel Sewage Pump Station	1975	Utilities	$10,000,000	$1,700,000	N/A	N/A
19	Lawn Way Storm Drain Pump Station	2002	Utilities	$500,000	N/A	N/A	N/A
20	Soquel Creek Water District Treatment Plant, Garnet Street		Utilities	$2,000,000	$700,000	N/A	4809 Garnet St
21	Soquel Creek Water District Seawater Intrusion Prevention Well, Monterey Avenue		Utilities	$2,000,000	$70,000	N/A	N/A
22	Soquel Creek Water District MacGregor Booster Pumping Station		Utilities	$300,000	N/A	N/A	McGregor Drive
23	Capitola Beach Flume	1940	Government	$2,000,000	N/A	N/A	Capitola Beach
24	Capitola Beach Jetty	1985	Government	$3,000,000	N/A	N/A	Capitola Beach
25	Grand Avenue Cliffs	N/A	N/A	N/A	N/A	N/A	Grand Ave b/w Saxon and Oakland Ave
	Total			**$125,500,000**	**$7,645,000**		

Capitola Local Hazard Mitigation Plan

Critical Facilities Inventory

Facility ID	Facility	Longitude	Latitude	Contact Person	Organization	Contact #	Generator
1	City Hall/Emergency Operations Center	121.57.12	36.58.28	Steve Jesberg	City of Capitola	831-475-7300	No
1	Capitola Police Station	121.57.12	36.58.28	Captain Andrew Dally	City of Capitola	831-475-4242	Yes
2	Central Fire Station #4	121.57.12	36.58.26	Chief Steve Hall	Central Fire Protection District	831-4796842	Yes
3	Jade Street Community Center - Emergency Shelter and Police Antenna	121.27.35	36.58.12	Elise LeGare	City of Capitola	831-475-5935	No
4	New Brighton Gym and Performing Arts Center-- Emergency Shelter	121.26.52	36.58.40	Steve Jesberg	City of Capitola	831-475-7300	No
4	New Brighton School Performing Arts Center- Back-up Emergency Shelter	121.26.52	36.58.40	Paul Rucker	Soquel Union School District	831-464-5639	No
5	Capitola Library -- Backup Emergency Operations Center	121.57.28	36.58.42	Jonell Jel'enedra	City of Capitola/SC Public Libraries	831-427-7705	No
6	Capitola Corporation Yard	121.56.44	36.59.01	Eddie Ray Garcia	City of Capitola	831-476-4227	No
7	Stockton Avenue Bridge	121.57.11	36.58.20	Steve Jesberg	City of Capitola	831-475-7300	No
8	Capitola Wharf	121.57.11	26.59.09	Steve Jesberg	City of Capitola	831-475-7300	No
9	Capitola Beach Sea Wall	121.57.02	36.58.18	Steve Jesberg	City of Capitola	831-475-7300	No
10	New Brighton State Park - staging area for emergency response	121.56.09	36.58.52	Charles Bockman	CA State Parks	831-247-3610	n/a
11	Cliff Drive - at risk arterial (sea wall and road)	121.57.19	36.58.12	Steve Jesberg	City of Capitola	831-475-7300	No
12	Park Avenue - at risk arterial (sea wall and road)	121.56.27	36.58.40	Steve Jesberg	City of Capitola	831-475-7300	No
13	Police Communications Antenna - Capitola Mall	121.57.39	36.58.24	Chief Steve Hall	City of Capitola	831-475-4242	Yes
14	Police Communications Antenna-AAA Building	121.57.59	36.58.37	Chief Steve Hall	City of Capitola	831-475-4242	Yes
15	Noble Gulch Storm Pipe	121.57.12	36.58.28	Steve Jesberg	City of Capitola	831-475-7300	No
16	38th Avenue Drainage Facility	121.58.01	36.58.11	Rachel Fatoohi	County of Santa Cruz	831-454-2160	No
17	Capitola Sewage Pump Station - Esplanade Park	121.57.00	36.58.19	Rachel Lather	SC County Sanitation	831-454-2160	Yes
18	Soquel Sewage Pump Station	121.57.25	36.58.48	Rachel Lather	SC County Sanitation	831-454-2160	Yes
19	Lawn Way Storm Drain Pump Station	121.57.03	36.58.20	Steve Jesberg	City of Capitola	831-475-7300	No
20	Soquel Creek Water District Treatment Plant, Garnet Street	121.57.26	36.58.19	Ron Duncan	Soquel Creek Water District	831-475-8500	Yes
21	Soquel Creek Water District Seawater Intrusion Prevention Well, Monterey Avenue	121.56.39	36.58.56	Ron Duncan	Soquel Creek Water District	831-475-8500	Yes
22	Soquel Creek Water District MacGregor Booster Pumping Station	121.56.08	36.59.00	Ron Duncan	Soquel Creek Water District	831-475-8500	Yes
23	Capitola Beach Flume	121.57.08	36.58.17	Steve Jesberg	City of Capitola	831-475-7300	No
24	Capitola Beach Jetty	121.56.59	36.58.17	Steve Jesberg	City of Capitola	831-475-7300	No
25	Grand Avenue Cliffs	121.56.50	36.58.23	Steve Jesberg	City of Capitola	831-475-7301	No
	Total						

Appendix C – City of Capitola Coastal Climate Change Vulnerability Report (June 2017)

City of Capitola

Coastal Climate Change Vulnerability Report

JUNE 2017

CENTRAL COAST WETLANDS GROUP

MOSS LANDING MARINE LABS | 8272 MOSS LANDING RD, MOSS LANDING, CA

This page intentionally left blank

Prepared by

Central Coast Wetlands Group at Moss Landing Marine Laboratories

Technical assistance provided by

ESA

Revell Coastal

The Nature Conservancy

Center for Ocean Solutions, Stanford University

Prepared for

City of Capitola

Funding provided by

The California Ocean Protection Council

Grant Number C0300700

CENTRAL COAST WETLANDS GROUP

Primary Authors

Central Coast Wetlands group
Ross Clark
Sarah Stoner-Duncan
Jason Adelaars
Sierra Tobin

Acknowledgements

California State Ocean Protection Council
Paige Berube
Abe Doherty
Nick Sadrpour

Santa Cruz County
David Carlson

City of Capitola
Rich Grunow
Steve Jesberg

Coastal Conservation and Research
Jim Oakden
Kamille Hammerstrom

Science Team
Bob Battalio, ESA
James Gregory, ESA
James Jackson, ESA
David Revell, Revell Coastal

GIS Layer support
Malena Clark
AMBAG
Soquel Creek Water District
Monterey County
Santa Cruz County

Adapt Monterey Bay
Kelly Leo, The Nature Conservancy
Sarah Newkirk, The Nature Conservancy
Eric Hartge, Center for Ocean Solutions

This page intentionally left blank

Contents

Summary of Findings .... **viii**

1. Introduction **1**

1.1 Project Goals 1

1.2 Study Area 2

2. Community Profile **3**

2.1 Setting and Climate 3

2.2 Demographics 3

2.3 Community Resources and Assets 3

2.4 Historic Events 6

2.5 Coastal Protection Infrastructure and Management 8

3. Projecting Impacts **10**

3.1. Disclaimer: Hazard Mapping and Vulnerability Assessment 10

3.2. Coastal Hazard Processes 11

3.3. Scenario Selection and Hazards 13

3.4. Assumptions and Modifications to ESA Hazard Zones 14

3.5. Assets Used in Analysis 15

4. Combined Impacts of Coastal Climate Change **17**

4.1 Background 17

4.2 Existing Vulnerability 17

4.3 Summary of Future Vulnerabilities by Planning Horizon 21

5. Vulnerability by Individual Coastal Hazard **25**

5.1 Vulnerability to Hazards by Time Horizon 26

5.2 Vulnerability to Rising Tides 26

5.3 Vulnerability to Coastal Storm Flooding 29

5.4 Vulnerability to River Flooding 33

5.5 Vulnerability to Erosion 37

5.6 Summary of Specific Vulnerable Assets 41

6. Economics of Future Climate Risks **45**

7. Adaptation **49**

7.1 Current Strategies Used by the City of Capitola 49
7.2 Future Adaptation Options and Strategies 52
7.3 Potential Strategies for Capitola Climate Adaptation 52
8. Conclusion 62
References 64
Appendix A .... Coastal Adaptation Policy Assessment for Monterey Bay (COS 2016)
Appendix B .... Climate Change Impacts to Combined Fluvial and Coastal Hazards (ESA 2016)

List of Tables

Figure 1. City of Capitola Vulnerability Assessment Study Area with Soquel Creek floodplain 2
Figure 2. Coastal access points within the City of Capitola 4
Figure 3. January 23rd, 1983: high tide, high river flow event in Capitola. 6
Figure 4. Coastal Protection Structures around the City of Capitola 9
Figure 5. Sea Level Rise scenarios for each time horizon 13
Figure 6. Existing (2010) Flood Hazard Zone Compared to FEMA 100-Year Flood zone 19
Figure 7. Future Combined Coastal Climate Change Hazard Zones (2030, 2060, 2100) 23
Figure 8. Assets vulnerable to coastal climate change hazards at each time horizon 25
Figure 9. Buildings Vulnerable to Rising Tides 27
Figure 10. Buildings Vulnerable to Coastal Storm Flooding 31
Figure 11. Buildings Vulnerable to River (Fluvial) Flooding 35
Figure 12. Buildings Vulnerable to Erosion 39
Figure 13. Storm drains with elevations within the projected tidal range for each time horizon 42
Figure 14. Berms built at Capitola Beach help to decrease coastal flooding of the Village 50
Figure 15. Distribution of natural habitats that may play protective role in Capitola. 53

List of Figures

Table 1. Major Floods in Soquel and Capitola Villages 1890 to Present 7
Table 2. Inventory of Existing Coastal Protection Structures in Capitola 8
Table 3. Sea level rise scenarios selected for analysis 14
Table 4. List of Data Layers used for Analysis 16
Table 5. Existing Conditions Comparison between FEMA and Existing (2010) hazard layers. 20
Table 6. Summary of Assets Vulnerable to all Coastal Hazards at 2030, 2060, and 2100 24
Table 7. Summary of Assets Vulnerable to Impacts by Rising Tides 28
Table 8. Summary of Assets Vulnerable to Coastal Storm Flooding 32
Table 9. Increase in 100-year Discharge for Soquel Creek Relative to Historic Period (1950-2000) 33
Table 10. Summary of Assets Vulnerable to River (Fluvial) Flooding 36

Table 11. Summary of Assets Vulnerable to Erosion 40
Table 12. Important Assets Vulnerable to Coastal Hazard Impacts 43
Table 13. Property valuation data sources for economic analysis 46
Table 14. Total Value (2016 dollars) of Capitola Properties at Risk 47
Table 15. City of Capitola Local Hazard Mitigation Plan Recommendations 51
Table 16. List of Adaptation Strategies 55
Table 17. Draft Adaptation Strategy for the City of Capitola 60

Summary of Findings

This hazard evaluation is intended to provide a predictive chronology of future risks to benefit local coastal planning and foster discussions with state regulatory and funding agencies. Estimates of the extent of assets at risk of various climate hazards were made using best available regional data. This approach allows planners to understand the full range of possible impacts that can be reasonably expected based on the best available science, and build an understanding of the overall risk posed by potential future sea level rise. The hazard maps provide projected hazard zones for each climate scenario for each of the three planning horizons. For clarity, this report focuses the hazard analysis on a subset of those scenarios, recommended by local and state experts.

Key findings for the City of Capitola include:

- Infrastructure closest to the beach will continue to be impacted by the force of waves, the deposition of sand, kelp and other flotsam, and by floodwaters that do not drain between waves.
- Infrastructure further inland is most vulnerable to flooding by a combination of ocean and riverine sources.
- Infrastructure identified as vulnerable to coastal flooding by 2030 is similar to that which is currently vulnerable.
- Total property values at risk from the combined hazards of coastal climate change for 2030 were estimated at $200 million.
- Property value at risk may increase to $275 million dollars by 2060. That value is reduced by approximately $50 million dollars if current coastal armoring is replaced or upgraded.
- By 2060 use of all 12 public access ways may be restricted due to various coastal climate vulnerabilities.
- Projected flood water depths along the river walkway are estimated to be as much as 8 feet by 2060.
- Cliff Drive remains a key western access road into the downtown area and is vulnerable to cliff erosion by 2060 if coastal armoring is not replaced.
- By 2100 most of the beach may be lost due to higher sea levels and beach erosion if back beach structures are rebuilt in their current locations.

- As many as 221 properties are within the 2100 bluff erosion zone if protective structures are not maintained or replaced.
- By 2100 SLR and Fluvial models used in this analysis project that much of the downtown area may be periodically flooded during winter storms and high river discharges.
- By 2100 tidal inundation within portions of the downtown area may become a serious challenge, risking 23 residential and 23 commercial buildings to monthly flooding.
- By 2100, portions of Capitola may be too difficult and costly to protect from the combined hazards of Coastal Climate Change.

This study confirms that coastal flooding will remain a primary risk to low-lying areas of Capitola Village. This study also suggests that river flooding may be of greater risk to the community than previously realized and significant investments will be required to protect all public and private infrastructure from future erosion risks. Establishing strategic managed retreat policies early will likely best enable the long-term implementation of these policies and ensure long term sustainability for the community.

1. Introduction

1.1 Project Goals

This report was funded by The Ocean Protection Council through the Local Coastal Program Sea Level Rise Adaptation Grant Program. This grant program is focused on updating Local Coastal Programs (LCPs), and other plans authorized under the Coastal Act[1] such as Port Master Plans, Long Range Development Plans and Public Works Plans (other Coastal Act authorized plans) to address sea-level rise and climate change impacts, recognizing them as fundamental planning documents for the California coast.

This project will achieve three key objectives to further regional planning for the inevitable impacts associated with sea-level rise (SLR) and the confounding effects of SLR on fluvial processes within the City of Capitola. This project will:

1. Identify what critical coastal infrastructure may be compromised due to SLR and estimate when those risks may occur;

2. Identify how fluvial processes may increase flooding risk to coastal communities in the face of rising seas; and

3. Define appropriate response strategies for these risks and discuss with regional partners the programmatic and policy options that can be adopted within Local Hazard Mitigation Plan and LCP updates.

This report is intended to provide greater detail on the risks to the city from coastal climate change during three future time horizons (2030, 2060 and 2100). Risks to properties were identified using the ESA PWA Monterey Bay Sea Level Rise Vulnerability Study[2] layers developed in 2014 using funding from the California Coastal Conservancy.

The City of Capitola adopted a Hazard Mitigation Plan in May 2013.[3] This plan "identifies critical facilities that are vital to the city's and other local agencies' response during a natural disaster, particularly those that are currently vulnerable or at risk, assesses vulnerability to a variety of natural disasters

---

[1] State of California. California Coastal Act of 1976. http://www.coastal.ca.gov/coastact.pdf

[2] ESA PWA. 2014. Monterey Bay Sea Level Rise Vulnerability Study: Technical Methods Report Monterey Bay Sea Level Rise Vulnerability Study. Prepared for The Monterey Bay Sanctuary Foundation, ESA PWA project number D211906.00, June 16, 2014

[3] RBF and Dewberry. 2013. City of Capitola Local Hazard Mitigation Plan. Prepared for the City of Capitola.

(earthquake, flood, coastal erosion, etc.), and identifies needed mitigation actions." Sea level rise is noted as a significant hazard to the city. The plan also sets goals to protect the city from sea level rise. Potential actions listed include integrating the results of this City of Capitola Coastal Hazards Vulnerability Report into the Local Hazard Mitigation Plan risk assessment and incorporating climate change risks and climate adaptation options into the general plan.

1.2 Study Area

The planning area for Capitola's Local Coastal Program encompasses the Coastal Zone within the City of Capitola. However, because the vulnerability study includes a fluvial analysis for Soquel Creek, the study area for the purpose of this report extends outside of the Coastal Zone along Soquel Creek (Figure 1).

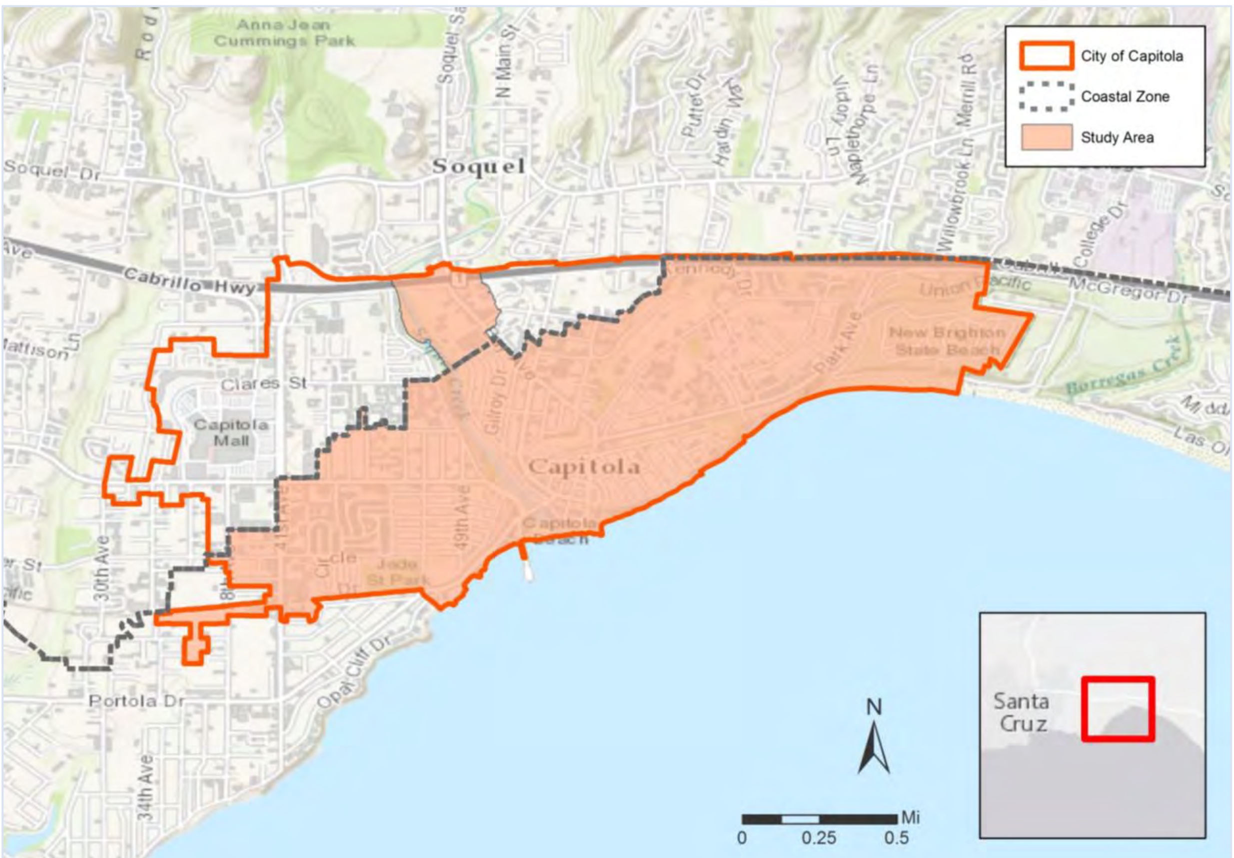


Figure 1. City of Capitola Vulnerability Assessment Study Area with Soquel Creek floodplain

2. Community Profile

2.1 Setting and Climate

Capitola is a small coastal city located in Santa Cruz County in California's Monterey Bay Area (figure 1.). The town was founded in the late 1800's first as a vacation resort. Capitola's main beach is located at the mouth of the Soquel Creek, buffered by coastal cliffs and pocket beaches to the East and West. The Capitola Esplanade provides a pleasant stroll along a row of restaurants, historic homes and small shops and unique vistas of Monterey Bay. In September, Capitola hosts a number of beach front events (Begonia Festival and the Capitola Art & Wine Festival) along the Esplanade.

According to the United States Census Bureau[5], the city has a total area of 1.7 square miles, of which 1.6 square miles is land and 0.1 square miles (5%) is water of Soquel Creek. Capitola's climate is mild with summer temperatures in the mid-70s and winter temperatures in the mid-50s. Capitola has an average of 300 sunny days a year with low humidity for a coastal city. Average rainfall is 31 inches per year, with most of the rainfall occurring between November and April.[4]

2.2 Demographics

The community has a population of 10,189 residents, 52.4% female and 47.6% male. 80.3% identify as white, 1.2% identify as black, 4.3% identify as Asian, and 19.7% identify as Hispanic or Latino (of any race). The median household income is $56,458, and 7.1% of the civilian workforce is unemployed, with 7.4% of people under the poverty line. 92.7% of people have a high school diploma, and 38.3% have a bachelor's degree or higher.[5]

2.3 Community Resources and Assets

Land Use

Critical Facilities*:* Capitola's Police and Fire Stations, as well as City Hall, are located downtown, in close proximity to the beach and the Village. Emergency shelters are located at Jade Street Community Center and New Brighton School, and the Public Library is used as a backup emergency response center. There are several storm and wastewater pump stations, one of which is located in Esplanade Park.

[4] National Oceanic and Atmospheric Administration. NowData – NOAA Online Weather Data. Retrieved from http://w2.weather.gov/climate/xmacis.php?wfo=ilx (Aug 6, 2016)

[5] United States Census Bureau. 2015. American Community Survey 5-Year Estimates. Retrieved from https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml (April 2, 2016)

Capitola Village: The downtown commercial and visitor serving district of Capitola supports about 45 tourist shops and 27 other businesses, 20 restaurants and 10 cafes, 4 hotels, and 30 vacation rentals (28 listed).[6] The Village is a true mixed-use district with a diversity of visitor-serving commercial establishments, public amenities, and residential uses.[7,8] Capitola has a popular beach and waterfront area, with the beach area used for tourism, junior lifeguarding, surfing, and more.

Capitola Wharf: The Wharf is a popular destination for fishermen. With its restaurant and great views of Capitola and the ocean, the wharf is popular with tourists and provides access to boat rentals and boat moorings offshore.

Historical Buildings and Districts*:* Based on a 1986 architectural survey of structures prior to 1936, that had retained architectural integrity, Capitola has approximately 240 buildings that "best represented traditional architectural styles locally or the community's vernacular architecture." As a result of the survey, three National Register Historic Districts were established in Capitola in 1987: Venetian Court District, Six Sisters/Lawn Way District, and Old Riverview Historic District.[9]

Recreation and Public Access

Beaches and Parks*:* Capitola Beach is a popular tourist destination and is in close proximity to Capitola Village's shops and restaurants, and the Capitola Wharf. The beach (averaging 5.8 acres of summer sand) supports numerous sports and community events including junior lifeguards program, surfing lessons, sand castle contests, volleyball and other beach activities. There are eight City parks in Capitola, totaling 18 acres, including Monterey Avenue Park, Noble Gulch Park, Peery Park, Soquel Creek Park, Jade Street Park and Esplanade Park. New Brighton State Beach is also located within Capitola.

Figure 2. Coastal access points within the City of Capitola

Coastal Access: Defined coastal access points (with specific access ways to coastal resources) were mapped specifically for this project (Figure 2). There are two stairway coastal access ways and one partially paved ramp near the wharf that are used extensively by the public to reach Capitola beach. The low wall along the Venetian Court allows easy access to

[6] Capitola Village Business Industry Association. Capitola Village. Retrieved from www.capitola village.com (March 2, 2016)

[7] City of Capitola. 2014. Capitola General Plan.

[8] For the purpose of this analysis Capitola building land use was cross-walked with Santa Cruz County and Monterey County land uses so that the analysis could be consistent between jurisdiction, however many of the buildings in the village are actually designated as mixed-use by the City of Capitola.

[9] Swift, C. 2004. Historical Context Statement for the City of Capitola. Prepared for City of Capitola Community Development Department.

the beach along its entire stretch. There are numerous access ways along the Esplanade, all of which can be blocked during winter storms to restrict incoming waves.

Public Visitor Parking: Public parking is distributed throughout the community and includes metered parking along the Esplanade and other downtown streets, several parking lots within the downtown area, and parking lots located within Noble Gulch and above City Hall.

Coastal Trail: The Coastal Trail in Capitola runs along the railroad track and the coastline.

Transportation

Roads*:* Some of the main roads in Capitola Village include Monterey Ave, Cliff Drive, Wharf Road, Stockton Avenue, and the Esplanade. The Stockton Bridge crosses Soquel Creek and connects the cliffs to the Village.

Summer Shuttle*:* There is a free weekend summer shuttle that transports people from parking lots to the beach.

Railroad*:* The railroad through Capitola has been closed to passengers since the 1950s but was recently purchased by the county to provide pedestrian, bike and rail opportunities in the future.[10] The railroad trestle bridge crosses Soquel Creek north of Stockton Bridge.

Natural Resources

Wetland: Soquel Creek and Noble Creek are mapped as Riverine systems by the National Wetland Inventory. The mouth of the creek is mapped as an Estuarine and Marine Wetland.[11]

Kelp Forest: Kelp forests persist offshore of Capitola and provide valuable habitat and fishing opportunities within a short boat ride of the wharf.

Critical Habitat*:* The Soquel Creek is home to several endangered species such as Steelhead Trout and Coho Salmon.[12] Restoration efforts are underway to help these populations recover.

Utilities

Water Infrastructure: The City of Capitola has extensive below ground drinking water, storm drain and wastewater infrastructure within the areas identified as vulnerable. There is a wastewater pump station located next to the Esplanade Park restroom. Storm drain structures discharge to the river and beach.

---

[10] Whaley, D., Santa Cruz Trains, Capitola. retrieved from: http://www.santacruztrains.com/2014/11/capitola.html (July 8, 2016)

[11] US Fish and Wildlife Service. National Wetland Inventory. Retrieved from https://www.fws.gov/wetlands/Data/Mapper.html (July, 8, 2016)

[12] California Natural Diversity Database (CNDDB). 2015. Records of Occurrence for Capitola USGS quadrangle. Sacramento, California. 2014. Retrieved from http://www.dfg.ca.gov/biogeodata/cnddb/mapsanddata.asp (October 2015)

Utility Infrastructure*:* PG&E electric and natural gas infrastructure data were not available for this study.

2.4 Historic Events

Capitola has experienced many coastal flooding events caused by high wave action during winter high tides. Table 1 provides a list of these storms. The 1982-1983 El Niño was an extreme example of the periodic impacts this coastal community faces from severe winter storms (Figure 3).

Historical flooding from the river is well documented, including the December 1931 flood, which is depicted as:

> *"Soquel "River" widens to sixty feet, the highest since 1890, damaging property in Soquel and all the way to the mouth at Capitola. Orchards are lost with the rapid rise of water. Hundreds gather to watch the tides batter the concessions at the beach. There is a "vortex of water where the river and sea meet." The waterfront is piled high with flood debris thrown back up the beach."*[13]

On March 26, 2011, a large flood event occurred on the Noble Creek causing a subsurface storm drain pipe to fail during a large winter storm, causing creek waters to flow down Noble Gulch, flooding the downtown commercial district. Commercial and residential properties, including the fire and police stations, were flooded, leading to significant costs for repair.

Figure 3. January 23rd, 1983: high tide, high river flow event in Capitola. (Photo: Minna Hertel)

[13] City of Capitola Historical Museum. 2013. Capitola Local Hazard Mitigation Plan, Appendix A: Timeline of Natural Hazard events impacting the City of Capitola

Table 1. Major Floods in Soquel and Capitola Villages 1890 to Present
(adapted from Appendix A of the Capitola Hazard Mitigation Plan)

NEWSPAPER DATE	HAZARD	DESCRIPTION OF DAMAGE
1862	Flood	Major event—Soquel village inundated; mills, flumes, school, town hall, houses and barns were destroyed. Massive pile of debris went out to sea and then washed ashore at Soquel Landing
1890	Flood	Capitola floods, footbridge and span of wagon bridge destroyed. Esplanade flooded
1906	Flood	Buildings from Loma Prieta Lumber Company camp above Soquel are destroyed. Debris at Capitola.
1913	Storms and Tide	Waves ran across the beach to the Esplanade and water spread "clear to the railroad tracks." Union Traction Company racks covered with sand. Water reached the Hihn Superintendent's Building (Capitola and Monterey Avenues), and waves were described as "monster." About 200 feet of wharf washed away.
1914	Flood	Flood along Soquel Creek
1926	High Tide	High Tide: Waves to 20 feet. Wharf damaged. Sea wall promenade broken at Venetian Courts. Apartments flooded. Breakers slammed into Esplanade, destroying boathouse/bathhouse, beach concessions. Tide hits the second floor of Hotel Capitola. Water runs a foot deep through village
1931	Storm and High Tide	Soquel "River" widens to sixty feet, the highest since 1890, damaging property in Soquel and all the way to the mouth at Capitola. The creek cuts across the beach and moves sand below the new outlet.
1935	Flood	Capitola Village floods; thirty feet of the sea wall is taken out. Beach playground disappears. Venetian Courts hit hard but damage minimal.
1940	Flood	Logs pile against bridge in downtown Soquel and village floods. Landslides in watershed.
1955	Flood	Capitola exceeded $1 million damage including the Venetian Courts. Noble Creek and Tannery Creek also flooded.
1982-1983	El Nino Storm and High Tide	Early winter storms initiated erosion and left the beaches eroded and vulnerable to subsequent storms in January-February 1983.
1995	Flood	The creek rose near the village.
1997-1998	Flood	Yards and basements of homes along both sides of Soquel Creek near the village were flooded.
2011	Flood	Noble Creek floods village; Tannery Creek rushes through New Brighton State Park parking lot and undermines the cliff roadway within the State Park

2.5 Coastal Protection Infrastructure and Management

There are 1.2 miles of sea walls and rip-rap that protect coastal structures from winter storms and wave impacts. Capitola's downtown commercial district is currently protected from winter storms by low hip-walls along the Esplanade and Venetian Court and a large concrete wall that protects portions of the eastern cliff from erosion. Two rip-rap groins on the east end of the beach lay perpendicular to the Esplanade and help accumulate sand and increase the width of the beach. Rip-rap protects the cliffs west of the wharf and concrete walls maintain the edge of the creek under restaurants along the Esplanade (Figure 4). Table 2 outlines the existing coastal armoring that helps protect Capitola from coastal hazards.

The Soquel River mouth lagoon is actively managed to minimize flooding during the winter and maximize recreational opportunities during the summer. The river mouth is closed before Memorial Day and remains closed (draining excess flow through the concrete spillway) until after Labor Day. The river is mechanically breached in the fall to reconnect the lagoon with the ocean and prepare for increased flows during winter storms. The lower 2000 feet of the river are channelized and restricted by a combination of wood and concrete channel walls. Private yards and a public access trail parallel the channel from the Stockton Ave Bridge inland 800 feet to the Noble creek culvert and Blue Gum Ave.

Table 2. Inventory of Existing Coastal Protection Structures in Capitola

STRUCTURE LOCATION	TYPE OF STRUCTURE	PUBLIC OR PRIVATELY OWNED
Grand Ave, eastern end of promenade, below Crest apartment	Retaining wall	Public
Grand Ave, eastern end of promenade, below Crest apartment	Concrete wall	Private
Esplanade, seaward of road and parking lot	Concrete wall	Public
Esplanade, in front of restaurant	Revetment	Public
Esplanade, in front of Zeldas at inlet of river	Revetment	Public
Seaward of Venetian Court adjacent to Capitola Beach	Wall	Private
Cliff Drive, seaward of residences at beach	Revetment	Private
Cliff Drive, at the top of coastal bluff underneath recreation path	Retaining wall	Public
Cliff Drive, seaward of road at base of bluff	Revetment	Public
Opal Cliff Drive, seaward of residence on the upper portion of bluff	Surface armor	Private
Grove Lane, base of cliff	Revetment	Private

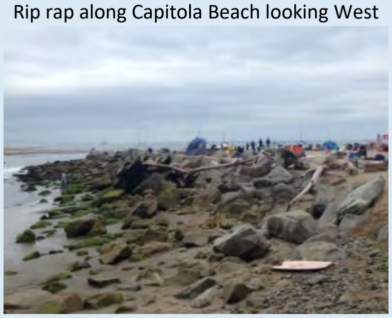
COASTAL PROTECTIONS

Sea Wall in front of Esplanade Park

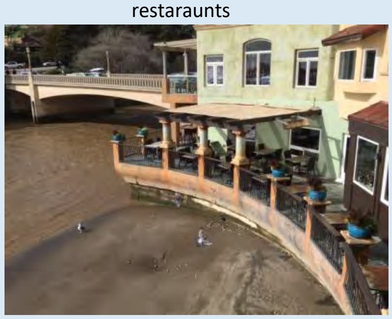
Hip wall in front of the Venetian

Rip rap against cliff below Cliff Drive

Rip rap along Capitola Beach looking West



Hip wall in front of Village Center restaraunts



Jetty off Capitola Beach looking East

Hip wall in front of the Esplanade

Figure 4. Coastal Protection Structures around the City of Capitola
(Photos: Ross Clark and Sarah Stoner-Duncan)

The coastal protection structures within Capitola are of various ages, conditions and levels of service. The current condition of these structures (sea walls, rip-rap and groins) was evaluated with the intent of estimating the expected future lifespan of these structures. Observational data were collected for the dominant structures along the city coastline. The technical team determined that these field observations can be used to provide some estimate of future life expectancy, but not at a level of certainty any more precise than assuming that all current coastal protection infrastructure will need to be replaced or significantly improved at some point between 2030 and 2060.

3. Projecting Impacts

3.1. Disclaimer: Hazard Mapping and Vulnerability Assessment

Funding Agencies

The hazard GIS layers were created with funding from The Coastal Conservancy and this Vulnerability Analysis was prepared with funding from the Ocean Protection Council. The results and recommendations within these planning documents do not necessarily represent the views of the funding agencies, its respective officers, agents and employees, subcontractors, or the State of California. The funding agencies, the State of California, and their respective officers, employees, agents, contractors, and subcontractors make no warranty, express or implied, and assume no responsibility or liability, for the results of any actions taken or other information developed based on this report; nor does any party represent that the uses of this information will not infringe upon privately owned rights. These study results are being made available for informational purposes only and have not been approved or disapproved by the funding agencies, nor has the funding agencies passed upon the accuracy, currency, completeness, or adequacy of the information in this report. Users of this information agree by their use to hold blameless each of the funding agencies, study participants and authors for any liability associated with its use in any form.

ESA PWA Hazard Layers

This information is intended to be used for planning purposes only. Site-specific evaluations may be needed to confirm/verify information presented in these data. Inaccuracies may exist, and Environmental Science Associates (ESA) implies no warranties or guarantees regarding any aspect or use of this information. Further, any user of this data assumes all responsibility for the use thereof, and further agrees to hold ESA harmless from and against any damage, loss, or liability arising from any use of this information. Commercial use of this information by anyone other than ESA is prohibited.

CCWG Vulnerability Assessment

This information is intended to be used for planning purposes only. Site-specific evaluations may be needed to confirm/verify information presented in these data. Inaccuracies may exist, and Central Coast Wetlands Group (CCWG) implies no warranties or guarantees regarding any aspect or use of this information. Further, any user of this data assumes all responsibility for the use thereof, and further agrees to hold CCWG harmless from and against any damage, loss, or liability arising from any use of this information. Commercial use of this information by anyone other than CCWG is prohibited.

Data Usage

These data are freely redistributable with proper metadata and source attribution. Please reference ESA PWA as the originator of the datasets in any future products or research derived from these data. The data are provided "as is" without any representations or warranties as to their accuracy, completeness, performance, merchantability, or fitness for a particular purpose. Data are based on model simulations, which are subject to revisions and updates and do not take into account many variables that could have substantial effects on erosion, flood extent and depth. Real world results will differ from results shown in the data. Site-specific evaluations may be needed to confirm/verify information presented in this dataset. This work shall not be used to assess actual coastal hazards, insurance requirements or property values, and specifically shall not be used in lieu of Flood insurance Studies and Flood Insurance Rate Maps issued by FEMA. The entire risk associated with use of the study results is assumed by the user. The Monterey Sanctuary Foundation and ESA shall not be responsible or liable to you for any loss or damage of any sort incurred in connection with your use of the report or data."

3.2. Coastal Hazard Processes

The ESA coastal hazard modeling and mapping effort[14] led to a set of common maps that integrate the multiple coastal hazards projected for each community (i.e. hazards of coastal climate change). There is however a benefit to evaluating each hazard (or coastal process) separately. Two important limitations of the original hazard maps were addressed within this focus effort for Capitola. ESA was contracted for this project to model the combined effects of rising seas and increased winter stream flows due to future changes in rainfall. CCWG staff further accounted for reductions in potential hazards provided by current coastal protection infrastructure (see section 3.4). This refinement of coastal hazard mapping helped to better understand the future risks Capitola may face from each coastal hazard process.

Each modeled coastal process will impact various coastal resources and structures differently. This report evaluates the risks to infrastructure from each coastal hazard process for each time horizon. The following is a description of the hazard zone maps that were used for this analysis. For more information on the coastal processes and the methodology used to create the hazard zones please see the Monterey Bay SLR Vulnerability Assessment Technical Methods Report.[15]

FEMA

FEMA flood hazard maps are used for the National Flood Insurance Program and present coastal and fluvial flood hazards. These flood maps were used to identify current hazards as defined by FEMA. These maps, however, are believed to underestimate coastal flood hazards for future time horizons.

Combined Hazards

CCWG merged the coastal hazard layers provided by ESA to create a new combined hazard layer for each planning horizon (2030, 2060 and 2100). These merged layers represent the combined vulnerability zone for "Coastal Climate Change" for each time horizon. Projections of the combined hazards of Coastal

[14] ESA PWA. 2014. Monterey Bay Sea Level Rise Vulnerability Assessment Technical Methods Report

[15] Ibid.

Climate Change are intended to help estimate the cumulative effects on the community and help identify areas where revised building guidelines or other adaptation strategies may be appropriate. Combined hazards however, do not provide municipal staff with the necessary information to select specific structural adaptation responses. Therefore, this study also evaluates the risks associated with each individual coastal hazard.

Rising Tides

These hazard zones show the area and depth of inundation caused simply by rising tide and ground water levels (not considering storms, erosion, or river discharge). The water level mapped in these inundation areas is the Extreme Monthly High Water (EMHW) level, which is the high water level reached approximately once a month. There are two types of inundation areas: (1) areas that are clearly connected over the existing digital elevation through low topography, (2) and other low-lying areas that don't have an apparent connection, as indicated by the digital elevation model, but are low-lying and flood prone from groundwater levels and any connections (culverts, storm drains and underpasses) that are not captured by the digital elevation model. This difference is captured in the "Connection" attribute (either "connected to ocean over topography" or "connectivity uncertain") in each Rising Tides dataset. These zones do not, however, consider coastal erosion or wave overtopping, which may change the extent and depth of regular tidal flooding in the future. Projected risks from rising tides lead to reoccurring flooding hazards during monthly high tide events.

Coastal Storm Flooding

These hazard zones depict the predicted flooding caused by future coastal storms. The processes that drive these hazards include (1) storm surge (a rise in the ocean water level caused by waves and pressure changes during a storm), (2) wave overtopping (waves running up over the beach and flowing into low-lying areas, calculated using the maximum historical wave conditions), and (3) additional flooding caused when rising sea level exacerbate storm surge and wave overtopping. These hazard zones also take into account areas that are projected to erode, sometimes leading to additional flooding through new hydraulic connections between the ocean and low-lying areas. These hazard zones do NOT consider upland fluvial (river) flooding and local rain/run-off drainage, which likely play a large part in coastal flooding, especially around coastal confluences where creeks meet the ocean. Storm flood risks represent periodic wave impact and flooding.

Cliff and Dune Erosion

These layers represent future cliff and dune (sandy beach) erosion hazard zones, incorporating site-specific historic trends in erosion, additional erosion caused by accelerating sea level rise and (in the case of the storm erosion hazard zones) the potential erosion impact of a large storm wave event. The inland extent of the hazard zones represents projections of the future crest of the dunes, or future potential cliff edge, for a given sea level rise scenario and planning horizon. Erosion can lead to a complete loss of habitat, infrastructure and/or use of properties.

Fluvial Flooding

An additional river flooding vulnerability analysis was done as part of this study to evaluate the cumulative impacts of rising seas and future changes in fluvial discharge due to changes in rainfall within the Soquel watershed. The ESA modeling team expanded hydrologic models of the Soquel watershed provided by the County to estimate discharge rates under future climate scenarios. The fluvial model estimates localized flooding along the Soquel Creek when discharge is restricted by future high tides. The model results are presented here and reviewed within the separate Fluvial Report by ESA.[16]

3.3. Scenario Selection and Hazards

The California Coastal Commission guidance document[17] recommends all communities evaluate the impacts from sea level rise on various land uses. The guidance recommends using a method called "scenario-based analysis" (described in Chapter 3 of this Guidance). Since sea level rise projections are not exact, but rather presented in ranges, scenario-based planning includes examining the consequences of multiple rates of sea level rise, plus extreme water levels from storms and El Niño events. As recommended in the Coastal Commission guidance, this report uses sea level rise projections outlined in the 2012 NRC Report, *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future*[18] (Figure 5). The goal of scenario-based analysis for sea level rise is to understand where and at what point sea level rise and the combination of sea level rise and storms, pose risks to coastal resources or threaten the health and safety of a developed area. This approach allows planners to understand the full range of possible impacts that can be reasonably expected based on the best available science, and build an understanding of the overall risk posed by potential future sea level rise. The coastal climate change vulnerability maps used for this study identify hazard zones for each climate scenario for each of the three planning horizons. For clarity, this report focuses the hazard analysis on a subset of those scenarios,

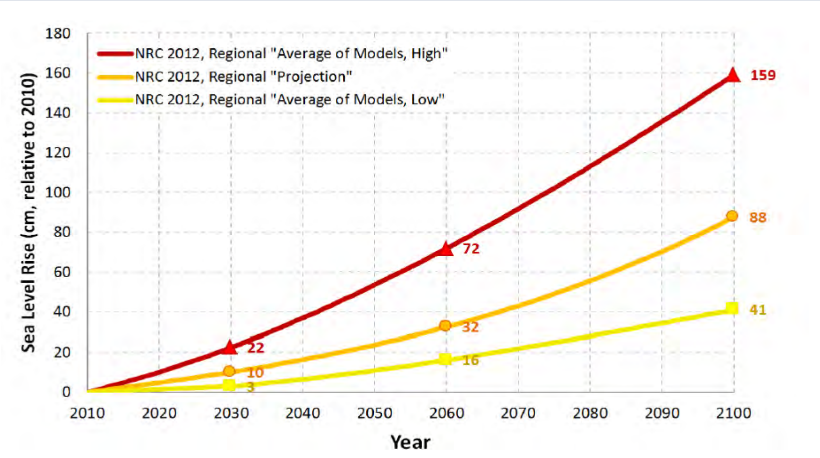


Figure 5. Sea Level Rise scenarios for each time horizon
(Figure source: ESA PWA 2014)

[16] ESA. 2016. Climate Change Impacts to Combined Fluvial and Coastal Hazards. May 13, 2016.

[17] California Coastal Commission. 2015. California Coastal Commission Sea Level Rise Policy Guidance: Interpretative Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits. Adopted August 12, 2015.

[18] National Research Council (NRC). 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future. Report by the Committee on Sea Level Rise in California, Oregon, and Washington. National Academies Press, Washington, DC. 250 pp.

recommended by local and state experts (Table 3).

The Coastal Commission recommends all communities evaluate the impacts of the highest water level conditions that are projected to occur in the planning area. Local governments may also consider including higher scenarios (such as a 6.6 ft (2m) Scenario) where severe impacts to Coastal Act resources and development could occur from sea level rise. We use a similarly high scenario of 1.59m with an increase in projected storm intensity for this analysis (Table 3). In addition to evaluating the worst-case scenario, planners need to understand the minimum amount of sea level rise that may cause impacts for their community, and how these impacts may change over time.

Table 3. Sea level rise scenarios selected for analysis

TIME HORIZON	EMISSIONS SCENARIO	SLR	NOTES
2030	med	0.3 ft (10 cm)	Erosion projection: Includes long-term erosion and the potential erosion of a large storm event (e.g. 100-year storm)
2060	high	2.4 ft (72 cm)	Erosion projection: Includes long-term erosion and the potential erosion of a large storm event (e.g. 100-year storm) Future erosion scenario: Increased storminess (doubling of El Niño storm impacts in a decade)
2100	high	5.2 ft (159 cm)	Erosion projection: Includes long-term erosion and the potential erosion of a large storm event (e.g. 100-year storm) Future erosion scenario: Increased storminess (doubling of El Niño storm impacts in a decade)

3.4. Assumptions and Modifications to ESA Hazard Zones

Coastal Armoring

The ESA coastal hazard projections do not account for the protections that existing coastal armoring provide. The areas identified as vulnerable by the original coastal erosion ESA GIS layers overestimate future hazard zones (as recognized within the ESA supporting documentation). A GIS layer of existing coastal armoring was referenced within this analysis to recognize areas where some level of protection currently exists.[19]

To account for the protections provided by coastal armor, properties and structures located behind those structures were in most cases reclassified as protected from erosion for the 2030 erosion vulnerability analysis. Coastal flooding layers, however, did account for the height of coastal structures (hip walls etc.) and estimate wave overtopping and flooding that may occur with those structures in place. Some structures were therefore identified as protected from coastal erosion and vulnerable to coastal flooding.

[19] California Coastal Commission. 2014. GIS layer of existing coastal armor structures in Santa Cruz County.

Because the life span of coastal infrastructure is limited, this vulnerability analysis assumes that all existing coastal protection infrastructure will fail and may need to be removed, replaced or significantly redesigned at some point between 2030 and 2060. If these structures are removed once they fail, erosion will accelerate and quickly meet projected inland migration rates (as documented at Stilwell Hall, Fort Ord) unless protective measures are implemented. Therefore, the vulnerability analysis for the 2060 and 2100 planning horizons assumes that current coastal armoring will no longer function and that the modeled hazard zone layers provided by the ESA technical team fully represent future hazards for these time horizons.

Erosion

Cliff erosion and dune erosion were originally two sets of separate coastal hazard layers provided by ESA-PWA. Cliff erosion was characterized as erosion of mudstone cliff sides generally along the Santa Cruz County coastline. Whereas dune erosion was characterized as erosion of sandy slopes predominantly found along the Monterey Bay coastline. Since these two hazards were functionally different and spatially separate, it was decided to merge them into one set of 'Erosion' coastal hazard process layers using the 'Merge' tool within ArcGIS. Therefore, for each time horizon both cliff erosion and dune erosion impact zones were combined into a single erosion impact zone. The 'erosion' coastal hazard series was used throughout the analysis and included in the tables. Erosion hazard layers were modified as described above to account for the protections provided by existing seawalls through 2030.

Coastal Storm Flooding

The ESA hazard layers included cliff areas predicted to have eroded during previous time horizons as being vulnerable to coastal flooding hazards, because the land elevation within those areas was assumed to have been reduced due to that cliff erosion. For example, sections of cliff in Capitola that are projected to erode by 2060 (after coastal armoring is assumed to no longer function) are also projected to experience coastal flooding and wave over-topping within those newly eroded coastal areas. This is an accurate interpretation of the projected coastal processes but does not reflect the progression of asset losses. For simplicity, Cliff top assets predicted to be vulnerable to coastal flooding for the 2060 and 2100 planning are reported as vulnerable. This is likely inaccurate because those assets would likely no longer be present but lost due to previous impacts from coastal erosion.

To more accurately represent coastal flooding and wave over-topping vulnerabilities of low-lying assets behind coastal armoring for the Existing (2010) and 2030 planning horizons, assets located below the 20- foot topographic contour line along the base of existing cliffs were reported to be vulnerable.

3.5. Assets Used in Analysis

For this study, city infrastructure and assets were categorized as: Land Use and Buildings; Water and Utility Infrastructure; Recreation and Public Access; Transportation; Natural Resources and Other. GIS layers were obtained from data repositories, or created by the Central Coast Wetlands Group. In some cases, assets that were used in the analysis fell outside of the planning area and therefore were not included in this report. Further, several data layers that were intended to be used in this analysis were not available. Table 4 lists the assets used in the analysis.

Table 4. List of Data Layers used for Analysis

ASSET CATEGORY	ASSET	STATUS OF ASSET IN ANALYSIS
Land Use	Building footprints	Analyzed
	Commercial, Residential, Public, Visitor Serving	Analyzed
	Emergency Services: Hospitals, Fire, Police	Analyzed
	Schools, Libraries, Community Centers	Analyzed
	Parcels	Not used in analysis[20]
	Farmland	None in Planning Area
	Military	None in Planning Area
	Historical and Cultural Designated Buildings	Analyzed, but not reported[21]
Water and Utilities	Sewer Structures & Conduits	Analyzed
	Water Main Lines	Analyzed
	Gas	Unable to obtain for analysis
	Storm Drain Structures & Conduits	Analyzed
	Tide gates	None in Planning Area
Recreation and Public Access	Coastal Access Points	Analyzed
	Parks	Analyzed, but not reported[22]
	Beaches	Analyzed
	Coastal Trail	Analyzed
	Coastal Access Parking	Analyzed
Transportation	Roads	Analyzed[23]
	Rail	Analyzed
	Bridges	Analyzed
	Tunnels	None in Planning Area
Natural Resources	Wetlands	Analyzed
	Critical Habitat	Analyzed, but not reported[24]
	Dunes	None in Planning Area
Other	Hazmat cleanup sites, Landfills, etc.	None in Planning Area

[20] Building foot print layers were used instead of parcels maps to better project future structural vulnerabilities.

[21] The data are available but not reported within this document.

[22] The parks layer included acres of State Beaches as well as City Parks and was duplicative with the Beach impact analysis. City parks vulnerable to various hazards are listed within the text but not included in tabular form.

[23] All projected impacts to Hwy 1 were determined to be unreliable in this area due to the height of the roadway.

[24] Critical habitat data layers were not of high enough resolution to provide accurate estimates of impacts.

4. Combined Impacts of Coastal Climate Change

4.1 Background

Predicted storm driven hazards to the Capitola shoreline and low-lying areas was derived by compiling the geographic extend of hazard areas for a combination of different coastal processes. Waves can damage buildings through blunt force impact, often damaging exterior doors and window, railings, stairways and walkways. Waves that overtop beaches and coastal structures lead to flooding of low lying areas. Flooding is often exacerbated by coastal walls and malfunctioning storm drains that impede drainage of those waters back to the ocean. Future risks of flooding and wave damage may be magnified as higher local sea levels and greater wave heights combined with higher river discharges during winter storms. Greater wave impact intensity may cause greater damage to coastal structures and greater wave heights may extend risks of damage further inland as waves overtop coastal structures more intensively and propagate further up the Soquel Creek. These cumulative threats are termed within this document as the risks of “Coastal Climate Change.”[25]

4.2 Existing Vulnerability

FEMA

FEMA maps identify a large portion of the Capitola Village as vulnerable to riverine flooding during a 100-year flood event (Figure 6). Similar flooding occurred during the 2011 Noble Gulch event that flooded much of the downtown commercial district. A total of 262 mixed use buildings, more than 6,500 feet of roadway, 6,800 feet of storm drain pipe and 132 storm drain boxes are located within the FEMA hazard map 100-year flood zone (Table 5).

Flooding within the FEMA hazard map areas is expected to become more severe (although not currently recognized by FEMA) due to changing rainfall patterns associated with climate change. Future threats from increased river flows during these less frequent but more intense rain events were investigated within this project and are reported in Section 5.4.

[25] This study did not investigate the risks from increased heat, decreases in water supply or increases in threats from fire that are also predicted for Santa Cruz County due to climate change.

Existing (2010 with Armoring)

The combined risks of Coastal Climate Change from current climatic conditions (2010 model year) were evaluated for Capitola (Figure 6). The ESA coastal hazard modeling results for the 2010 planning year overlay 62 residential and 134 commercial properties, suggesting they are presently vulnerable to the impacts of storm flooding, classified as Coastal Climate Change (Table 5).

To note, FEMA flood maps do not account for projected sea level rise which may lead to greater regularity of flooding than that FEMA 100-year flood zone identifies. Figure 6 compares assets that lie within the FEMA hazard zone and the modified 2010 combined coastal climate change hazard zone. Many of the additional residents that fall within the FEMA hazard zone are located further upstream along the river outside of the zone threatened by storm induced ocean swells. One of the main emergency service facilities (Capitola fire station) is within this flood hazard area, and was impacted during the 2011 flood. The police station falls outside of the ESA modeled existing (2010) hazard zone, but within the FEMA 100-year flood hazard zone. The station was also impacted during the 2011 flood.

Figure 6. Existing (2010) Flood Hazard Zone Compared to FEMA 100-Year Flood zone

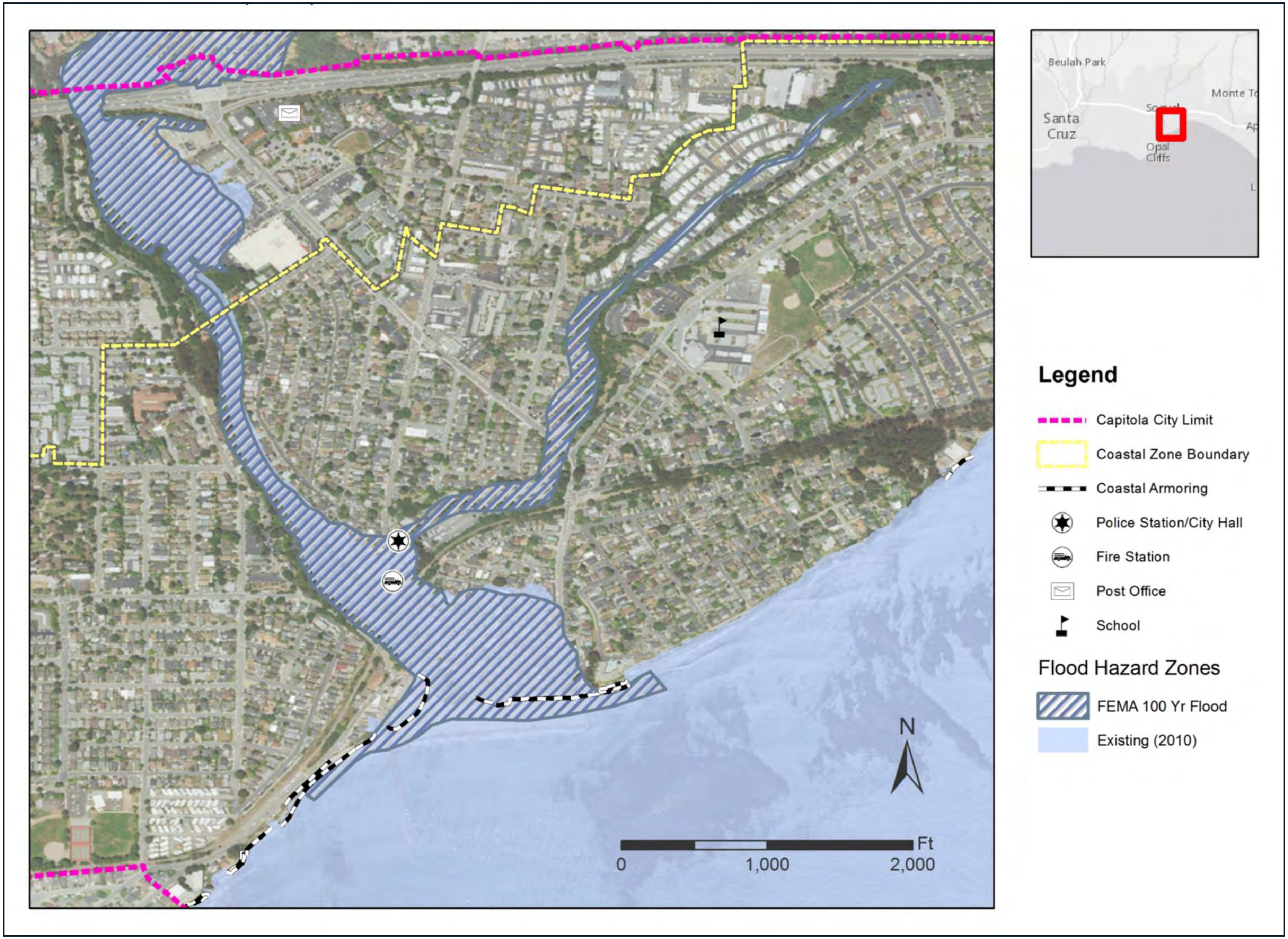


Table 5. Existing Conditions Comparison between FEMA and Existing (2010) hazard layers.

ASSET	UNIT	TOTAL	FEMA	2010 (WITH ARMOR)
Land Use and Buildings				
Total Buildings	Count	3,025	262	206
Residential	Count	2,600	122	62
Commercial	Count	326	132	134
Public	Count	67	6	6
Visitor Serving	Count	15	2	4
Other	Count	17	0	0
Schools	Count	1	0	0
Post Offices	Count	1	0	0
Emergency Services	Count	2	2	0
Transportation				
Roads	Feet	119,994	6,651	6,473
Rail	Feet	8,503	496	422
Bridges	Count	4	3	3
Recreation and Public Access				
Beaches	Acres	5.8	3.9	6
Coastal Access Points	Count	12	9	11
Parking Lots	Acres	4	1	0.7
Coastal Trail	Feet	9,543	0	0
Water and Utility Infrastructure				
Storm Drain Structures	Count	667	132	160
Storm Drain Conduits	Feet	50,173	6,869	8,039
Sewer Structures	Count	472	59	55
Sewer Conduits	Feet	118,365	12,555	12,636
Water Mains	Feet	144,206	11,946	12,857
Natural Resources				
National Wetlands	Acres	16	10	16

4.3 Summary of Future Vulnerabilities by Planning Horizon

Due to climate change, the cumulative number of Capitola properties and infrastructure at risk increases as projected ocean water elevation and storm intensity increase (Table 6). There is a significant increase in the number of properties projected to be at risk of coastal climate change impacts after the 2030 planning horizon. This increase in vulnerability is driven by two assumptions made when interpreting the model outputs. First, by 2060 ocean levels are estimated to rise by 72 cm[26], leading to a greater portion of the downtown area being vulnerable to flooding during winter storms. Flood waters in the downtown area are projected to be higher due to increased wave energy and higher tides pushing more water past current beachfront infrastructure. Some buildings within the downtown area at elevations that do not flood today may be affected by flooding in the future.

Secondly, the technical team determined that it is likely that all coastal protection infrastructure (sea walls, rip-rap, and groins) will need to be replaced or significantly improved at some point before 2060, and therefore the 2060 and 2100 coastal erosion analyses do not account for the protections provided by existing structures. Rather, the analysis accounts for the expected lifespan of coastal structures and assumes that future actions must be taken to replace structures if the community intends to protect structures from these projected hazards. This approach to future hazard analysis recognizes that current coastal armoring may continue to provide protection from wave impacts through 2030 but may fail prior to 2060.

2030

For 2030, the vulnerability analysis was completed assuming that current coastal protective structures would still be present and functioning. A total of 219 buildings are vulnerable to coastal climate impacts by 2030, only 13 more properties than currently at risk (2010 vulnerability assessment). This suggests that current coastal protection infrastructure does not provide full protection from all future hazards.

More than 7,000 linear feet of roadway may be vulnerable to coastal climate change (primarily flooding) by 2030 and approximately 10% of sewer and storm drain infrastructure is within the identified hazard areas. Roads and utilities are not equally vulnerable to different coastal hazards (flooding, erosion etc.) and therefore the analysis of individual coastal hazards (Section 5) may be more useful for response planning.

2060

By 2060, 113 residential buildings and 166 commercial mixed use buildings may become vulnerable to the combined effects of coastal climate change. Only 76 additional buildings are vulnerable to Coastal Climate Change by 2060 than are vulnerable in 2030 even though the 2060 vulnerability model no longer accounts for protections provided by current coastal armoring. Risks to roadways nearly double (in linear feet) by 2060, reflecting the predicted loss of protections provided by coastal armoring for Cliff

[26] National Research Council (NRC). 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future.

Drive. Upgraded coastal armoring is estimated to cost between $20 and $52 million per mile ($10,000 per linear foot) to construct.[27]

2100

By 2100 the combined models used in this analysis project that much of the downtown area may be flooded during winter storms and high river discharges. Furthermore, most of the dry beach (98%) may be lost due to higher sea levels and beach erosion if back beach structures are rebuilt in their current locations. Further, hundreds of storm drain structures may be compromised and may become conduits for inland flooding if modifications are not made.

By 2100 the impacts experienced periodically during large winter storms may become more frequent and for many coastal properties, may become an annual event. Wave run-up energy may impact structures during most high tides causing flood and wave damage. River flooding is projected to be more frequent and threats of coastal erosion may become more significant as ocean forces migrate inland and impact structures more routinely and forcefully. Maintaining and replacing coastal armoring may become more costly and difficult to engineer. By 2100, portions of Capitola may be too difficult and costly to protect from the combined hazards of Coastal Climate Change.

[27] Evaluation of erosion mitigation alternatives for Southern Monterey Bay, ESA PWA 2012.

Figure 7. Future Combined Coastal Climate Change Hazard Zones (2030, 2060, 2100)

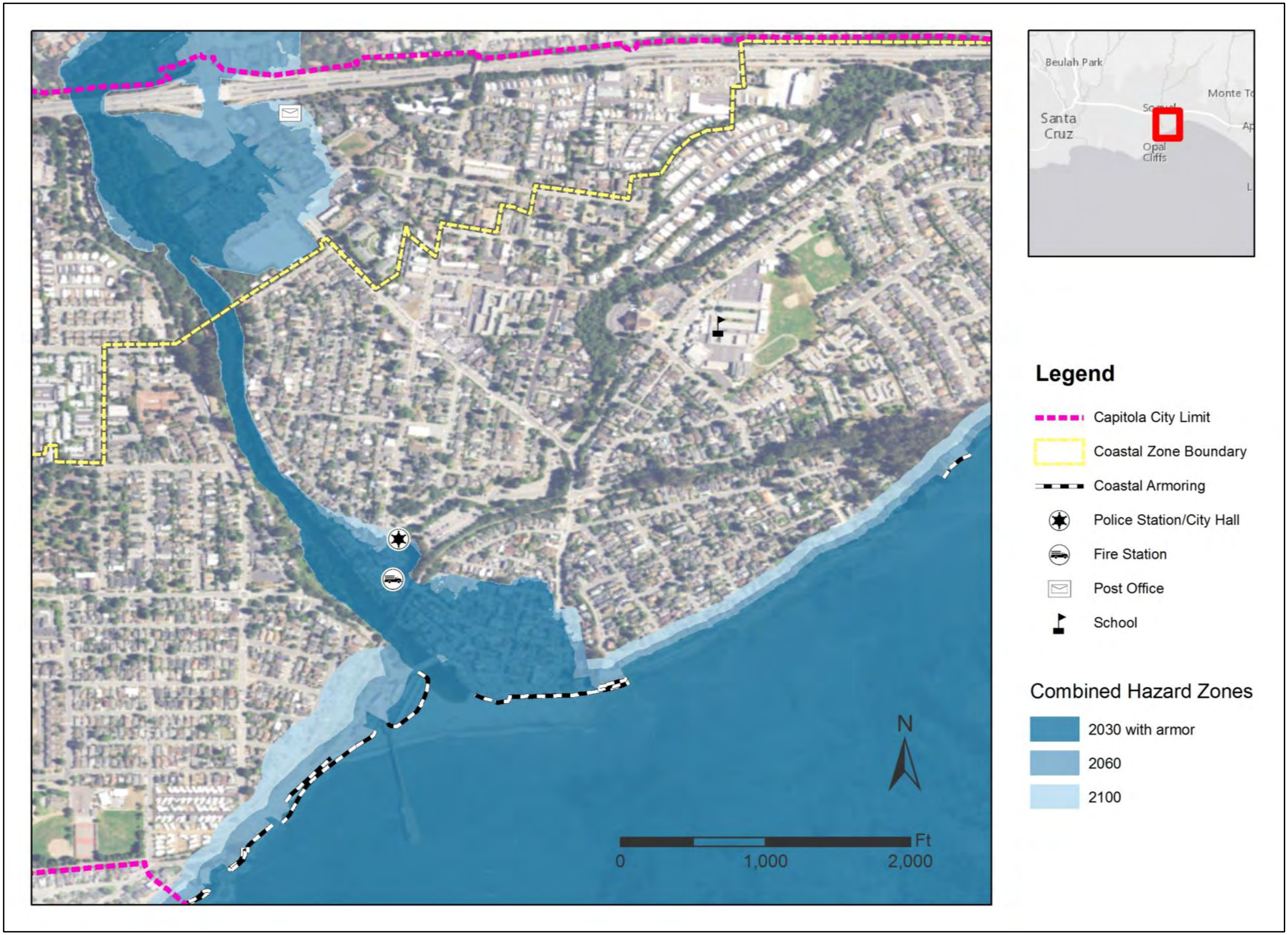


Table 6. Summary of Assets Vulnerable to all Coastal Hazards at 2030, 2060, and 2100

ASSET	UNIT	TOTAL	2030 (WITH ARMOR)	2060 (NO ARMOR)	2100 (NO ARMOR)
Land Use and Buildings					
Total Buildings	Count	3,025	219	295	370
Residential	Count	2,600	68	113	176
Commercial	Count	326	138	166	172
Public	Count	67	7	9	13
Visitor Serving	Count	15	6	7	9
Other	Count	17	0	0	0
Public Facilities	Count	16	0	0	0
Schools	Count	1	0	0	0
Post Offices	Count	1	0	0	1
Emergency Services	Count	2	1	2	2
Transportation					
Roads	Feet	119,994	7,012	13,316	17,138
Rail	Feet	8,503	422	2,076	3,261
Bridges	Count	4	3	3	4
Recreation and Public Access					
Beaches	Acres	5.8	5.8	5.8	5.8
Coastal Access Points	Count	12	11	12	12
Parking Lots	Acres	4	0.7	1.4	1.9
Coastal Trail	Feet	9,543	0	1,705	3,020
Water and Utility Infrastructure					
Storm Drain Structures	Count	667	185	239	244
Storm Drain Conduits	Feet	50,173	8,686	11,864	11,992
Sewer Structures	Count	472	56	83	102
Sewer Conduits	Feet	118,365	13,452	19,819	23,901
Water Mains	Feet	144,206	13,744	19,360	23,339
Natural Resources					
National Wetlands	Acres	16	16	16	16

5. Vulnerability by Individual Coastal Hazard

Estimating the risks from the combined hazards of Coastal Climate Change can help establish areas for modified building guidelines and estimate the cumulative effects on sectors of the social and economic community. Combined hazards, however, do not provide city staff with the necessary information to select appropriate adaptation responses. Therefore, to better link vulnerabilities with adaptation alternatives (Section 7), this project has evaluated the temporal risks of infrastructure for each time horizon and for each coastal hazard process separately.

The risks associated with each of the modeled coastal processes (wave run-up and overtopping, coastal erosion, rising tides and fluvial flooding) threaten various types of coastal infrastructure differently. Wave and fluvial flooding can damage buildings, temporarily restrict use of public amenities, make storm drains and tide gates ineffective and limit the use of roads and walkways. Many of these impacts are temporary and repairs can be made. Cliff erosion and monthly high tide flooding, however, are permanent impacts and may require extensive rebuilding, a change in property use or the abandonment of the property. In Section 7 of this report we investigate possible adaptation strategies for properties at risk from these various hazards.

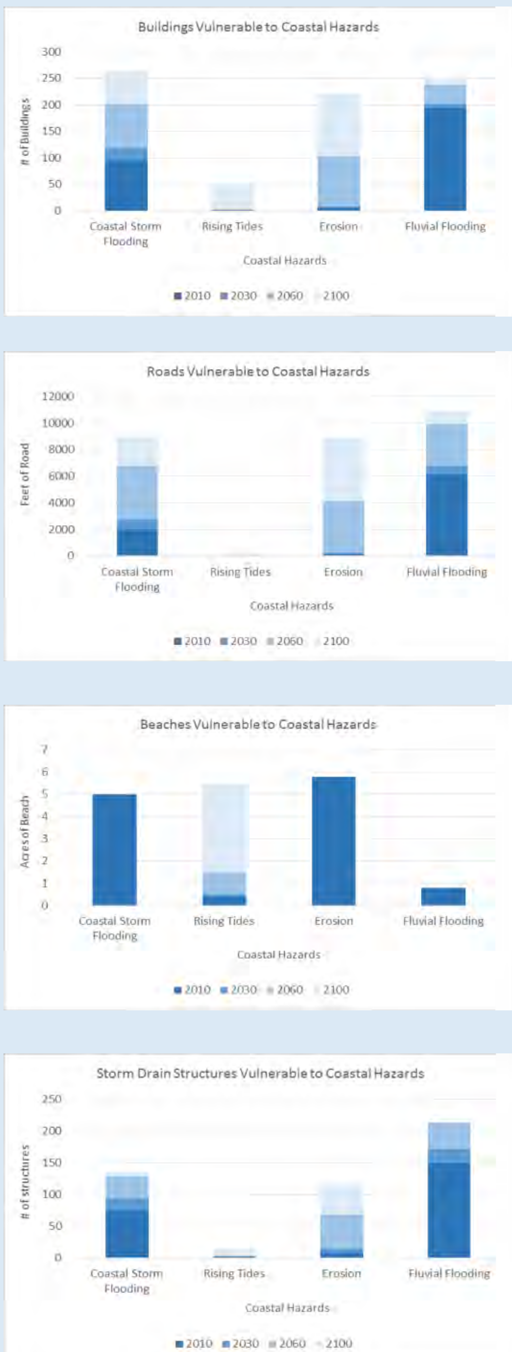


Figure 8. Assets vulnerable to coastal climate change hazards at each time horizon

5.1 Vulnerability to Hazards by Time Horizon

Different hazards threaten different assets more significantly at different times (Figure 8). River and coastal storm flooding hazards threaten the greatest number of buildings up through 2030. Coastal erosion begins to threaten similar numbers of buildings between 2060 and 2100. Storm drains and roads are vulnerable to river flooding as well and erosion threatens more infrastructure by 2060. By 2100, Capitola beach is potentially lost due to frequent tidal flooding.

5.2 Vulnerability to Rising Tides

Flooding from the predicted increases in monthly high tides (due to local sea level rise) poses minimal threat to Capitola until 2100. Table 7 outlines the projected impacts to assets within Capitola from rising tides. Tidal inundation poses unique threats to low lying areas that may be difficult for many types of development to adapt. Specifically, monthly tidal flooding may lead to salt water damage and a reduction in reliability and availability of some properties and infrastructure. Monthly tidal flooding poses long term maintenance issues and the loss of public service reliability.

Land Use and Buildings

Projected inundation from 2060 high tides is limited. By 2100 high tides may become a more serious risk and may impact 23 residential and 23 commercial properties along Soquel Creek. The areas projected to be vulnerable to tidal flooding by 2100 (mainly properties along the creek) may need to be elevated by approximately 20-40cm to be above projected tidal range.

Transportation

Few roads are projected to be at risk from rising tides till 2100. By 2100, one street (Riverview Ave) may be flooded monthly.

Recreation and Public Access

Rising tides may lead to a reduction in beach width and a loss of recreational opportunities. By 2100 the Capitola main beach width is estimated to be reduced by 95% if back shore structures remain in their current location. By 2100 high tides may temporarily impact four of the 12 public access ways.

Water and Utilities

Two storm drains are already under water along the Soquel Creek. The number of storm drains that will be below mean water elevation in the river and ocean may increase to 13 by 2100.

Natural Resources

Higher tides driven by sea level rise may modify hydrology of the Soquel Creek and flood up to 2/3 of existing wetland habitat monthly with salt water by 2100. These wetlands will likely transition towards a brackish water ecosystem.

Figure 9. Buildings Vulnerable to Rising Tides

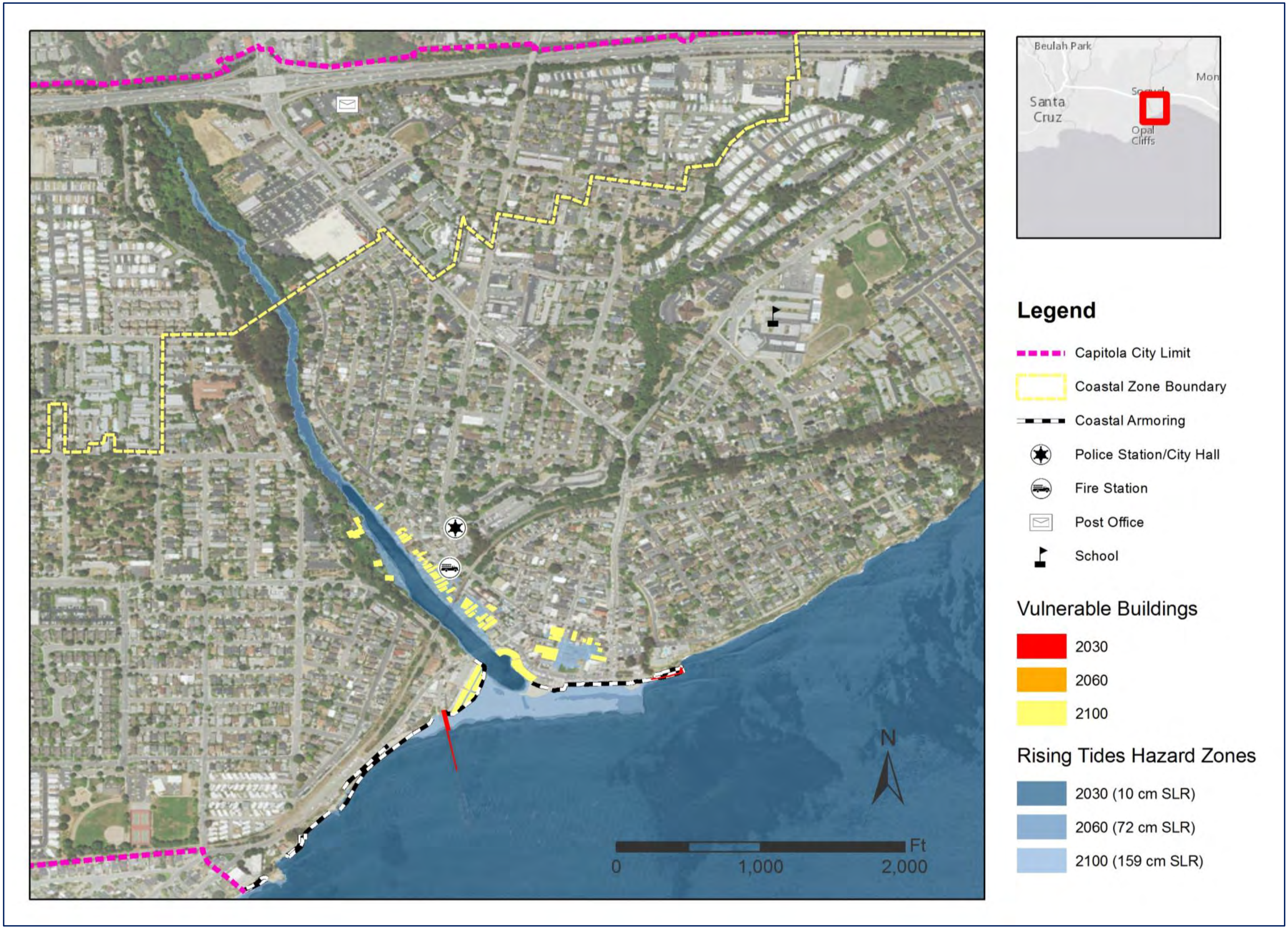


Table 7. Summary of Assets Vulnerable to Impacts by Rising Tides

ASSET	UNIT	TOTAL	2010 (WITH ARMOR)	2030 (WITH ARMOR)	2060 (NO ARMOR)	2100 (NO ARMOR)
Land Use and Buildings						
Total Buildings	Count	3,025	1	1	2	48
Residential	Count	2,600	0	0	1	23
Commercial	Count	326	0	0	0	23
Public	Count	67	1	1	1	1
Visitor Serving	Count	15	0	0	0	1
Other	Count	17	0	0	0	0
Schools	Count	1	0	0	0	0
Post Offices	Count	1	0	0	0	0
Emergency Services	Count	2	0	0	0	0
Transportation						
Roads	Feet	119,994	0	0	0	238
Rail	Feet	8,503	0	0	0	183
Bridges	Count	4	0	0	0	2
Recreation, and Public Access						
Beaches	Acres	5.8	0.4	0.5	1.5	5.5
Coastal Access Points	Count	12	0	0	1	4
Parking Lots	Acres	4.1	0	0	0	0
Coastal Trail	Feet	9,543	0	0	0	0
Water and Utility Infrastructure						
Storm Drain Structures	Count	667	2	2	2	13
Storm Drain Conduits	Feet	50,173	17	21	34	342
Sewer Structures	Count	472	0	0	0	1
Sewer Conduits	Feet	118,365	0	0	0	552
Water Mains	Feet	144,206	0	0	0	564
Natural Resources						
National Wetlands	Acres	16	1.6	1.6	2.1	10.3

5.3 Vulnerability to Coastal Storm Flooding

Coastal flooding due to high winter waves has long been a hazard to Capitola. The ESA hazard models estimated that both wave run-up force and the height of flood water within low lying areas may be greater over time. Infrastructure closest to the beach will continue to be impacted by the force of waves, the deposition of sand, kelp and other flotsam, and by the floodwaters that do not drain between waves. Infrastructure further inland is most vulnerable to flooding by a combination of ocean and riverine sources (Section 5.4). Table 8 outlines the projected impacts to assets within Capitola from coastal storm flooding.

Land Use and Buildings

Infrastructure projected to be at risk from coastal flooding by 2030 is similar to those properties currently vulnerable. In total, 27 residential and 84 commercial buildings may be vulnerable to storm flooding by 2030 (22 more than presently).

Coastal storm flooding may pose risks to 84 additional buildings by 2060 than are projected at risk in 2030, including the Capitola fire station. By 2100, even more structures may be at risk of flooding (48 additional residential and 11 commercial). Before 2060, structures adjacent to the shore may see more frequent and severe wave damage due wave run-up encroachment inland while infrastructure location remains static (Figure 10). However, for the 2060 and 2100 planning horizons projected flood zones may be misleading. For instance, cliff areas where coastal armoring is not replaced by 2060 are assumed to retreat as projected in the erosion hazard models (see Section 5.5). Houses within this erosion zone will be lost prior to this area becoming vulnerable to flooding in 2060.

Tidal inundation and wave run-up in Capitola Jan, 2008 (Photo: Patrick Barnard, USGS Santa Cruz)

Transportation

For the 2030 planning horizon, six local roadways (Esplanade Rd, San Jose Ave, Riverview Ave, Capitola Ave, Monterey Ave, and California Ave) are projected to be at risk of flooding during winter storms, restricting crosstown traffic and totaling more than 2,700 feet. Almost twice as many feet of roadway may be flooded by 2060.

Recreation and Public Access

Most of Capitola beach currently floods and may continue to flood during winter storms. Most coastal access ways may be unavailable during storms. Areas of Esplanade Park and Soquel Creek Park may be impacted by coastal storm flooding as early as 2030.

Water and Utilities

Currently, more than 70 storm drains are projected to be impacted by coastal storm flooding, with an additional 19 storm drains projected by 2030. Additionally, four of the storm drain discharge points along the Esplanade that provide coastal storm flood relief, may be compromised. Significant amounts of subsurface water and wastewater infrastructure is located within the flood zones and may see impacts from periodic flooding.

Natural Resources

Few natural resources are vulnerable to flooding by 2100 other than 6.8 acres of Soquel Creek, most of which is currently vulnerable.

Figure 10. Buildings Vulnerable to Coastal Storm Flooding

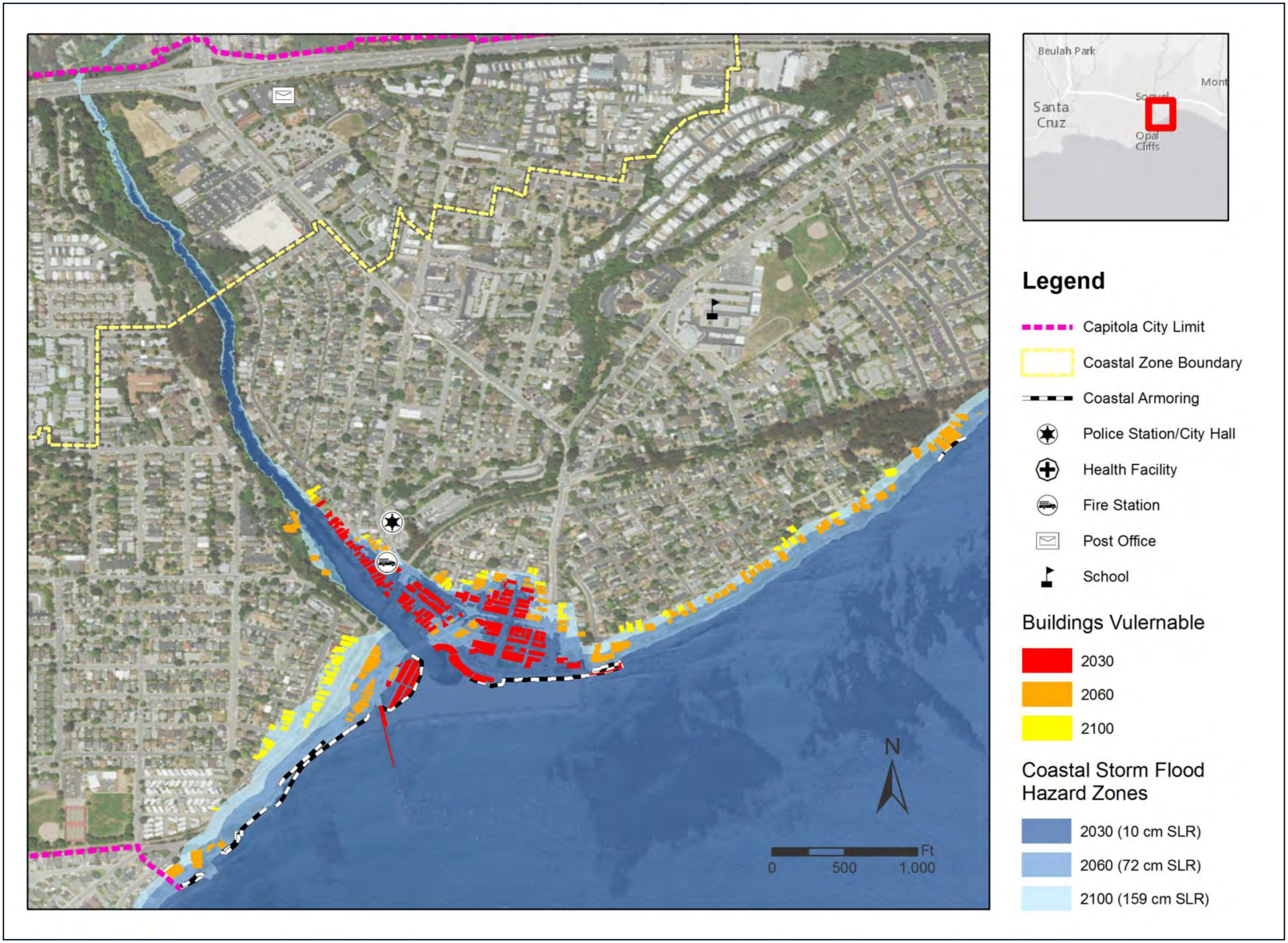


Table 8. Summary of Assets Vulnerable to Coastal Storm Flooding

ASSET	UNIT	TOTAL	2010 (WITH ARMOR)	2030 (WITH ARMOR)	2060 (NO ARMOR)	2100 (NO ARMOR)
Land Use and Buildings						
Total Buildings	Count	3,025	94	118	201	263
Residential	Count	2,600	24	27	66	114
Commercial	Count	326	65	84	122	133
Public	Count	67	4	4	6	7
Visitor Serving	Count	15	1	3	7	9
Other	Count	17	0	0	0	0
Schools	Count	1	0	0	0	0
Libraries	Count	0	0	0	0	0
Post Offices	Count	1	0	0	0	0
Emergency Services	Count	2	0	0	1	1
Transportation						
Roads	Feet	119,994	2,014	2,759	6,772	8,950
Rail	Feet	8,503	229	291	1,107	3,261
Bridges	Count	4	2	2	3	3
Recreation and Public Access						
Beaches	Acres	5.8	5.8	5.8	5.8	5.8
Coastal Access Points	Count	12	10	10	12	12
Parking Lots	Acres	4.1	0.4	0.5	1.3	1.7
Coastal Trail	Feet	9,543	0	0	1,428	1,684
Water and Utility Infrastructure						
Storm Drain Structures	Count	667	74	93	128	135
Storm Drain Conduits	Feet	50,173	2,429	3,125	5,007	5,869
Sewer Structures	Count	472	19	24	51	70
Sewer Conduits	Feet	118,365	4,741	5,916	12,925	16,219
Water Mains	Feet	14,4206	4,127	6,128	9,870	11,238
Culverts	Count	3	0	0	0	0
Natural Resources						
National Wetlands	Acres	16	5.2	5.3	6.3	6.8

5.4 Vulnerability to River Flooding

Storm intensity is predicted to increase within Santa Cruz County through 2100. These more infrequent but intense rain events are predicted to cause rivers and creeks to rise rapidly leading to localized flooding and erosion. This study evaluated the combined threats of higher ocean levels during storm events and higher river discharge caused by excessive localized rain events within the Soquel watershed. This fluvial analysis generated an additional hazard zone for each time horizon that was then used to evaluate structures vulnerable to this river flooding. The projected increase in fluvial discharge within Soquel Creek due to more intense rainfall during storms used for this analysis is outlined in Table 9.[28] River flooding height due to more intense rainfall is estimated to increase by approximately 2 feet (increasing depth to 8.5 feet in parts of downtown) between 2010 and 2060. Table 10 outlines the projected impacts to assets within Capitola from fluvial flooding.

Table 9. Increase in 100-year Discharge for Soquel Creek Relative to Historic Period (1950-2000)

EMISSIONS SCENARIO	2030	2060	2100
Medium (RCP 4.5 5th percentile)	13%	15%	20%
High (RCP 8.5 90th percentile)	62%	68%	95%

Land Use and Buildings

Large areas of Capitola and Soquel are vulnerable to river flooding along Soquel Creek, Capitola Village and the Nob Hill shopping center (Figure 11). Fifty-nine residential properties (along Riverview Dr. and within Capitola Village) are currently projected to be vulnerable to flooding from the combined threat of high river levels during high tide events. In total, 84 more buildings are identified as at risk of river flooding by 2030 than identified within the coastal flooding layer for 2030.

Transportation

Twice the length of roadway is projected to be at risk of flooding from the Soquel River than is projected to be at risk from coastal storm flooding alone. Access to Highway 1 may be compromised due to flooding of on-ramps by 2100.

Recreation and Public Access

River flooding poses a lesser risk to coastal access but may impact parks adjacent to Soquel Creek such as Soquel Creek Park. Peery Park, although adjacent to the Soquel Creek, is at an elevation where it should not be impacted.

[28] ESA. 2016. Monterey Bay Sea Level Rise: Climate Change Impacts to Combined Fluvial and Coastal Hazards.

Water and Utilities

Currently 149 storm drains are projected to be impacted by Soquel Creek flood waters (twice that of coastal flooding) and an additional 22 storm drains may be compromised by the higher ocean and river elevation by 2030. Several drains that currently provide flood relief may be further compromised due to higher river water levels and may become conduits for inland flooding by 2060 to areas isolated from current flooding.

Natural Resources

Wetland and Riparian resources along Soquel Creek are identified within the fluvial hazard layer as early as 2030 but are likely resilient to these hazards.

Capitola Avenue flooded from Noble Gulch Creek on Saturday March 26, 2011 (Photo: Santa Cruz Sentinel)

Figure 11. Buildings Vulnerable to River (Fluvial) Flooding

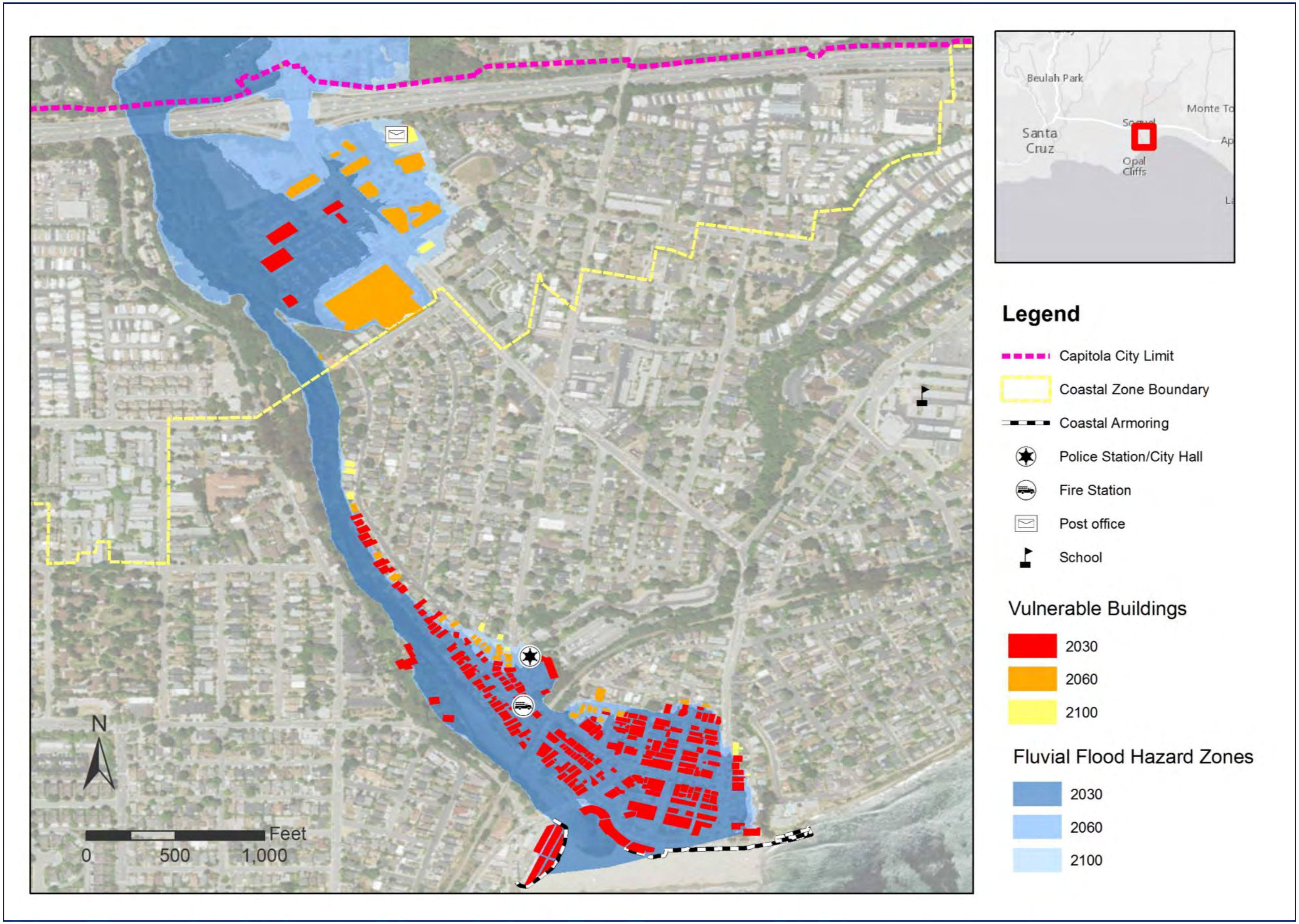


Table 10. Summary of Assets Vulnerable to River (Fluvial) Flooding

ASSET	UNIT	TOTAL	2010	2030	2060	2100
Land Use and Buildings						
Total Buildings	Count	3,025	194	202	238	248
Residential	Count	2,600	59	62	78	82
Commercial	Count	326	130	134	154	160
Public	Count	67	4	4	4	4
Visitor Serving	Count	15	1	2	2	2
Other	Count	17	0	0	0	0
Schools	Count	1	0	0	0	0
Post Offices	Count	1	0	0	0	1
Emergency Services	Count	2	1	2	2	2
Transportation						
Roads	Feet	119,994	6,128	6,783	9,932	10,889
Rail	Feet	8,503	428	431	435	435
Bridges	Count	4	3	3	3	3
Recreation and Public Access						
Beaches	Acres	5.8	0.8	0.8	0.8	0.8
Coastal Access Points	Count	12	2	2	2	2
Parking Lots	Acres	4.1	0.6	0.6	0.7	0.8
Coastal Trail	Feet	9,543	0	0	0	0
Water and Utility Infrastructure						
Storm Drain Structures	Count	667	149	171	213	214
Storm Drain Conduits	Feet	50,173	7,319	8,068	10,685	10,836
Sewer Structures	Count	472	44	45	58	61
Sewer Conduits	Feet	118,365	8,846	9,703	12,301	12,854
Water Mains	Feet	144,206	11,078	11,911	14,539	15,326
Natural Resources						
National Wetlands	Acres	16	7.2	7.2	7.3	7.3

5.5 Vulnerability to Erosion

Capitola is vulnerable to impacts from coastal erosion along the cliff edges west and east of downtown. There are rip-rap and concrete structures in place along the base of portions of these cliffs that have reduced bluff erosion significantly. If these structures are not upgraded or replaced they may continue to decay as climate change stresses add to current intensity of storm damage. Table 11 outlines the assets vulnerable to beach and cliff erosion. Project specific studies however may be needed to better estimate site specific erosion rates.

Photo Source: Timeline of Natural Hazard Events Impacting the City of Capitola, City of Capitola

Land Use and Buildings

Several residential and commercial structures are currently threatened by coastal erosion in areas where seawalls or other structures are not present. Five buildings are at risk of bluff erosion currently and this may increase to 8 properties by 2030. The number of properties vulnerable to erosion may increase significantly (32) by 2060 as new areas not protected by armoring begin to become vulnerable. An additional 100 properties are at risk by 2060 if current coastal armoring is not upgraded or replaced. A total of 98 homes are at risk of being lost by 2100 along Grand Avenue and Cliff Drive if coastal armoring is allowed to deteriorate or is removed. Bluff erosion is also predicted for the base of the Wharf and the Venetian Courts if sea walls are not maintained or rebuilt. As many as 221 properties are within the bluff erosion zone by 2100 if protective structures are not maintained, expanded or replaced.

Although many of these homes are more than 200 feet from the current bluff edge, the models highlight the significant erosion risk to this area in the future if existing coastal armoring fails. If bluff retreat is halted by replacing coastal armoring, however, many beach access ways and most of Capitola beach may be lost (Figure 12) as ocean tides progress inward towards these stationary structures (aka Coastal Squeeze).

Transportation vulnerable to erosion

Lateral road access along the east side of town has already been lost due to cliff erosion. Cliff Drive remains a key western access road into the downtown area and is vulnerable to cliff erosion by 2060 if protective measures are not implemented. Additional transportation infrastructure that is in jeopardy include the public access way along what remains of Grand Avenue and the rail corridor which was recently purchased by the county to provided alternate transportation corridor throughout the county.

Recreation and Public Access

Cliff erosion threatens numerous parks and visitor serving resources within Capitola. Five coastal access points are currently vulnerable to bluff erosion and by 2060 all access ways may be at risk unless coastal protection is updated. Loss of beach area (95% by 2100) is reported within Section 5.4 (Tidal Inundation).

Water and Utilities

A significant number of storm water and wastewater structures are currently vulnerable to erosion, when accounting for coastal protective structures. The number of structures and feet of pipe at risk increase significantly by 2060 if coastal armoring is not maintained or replaced. Sewer and water mains are vulnerable during all time horizons to failure due to coastal erosion.

Natural Resources

Approximately half of the wetland habitat along Soquel Creek is vulnerable to erosion by 2100.

Figure 12. Buildings Vulnerable to Erosion

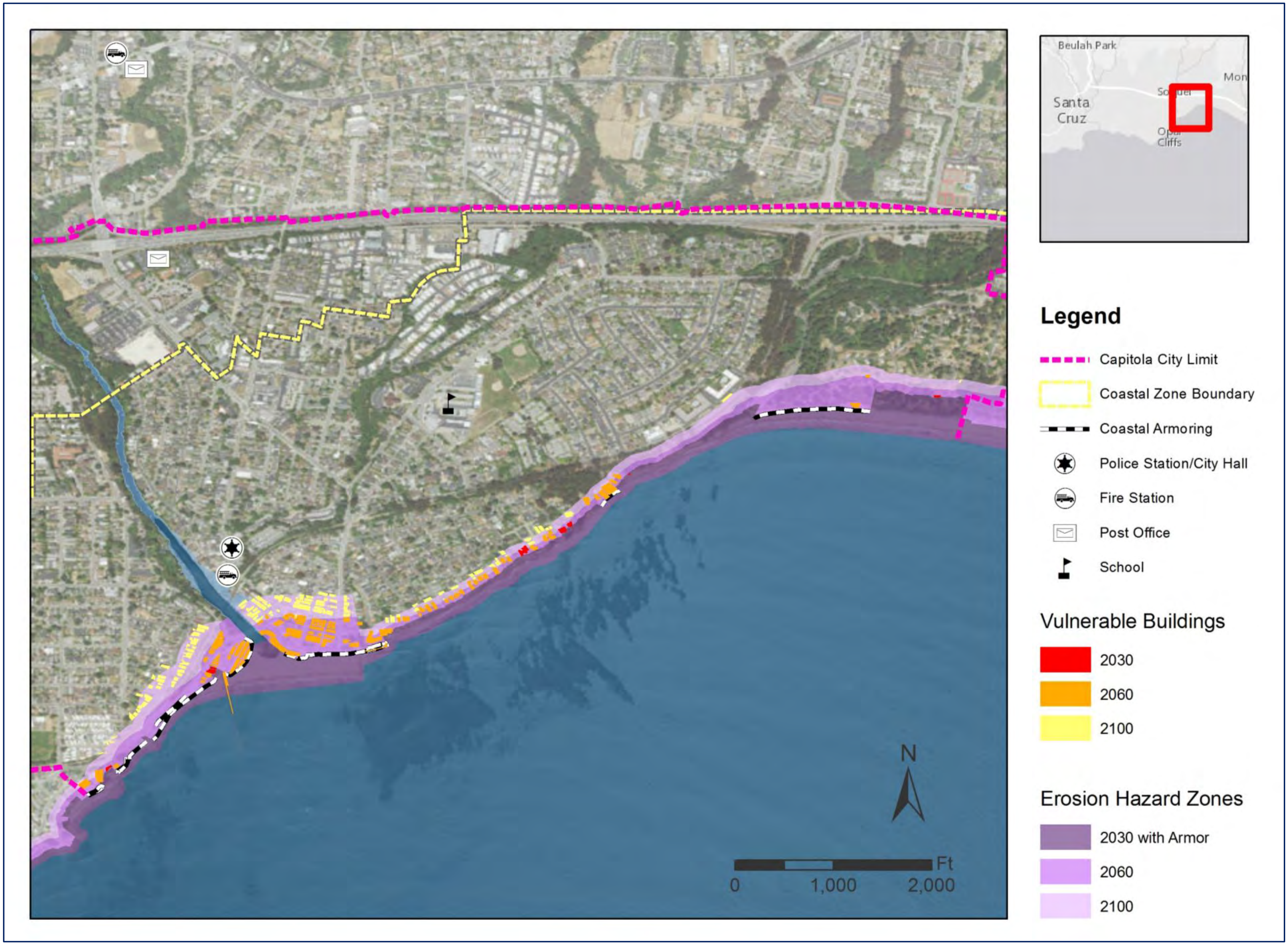


Table 11. Summary of Assets Vulnerable to Erosion

ASSET	UNIT	TOTAL	2010 (WITH ARMOR)	2030 (WITH ARMOR)	2060 (NO ARMOR)	2100 (NO ARMOR)
Land Use and Buildings						
Total Buildings	Count	3,025	5	8	103	221
Residential	Count	2,600	0	3	39	98
Commercial	Count	326	2	2	52	105
Public	Count	67	1	1	6	10
Visitor Serving	Count	15	2	2	6	8
Other	Count	17	0	0	0	0
Schools	Count	1	0	0	0	0
Post Offices	Count	1	0	0	0	0
Emergency Services	Count	2	0	0	0	0
Transportation						
Roads	Feet	119,994	152	247	4,140	8,891
Rail	Feet	8,503	0	0	986	3,142
Bridges	Count	4	0	0	0	1
Recreation and Public Access						
Beaches	Acres	5.8	5.8	5.8	5.8	5.8
Coastal Access Points	Count	12	5	8	12	12
Parking Lots	Acres	4.1	0.1	0.0	1.4	1.9
Coastal Trail	Feet	9,543	3	32	1,550	2,404
Water and Utility Infrastructure						
Storm Drain Structures	Count	667	8	14	68	114
Storm Drain Conduits	Feet	50,173	387	500	2,914	4,568
Sewer Structures	Count	472	3	3	38	63
Sewer Conduits	Feet	118,365	892	950	9,808	17,192
Water Mains	Feet	144,206	756	1,038	6,966	13,898
Natural Resources						
National Wetlands	Acres	15.6	0.9	1.2	8.3	8.3

5.6 Summary of Specific Vulnerable Assets

Venetian Court

The Venetian court hip-wall provides protection from mild winter storms and maintains a sand free walkway adjacent to the beach. Currently the beach and walkway are approximately the same elevation on opposite sides of the wall. As ocean encroachment progresses, the wall will provide a hard backshore resisting the migration of the beach inward but may provide less protection from wave overtopping and wave damage.

Capitola Esplanade

The Esplanade walkway provides a defined boundary between the urban area and the beach. The hip-wall adjacent to the walkway provides a key protective function during winter high wave events, reducing wave impacts and flooding to the Village. The Esplanade includes several public access points that can be blocked off during winter storms. There are discharge holes that provide minimal drainage and several storm drain discharge points seaward of the wall. As wave height and sea levels rise, the hip-wall may provide less and less protection to the commercial district along the Esplanade. Wave run-up energy may be more significant in the future, leading to greater volumes of water overtopping the wall, causing additional flooding downtown. Greater wave heights may possibly lead to greater structural impacts from water and debris. The Esplanade may need to be realigned landward in the future if the community wishes to maintain beach width and storm protection capacity.

Historic Districts

All three of the designated Historic Districts in Capitola are projected to be impacted by coastal climate change hazards. The proximity of the Venetian Historic District to coastal hazards leaves it vulnerable to coastal erosion, coastal storm flooding and wave impacts. The Old Riverview Historic District is adjacent to Soquel Creek making it most vulnerable to river flooding. Six Sisters/Lawn Way Historic District lies within the low-lying areas of Capitola Village and is vulnerable to coastal wave impacts and storm flooding, river flooding, and erosion after 2030 if coastal armoring begins to fail.

River walkway

The river walkway parallels the east side of Soquel Creek from the Stockton St. Bridge inland to the Noble Creek culvert near Riverview and Blue Gum avenues. The walkway provides a valuable public access way along the river and a pedestrian link between the residential area and the coast. Presently there are private patios and yards westward of the walkway. The yards and the walkway are approximately 3 feet above base flow within the creek. During extreme river flow conditions, this area is prone to flooding. In addition, a number of storm drains flow under the walkway and discharge to the creek. Flood water depths along the river walkway are estimated to be as much as 8 feet by 2060.

Parking lots and public access ways

Parking spaces along the Esplanade are already vulnerable to periodic flooding during storm events. By 2030 such flooding may occur more often. Beach and Village Parking Lots number 1 and 2 near City Hall are also vulnerable to river flooding. A number of public access ways are vulnerable to flooding due to higher river levels, wave impacts and coastal erosion. By 2060 use of all 12 public access ways may be periodically restricted due to various coastal climate risks.

Emergency services and city hall

The Capitola fire station is currently at risks of coastal storm flooding and river flooding (FEMA flood maps). City Hall and the police station, which are currently located in the 100-year FEMA flood zone, are vulnerable to river flooding by 2030.

Schools

No schools are at risk.

Storm drains

Capitola already experiences periodic flooding of the downtown during winter storms. During these storms the storm drain system may back up or be overwhelmed when submerged during ocean storms and high river elevations. These submerged discharge pipes may also become a conduit for inland flooding, bypassing coastal protection structures. Field surveys were completed to document the surface elevation of storm drains and drop inlets throughout the village. Storm drain elevations were correlated with tidal water height for each planning horizon to document when these storm drains may act as conduits for inland flooding (Figure 13). By 2060, five storm drain drop boxes located within city streets may be below high tide elevations, posing a monthly flood risk to these areas of the community. Some of these storm drains are inland of the Rising Tides hazard zones, suggesting that storm drains may prove to exacerbate tidal flooding by mid-century.

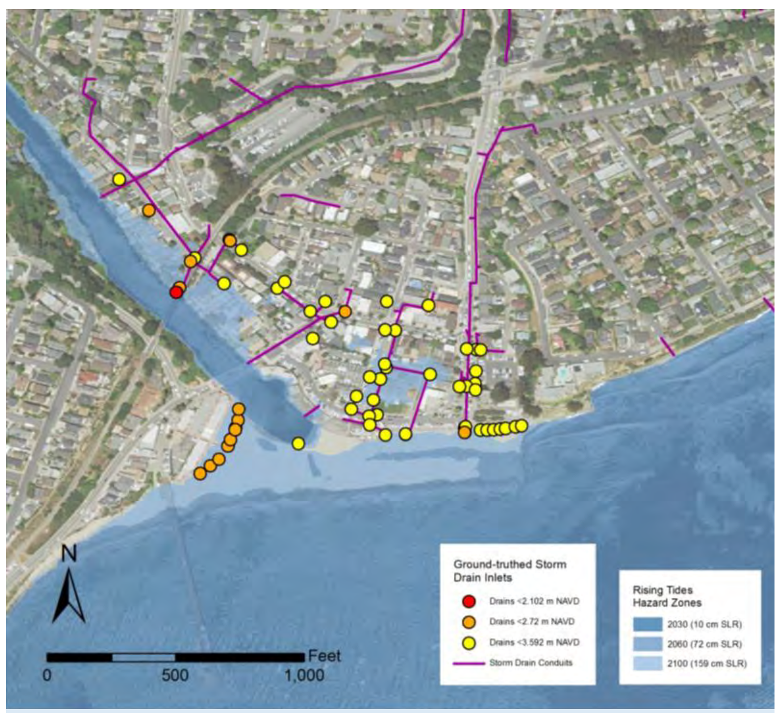


Figure 13. Storm drains with elevations within the projected tidal range for each time horizon

Table 12 further outlines the earliest time horizon that specific assets may become vulnerable to each of the coastal hazards.

Table 12. Important Assets Vulnerable to Coastal Hazard Impacts

FACILITY	TYPE	COASTAL HAZARD IMPACT	IMPACT THRESHOLD
Fire Station	Emergency	Coastal storm flooding River flooding	2060 2030
Police Station	Emergency	River flooding	2030
City Hall/ Emergency Operations	Public	River flooding	2030
Post office	Government	River flooding	2100
Capitola Historical Museum	Public/Visitor Serving and Historic District	River flooding	2030
Capitola Venetian (and Historical District)	Visitor Serving	Coastal storm flooding River flooding Erosion Rising Tides	2010 2010 2060 2100
Capitola Wharf	Public/Visitor Serving	Coastal storm flooding Erosion	2030 2060
Soquel Creek Park	Park	Coastal storm flooding River flooding Rising tides	2010 2030 2100
Esplanade Park	Park	Coastal storm flooding Erosion	2010 2030
Capitola Beach	Beach	Coastal storm flooding Erosion River flooding	2010 2030 2030
Beach access at Esplanade	Coastal Access	Coastal storm flooding Erosion Rising tides River flooding	2010 2030 2060 2030
Cliff Drive beach access	Coastal Access	Erosion	2060
Coastal Trail	Trail	Coastal storm flooding Erosion	2060 2060
Esplanade parking lot	Parking lot	Coastal storm flooding Erosion River flooding	2010 2060 2030
Wharf Rd parking lot	Parking lot	Coastal storm flooding Erosion	2030 2060

FACILITY	TYPE	COASTAL HAZARD IMPACT	IMPACT THRESHOLD
Cliff Drive parking	Parking lot	Erosion	2060
Prospect Avenue parking	Parking lot	Erosion	2100
City Hall parking lot	Parking lot	River flooding	2030
Esplanade Road	Road	Coastal storm flooding Erosion River flooding	2010 2060 2030
Cliff Drive	Road	Erosion	2060
Wharf Avenue	Road	Coastal storm flooding	2030
Grand Avenue	Road	Erosion	2030
Prospect Drive	Road	Erosion	2100
Stockton Bridge	Bridge	Erosion	2060
Soquel Creek	Creek/Wetland	Coastal storm flooding Rising Tides	2010 2030
Six Sisters/Lawn Way Historic District	Historic District	Coastal storm flooding Erosion River flooding Rising Tides	2010 2060 2030 2100
Old Riverview Historic District	Historic District	Coastal storm flooding Erosion River flooding Rising Tides	2010 2060 2010 2100

CUMULATIVE RISKS TO CAPITOLA FROM COASTAL CLIMATE CHANGE

This study suggests that by 2030 flooding during winter storms may increase in intensity as ocean wave run-up energy and increases in river discharge act together. Coastal erosion currently threatens five unprotected structures in Capitola including two commercial properties (Figure 12). By 2030 eight structures may be at risk including two residential properties if current coastal protection structures remain in place but no new structures are constructed. A significant number of storm, water and wastewater structures and many feet of pipe are vulnerable from coastal erosion during all time horizons. Cliff Drive remains a key western access road into the downtown area and is vulnerable to cliff erosion by 2060 if protective measures are not replaced. A table of key facilities at risk of various hazards and time horizons (Table 12) is intended to aid adaptation planning. This study confirms that coastal flooding may remain a primary risk for Capitola. This study also finds that river flooding may be of greater risk to the community than previously realized and that sea level rise may greatly impact the beach and public areas by 2100 unless retreat policies are adopted.

6. Economics of Future Climate Risks

The costs to repair damage caused by wave impacts and flooding can be quite large. For example, the Capitola Public Works Director estimated that approximately $500,000 worth of damage to city property, and several million dollars' worth of damage to the city-owned Pacific Cove Mobile Park occurred as a result of the 2011 flood event in Capitola Village.

The protection of structures and properties within the coastal and fluvial flood hazard zones is a high priority for the community. Understanding the cumulative value of the properties and infrastructure that are vulnerable to the identified hazards may aid the selection of protection and adaptation strategies, and help to direct limited public and private resources towards the most pragmatic and effective actions. Longevity of various protection and adaptation strategies, the costs to construct and the future reliability of coastal infrastructure should all be weighed before response strategies are selected.

Property valuation of vulnerable properties and infrastructure

Some studies (Santa Cruz County Hazard Mitigation Plan[29] and Coastal Regional Sediment Management Plan for the Santa Cruz Littoral Cell[30]) have estimated future property loss separately for building values and land values. This technique allows impacts to be calculated separately for structural impacts (due to coastal and river flooding) and property loss (due to coastal erosion and sea level rise). Unfortunately, the property value estimates used within these studies are linked to County assessor data which are often much lower than current appraised value and thus underrepresent real economic risks.

A simple economic estimation of costs of the projected climate hazards was completed to provide rough estimates of property loss for each time horizon. The average property value for residential and commercial properties within Capitola were estimated (Table 13) and used to quantify the cumulative economic impact of replacing or relocating these buildings and services. The Capitola Hazard Mitigation Plan identified costs to replace or move critical municipal infrastructure found to be at risk of various natural hazards (not including price of property to relocate).

[29] County of Santa Cruz. 2015. Santa Cruz County Local Hazard Mitigation Report

[30] United States Army Corps. 2015. Coastal Regional Sediment Management Plan for the Santa Cruz Littoral Cell, Pillar Point to Moss Landing. Prepared for The California Coastal Sediment Management Workgroup.

Table 13. Property valuation data sources for economic analysis

ASSET	VALUATION	SOURCE
Residential properties	$930,000	Capitola average sale price[31]
	$2,100,000	Capitola beach front sale price[32]
	$662,631	US Census[33]
	$809,860	Santa Cruz Littoral Cell report[34]
	$1,400,000	Pacific Institute Report 2009[35]
	$987,727	SCC-LHMP fire residential[36]
	$958,043	**Average of studies**
Commercial properties	$145,005	SCC-LHMP fire commercial
	$2,600,000	Average LoopNet Listings[37]
Public	$4,000,000	Capitola Local Hazard Mitigation Plan[38]
Emergency Services	$1,500,000	Capitola Local Hazard Mitigation Plan
Roads /ft	$280	TNC 2016[39]
Rail /ft	$237	SJVR Business Plan[40]
Storm Drain conduit /ft	$1,080	TNC 2016
Waste Water conduit /ft	$1,080	TNC 2016
Drinking Water conduit /ft	$189	TNC 2016

[31] Zillow. Capitola. http://www.zillow.com/capitola-ca/ (Dec 2016)

[32] Ibid.

[33] United States Census Bureau. Capitola Quick Facts. http://www.census.gov/quickfacts/table/PST045215/0611040 (Dec 2016)

[34] United States Army Corps. 2015. Coastal Regional Sediment Management Plan for the Santa Cruz Littoral Cell, Pillar Point to Moss Landing.

[35] Heberger M, H Cooley, P Herrera, PH Gleick, E Moore. 2009. The Impacts of Sea-Level Rise on the California Coast. Prepared by the Pacific Institute for the California Climate Change Center.

[36] County of Santa Cruz. 2015. Santa Cruz County Local Hazard Mitigation Report

[37] LoopNet. Capitola. http://www.loopnet.com/for-sale/capitola-ca/?e=u (Dec 2016)

[38] City of Capitola. 2014. Capitola Local Hazard Mitigation Plan

[39] Leo, K.L., S.G. Newkirk, W.N. Heady, B. Cohen, J. Calil, P. King, A. McGregor, F. DePaolis, R. Vaughn, J. Giliam, B. Battalio, E. Vanderbroek, J. Jackson, D. Revell. 2017. Economic Impacts of Climate Adaptation Strategies for Southern Monterey Bay. Technical Report prepared for the California State Coastal Conservancy by The Nature Conservancy. SCC Climate Ready Grant #13-107.

[40] Railroad Industries Incorporated. 2011. Business Plan for Operations of the SJVR in Fresno County. Prepared for Fresno Council of Governments

Currently $211 million in property and infrastructure are vulnerable to the combined hazards of coastal climate change within the City of Capitola (Table 14). By 2030, the total value increases to $227 million in property and infrastructure. By 2030 $62 million (26% of potential losses) in residential properties are at risk. Almost $130 million in commercial properties (57% of potential losses) are vulnerable to 2030 hazards. Approximately $35 million in public properties and infrastructure are within the hazard zone for 2030. Waste water and storm drain conduit are the infrastructure at greatest risk of projected hazards within the City.

Table 14. Total Value (2016 dollars) of Capitola Properties at Risk

ASSET	VALUE PER UNIT	2010 (WITH ARMOR)	2030 (WITH ARMOR)	2060 (NO ARMOR)	2100 (NO ARMOR)
PROPERTIES					
Residential	$930,000	$56,730,000	$62,310,000	$104,160,000	$162,750,000
Commercial	$930,000	$124,620,000	$128,340,000	$154,380,000	$159,960,000
Public	$500,000	$4,500,000	$7,500,000	$12,500,000	$17,500,000
Emergency Services	$2,000,000	$0	$2,000,000	$4,000,000	$4,000,000
Property losses		*$185,850,000*	*$200,150,000*	*$275,040,000*	*$344,210,000*
TRANSPORTATION					
Roads (ft)	$280	$1,812,440	$1,963,360	$3,728,480	$4,798,640
Rail (ft)	$280	$118,160	$118,160	$581,280	$913,080
Transportation losses		*$1,930,600*	*$2,081,520*	*$4,309,760*	*$5,711,720*
WATER AND UTILITY INFRASTRUCTURE					
Storm Drain conduit (ft)	$1,080	$8,678,466	$9,376,932	$12,807,727	$12,945,909
Waste Water conduit (ft)	$1,080	$12,872,500	$12,872,500	$21,839,205	$28,457,898
Drinking Water conduit (ft)	$189	$2,603,030	$2,603,030	$3,666,667	$4,420,265
Utility Losses		*$24,153,996*	*$24,852,462*	*$38,313,598*	*$45,824,072*
TOTAL COMBINED LOSSES		**$211,934,596**	**$227,083,982**	**$317,663,358**	**$395,745,792**

Property values within the 2060 coastal climate hazard zone increase to $317 million unless current coastal armoring is replaced and new structures are constructed to protect infrastructure vulnerable to 2060 hazards. If almost one mile of coastal armoring within the city is upgraded or replaced before 2060 (at an estimated cost of $20-52 million to construct), the total value of properties at risk is reduced by relatively small $56 million. The total value of private residential properties at risk increases to $162 million (41% of all assets at risk) by 2100.

Many of the properties identified during each time horizon are vulnerable to multiple hazards (i.e. erosion and coastal flooding). Depending on the engineering complexity and costs of replacing these coastal protection structures, and the secondary environmental and economic impacts of such construction, protecting all of the identified properties is likely cost prohibitive.

This initial economic evaluation highlights the need for constructive discussions between city decision makers, public citizens and private property owners to establish protection and adaptation policies that fairly allocate costs of protection and adaption efforts and that weigh public and private property concerns equitably.

A more comprehensive economic analysis that accounts for relative scale of property damage for each projected hazard (i.e. temporarily flooded or total loss of property) is possible with the current data but is beyond the scope of this study. Using the compiled hazard and vulnerability data generated by this project, coastal armor construction costs and the secondary environmental and economic impacts resulting from constructed structures can be compared with costs to move structures and losses resulting from abandoning vulnerable structures. Together these data can be used to generate temporal cost/benefit/consequence scenarios for each section of coastline and each time horizon.

7. Adaptation

The risks associated with each of the modeled coastal processes (wave run-up and overtopping, coastal erosion, rising tides and fluvial flooding) threaten various types of coastal infrastructure differently. Selection of adaptation options must be driven by consideration of the possible damage of each risk and the frequency of reoccurring impact. Unfortunately, the models used for this report estimate the likelihood of each hazard for each of three time horizons, but do not report the likely frequency.

Wave and fluvial flooding can damage buildings, and temporarily restrict use of public amenities, make storm drains ineffective and limit the use of roads and walkways. Storm flood risks represent periodic impacts and require periodic responses.

Cliff erosion and flooding during high tides are permanent or reoccurring impacts that can lead to a complete loss of infrastructure and use of those properties. Such hazards require extensive rebuilding or reinforcement, a change in use of the property, or abandonment of the property entirely.

Future investments in the protection of public and private structures need to be weighed by city staff and property owners against the property's value, construction costs of selected adaptive measures, limitations provided by regulatory agencies, and the expected effectiveness and longevity of the adaptation strategy selected. Secondary implications of adaptation options should also be considered, including restrictions to coastal access, loss of beach and the visual degradation of the coastline. This adaptation analysis highlights the need for long-range coastal management planning to best balance property values and adaptation measures costs with the resulting changes to the public beach and coastline.

7.1 Current Strategies Used by the City of Capitola

Capitola currently relies on various storm protection strategies to reduce winter storm flooding. These include building sand berms on the beach to reduce wave impacts (Figure 14), placement of flashboards at access points in the Esplanade hip-wall, sandbags within door and access ways, opening Soquel Creek to the ocean and ensuring that storm drains have been services and are functioning properly. Capitola has also installed 1.2 miles of sea walls along the coastline to reduce cliff erosion and flooding during winter storms. Residents and businesses in Capitola prepare for impacts by boarding doors and windows and placing sand bags.

Figure 14. Berms built at Capitola Beach help to decrease coastal flooding of the Village (Photo: R. Clark)

During storms, City staff provides response services including visual monitoring of creeks and storm drain inlets throughout the city and manned response with equipment including pumps and generators as needed to address localized flooding. Once storms have ended, cleanup of sand and debris and repair of damaged infrastructure begins. Response and municipal repair costs for the 2014-2015 El Niño winter totaled an estimated $20,000 to date with another $130,000 pending.

Costs of storm response for the 2016-2017 winter La Niña are not tallied as of completion of this report but are expected to be significantly higher. Early estimates for 2017 road repairs for Santa Cruz County exceed $30 million.

Strategies listed within existing Capitola Plans

General Plan

On June 26 2014, the Capitola City Council adopted the General Plan Update to replace the City's previous 1989 General Plan. The General Plan Update provides new goals and policies to promote sustainability, improve protections of residential neighborhoods and historic resources, and enhance economic vitality.[41] Among the Guiding Principles described within the General Plan for Environmental Resources is to:

> *"Embrace environmental sustainability as a foundation for Capitola's way of life. Protect and enhance all natural resources—including the beaches, creeks, ocean, and lagoon—that contribute to Capitola's unique identify and scenic beauty. Reduce greenhouse gas emissions and prepare for the effects of global climate change, including increased flooding and coastal erosion caused by sea-level rise."*

Hazard Mitigation Plan

The 2014 Capitola Local Hazard Mitigation Plan[42] evaluates risks from river and coastal flooding and makes programmatic and project related recommendations to address these risks. A number of those recommended actions will directly address the risks identified within this report (Table 15).

[41] City of Capitola. 2014. Capitola General Plan.

[42] RBF and Dewberry. 2013. Capitola Local Hazard Mitigation Plan

Table 15. City of Capitola Local Hazard Mitigation Plan Recommendations

ACTIONS WITHIN HAZARD MITIGATION PLAN THAT ADDRESS PREDICTED CLIMATE RISKS
▪ Evaluate the likelihood of debris flow impacts to the Stockton Avenue bridge during a catastrophic flooding event. ▪ Relocate or elevate critical facilities (e.g. City hall, police, fire, etc.) above the level of the 100-year flood elevation. ▪ Assist in the planning and/or improvement of infrastructure (sewers) and facilities to help minimize flooding impacts, particularly in critical flood-prone areas (e.g. Capitola Village). ▪ Continually monitor and review FEMA's National Flood Insurance Program (NFIP) requirements to ensure the City's floodplain management regulations are in compliance. ▪ Review and update the city's existing ordinances as they relate to storm / flooding hazards, consistent with the risks identified in this LHMP. ▪ Work in close coordination with state and local agencies and organizations to protect and preserve the coastline and its coastal bluffs through restoration efforts to help ensure safe coastal access and the protection of adjacent infrastructure and facilities. These efforts may include beach replenishment, coastal bluff protection, seawall construction, and other appropriate measures. ▪ Support the timely and accurate update of tsunami inundation maps within the Monterey Bay area. Then integrate the new tsunami inundation maps into the risk assessment of this Local Hazard Mitigation Plan ▪ Continue to update and enhance mapping data and the City's GIS for all hazards *(including coastal climate change).* ▪ Integrate the results of the Monterey Bay Sea Level Rise Study (this report) into the Local Hazard Mitigation Plan risk assessment and the General Plan Safety Element. ▪ As part of the General Plan Update process, develop a plan to address climate change/ climate adaptation issues within the City and its surroundings. ▪ Protect and preserve the coastline through permit review and continue to review coastal development for conformance with applicable City regulations (e.g. geologic, flood). ▪ Review and update the city's existing ordinances as they relate to hazards and risks identified in this LHMP

7.2 Future Adaptation Options and Strategies

Numerous reports have compiled lists of sea level rise adaptation options and described their use in addressing different climate risks.[43] Information on the costs to implement these strategies is limited but examples of most strategies exist. Local public works departments are best able to estimate the true costs of various construction projects and municipal planners, NGOs and consultants continue to evaluate the feasibility and efficacy of planning and regulatory options. Table 16 provides an overview of which adaptation strategies may be appropriate for each coastal climate change hazard. A special investigation of the role that natural habitats may play in reducing the vulnerabilities identified within this report was completed by Center for Ocean Solutions[44] (Appendix A). Policy options are also discussed within the report.

7.3 Potential Strategies for Capitola Climate Adaptation

2017-2030 Adaptation Options

Adopt policies to limit municipal capital improvements that would be at risk (Building Codes and Resilient Designs)

Prudent adaptive management to climate change begins with not placing new municipal infrastructure at risk to known future hazards. City policies that establish review processes for proposed Capital Improvement Projects located within future hazard zones have been adopted by the City of San Francisco.[45] These guidelines help staff to review proposed infrastructure projects and ensure that those projects will not become vulnerable to projected climate risks within the projects expected lifespan.

Improve resiliency to flooding along the Creek and Coast (Flood Wall and Elevate)

This risk assessment suggests that flooding of the downtown area will continue to be a primary hazard. Continued focus on emergency response and improved building guidelines (increase free board and first floor parking) can help reduce temporary impacts of flooding. A temporary or permanent flood wall along the Soquel Creek walking path may help to reduce flooding within high risk areas.

Investigate natural habitat buffering to reduce coastal flooding (beach and kelp management)

The Center for Ocean Solutions investigated the protective role that coastal habitats (Kelp, surf grass, wetlands, dunes) may play to reduce projected hazards.[46] Figure 15 shows locations of these habitats. For Capitola, the report finds that "the small beach and lagoon system at the mouth of Soquel Creek plays a relatively moderate role in reducing exposure to erosion and inundation." The report similarly

[43] Grannis, J. 2011. Adaptation Tool Kit: Sea Level Rise and Coastal Land Use

[44] Center for Ocean Solutions. 2016. Coastal Adaptation Policy Assessment: Monterey Bay

[45] City and County of San Francisco Sea Level Rise Committee. Guidance for Incorporating Sea Level Rise into Capital Planning in San Francisco: Assessing Vulnerability and risk to Support Adaptation. Prepared for the San Francisco Capital Planning Committee. Adopted by Capital Planning Committee December 14, 2015.

[46] Center for Ocean Solutions. 2016. Coastal Adaptation Policy Assessment: Monterey Bay

finds that "the proximity of Capitola's commercial development to the coast limits the city's options for nature-based adaptation strategies." Maintaining Capitola's beach and kelp forests, however, will likely provide some reduction in wave impacts.

Figure 15. Distribution of natural habitats that may play protective role in Capitola.
(Figure source: COS, 2016)

Storm drain upgrades (tidal (flap) gate and pumps)

Storm drains are currently vulnerable to high water during winter storms and these systems may be compromised further as water levels rise at discharge points along the coast and creek. Greater flood water volumes projected in the downtown by 2030 may further strain the effectiveness of the storm drain system. Coastal flood hazard models suggest that 93 storm drain structures may be compromised by high water levels by 2030 (Table 8, page 29). These submerged discharge pipes may become a conduit for inland flooding, possibly bypassing coastal protection structures. To address this issue, storm drain upgrades including gates and check valves should be investigated and additional pumping of storm water within vulnerable storm drains may be needed by 2030. The Capitola Hazard mitigation plan similarly identifies several structures (Noble Gulch Storm Pipe (already repaired), Capitola Pump Station and Soquel Pump Station (both wastewater facilities), and Lawn Way Storm Drain Pump Station) within the FEMA flood zone that may need to be upgraded.

STATE GUIDANCE

The Coastal Act allows for protection of certain existing structures. However, armoring can pose significant impacts to coastal resources.

To minimize impacts, innovative, cutting-edge solutions will be needed, such as the use of living shorelines to protect existing infrastructure, restrictions on redevelopment of properties in hazardous areas, managed retreat, partnerships with land trust organizations to convert at risk areas to open space, or transfer of development rights programs. Strategies tailored to the specific needs of each community should be evaluated for resulting impacts to coastal resources, and should be developed through a public process, in close consultation with the Coastal Commission and in line with the Coastal Act

Coastal Commission support of Cities that update their Local Coastal Plans to include the adaptation measures prioritized by the community can aid successful implementation of a community's adaptation strategy

Living shorelines provide an alternative to bulkheads and seawalls, while also providing critical habitat. (Photo: Tracey Skrabal)

Table 16. List of Adaptation Strategies (short= 0-5 years, med= 5-30 years, long= 30+ years)

TYPE	DURATION OF PROTECTION	RIVER FLOODING	COASTAL STORM FLOODING	EROSION	WAVE IMPACTS	RISING TIDES
Hard						
Levee	medium	●	●			●
Seawall or Revetment	medium		●	●	●	
Tidal Gate	medium		●			●
Flood wall	medium	●	●			●
Groin	medium		●	●	●	
Soft						
Wetland shoreline	medium		●		●	
Dune restoration	medium		●	●	●	●
Beach Nourishment	short		●		●	
Offshore structure	medium		●		●	
Accommodate						
Elevate	medium	●	●			
Managed Retreat						
Retreat	long	●	●	●	●	●
Rolling easement	long	●	●	●	●	●
Strict land use re-zone	long	●	●	●	●	●
Regulatory Tools						
Stricter Zoning	long	●	●	●	●	●
Floodplain Regulations	long	●	●		●	●
Building Codes and Resilient Designs	long	●	●		●	●
Setbacks/Buffers	long	●	●	●	●	●
Rebuilding Restrictions	long	●	●	●	●	●
Planning Tools						
Comprehensive Plan	long	●	●	●	●	●

Rebuild current beach groins

Capitola currently has two groins located on the east end of the main beach. These structures were designed and constructed in response to changes in sediment supply that occurred after the construction of Santa Cruz harbor breakwater. The two groins were constructed in the 1960's to capture sediment being transported east and to build the width of Capitola beach. The groins have since deteriorated, reducing their height and sediment capture efficiency. Rebuilding or upgrading these structures may be a cost-effective adaptation response to mitigate short term beach loss. Long term (2060-2100) capacity of these structures to retain beach width may be reduced as ocean elevations rise.

Using groins to capture sand may lead to accelerated cliff erosion along Grand Avenue. The 2016 TNC report[47] found that the combination of groin construction and beach nourishment was a cost effective medium duration adaptation measure that helped reduce the loss of public beaches and natural habitats for an estimated twenty years (periodic sand replenishment would be required). Although this analysis was done in Monterey County, it provides useful information that may be transferable to Capitola.

Investigate beach nourishment in concert with groins

Small to medium scale opportunistic beach nourishment has been found to be a cost effective, although temporary, adaptation measure when material is available.[48] Such materials are routinely diverted from the Santa Cruz harbor down current towards Capitola (providing beach sands for the Pleasure Point area). Other sources may include excess accumulation in local rivers that compromise flood management. Sediments from dam maintenance projects may also be obtained. Off shore sand has also been examined by the 2016 TNC report and may be cost effective but may also initiate more complex regulatory processes. Groins are recommended to extend sand retention time and upgrades to existing groins should be considered in Capitola to support any beach nourishment project.

Large sand placement projects were estimated to cost approximately $3,300,000 per linear km and opportunistic nourishment was estimated at $400,000 per linear km but must be repeated more often.[49] An example opportunistic sand placement project occurred along Del Monte Beach in Monterey where approximately 8000 cubic meters of sand was placed on the beach between 2012 and 2013. Sand helped protect inland structures but, because no groins were present to limit sand movement, much of the sand was redistributed during 2015 winter storms.[50]

Prioritize coastal protection structures for upgrade and replacement (seawall and revetment)

The most common community response to cliff erosion that threatens private and public property and infrastructure is to construct or upgrade coastal armoring structures. The costs to replace or construct new coastal armoring however, is high. Recent estimates for constructing new seawalls that withstand

---

[47] Leo et al. 2017. Economic Impacts of Climate Adaptation Strategies for Southern Monterey Bay.

[48] Ibid.

[49] Ibid.

[50] The Watershed Institute, California State University Monterey Bay. A Small-Scale Beach Nourishment Project in Monterey. California. Publication No. WI-2015-05. 25pp.

periodic wave impacts are estimated at up to $52 million per mile.[51] Therefore, completion of a coastal bluff and beach management plan for Capitola that outlines short and long term coastal bluff management strategies will help to establish local protection and adaptation priorities.

The secondary environmental and economic impacts that result from the construction of sea walls are significant. The 2016 TNC report found that coastal armoring was less expensive than beach nourishment and groin construction (although Capitola already has groins in place that may lower costs) and effectively reduced municipal and private property losses. Economic and community impacts from the loss of beach area, however, were estimated to be twice the value of the properties those structures were intended to protect. Therefore, the future allocation of public funds to protect current infrastructure should to be prioritized and weighed against the longevity and feasibility of the proposed protective structures.

Depending on cost, construction feasibility and legality of replacing current protective structures, it may be decided that some of the sea walls may be replaced or upgraded while other development may need to adapt to the projected hazards or be lost. Both the construction costs as well as the secondary implications of such armoring on coastal resources (access, beach width, view) may likely be significant.

Consider resiliency improvements to protect coastal access ways

The City may consider additional resiliency improvements and/or new protective structures to maintain critical vehicular and coastal access ways (including Cliff Drive and the Wharf. note: the City is currently evaluating resiliency improvements for the wharf).

2030-2060 Adaptation Options

Protection of all properties and infrastructure identified at risk during each time horizon is likely infeasible. Therefore, Capitola will need to establish adaptation strategies that best meet local long-term goals. Coastal municipalities will need to set adaptation policies that weigh public cost considerations, longevity of adopted strategies and resultant changes to the community. Establishing equitable managed retreat policies for coastal properties years before they are implemented will benefit successful long-term implementation of these policies and help to ensure the sustainability of the community. Selecting time horizons and climate conditions for which next phase adaptation strategies are triggered will allow the community to anticipate and prepare for future actions.

Identify priority areas for future protection accounting for costs, structural feasibility and secondary implications. (flood wall, seawall or revetment)

This study assumes that the 1.2 miles of coastal protection infrastructure will need to be replaced, upgraded or removed sometime after 2030. Decisions regarding which structures to rebuild in their current location and which structures to remove or relocate (managed retreat) will need to be made.

---

[51] ESA-PWA. 2012. Evaluation of Erosion Mitigation Alternatives for Southern Monterey Bay. Report prepared for the Monterey Bay Sanctuary Foundation and the Southern Monterey Bay Coastal Erosion Working Group. http://montereybay.noaa.gov/research/techreports/tresapwa2012.html.

Secondary impacts of coastal protection should be considered including loss of public access, beach area, economic valuation of the beach and impacts to community identity.

Between 2060 and 2100, Capitola is at risk of losing much (95%) of its public beach if all current coastal protection structures are rebuilt in their current location. Additionally, some structures (Venetian Court and Esplanade hip walls) would need to be raised significantly to protect structures from future projected wave impacts. The raising of these walls would likely compromise public and private valuation of the coastline significantly, making such actions undesirable and contrary to Capitola community values.

TNC ECONOMIC ANALYSIS REPORT 2016

The 2016 TNC report suggests that net benefits of non-armoring approaches are consistently greater than armoring approaches for almost all near-term scenarios. Future funding should be sought to further investigate the cost benefit relationships of various adaptation strategies and the legal and financial strategies necessary to offset municipal and private losses with public benefits.

Identify priority areas for managed retreat to retain sufficient beach area for recreational use (Stricter Zoning, Floodplain regulation, Rolling Easements, Retreat)

Further site-specific modeling is needed to identify which areas can be protected from the combined forces of sea level rise and increased storm intensity. Between 2060 and 2100, some properties may be too difficult or expensive to protect in place and therefore a change in use may be necessary. Such policy decisions should be made early enough for property owners to accommodate these changes. Coordination with State and federal agencies can help municipalities implement these policies and ensure that programs are established to compensate private property owners for the transition of private properties to public use (i.e. beaches, public access and river and bluff setbacks).

2060-2100 Adaptation Options

Between 2060 and 2100, increased coastal wave damage, greater flooding frequency and depth, and higher tides may threaten significant portions of current beach front properties. Protection of all properties from these risks may be costly, technically challenging and may degrade *Capitola's unique identity and scenic beauty*. Decisions regarding what the urban/beach front area may look like in 2100 will need to be made much earlier (i.e. coastal bluff and beach management plan) if adaptation is to be strategic and cost effective. Adopting coastal adaptation and retreat policies once all efforts to protect existing infrastructure fail is a more costly strategy.

Implement managed retreat strategies (Comprehensive Plan, Strict land use Re-zone, Rolling Easement)

There are a number of theoretical managed retreat strategies that have been described within the literature. Examples of coastal communities adopting re-zoning, building restrictions and other land use policies to drive the removal of buildings and infrastructure from the California coast, however, are few.

How retreat strategies can be adopted within a fully developed community like Capitola is unclear. Restrictions on redevelopment triggered by coastal development permit actions may lead to individual property owners implementing setbacks and building restrictions while neighbors are not required to comply. Such a case by case (or "Swiss Cheese") approach will most likely have limited success protecting either coastal properties or coastal resources. Rather, adaptation strategies and future land use decisions (that account for the costs to private property owners and the city) should be drafted long before they become enforceable. Programs to systematically implement adopted adaptation strategies along stretches of coastline (similar to Pacifica) will need support of state agencies and non-governmental organizations. The Local Coastal Program could be an excellent tool to drive these strategies.

Cost sharing between private property owners and state and local agencies will need to be defined and local land trusts may play an important role in administering these programs in years to come. Coastal Hazard (similar to Geologic Hazard) Abatement Districts where neighbors collect taxes on their properties to fund neighborhood scale

EXPLORING ADAPTATION POLICY

The Coastal Commission 2015 Guidance references strategies that include:

> *"restrictions on redevelopment of properties in hazardous areas, managed retreat, partnerships with land trust organizations to convert at risk areas to open space, or transfer of development rights programs"*

The 2014 Pacifica LCP[52] sets policy for coastal bluff development so that,

> *"All new development proposed on or adjacent to a coastal bluff shall require a site stability survey conducted by a licensed Certified Engineering Geologist or Geotechnical Engineer to determine the necessary setback, taking into account bluff retreat projected over the economic life of the development."*

This and most revised municipal policies set a process to establish setbacks for new development, there are no policies yet adopted that outline areas where current development will be modified or removed due to changing coastal hazards projected from these climate models.

The Marin SLR Adaptation effort[53] completed focus area analysis of coastal communities (i.e. Bolinas) similar to this Capitola report and has identified infrastructure that will need to be raised or otherwise modified to respond to tides and coastal flooding. Agriculture lands have been identified for transition to wetlands. No residential or commercial private properties have been identified for removal and no procedures have been identified to support municipalities to *"convert at risk areas to open space."*

[52] Dyett and Bhatia. 2014. Draft Pacifica Local Coastal Land Use Plan. Prepared for City of Pacifica. March 2014.

[53] Sea-Level Marin: Adaptation Response Team and Marin County Community Development Agency. 2015. Marin Ocean Coast Sea Level Rise Vulnerability Assessment, Draft Report.

solutions have been suggested to serve this function.

Realign roads and utility infrastructure (Retreat and other building designs)

Future realignment of roadways and utility infrastructure is costly but those costs can be minimized if managed adaptation and retreat policies are established decades before implementation. City and utility districts and companies can integrate future land use changes into current infrastructure repair and replacement decisions to minimize future costs of infrastructure loss and realignment. Basic cost estimate (based on previous reports) to realign roads and infrastructure that may be at risk by 2100 is outlined in Table 14 (page 47).

A draft adaptation strategy for the City of Capitola is provided below (Table 17).

Table 17. Draft Adaptation Strategy for the City of Capitola

ADAPTATION CATEGORY:

1. hard protection 2. soft protection 3. accommodate 4. Managed retreat 5. regulatory 6. planning

COASTAL HAZARDS	THROUGH 2030	CATEGORY	THROUGH 2060	CATEGORY	THROUGH 2100	CATEGORY
Coastal Storm Flooding	employ temporary protective structures	1, 2	employ secondary containment	1, 2	Implement Managed retreat policies	5
	upgrade storm drains	3	upgrade building guidelines in vulnerable areas	6		
	integrate storm pumps into flood response	3	Establish Managed retreat policies	6		
	investigate secondary barriers to coastal flooding	1, 2				
	Maintain and upgrade building standards in vulnerable areas	5				
Wave Impacts	continue winter sand berm placement	2	Establish Managed retreat policies	6	Implement Managed retreat policies	5
	increase efficiency of sand bag deployment	2				
	upgrade building guidelines in vulnerable areas	6				
	maintain coastal protection structures	1				

COASTAL HAZARDS	THROUGH 2030	CATEGORY	THROUGH 2060	CATEGORY	THROUGH 2100	CATEGORY
River Flooding	Increase freeboard along riverwalk (hip wall)	1	Establish Managed retreat policies	6	Implement Managed retreat policies	5
	upgrade storm drains	3				
	integrate storm pumps into adaptation	3				
	upgrade building standards in vulnerable areas	5				
	investigate secondary barriers to river flooding	1, 2				
Erosion	Maintain current coastal protective structures	1	prioritize replacement of coastal protection structures based on cost, feasibility, longevity and secondary implications	1	Implement Managed retreat policies	5
	Upgrade groins on beach	1	Establish Managed retreat policies	6		
	Investigate beach nourishment options	1, 2	Implement Coastal management strategy	5		
	set strategies for unprotected areas identified at risk	6				
	Investigate long-term feasibility and costs of maintaining current placement of coastal structures	6				
Rising Tides	Identify areas vulnerable to tidal flooding and integrate into zoning and building guidelines	6	Establish Managed retreat policies	6	Implement Managed retreat policies	5
	Draft coastal management plan for 2030, 2060 and 2100 to inform land use policy and private investments	6				

8. Conclusion

This vulnerability analysis is intended to provide a projected chronology of future hazards in order to support local adaptation planning and inform discussions within the community and with State regulatory and funding agencies.

Capitola has responded to and adapted to numerous environmental hazards throughout its 150 years. Development has changed, hotels have burned, and the city has flooded. After each disaster, the community has responded through reconstruction, upgraded infrastructure, and modifications in land use, all intended to retain Capitola's unique charm while responding to nature's lessons.

This vulnerability assessment provides projections of future hazards so the community can begin planning for strategic adaptation to these hazards rather than responding to future climatic events without sufficient forethought or understanding of costs and consequences. Capitola is uniquely vulnerable to coastal climate change. Capitola has stepped forward to partner with County and State agencies to complete this vulnerability assessment and begin planning proper responses to these environmental risks. The State has recently begun providing funding for projects that implement adaptation strategies. This vulnerability report is intended to provide Capitola with necessary information to prioritize actions to become more resilient and to partner with state agencies to implement selected priority actions. Additional State and federal funding is needed to aid local municipalities like Capitola who have taken steps to identify appropriate adaptation strategies.

POSSIBLE NEXT STEPS

- Adopt Capital Improvement Project review guidelines for sea level rise hazard areas.
- Integrate 2030 hazard maps into future Capitola Local Hazard Mitigation Plan updates.
- Investigate beach groin upgrade costs and effectiveness.
- Identify and prioritize storm drain upgrades necessary to address future hazards.
- Work with California Coastal Commission to integrate preferred adaptation strategies into the Capitola Local Coastal Program.
- Continue to participate in regional discussions regarding climate hazard avoidance and adaptation best practices.
- Initiate public outreach and education efforts to inform citizens of projected future hazards.

Mechanisms to implement the identified adaptation strategies requires further investigation, coordination among municipalities within the Monterey Bay and coastal California and development of partnerships that ensure efficient implementation of adopted strategies. Additional strategic dialog with California Coastal Commission staff is needed. The climate report team will work with the City of Capitola and Santa Cruz County to obtain additional funding to extend the adaptation opportunity analysis to the rest of Santa Cruz County, expand the environmental and economic implication analysis and further develop an adaptation implementation strategy for integration into general plans and local coastal programs.

References

California Coastal Commission. 2016. California Coastal Commission Sea Level Rise Policy Guidance: Interpretative Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits. Adopted August 12, 2015.

California Coastal Commission. 2014. GIS layer of existing coastal armor structures in Santa Cruz County. (revised by CCWG for this project).

California Natural Diversity Database (CNDDB). 2015. Records of Occurrence for Capitola USGS quadrangle. Sacramento, California. 2014. Retrieved from http://www.dfg.ca.gov/biogeodata/cnddb/mapsanddata.asp (October 2015)

Capitola Village Business Industry Association. Capitola Village. Capitola village.com (retrieved March 2, 2016)

Center for Ocean Solutions. 2016. Coastal Adaptation Policy Assessment: Monterey Bay. Prepared for Central Coast Wetlands Group.

Central Coast Wetlands Group (CCWG). 2017. Santa Cruz County Coastal Climate Change Vulnerability Report, Draft Report. Prepared for the County of Santa Cruz with funding from the Ocean Protection Council Grant # C0300700

City of Capitola. 2014. Capitola General Plan. http://www.cityofcapitola.org/sites/default/files/fileattachments/community_development/page/1464/general_plan_2014.pdf

City of Capitola Historic Museum. 2013. Capitola Local Hazard Mitigation Plan, Appendix A: Timeline of Natural Hazard events impacting the City of Capitola. http://www.cityofcapitola.org/sites/default/files/fileattachments/community_development/page/2484/appendixa_timeline_of_capitola_natural_hazard_events-jun2013-small.pdf

City and County of San Francisco Sea Level Rise Committee. Guidance for Incorporating Sea Level Rise into Capital Planning in San Francisco: Assessing Vulnerability and risk to Support Adaptation. Prepared for the San Francisco Capital Planning Committee. Adopted by Capital Planning Committee. December 14, 2015. onesanfrancisco.org/wp-content/uploads/Guidance-for-Incorporating-Sea-Level-Rise-into-Capital-Planning1.pdf (November 2016)

County of Santa Cruz. 2015. Santa Cruz County Local Hazard Mitigation Report. http://www.co.santa-cruz.ca.us/Portals/0/Local%20Hazard%20Mitigation%20Plan%202015-2020.pdf

CSUMB Class ENVS 660: Henson A., D. Muratore, A. Olson, D. Smith, A. Snyder. 2015. A Small-Scale Beach Nourishment Project in Monterey, California. The Watershed Institute, California State University Monterey Bay, Publication No. WI-2015-05. http://ccows.csumb.edu/pubs/reports/CSUMB_ENVS660_ClassReport_BeachNourishment_151116.pdf

Dyett and Bhatia. 2014. Draft Pacifica Local Coastal Land Use Plan. Prepared for City of Pacifica. March 2014.

ESA. 2016. Monterey Bay Sea Level Rise: Climate Change Impacts to Combined Fluvial and Coastal Hazards. Prepared for Moss Landing Marine Labs with funding from the California Ocean Protection Council, ESA Project Number D130523.00, May 13, 2016.

ESA-PWA. 2014. Monterey Bay Sea Level Rise Vulnerability Study: Technical Methods Report Monterey Bay Sea Level Rise Vulnerability Study. Prepared for The Monterey Bay Sanctuary Foundation, ESA PWA project number D211906.00, June 16, 2014.

ESA-PWA. 2012. Evaluation of Erosion Mitigation Alternatives for Southern Monterey Bay. Report prepared for the Monterey Bay Sanctuary Foundation and the Southern Monterey Bay Coastal Erosion Working Group. http://montereybay.noaa.gov/research/techreports/tresapwa2012.html.

Grannis, J. 2011. Adaptation Tool Kit: Sea Level Rise and Coastal Land Use. Georgetown Climate Center. http://www.georgetownclimate.org/files/report/Adaptation_Tool_Kit_SLR.pdf

Heberger M, H Cooley, P Herrera, PH Gleick, E Moore. 2009. The Impacts of Sea-Level Rise on the California Coast. Prepared by the Pacific Institute for the California Climate Change Center. http://dev.cakex.org/sites/default/files/CA%20Sea%20Level%20Rise%20Report.pdf.

Leo, K.L., S.G. Newkirk, W.N. Heady, B. Cohen, J. Calil, P. King, A. McGregor, F. DePaolis, R. Vaughn, J. Giliam, B. Battalio, E. Vanderbroek, J. Jackson, D. Revell. 2017. Economic Impacts of Climate Adaptation Strategies for Southern Monterey Bay. Technical Report prepared for the California State Coastal Conservancy by The Nature Conservancy. SCC Climate Ready Grant #13-107.

LoopNet. Capitola. Retrieved from http://www.loopnet.com/for-sale/capitola-ca/?e=u (Dec 2016)

National Oceanic and Atmospheric Administration. "NowData – NOAA Online Weather Data." Retrieved from http://w2.weather.gov/climate/xmacis.php?wfo=ilx (Aug 6, 2016)

National Research Council (NRC). 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future. Report by the Committee on Sea Level Rise in California, Oregon, and Washington. National Academies Press, Washington, DC. 250 pp. http://www.nap.edu/catalog/13389/sea-level-rise-for-the-coasts-of-california-oregon-and-washington.

Railroad Industries Incorporated. 2011. Business Plan for Operations of the SJVR in Fresno County. Prepared for Fresno Council of Governments.

RBF and Dewberry. 2013. City of Capitola Local Hazard Mitigation Plan. Prepared for the City of Capitola. http://www.cityofcapitola.org/sites/default/files/fileattachments/community_development/page/2484/capitola_lhmp_june_19-2013-final-small.pdf

Sea-Level Marin Adaptation Response Team and Marin County Community Development Agency. 2015. Marin Ocean Coast Sea Level Rise Vulnerability Assessment, Draft Report. http://www.marincounty.org/~/media/files/departments/cd/planning/slr/vulnerability-assessment/part-01_draft_marin_coast_slr_va_v2.pdf?la=en

State of California. California Coastal Act of 1976. http://www.coastal.ca.gov/coastact.pdf

Swift, Carolyn. 2004. City of Capitola Historical Context Statement. Prepared for City of Capitola Community Development Department. http://www.cityofcapitola.org/sites/default/files/fileattachments/community_development/page/2482/entire_historical_context.pdf

United States Army Corps. 2015. Coastal Regional Sediment Management Plan for the Santa Cruz Littoral Cell, Pillar Point to Moss Landing. Prepared for The California Coastal Sediment Management Workgroup. http://www.dbw.ca.gov/csmw/pdf/Santa_Cruz_Littoral_Cell_CRSMP_Final.pdf

United States Census Bureau. 2015. American Community Survey 5-Year Estimates. https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml (June, 2016)

United States Census Bureau. Capitola Quick Facts. Retrieved from: http://www.census.gov/quickfacts/table/PST045215/0611040 (Dec 2016)

US Fish and Wildlife Service. National Wetland Inventory. Retrieved from https://www.fws.gov/wetlands/Data/Mapper.html (July 8, 2016)

Whaley, D., Santa Cruz Trains. Capitola. Retrieved from: http://www.santacruztrains.com/2014/11/capitola.html (July 8, 2016)

Zillow. Capitola. Retrieved from http://www.zillow.com/capitola-ca/ (Dec 2016)

City of Capitola
Coastal Climate Change Vulnerability Report

Appendices

JUNE 2017

CENTRAL COAST WETLANDS GROUP

MOSS LANDING MARINE LABS | 8272 MOSS LANDING RD, MOSS LANDING, CA

Appendix A.

Coastal Adaptation Policy Assessment: Monterey Bay

(Center for Ocean Solution, 2016)

Coastal Adaptation Policy Assessment: Monterey Bay

August 30, 2016

To support decisionmakers in their efforts to manage coastal resources in a changing climate, the Center for Ocean Solutions (Center) engaged with Monterey and Santa Cruz Counties and other partners to model, map and assess the role of natural habitats along the coast of Monterey Bay in providing the ecosystem service of coastal protection. In addition, the Center evaluated existing and potential land use policy strategies that prioritize nature-based climate adaptation strategies. Ecosystem service modeling and assessment was conducted using the Integrated Valuation of Environmental Services and Tradeoffs (InVEST) decision support tool, a suite of tools to map and value the goods and services from nature. Specifically, the Center utilized the InVEST Coastal Vulnerability model for this assessment.

This ecosystem services and adaptation policy assessment focuses on the coastline of Monterey Bay and two specific geographic areas of interest: Capitola in Santa Cruz County and Moss Landing in Monterey County. For each location, we identify the distribution and ecosystem services provided by coastal habitats, map the role of those habitats in reducing exposure to storm impacts, evaluate land use policy adaptation strategies with the potential to maintain or improve nature's role in reducing exposure to these impacts, and highlight policy considerations relevant for each strategy. In addition, we include an introduction to our science-to-policy approach, a compilation of general considerations for pursuing land use policy approaches, as well as a summary of our analysis methodology.

This assessment addresses Task 4B of the Ocean Protection Council's grant entitled: "Collaborative Efforts to Assess SLR Impacts and Evaluate Policy Options for the Monterey Bay Coast." Results from this assessment will inform local planning in both Capitola and Moss Landing, as well as regional or county-wide planning in both Monterey and Santa Cruz Counties. This collaborative, regional project is underway in parallel with other coastal jurisdictions through a statewide investment in updating coastal land use plans in accordance with projections of rising sea levels and more damaging storms.

Coastal Adaptation Policy Assessment: Monterey Bay

Table of Contents

Executive Summary 3

Our Climate and Ecosystem Services Science-to-Policy Approach 5

Monterey Bay Coastal Study Area 8
- **Coastal Management Context**
- **Protective Role of Habitats**
- **Ecosystem Services of Coastal Habitats**
- **General Policy Considerations**

Community-Level Study Areas 16
- Capitola: 16
  - Coastal Setting
  - Protective Role of Habitats
  - Ecosystem Services of Coastal Habitats
  - Adaptation Strategies & Considerations
- Moss Landing: 23
  - Coastal Setting
  - Protective Role of Habitats
  - Ecosystem Services of Coastal Habitats
  - Adaptation Strategies & Considerations

Summary 27
Table: Compilation of Ecosystem Services 28
Table: Compilation of Adaptation Strategies 29
Analysis, Methodology and Assumptions 30

Authors

Eric Hartge, MSc; Research Development Manager
Lisa Wedding, PhD; Research Associate in Spatial Ecology & Analysis
Jesse Reiblich, JD, LLM; Early Career Law & Policy Fellow
Don Gourlie, JD; Early Career Law & Policy Fellow
Gregg Verutes, MSc; Geographer; Natural Capital Project
Monica Moritsch, PhD Candidate; Science & Policy Intern
Winn McEnery, MSc; Spatial Research Assistant

Acknowledgements

The authors would like to thank all those who provided feedback during the development of this assessment. Specifically, Ashley Erickson, JD, reviewed the entire document with a focus on the law and policy sections. Ross Clark and Sarah Stoner-Duncan, of the Central Coast Wetlands Group, also provided helpful clarifying recommendations as reviewers.

Coastal Adaptation Policy Assessment: Monterey Bay

EXECUTIVE SUMMARY

As sea levels rise, the impacts of more frequent large storm events driven by the El Niño Southern Oscillation (ENSO) will be greater than those historic events of similar magnitude, exposing coastal areas to the combined effects of elevated tides, increased storm run up and enhanced wave impacts. This increase in the frequency and intensity of storms will likely lead to economic, social and environmental vulnerabilities for coastal communities. California has proactively prioritized coastal adaptation planning that addresses vulnerabilities associated with a changing climate. As a result, the Monterey Bay Region is one of many locations to receive significant funding support to conduct a regional assessment of coastal vulnerability. The results of this coastal adaptation policy assessment will provide information that municipalities can leverage as they engage in adaptation planning for coastal land use.

Successful local, regional and state climate adaptation planning should take into account the role of natural habitats in ensuring a resilient coastline. Coastal habitats can play a protective role in reducing exposure to wind and wave impacts while also providing many additional beneficial ecosystem services to people and nature. Through proactive climate adaptation planning, coastal communities should prioritize nature-based strategies (e.g., dune or wetland restoration, conservation easements, etc.) when and where they are most feasible. If nature-based strategies are not practical in a given location, then coastal planners should consider approaches that seek to maintain the integrity of natural habitats and allow for adaptive coastal planning in the future (e.g., planned retreat, redevelopment limits, etc.).

With combined funding from the State Coastal Conservancy's (SCC) Climate Ready and Ocean Protection Council's (OPC) Local Coastal Program Sea Level Rise grant programs, the Monterey Bay Region is a part of a statewide investment to update coastal land use plans in accordance with projections of rising sea levels and more damaging storms. In parallel with additional select counties, the SCC and OPC provided funding in 2013 for Monterey and Santa Cruz Counties to include impacts from rising sea levels in their ongoing Local Coastal Program updates. The full study area includes the Monterey Bay coastline from Año Nuevo in Santa Cruz County to Municipal Wharf Two in Monterey County. Through discussion with county and city planners as well as with grant organizers from Central Coast Wetlands Group, two community-level study areas were identified—Capitola and Moss Landing—for exposure of coastal assets analyses, the role of natural habitats in reducing coastal exposure and the implications for potential climate adaptation strategies. Detailed analysis and synthesis in these case study locations will be the catalyst for similar investigations throughout Monterey Bay and potentially other sections of the California coast.

Executive Summary: Key Messages

Monterey Bay Coastal Study Area

- The Monterey Bay coastline features diverse coastal habitats including: dense kelp forests; brackish wetland habitats along creeks, lagoons, and sloughs; and expansive beach and dune systems that cover the central and southern sections of the coastline.
- While each coastal habitat plays some protective role, the dune systems in southern Monterey Bay play the highest role in reducing exposure of coastal development to erosion and inundation during storms relative to the entire study area.
- Any climate adaptation strategies under consideration along the Monterey Bay coastline should conform with the strictures of the Coastal Act, consider the recommendations from the Coastal Commission's sea level rise guidance, and respect the cultural significance of the region.
- A primary consideration for proactive coastal adaptation is to incentivize proactive climate adaptation planning that utilizes a blend of approaches across multiple timescales; optimal strategies should not limit adaptation options for future generations.

Capitola

- The small beach and lagoon system at the mouth of Soquel Creek plays a relatively moderate role in reducing exposure to erosion and inundation in comparison with the entire study area.
- The proximity of Capitola's commercial development to the coast limits the city's options for nature-based adaptation strategies.
- Adaptation options for developed sections of Capitola include implementing overlay zones that account for anticipated rising seas. In addition, limiting redevelopment or implementing redevelopment guidelines in these zones can provide a plan for relocation in coming years.

Moss Landing

- Relative to the entire Monterey Bay study area, the large dunes north and south of Moss Landing provide the highest protective role from coastal storm impacts.
- Nature-based climate adaptation options in the Moss Landing case study area include restoration or preservation of dune and wetland habitats. In addition, nourishing beachfront locations with additional sediment can be an option if appropriate environmental concerns are addressed.
- Built structures—including some coastal dependent structures—limit adaptation options for parts of Moss Landing. Critical infrastructure such as the Moss Landing power plant, harbor infrastructure, and Highway 1 all present challenges to implementing many otherwise viable strategies.

Our Climate and Ecosystem Services Science-to-Policy Approach

Coastal decisionmakers are actively determining how coastal communities will adapt to rising sea levels and more damaging storms. Favorable adaptation approaches consider the role of natural habitats and prioritize resilient strategies that do not limit future planning options.[1] Since 2010, the Center for Ocean Solutions has worked with coastal planners and managers to incorporate the role of natural habitats in climate adaptation planning.[2] Below, we outline our scalable, transferable approach to bridging a spatial assessment of natural protective services with coastal land use policy decisions in an era of changing climate.[3]

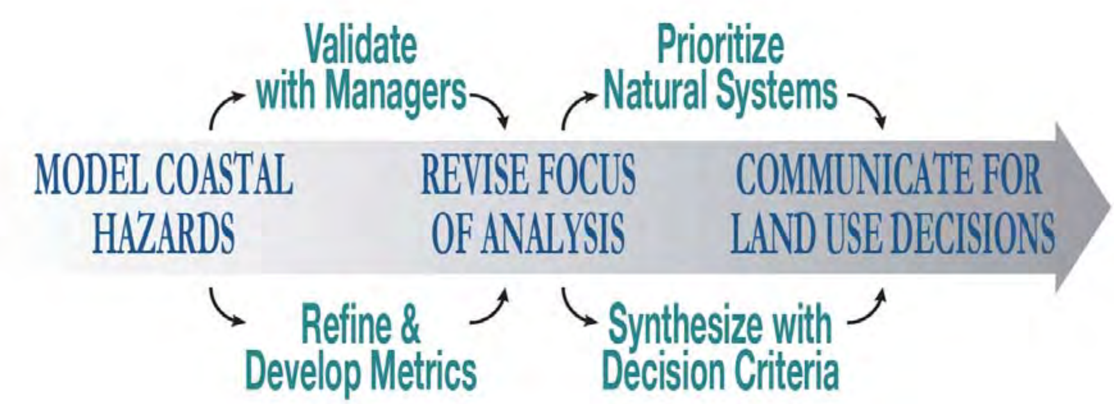


Fig. 1: Our transferable, scalable ecosystem services to coastal adaptation policy approach.

Coastal Ecosystem Services

Ecosystem services are the benefits that natural habitats provide to people (e.g., water purification, aesthetic attachment, carbon sequestration and coastal protection). Thriving, healthy ecosystems provide the greatest provision of services and are most resilient in the face of dynamic environmental conditions. In the coastal context, ecosystems play an important role in protecting shorelines against wave action by dissipating wave energy, or, in the case of sand dunes, physically impeding wave run-up. Climate change impacts, such as rising sea levels and increased storm intensity, are altering patterns of wave action along the coast and exposing new locations to physical forces. As waves travel from the open sea to coastal regions with shallower waters, they interact with the natural and geologic features of the seabed. Increased intensity and frequency of storms and rising seas, further emphasizes the important role of coastal habitats in reducing shoreline erosion and of increasing resilience in coastal areas.

[1] Jon Barnett & Saffron O'Neill, *Maladaptation* 20 GLOBAL ENVTL. CHANGE 211 (2010).

[2] Suzanne Langridge et al., *Key lessons for incorporating natural infrastructure into regional climate adaptation planning* 95 OCEAN & COASTAL MANAGEMENT 189 (2014); Sarah Reiter et al., *Climate Adaptation Planning in the Monterey Bay Region: An Iterative Spatial Framework for Engagement at the Local Level* 6 NATURAL RESOURCES 375 (2015); Lisa Wedding et al., *Modeling and Mapping Coastal Ecosystem Services to Support Climate Adaptation Planning*, *in* OCEAN SOLUTIONS EARTH SOLUTIONS 389 (Dawn J. Wright ed., 2016).

[3] *See* Figure 1. For further information on this approach, see also the "Analysis, Methodology and Assumptions" section *infra*.

Diverse habitats along California's coastline (e.g., sea grasses, kelp forests, salt marshes, dunes) play a role in reducing exposure to storm impacts while also providing a variety of additional services. As coastal development and rising sea levels degrade or damage these habitats, coastlines, communities and infrastructure become increasingly vulnerable to storms. An important challenge for decisionmakers is determining the best climate adaptation strategies that protect people and property while also protecting the ability of coastal habitats to provide a protective service into the future. To address this challenge, coastal communities need to identify where natural habitats provide the greatest protective benefits so that they may prioritize adaptation planning efforts that protect or restore their critical natural habitats.

Spatial Modeling and Mapping of the Protective Services

Modeling and mapping the ecosystem service of coastal protection can support the spatial prioritization of science-based climate adaptation strategies. For this assessment, we used InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) in combination with ArcGIS to identify areas where natural coastal habitats provide greater relative protection from storms and shoreline erosion.[4] The spatial models account for service supply (e.g., natural habitats as buffers for storm waves), the location and activities of people who benefit from services and infrastructure potentially affected by coastal storms. The InVEST Coastal Vulnerability model produces a qualitative estimate of coastal impact exposure to erosion and inundation during storms. By coupling exposure results with population information, it can identify the areas along a given coastline where humans are most vulnerable to storm waves and surge. The model does not value any environmental service directly, but ranks sites as having a relatively low, moderate or high risk of erosion and inundation through an exposure index.

The Coastal Exposure index is calculated by combining the ranks of the seven biophysical variables at each shoreline segment: geomorphology, natural habitats (biotic and abiotic), net sea level change, wind and wave exposure, surge potential and relief (bathymetry and topography). Model inputs serve as proxies for various complex shoreline processes that influence exposure to erosion and inundation. The resulting coastal exposure ranks range from very low exposure (rank=1) to very high exposure (rank=5), based on a mixture of user- and model-defined criteria. The model output helps to highlight the relative role of natural habitats at reducing exposure—also through a 1–5 ranking. This relative role output can be used to evaluate, how certain management actions can increase or reduce exposure of human populations to the coastal hazards of erosion and inundation. For this assessment, the model outputs were mapped on the shoreline of the Monterey Bay study area in order to interpret the relative role of natural habitats in reducing nearshore wave energy levels and coastal erosion—thus highlighting the protective services offered by natural habitats to coastal populations.

---

[4] InVEST is a free and open-source suite of software models created by the Natural Capital Project at the Stanford Woods Institute for the Environment to map and value the goods and services from natural capital. *See* INTEGRATED VALUATION OF ECOSYSTEM SERVICES AND TRADEOFFS, http://www.naturalcapitalproject.org/models/coastal_vulnerability.html (last visited Aug. 30, 2016).

Coastal Vulnerability Model Considerations

While this vulnerability modeling approach includes average wave and storm conditions, the InVEST Coastal Vulnerability model does not account for coastal processes that are unique to a region, nor does it predict changes in fluvial flooding or shoreline position or configuration. The model incorporates a scenario-based approach to evaluate the role that coastal habitats play in reducing exposure to coastal impacts. We use the Coastal Vulnerability index here to better understand the relative contributions of different input variables to coastal exposure and highlight the protective services offered by natural habitats to coastal populations. Results provide a qualitative representation of erosion and inundation risks, rather than quantifying shoreline retreat or inundation limits. The compiled role of habitat map products depicts results from a "presence/absence" analysis that calculates the difference between erosion indices with and without habitats in place. In effect, this approach indicates the change in coastal exposure if natural habitats are lost or degraded.

Connecting Spatial Modeling to Planning

Understanding the role that nearshore habitats play in the protection of coastal communities is increasingly important in the face of a changing climate and rising seas. To develop this analysis, we integrated feedback from coastal planners to better understand their information needs on coastal vulnerability and potential adaptation options. The map products created from the InVEST Coastal Vulnerability model support the spatial evaluation of nature-based adaptation planning alternatives with rising sea levels, and highlight how protective services might change in the future. Connecting these model results with existing land use planning and zoning information and current policies provides a pathway for identifying locations in which nature-based strategies can be prioritized as more effective and feasible than competing traditional strategies.

Monterey Bay Coastal Study Area

Monterey Bay Coastal Management Context

The study area from Año Nuevo in Santa Cruz County to Wharf Two in Monterey County features a diverse range of land uses and densities. This range includes the City of Santa Cruz's highly developed coastline, the sparsely populated coastal properties of southern Santa Cruz County, and undeveloped beaches in Santa Cruz and Monterey Counties.[5] Farmlands dominate much of the inland areas, especially around Watsonville, Castroville, and Salinas. The main feature of the coastline is the Monterey Bay itself, which includes a submarine canyon leading seaward from Elkhorn Slough and the coast of Moss Landing. The Moss Landing power plant is the largest structure on the Bay, and the coastline features numerous important points of interest, roads, critical infrastructure, and research and educational facilities.

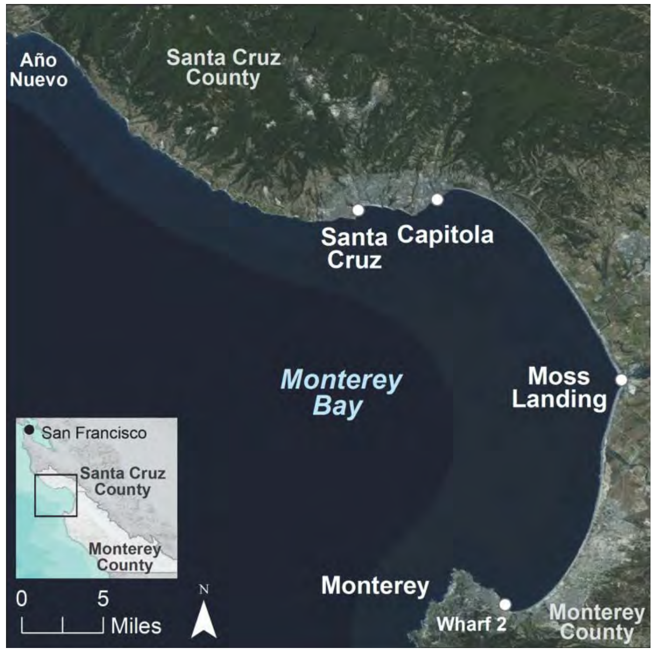


Fig. 2: Satellite image of Monterey Bay.

Several governmental agencies oversee the Monterey Bay coastline. For instance, the California Department of Parks and Recreation manages the state parks and reserves. The California Department of Transportation (CalTrans) oversees the coastal roadways, particularly the Pacific Coast Highway (Highway 1). The California Energy Commission regulates the Moss Landing power plant. The U.S. Fish and Wildlife Service governs the Salinas River National Wildlife Refuge. The National Oceanic and Atmospheric Administration (NOAA) administers the Elkhorn Slough National Estuarine Research Reserve (ESNERR) in partnership with the California Department of Fish and Wildlife. ESNERR and the non-profit Elkhorn Slough Foundation protect 5,500 acres of land, comprising property owned and managed by the reserve and property owned or managed by the foundation in the surrounding hillsides.[6] NOAA also administers the Monterey Bay National Marine Sanctuary and has jurisdiction over the marine mammals in the area. The most active land management agencies in the coastal zone include: the California Coastal Commission, which oversees land use and public access; the State Coastal Conservancy, which strives to protect or improve natural coastal ecosystems; and the State Lands Commission, which manages California's public trust lands.[7]

---

[5] The full project study area includes the Monterey Bay coast from Año Nuevo in Santa Cruz County to Municipal Wharf Two in the City of Monterey. Note that this study area does not include sections of Santa Cruz County north of Año Nuevo or sections of Monterey County west and south of Wharf 2. *See* Figure 2.

[6] ELKHORNSLOUGH.ORG, http://www.elkhornslough.org/conservation/what.htm (last visited Aug. 29, 2016).

[7] Public trust lands are held and managed by the state for the benefit of the public. In the coastal zone, public trust lands include all ungranted tide and submerged lands. The Coastal Commission also retains some oversight over the use of granted tide and submerged lands.

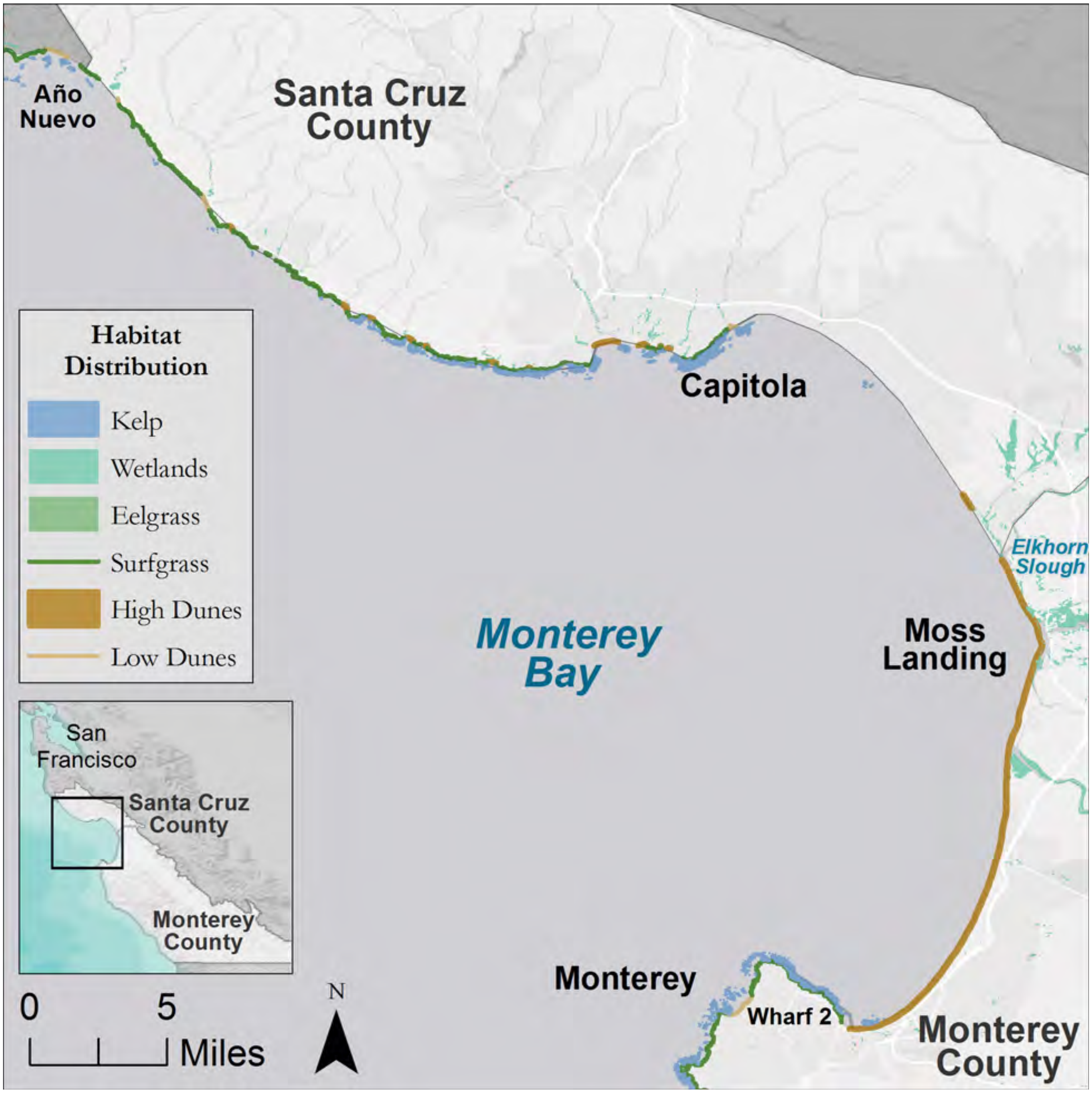


Fig. 3: Coastal habitats in Monterey Bay and surrounding area.

The Pacific coast of Santa Cruz and Monterey Counties has extensive natural habitats including some of the most imperiled habitats in the United States. Freshwater wetlands, coastal prairie and maritime chaparral, as well as kelp forests, estuarine wetlands, small and large beaches, and dunes are all present in the region.[8] The northern section of the study area (Año Nuevo to Capitola) includes a mostly rocky coastline fronted by seaweeds and surfgrass, backed by open agricultural lands. Occasional pocket beaches, typically fed by creeks, interrupt the bluffs and provide coastal access. Near the river mouths of the city of Santa Cruz, there is a greater concentration of small pocket beaches and wetland habitats than elsewhere in the area. The central section of the study

[8] *See* Figure 3.

area (Capitola to Moss Landing), is predominantly characterized by beaches and low dune systems backed by cliffs that decrease in size from north to south. The southern section of the study area (Moss Landing to Monterey) is dominated by large dune systems at the southern extent of the Santa Cruz littoral cell—the cycle of sediment sources and sinks from Pillar Point to the Monterey Canyon.[9] These habitats are all locally important and provides significant ecosystem services and benefits to certain communities.

Monterey Bay Protective Role of Habitats

Coastal habitats provide the ecosystem service of coastal protection for people, property and infrastructure by providing a natural buffer to mitigate erosion and inundation from ocean waves and storms. Our analysis focused on the direct effects of sea level rise on the risk of coastal communities to erosion and flooding. Our model results suggest that with rising sea levels the ability of dune systems to mitigate coastal exposure and keep this section of coastline in the low-moderate exposure range could be compromised.[10] Rising seas will likely impact the protective role of many beaches and dune habitat backed by coastal armoring that could result in the loss of existing beach area and the associated recreation and tourism income to coastal communities.[11] Overall, the loss of coastal dunes, wetlands, kelp forests and seagrass habitats would increase the exposure to erosion and flooding along the Monterey Bay study area. The extensive high dune systems throughout the southern section of Monterey Bay play a relatively high protective role compared to other natural habitats along the coastline. Storm surge is an important model factor from Marina to Monterey which alludes to the high role of coastal habitats in this area for protecting people and property along the coast. The coastal dune habitat in the Monterey Bay region suffers from high rates of erosion.[12] As a result, shoreline armoring has been used extensively along developed areas to address erosion and protect infrastructure and other areas of coastal development from waves, erosion and inundation. With increasing human pressure on these coastal ecosystems, there is a need to prioritize adaptation planning efforts in these important dune systems and other habitats that play significant roles in coastal protection.

Coastal wetlands along Monterey Bay stabilize shorelines and protect coastal communities by attenuating waves. Wetland habitat in the study area provides a relatively moderate role in mitigating erosion and inundation during storms. As sea levels rise, wetlands need to migrate to maintain their protective role. A recent study in Santa Cruz found that 17% of wetland habitat will be unable to migrate with sea level rise due to existing development.[13] The model does not predict migration or loss of habitat under the different sea level rise scenarios. Further research is needed to understand the extent to which habitats will be able to adapt to climate change effects.[14]

---

[9] U.S. ARMY CORPS OF ENGINEERS, COASTAL REGIONAL SEDIMENT MANAGEMENT PLAN FOR THE SANTA CRUZ LITTORAL CELL, PILLAR POINT TO MOSS LANDING (2015).
[10] *See* Figure 4.
[11] Philip G. King et al., THE ECONOMIC COSTS OF SEA-LEVEL RISE TO CALIFORNIA BEACH COMMUNITIES (2011).
[12] Gary Griggs & Rogers Johnson, *Coastline erosion: Santa Cruz County, California* 32 CALIFORNIA GEOLOGY 67 (1979); Edward Thornton et al., *Sand mining impacts on long-term dune erosion in southern Monterey Bay* 229 MARINE GEOLOGY 45 (2006).
[13] MATTHEW HEBERGER ET AL., THE IMPACTS OF SEA-LEVEL RISE ON THE CALIFORNIA COAST (2009).
[14] Langridge, *supra* note 2.

The southern coastline of Monterey Bay is exposed to high wave energy, which was a substantial driver of the high coastal exposure in this area. Surfgrass provides some wave attenuation for the adjacent shoreline but compared to other habitats in the study area, it plays a relatively low role in reducing overall exposure. Although kelp forest habitats along the broader Monterey Bay coastline also play a relatively low role in reducing exposure to coastal hazards compared to the coastal dune habitats, these habitats offer important co-benefits to California's people and the economy such as fisheries habitat and recreation.

Monterey Bay Ecosystem Services of Coastal Habitats

The Monterey Bay is nationally regarded as a culturally important marine habitat. This section of the coast includes six state marine protected areas as well as a national marine sanctuary.[15] Monterey Bay also supports a diverse ocean and coastal-based economy including agriculture, tourism, industry, aquaculture, fishing as well as a number of marine research and education institutions. Many tourists flock to the area for offshore whale watching, coastal birding, kayaking, surfing, boating, fishing, and beach-going. The diverse habitats noted below play an important role in preserving the open natural system of this region.

Creeks, Rivers, and Lagoons

Along the Northern coast of Monterey Bay there are numerous creeks and rivers reaching coastal lagoons and beaches along the Pacific shoreline. Several waterways also weave through the urbanized residential areas in Santa Cruz or Capitola, along with more rural neighborhoods such as in Aptos. These coastal waterways provide habitat for commercially important fish species (e.g., salmon and steelhead) during juvenile stages of their lifecycle. Many non-commercial fish and birds are also endemic to these creeks, while amphibians and reptiles use the damp banks for shelter and a source for food.[16] These riparian corridors and their lagoons provide aesthetic value and streamside recreation opportunities in the form of parks and trails, particularly in more urbanized neighborhoods. They also perform water filtration services, and nutrient cycling. When this habitat remains intact, it can aid in flood control and water storage during the wet season and major storm events.[17]

[15] The Marine Protected Areas include: Greyhound Rock and Elkhorn Slough State Marine Conservation Areas as well as Año Nuevo, Natural Bridges, Elkhorn Slough, and Moro Cojo State Marine Reserves.
[16] Mary E. Power et al., *Rivers*, *in* ECOSYSTEMS OF CALIFORNIA 713 (Harold Mooney & Erika Zavaleta eds., 2016).
[17] Walter G. Duffy et al., *Wetlands*, *in* ECOSYSTEMS OF CALIFORNIA 669 (Harold Mooney & Erika Zavaleta eds., 2016).

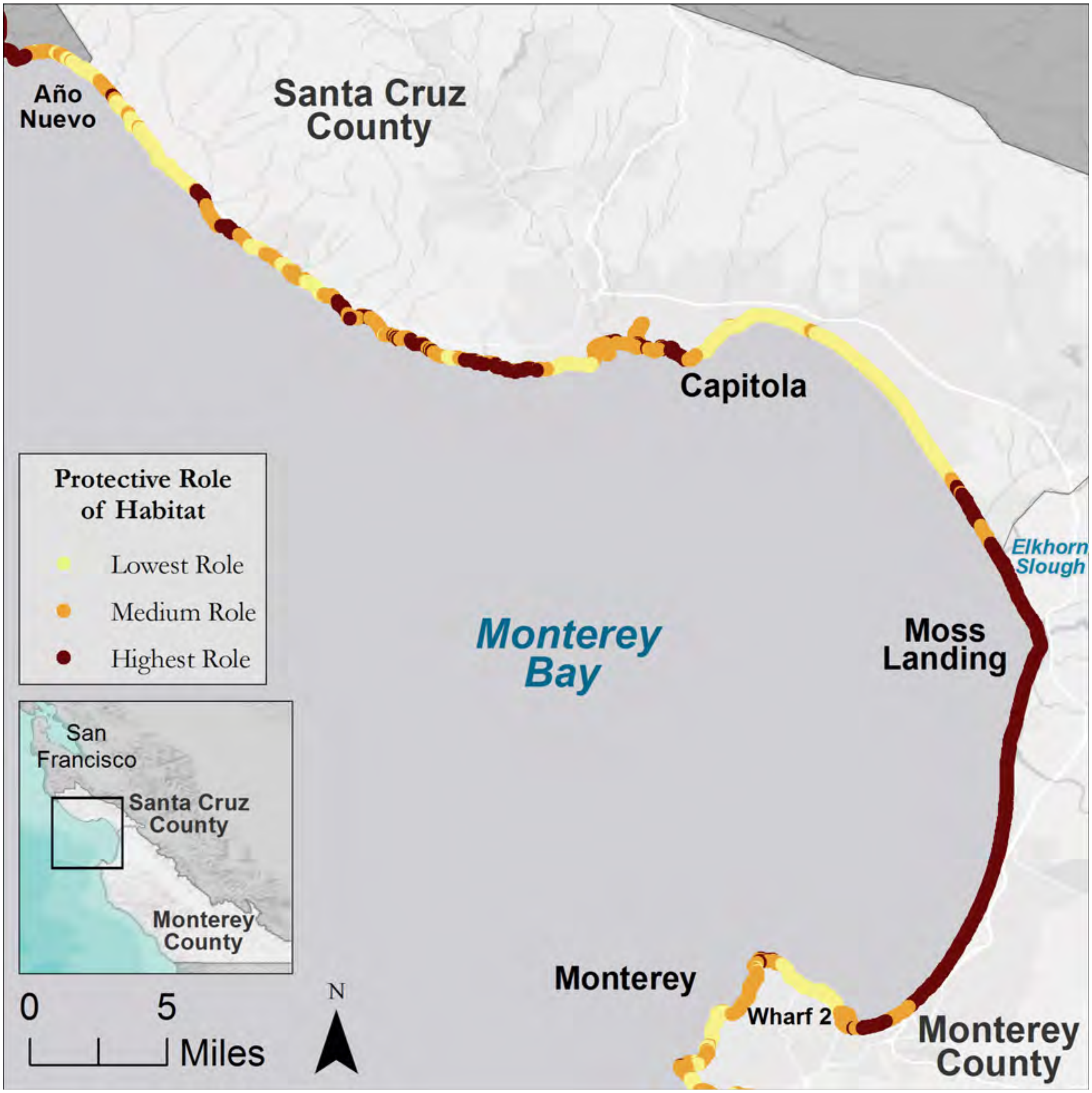


Fig. 4: Relative role of coastal habitats around Monterey Bay in reducing exposure to erosion and inundation.

Kelp Forests of Monterey Bay's Northern Coast

On the Northern end of the bay, near Año Nuevo, dense kelp forests grow from the sandstone and claystone reefs offshore. Kelp forests provide juvenile fish habitat and shelter them from predation. Kelp is also harvested at small scales to provide food for abalone aquaculture, particularly for abalone farms along the wharfs of Monterey.[18] Since no recreational or commercial fishing of any abalone species is allowed south of San Francisco, local aquaculture operations are the only source

[18] Mark H. Carr & Daniel C. Reed, *Shallow Rocky Reefs and Kelp Forests*, *in* ECOSYSTEMS OF CALIFORNIA 311 (Harold Mooney & Erika Zavaleta eds., 2016).

of Monterey Bay abalone for human consumption.[19] Forests of giant kelp (*Macrocystis pyrifera*) and bull kelp (*Nereocystis luetkeana*), nourished by cold, nutrient-rich waters, are highly productive and support a food web of hundreds of fish and invertebrate species along with a diverse assemblage of birds and marine mammals.[20] In addition, litter from broken kelp fronds washes up on local beaches as wrack and detritus, sustaining a separate food web of terrestrial insects and shorebirds.[21] Kelp require high light levels and cool water temperatures to grow. As such they are sensitive to excess sedimentation and nutrient overloads that stimulate growth of light-blocking organisms. Strong wave action from storms can rip out entire kelp patches and significantly damage the remaining fronds. Accordingly, shifts in ocean thermal regimes or winter storm patterns such as El Niño can pose threats to sustaining kelp habitats.[22]

Wetlands of Elkhorn Slough

At the heart of Monterey Bay is Elkhorn Slough, an estuarine system known for its biological significance. Its channels, mudflats, eelgrass beds, salt marshes, and hard substrates provide habitat for more than 100 fish, 265 bird, and 500 marine invertebrate species, and more than two dozen rare, threatened, or endangered species.[23] Elkhorn Slough also provides safe habitat for several species of marine mammals. Sheltered from larger marine predators, harbor seals and Southern sea otters use the Slough as a safe feeding and pupping ground. Because of its rich diversity of birds and mammals, Elkhorn Slough's sheltered waters are a popular location for kayaking, paddle boarding, and wildlife viewing. These wetlands contribute to flood control, water filtration, and nitrogen runoff control services.[24] Wetlands provide additional benefits as sinks for carbon through their vegetation growth and accumulation of slowly decomposing sediment.[25]

Coastal Dune and Beach Systems

Extensive coastal dune systems along the southern coast of Monterey Bay support important plant communities between mean high tide and the furthest reach of storm waves.[26] The Monterey Bay beaches and dunes are also a favorite for locals and tourists alike due to its pristine coastline and sandy shores along many coastal access sites. The beach and dune habitats in this region also

---

[19] CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE, STATUS OF THE FISHERIES REPORT (2011).

[20] Yuri Springer et al., *Toward ecosystem-based management of marine macroalgae—the bull kelp, Nereocystis luetkeana* 48 OCEANOGR. MAR. BIOL. ANNUAL REVIEW 1 (2010); *see also* Carr & Reed, *supra* note 18.

[21] Jenny Dugan et al., *The response of macrofauna communities and shorebirds to macrophyte wrack subsidies on exposed sandy beaches of southern California* 58 ESTUARINE COASTAL AND SHELF SCIENCE 25 (2003).

[22] Yuri Springer et al., *Toward ecosystem-based management of marine macroalgae - the bull kelp, Nereocystis luetkeana* 48 OCEANOGRAPHY AND MARINE BIOLOGY: AN ANNUAL REVIEW 1 (2010); Paul Dayton & Mia Tegner, *Catastrophic Storms, El Niño, and Patch Stability in a Southern California Kelp Community* 224 SCIENCE 283 (1984).

[23] CHANGES IN A CALIFORNIA ESTUARY: A PROFILE OF ELKHORN SLOUGH 4 (Jane Caffrey et al. eds., 2002) (Elkhorn Slough's habitats include "the slough's channels, mudflats, eelgrass beds, salt marsh, and hard substrate; the adjacent harbor, coastal dunes, and open beaches; and the grasslands, oak, woodlands, chaparral, and other upland areas.").; Jessica Lyons, *Scientists and Activists Aim to Save Elkhorn Slough from Erosion and Development Before it is too Late*, MONTEREY CNTY. WEEKLY, Dec. 13, 2007, *available at* http://www.montereycountyweekly.com/news/cover/article_11c69d2e-dfd5-502d-92ca-bada34be8709.html.

[24] James E. Cloern et al., *Estuaries: Life on the Edge*, *in* ECOSYSTEMS OF CALIFORNIA 359 (Harold Mooney & Erika Zavaleta eds., 2016).

[25] John Callaway et al., *Carbon Sequestration and Sediment Accretion in San Francisco Bay Tidal Wetlands* 35 ESTUARIES AND COASTS 1163 (2012).

[26] Iris Hendriks et al., *Photosynthetic activity buffers ocean acidification in seagrass meadows* 11 BIOGEOSCIENCES 333 (2014).

provide numerous benefits to people and nature, such as critical shoreline bird habitat, mammal haul out locations, as well as coastal recreation and shoreline fishing spots.

General Policy Considerations

There are several general policy considerations that apply to the entire study area, regardless of the adaptation strategy implemented.[27] Most importantly, any climate adaptation strategies should conform to the various strictures of the Coastal Act, and take into account the Coastal Commission's sea level rise recommendations. Additionally, adaptation solutions should be place-based, designed with each specific location's characteristics and limitations in mind. Adaptation strategies should also incentivize proactive planning and limit subsidizing building in hazardous locations. Finally, the cultural significance of the study area should be considered. These considerations are investigated below.

The Coastal Act sets out various legal requirements with which all coastal adaptation policies must be consistent.[28] Likewise, the Commission's Sea Level Rise Guidance (Guidance) contains several persuasive and compelling recommendations. The Guidance recommends pursuing a suite of actions designed to protect in the short term, accommodate in the midterm, and promote retreat in the long term, instead of focusing on any one strategy type or time scales.[29] This hybrid approach permits flexibility and allows communities to tailor adaptation strategies to their unique circumstances. For instance, it would allow the use of protection, accommodation, and retreat strategies simultaneously—as needed and as appropriate—and would also allow these strategies to change over time.[30] Under such an approach, protection of existing structures is allowed but may be limited by certain factors, such as the economic life of a structure.

While a variety of coastal adaptation strategies for adjusting coastal land uses in response to climate impacts are possible in any given area, the appropriate adaptation measures for specific locations will depend on factors such as those locations' topographies and existing infrastructure. Accordingly, each location's unique characteristics should inform the adaptation strategies employed there. For example, the strategies suitable for the study area's open and undeveloped coastlines are likely unsuitable for the city of Santa Cruz and other highly developed areas. Furthermore, specific strategies should take into account predicted rates of local sea level rise and an area's vulnerability to storm events. Finally, existing regulations for each targeted location—such as local coastal programs, rules specific to the Monterey Bay National Marine Sanctuary[31] and any other applicable federal, state or local laws[32]—should be noted and followed.

[27] These considerations are in addition to the overarching policy consideration of this assessment: that nature-based solutions could be prioritized when possible to ensure maximum co-benefits and beneficial services associated with these strategies.
[28] *See, e.g.*, CAL. PUB. RES. CODE §30235.
[29] CALIFORNIA COASTAL COMMISSION, SEA LEVEL RISE ADOPTED POLICY GUIDANCE 125 (2015) *available at* http://www.coastal.ca.gov/climate/slrguidance.html.
[30] *Id.* at 122-23 ("In many cases, a hybrid approach that uses strategies from multiple categories will be necessary, and the suite of strategies chosen may need to change over time.").
[31] *See, e.g.*, 15 C.F.R. § 922.132 (listing prohibited or otherwise regulated activities in the MBNMS).
[32] For instance, the National Historic Preservation Act of 1966 would govern efforts to move or alter historic buildings on the National Register of Historic Places. 16 U.S.C. §§ 470 *et seq.*

Keeping these limitations in mind, communities should pursue strategies that internalize the risks associated with building and buying properties in hazardous locations and incentivize proactive planned retreat and relocation where appropriate. Proactive planning is especially important in areas with a large number of repetitive loss properties, such as Aptos.[33] Superstorm Sandy and other disasters have proven that making decisions early is less expensive, and potentially less devastating, than waiting until the effects of a disaster take hold.[34] One way governments could internalize the risks associated with building in hazardous locations would be to stop spending public funds to rebuild private structures on sites damaged by rising seas and storms. Another option to internalize these risks would be to amend existing flood insurance policies.[35]

The cultural significance of California's beaches and the Monterey area can also be considered. California's beaches are important to Californians and play a large part in the State's identity. Furthermore, Monterey, and its surrounding areas, are culturally important for many reasons. Coastal adaptation planning can take the area's rich heritage into account when considering which coastal adaptation strategies to pursue. Particularly, adaptation decisions should consider the potential social impacts of decisions affecting culturally and socially significant areas. Moreover, culturally important points of interest in the area should be preserved if possible. Accordingly, decisionmakers can consider the social impacts of any proposed adaptation actions when prioritizing coastal adaptation strategies.

[33] Particularly State Park Drive and Beach Drive in Aptos, CA. COUNTY OF SANTA CRUZ LOCAL HAZARD MITIGATION PLAN 2015-2020 64 (2015) *available at* http://www.sccoplanning.com/Portals/2/County/Planning/policy/2015%20LHMP%20Public%20Review%20Draft.pdf.

[34] *See, e.g.*, Anne R. Siders, *Anatomy of a Buyout—New York Post-Superstorm Sandy*, Vermont Law School 16th Annual Conference on Litigating Takings Challenges to Land Use and Environmental Regulations (Nov. 22, 2013) (explaining lessons learned in acquisition and buyout programs post-Sandy in New York).

[35] Such a change would need to come at the federal level through amendment to the National Flood Insurance Program. 42 U.S.C. § 4001.

Community-Level Study Areas

Capitola: Coastal Setting

Capitola was one of the earliest populated beaches on the west coast and hosts a highly developed coastline. Similar to the neighboring city of Santa Cruz, Capitola faces flooding, cliff erosion and episodic bluff failure during King Tides—highest annual tides—and ENSO storm events. Soquel Creek bisects Capitola, and its beach, and plays a large role in riverine inundation in the area. Riprap lines the beach and protects both the beach and development beyond it, such as a modest commercial area that is the economic center of the community.

Fig. 5: Satellite image of Capitola.

Capitola's unique characteristics inform the adaptation policies and strategies that might be prioritized in the area.[36] The coastal city of Capitola is dominated by steep cliffs, pocket beaches and low dune systems. Surfgrass beds line the shore and kelp forests populate nearshore reefs from the mouth of Soquel Creek westward toward the city of Santa Cruz. There are a number of low coastal terraces and cliffs that allow coastal access to these scattered beaches. Downtown Capitola and Capitola Beach are saddled between two steep coastal cliffs forming an economically important beachfront tourist destination and coastal recreation site for the community. Soquel Creek runs through downtown Capitola, housing a string of wetlands before flowing to the ocean through an ephemeral lagoon system.

Capitola: Protective Role of Habitats

The low dune and beach habitat in Capitola plays a relatively moderate role in reducing the exposure of Capitola Village and the mouth of Soquel Creek to erosion and inundation during storms compared to the lower protection provided by rest of the adjacent coastline.[37] Beach sands in front of the creek mouth buffer wave run-up and the reach of salt water upstream during storm surge. The main drivers of coastal exposure in the Capitola area are the low elevation and erodible geomorphology surrounding Soquel Creek. The presence of wetlands reduces wave heights along the overall Monterey Bay coastline as coastal wetland and creek vegetation serve as a shoreline buffer. However, model results suggest that Soquel Creek does not serve a strong role in protecting the Capitola shoreline in all locations or scenarios due to the low-lying elevation and coastal flooding during storm events. This phenomenon is not unique to Soquel Creek as large scale regional erosion and river outflow can often overwhelm the ability of vegetation to attenuate waves.[38] The Capitola area is less exposed to wind and waves compared to the broader Monterey Bay study region, yet the relatively greater distance from the continental shelf drives an increase in storm surge potential. Kelp forest habitats along the broader Capitola coastline play a relatively low protective role, based on the model ranking methodology, in reducing exposure compared to the coastal dune and wetland habitats in this area.

---

[36] *See* Figure 5.

[37] *See* Figure 6.

[38] Keryn Gedan et al., *The present and future role of coastal wetland vegetation in protecting shorelines: answering recent challenges to the paradigm* 106 CLIMATIC CHANGE 7 (2011).

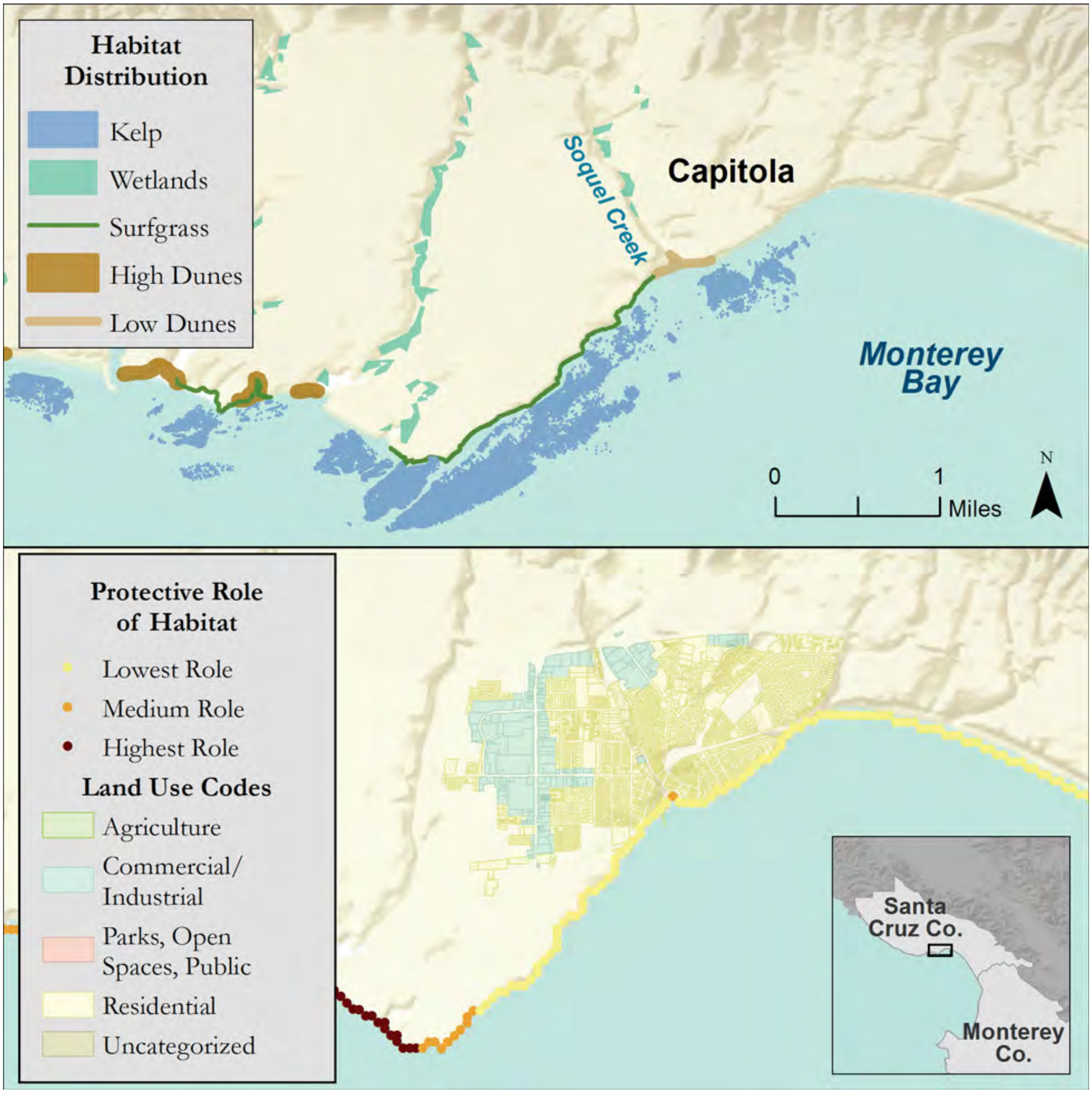


Fig. 6: Coastal habitats around Capitola, CA (Top). The relative role of coastal habitats along the shoreline of Capitola in reducing exposure to erosion and inundation with relevant land use zoning information (Bottom). Land use categories from the General Plan Land Use Codes were aggregated into four broad land use codes (see Bottom legend). Nearly all areas belonged distinctly to one category of land use. Only one land classification, Visitor Serving/L-M Density Residential, had uses from multiple categories, and it was categorized as Residential for this map.

Capitola: Ecosystem Services of Coastal Habitats

Wetlands in Riverine System

As Soquel Creek approaches the Pacific Ocean, the change in slope provides opportune locations for wetland habitats that slow the pace of the river and filter nutrients and pollutants, which leads to an improvement in water quality.[39] Closer to the coast, the river may transition into a lagoon

[39] Duffy et al., *supra* note 17.

system depending on the extent of the beach and low dune system at the mouth. Fish, small invertebrates and birds inhabit the lagoon as a feeding and breeding ground.[40] During strong rains, the lagoon typically breaches to create a direct opening to the ocean.[41] The distinction between this tidal versus lagoon interface plays a significant role in managing flood risks for the city of Capitola, particularly due to the many homes that line the creek and lagoon. While lagoon status influences the volume of tidal water that enters the creek system, intact wetlands can buffer surrounding areas against inundation. For instance, water is absorbed into soils instead of collecting on impermeable surfaces.[42]

Coastal Dune and Beach Systems

The beach and low dune habitat along the mouth of Soquel Creek provides the coastal community with recreation opportunities (e.g., surfing, fishing, kayaking, swimming, beach access). The Capitola Village and beach areas near the mouth of the creek draw over twenty percent of Santa Cruz County's tourism visitors annually.[43] The lagoon system at the mouth of Soquel Creek is actively managed by articifical breaching to release water as part of flood control and water quality maintainence. When open to the ocean, lagoons effectively function as small estuaries. Breaching alters the amount of tidal exchange, temperatures, salinity profiles and water flow for the lower portion of the creek. Depending on time of year and conditions surrounding the breaching event, the shift from closed to open system may influence patterns of species movement and habitat use.[44] Controlled breaching events are typically closely overseen by City Watershed Management monitoring teams, with crews on hand to keep threatened and endangered fish in their respective habitats with nets or transport upstream if needed.[45]

Kelp Forests and Surfgrass

Surfgrass and kelp forest habitats near the Capitola shoreline serve an important natural service by providing food and habitat for a suite of marine species that are also important to recreational fishing for residents and visitors. Kelp forests of the Monterey Bay support rockfish, urchins, crabs and many other commercially valuable species, while surfgrass acts as a nursery for juveniles of these adult kelp forest species.[46] Detritus from kelp forests washes out into open water and submarine canyons, providing subsidies of nutrients and food material to the Monterey Bay's deeper habitats.[47]

---

[40] Cloern et al., *supra* note 24.
[41] *Id.*
[42] Walter Duffy and Sharon Kahara, *Wetland ecosystem services in California's Central Valley and implications for the Wetland Reserve Program* 21 ECOLOGICAL APPLICATIONS S18 (2011).
[43] LAUREN SCHLAU CONSULTING, SANTA CRUZ COUNTY VISITOR PROFILE (2010).
[44] Cloern et al., *supra* note 24.
[45] Jessica York, *Beach lagoon breached to alleviate flooding*, SANTA CRUZ SENTINEL, August 17, 2015, http://www.santacruzsentinel.com/article/NE/20150817/NEWS/150819676.
[46] Kevin Hovel, *Habitat fragmentation in marine landscapes: relative effects of habitat cover and configuration on juvenile crab survival in California and North Carolina seagrass beds* 110 BIOLOGICAL CONSERVATION 401 (2003); Carey J. Galst & Todd W. Anderson, *Fish-habitat associations and the role of disturbance in surfgrass beds* 365 MARINE ECOLOGY PROGRESS SERIES 177 (2008); *see also* Carr & Reed, *supra* note 18.
[47] Christopher Harrold et al., *Organic enrichment of submarine-canyon and continental-shelf macroalgal drift imported from nearshore kelp forests benthic communities by macroalgal drift imported from nearshore kelp forests* 43 LIMNOLOGY & OCEANOGRAPHY 669 (1998).

Both kelp forests and surfgrass beds also have potential to sequester some carbon dioxide from the atmosphere and surrounding water by incorporating carbon into their tissues. On a short-term scale, photosynthesis temporarily removes carbon dioxide from the water during the day, potentially reducing the impacts of ocean acidification.[48] Over time, marine sediments slowly bury and trap the plant matter—and therefore the carbon—for longer time scales.[49] As carbon sequestration markets develop, this ecosystem function could be of economic interest to the Capitola area from both a hazard and emission mitigation perspective.

Capitola: Adaptation Strategies & Considerations

Coastal Adaptation Options

Capitola's highly developed coastline limits the available coastal adaptation options. Due to high-density development and the prevalence of cliffs and bluffs, limited opportunities exist to apply nature-based strategies, with the exception of Capitola's beach—a possible candidate for beach nourishment. Beach nourishment could reinforce the beach and surrounding areas, slowing coastal erosion due to rising seas. This strategy would also buffer the upland structures—at least in the short term—from rising seas and storm events.

Other adaptation options would also be feasible in Capitola. A particularly useful and flexible option would be to develop sea level rise overlay zones for Capitola's vulnerable areas.[50] An overlay zone is a tool that groups certain properties together because of a feature they share, or because of some regulatory aim that a local government wishes to accomplish. An overlay zone would allow additional zoning regulations or building code restrictions to be established in the future for the properties in that zone, as deemed necessary. Establishing a sea level rise overlay zone would provide immediate notice to owners of homes and businesses that they are in an area that is vulnerable to rising sea levels.[51] This zone could be coterminous with, or go beyond, existing floodplain zones in the area.[52]

Overlay zones can also designate certain areas as protection, accommodation, or retreat zones and implement appropriate regulations for restricting future development and redevelopment in each zone. For instance, regulations might allow rebuilding of structures in an "accommodation zone," but only if they are raised or otherwise built to withstand rising seas. Likewise, a "retreat zone" might include setbacks and other redevelopment restrictions, such as requiring certain uses to end after a specific time period. Finally, a "protection zone" could allow protection strategies for properties that feature coastal dependent structures, such as harbors.

An overlay zone might also include additional strategies to promote responsible coastal adaptation. For instance, redevelopment in vulnerable areas could be limited through downzoning. This

---

[48] Hendriks, *supra* note 26; Lester Kwiatkowski et al., *Nighttime Dissolution in a Temperate Coastal Ocean Ecosystem Increases under Acidification* 6 SCIENTIFIC REPORTS 1 (2016).

[49] Elizabeth McLeod et al., *A blueprint for blue carbon: Toward an improved understanding of the role of vegetated coastal habitats in sequestering CO_2* 9 FRONTIERS IN ECOLOGY AND THE ENVIRONMENT 552.

[50] Capitola currently uses several overlay districts in its zoning classifications. *See, e.g.,* CAPITOLA CITY, CAL., MUNICIPAL CODE §17.20.010 (affordable housing overlay district).

[51] A building moratorium could be put in place while overlay zones are developed. The building moratorium could encompass all areas that might be included in these zones. *See* CAL. GOV. CODE § 65858 (outlining procedures for local governments adopting interim ordinances as urgency measures).

[52] CAPITOLA CITY, CAL., MUNICIPAL CODE §17.50.090.

strategy rezones land to less intensive uses. Currently, the properties at the greatest risk of flooding and rising seas in Capitola are those close to Soquel Creek. These properties are currently zoned for several different land uses and could be prioritized for efforts to downzone.[53] Downzoning would lead to nonconforming uses in the short term—i.e., uses not allowed under the new zoning ordinances, but nonetheless "grandfathered" in because they existed prior to the downzoning. Regulations can be framed to allow these nonconforming uses initially but require them to cease after some period of time.

To achieve these longer-term coastal adaptation strategies, Capitola could consider taking several proactive steps in the short term. For instance, retreat strategies require that uplands be identified and purchased to make space for relocated structures. Land banking properties now could satisfy this future need.[54] Since these lands might not be used for this purpose immediately, this strategy could proceed gradually through phased and voluntary purchases of suitable upland properties. If this strategy does not succeed, or if the timeline becomes more urgent due to rising seas, it could be accomplished through eminent domain.[55] Likewise, Capitola could use transfers of development rights (TDRs) (where landowners sell the rights to develop their property) of vulnerable properties to help facilitate retreat.[56] This strategy could monetarily incentivize coastal landowners to provide their properties for retreat, and it could keep undeveloped coastal land undeveloped.

Capitola's existing coastal protection structures might also be studied to determine their efficacy and need for replacement or removal. Capitola's large sandy beach currently relies on two rip-rap groins on its east end to accumulate sand. To facilitate managed retreat, some of the existing coastal protection structures might need to be phased out. Others might need to be replaced if they are deemed necessary to coastal protection and provided they fit within Capitola's overall coastal adaptation strategy now and in the projected future.

Barriers and Considerations

There are several considerations that should be taken into account when moving forward with any of these coastal adaptation strategies in Capitola. First, limited undeveloped land is available immediately upland of the vulnerable areas, limiting retreat options in the area. As a result, businesses and residences that relocate might have to be moved farther inland than would be necessary elsewhere on the coast. Furthermore, the vulnerability of properties on bluffs and cliffs are less predictable than those along the lower-lying coastline, making long-term planning in these areas more challenging.[57]

---

[53] *See* Figure 6.

[54] Land banking is the buying of land for some future use. Michael Allan Wolf, *Strategies for Making Sea-Level Rise Adaptation Tools "Takings-Proof"* 28 J. LAND USE & ENVTL. L. 157, 182 (2013).

[55] Eminent domain is the power of the government to take land for a public purpose. This power is limited by the U.S. Constitution and the California Constitution. U.S. CONST. AMEND. V; CAL. CONST. ART. I § 19.

[56] JESSICA GRANNIS, ADAPTATION TOOL KIT: SEA-LEVEL RISE AND COASTAL LAND USE 57-60 (2011).

[57] Cliffs and bluffs are more vulnerable to episodic erosion than beaches, which alternatively face constant erosive pressures. *See, e.g.,* episodic erosion events at Pacifica Lands End Apartments.

Takings concerns routinely arise when local governments undertake proactive planning for rising seas.[58] To avoid takings concerns, restrictions could be tailored to avoid depriving property owners of all economic value of their parcels.[59] Furthermore, restrictions could account for the economic lives of properties to avoid takings concerns, or could be grounded in avoiding and abating nuisances. Furthermore, any building moratoria could be tailored to be temporary.[60]

Third, regarding zoning classifications, any changes to the current classifications would likely include a grandfather provision allowing existing nonconforming uses to continue.[61] If grandfathering provisions are included in new ordinances, downzoning would only immediately affect undeveloped properties or properties whose uses have been abandoned. But, "grandfathered" provisions could be written to require landowners to comply with new zoning restrictions after a landowner renovates or rebuilds on his property, or when s/he changes the use.[62] Furthermore, as explained above, nonconforming uses could only be allowed for a certain period of time, after which they must cease.

Finally, cost and ecological drawbacks of proposed coastal adaptation strategies are necessary considerations when planning coastal adaptation strategies in Capitola. Cost is an important consideration because Capitola is highly developed and much of its vulnerable areas are in private ownership. Some parcels will be more expensive to buyout or pay just compensation for than others. Likewise, buyouts of private property might be less feasible than comparable options involving state or city lands. Property buyouts to facilitate relocation and to promote retreat face similar concerns. Likewise, cost versus long-term benefits of competing coastal adaptation options should be considered. Similarly, the ecological drawbacks of strategies such as beach nourishment should be weighed against their cost and their relatively short-term effectiveness.

---

[58] Governmental taking of private property for public good—as well as regulations that "go too far" and result in "regulatory takings"—are common themes and constant considerations that arise when considering coastal adaptation strategies that require retreat from increasingly dangerous coastlines due to rising seas. Penn Coal Co. v. Mahon, 260 U.S. 393 (1922).

[59] Lucas v. South Carolina Coastal Council, 505 U.S. 1003 (1992).

[60] Tahoe-Sierra Preservation Council, Inc. v. Tahoe Regional Planning Agency, 535 U.S. 302 (2002).

[61] *See, e.g.,* CAPITOLA MUNICIPAL CODE § 17.50.310 ("A structure which was lawful before enactment of this chapter, but which is not in conformity with the provisions of this chapter, may be continued as a nonconforming structure subject to the following condition: if any nonconforming structure is destroyed by flood, earthquake, tsunami or, for another cause to the extent of fifty percent or more of its fair market value immediately prior to the destruction, it shall not be reconstructed except in conformity with the provisions of this chapter.").

[62] Local governments may end nonconforming uses in a variety of ways. Declare nuisance, pay just compensation, or require use to stop after a date certain. CECILY TALBERT BARCLAY & MATTHEW S. GRAY, CALIFORNIA LAND USE & PLANNING LAW 60-61 (2016).

Moss Landing: Coastal Setting

Moss Landing's relatively undeveloped coastline, surrounded by large tracts of farmlands, provides more adaptation options than other more densely populated sections of the coast. The shores surrounding Moss Landing are lined with high dune and sandy beach habitats extending north to Rio Del Mar and south to the edges of the city of Monterey.[63] This area includes many state beaches as well as local beach access points. Sediment for these beaches originates from rivers draining into the Monterey Bay.[64] Just inland of Highway 1, Elkhorn Slough drains the seasonal creeks and rivers that supply water to the surrounding agricultural areas, creating a network of wetlands and estuaries of gradually changing salinity.[65] Within the estuary, eelgrass and salt marsh habitats are prevalent. Much of this area is part of the ESNERR or the California network of Marine Protected Areas. While agriculture often runs up to the boundaries of arable land, most public recreational access to the water is constrained to a few entry points in local parks or at the Moss Landing Harbor.

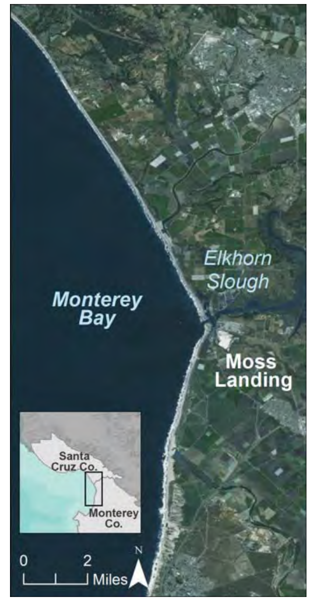


Fig. 7: Satellite image of Moss Landing.

Moss Landing is the center point of the Monterey Bay coastline and is adjacent to diverse natural systems, including extensive wetland habitats in nearby Elkhorn Slough, sand dunes along the open coast, and sandy beaches north and south of the harbor mouth. Along with this connection to multiple natural systems, Moss Landing is a primary commercial and party-boat fishing hub for the central California coast with landing locations for market squid, rockfish, crab, lingcod, groundfish and other fisheries. Moss Landing also functions as a key marine research center due to the confluence of ecosystems and direct access to the deep Monterey Submarine Canyon.[66]

Moss Landing: Protective Role of Habitats

The dune and beach systems starting just north of Moss Landing and continuing south to Monterey play a greater protective role relative to the full study area extent.[67] The orientation of the coastline in the Moss Landing study area, which directly faces predominant incoming waves, is a significant driver of exposure in this region. In addition, coastal geomorphology and low elevation contribute to high exposure index scores in this location, meaning that existing habitats are critical to countering this relatively high exposure to hazards. Model results indicate that the presence of wetlands can reduce wave heights and associated damages to property from storm events. Coastal wetlands are not as effective at reducing erosion in areas of high wave energy.[68] The Moss Landing coastline is a high wave energy environment and the wetlands in this area play a moderate role in reducing coastal exposure to erosion and inundation during storms compared to the large dune

---

[63] *See* Figure 7.
[64] *See* U.S. ARMY CORPS OF ENGINEERS, *supra* note 9.
[65] A key concern in this area is the historic changes in groundwater levels in the Pajaro and Salinas Valleys. These changes are further exacerbated by the effect of saltwater intrusion on highly productive agricultural lands as well as domestic potable water quality.
[66] Monterey Bay Aquarium Research Institute (MBARI) and Moss Landing Marine Labs (MLML) are two primary centers for marine research in the region.
[67] *See* Figure 7.
[68] Gedan, *supra* note 38.

systems. Loss of wetland habitat with rising seas will affect agriculture lands near Moss Landing. These wetland areas are highly exposed to waves mainly due to their large extent and proximity to the coastal zone.

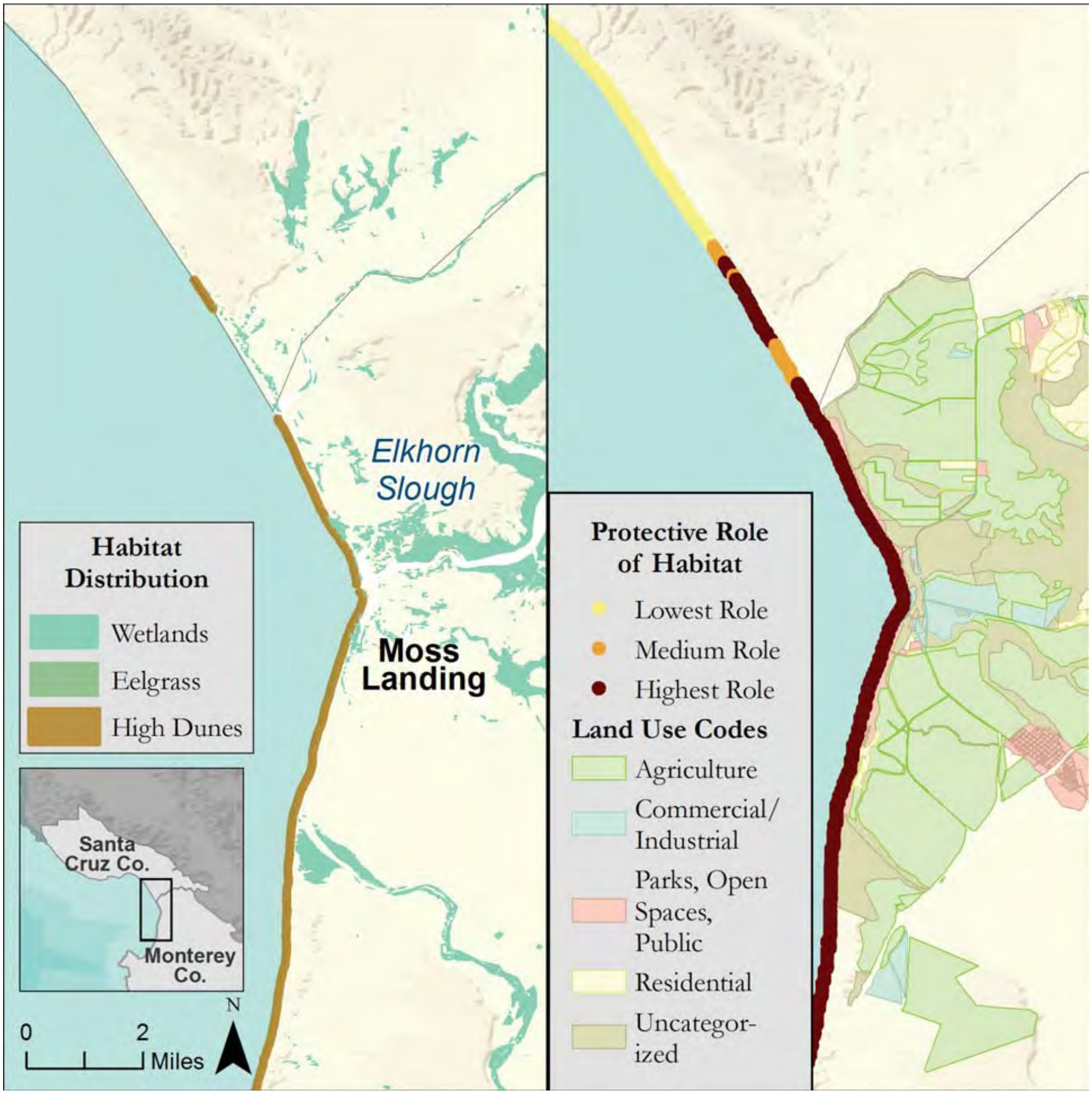


Fig. 7: Coastal habitats around Moss Landing, CA (Left). The relative role of coastal habitats near the mouth of Elkhorn Slough in reducing exposure to erosion and inundation with relevant land use zoning information (Right). Zoning information was distilled using the same methodology used for Capitola (Fig. 5).

Moss Landing: Ecosystem Services of Coastal Habitats

Coastal Dune and Beach Systems

The relatively dry areas on the high beach behind dunes are sheltered from wind and spray, serving as nesting grounds for endemic shorebirds and haul out spots for marine mammals. These beaches provide opportunities for coastal recreation, fishing, and wildlife viewing in the surrounding area in addition to their role protecting the coastline from high energy waves.

Elkhorn Slough

The estuarine system of Elkhorn Slough is the largest marsh habitat in California outside of San Francisco Bay and provides critical habitat for shorebirds and fishes. This area has also been home to a suite of competing human uses for more than 150 years (e.g., agriculture, cattle grazing, railroad and road construction, fishing, municipal energy production, marine research, tourism, recreation) that have led to the historical development of engineered structures (e.g., levees, embankments) and the construction of Moss Landing Harbor at the mouth of the estuary. These engineered structures have significantly influenced the structure and function of the estuarine system.[69] While the wetland systems in Elkhorn Slough are an ecologically and economically important feature of the area, they are also at risk due to a squeeze between rising sea levels and little room to migrate inland.[70]

Wetland habitats provide a number of key ecosystem services beyond coastal protection, including carbon sequestration, water quality improvement, flood abatement and biodiversity support.[71] The sheltered estuarine waters and seagrass meadows within the slough serve as a nursery for juveniles of commercially important fish species.[72] Elkhorn Slough is one of the few remaining freshwater and saltwater resting stops on the Pacific flyway. The slough is a critical habitat for migratory bird species and was designated a globally important bird area in 2000.[73] The banks of the Slough also serve as a major haul out area for marine mammals.

Additionally, wetland habitats store large amounts of carbon in their submerged soils when kept intact and have the potential to be used for carbon sequestration on the scale of decades or longer.[74] On a more immediate time scale, coastal vegetation helps buffer against ocean acidification by removing carbon dioxide from the water.[75] As larval fish and invertebrates experience more harmful effects from acidifying water conditions than adults, the wetlands and marshes of Elkhorn Slough may aid in protecting important species from harmful water chemistry in addition to protecting them from predators.[76]

---

[69] Eric Van Dyke & Kerstin Wasson, *Historical Ecology of a Central California Estuary*: *150 Years of Habitat Change* 28 ESTUARIES 173, 179 (2005); *see also* CHANGES IN A CALIFORNIA ESTUARY: A PROFILE OF ELKHORN SLOUGH (Jane Caffrey et al. eds., 2002).

[70] Kerstin Wasson et al., *Ecotones as Indicators of Changing Environmental Conditions: Rapid Migration of Salt Marsh–Upland Boundaries* 36 ESTUARIES AND COASTS 654 (2013).

[71] WORLD RESOURCES INSTITUTE, ECOSYSTEMS AND HUMAN WELL-BEING: WETLANDS AND WATER SYNTHESIS (2005) (a report of the Millennium Ecosystem Assessment).

[72] Michael Beck et al., *The identification, conservation, and management of estuarine and marine nurseries for fish and invertebrates* 51 BIOSCIENCE 633 (2001).

[73] CHANGES IN A CALIFORNIA ESTUARY: A PROFILE OF ELKHORN SLOUGH, *supra* note 23.

[74] Cloern et al., *supra* note 24; McLeod, *supra* note 49.

[75] Hendriks, *supra* note 26.

[76] Haruko Kurihara, *Effects of CO2-driven ocean acidification on the early developmental stages of invertebrates* 373 MARINE ECOLOGY PROGRESS SERIES 275 (2008); Philip Munday et al., *Replenishment of fish populations is threatened*

Wetland habitats are threatened in the Elkhorn Slough area—and throughout the state—due to increased erosion from rising sea levels and land use development (agricultural, urban and/or rural). Fertilizer from agricultural runoff contributes to eutrophication and massive algal blooms that smother native flora, while urban pollutants may impair water quality.[77] Wetlands and coastal dunes that are exposed to coastal hazards could potentially migrate upslope given a path free of barriers from coastal development or shoreline hardening.

Moss Landing: Adaptation Strategies & Considerations

Coastal Adaptation Options

Moss Landing's coastline lends itself to several nature-based adaptation strategies. For instance, because the dunes in the area play a large role in protecting Moss Landing's coastline, adaptation strategies that protect, restore and enhance these areas could be targeted to maintain the integrity of the area. A dune restoration and enhancement project currently provides protection for MBARI. Additional suitable areas for dune restoration in Moss Landing could be identified and prioritized based on the protective role of specific dune habitats as well as factors specifically relevant to the local planning community. Beach nourishment might also be used to stem beach loss and to buffer these important dunes from erosion. Wetland restoration is another nature-based solution possible for Moss Landing. Wetland restoration in the area would carry various possible co-benefits including: sequestration of carbon dioxide, maintaining these areas as corridors for gradual coastline retreat and providing protection against storm surges.

Other nature-based options might be suitable here as well. Conservation easements could be implemented in some of these areas, particularly those most vulnerable to rising seas. This strategy involves either paying a landowner not to develop vulnerable land, or the landowner agreeing to do so without compensation, or in exchange for some other incentive, such as a tax break. This strategy would ensure that undeveloped lands stay undeveloped, and it could help transition currently developed but threatened lands to undeveloped lands. Rolling easements are another attractive but controversial option.[78] These can be used to allow the sea to migrate inland while slowly requiring the removal of structures within some distance of the approaching sea.[79]

In addition to the nature-based options outlined above, Moss Landing's coastline might also be suitable for other coastal adaptation strategies. For instance, accommodation and armoring might be appropriate for Moss Landing because it features a number of coastal dependent structures, such as the Monterey Bay Aquarium Research Institute, the Moss Landing Marine Laboratories, the Moss Landing power plant, and various boating and fishing facilities. Any of these structures might be protected or raised, depending on building design and construction, the anticipated

---

by ocean acidification 107 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCE OF THE UNITED STATES OF AMERICA 12930 (2010).

[77] Brent Hughes et al., *Recovery of a top predator mediates negative eutrophic effects on seagrass* 111 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES 36444 (2014).

[78] *See generally* Meg Caldwell & Craig Holt Segall, *No Day at the Beach: Sea Level Rise, Ecosystem Loss, and Public Access Along the California Coast*, 34 ECOLOGY L.Q. 533, 535 (2007) (explaining that a rolling easement is "a device, rooted in statutory or common law or in permit conditions, that allows the publicly owned tidelands to migrate inland as the sea rises, thereby preserving ecosystem structure and function.").

[79] JAMES G. TITUS, ROLLING EASEMENTS (2011) *available at* https://www.epa.gov/sites/production/files/documents/rollingeasementsprimer.pdf.

building life cycle, end of use, and planned deconstruction. Furthermore, because of the various coastal-dependent buildings in the area, moveable structures could be installed and moved as needed in order to keep these structures on the coast as needed.

Other options can be pursued for undeveloped parcels in the area and existing structures that are not coastal dependent. Highway 1 could be moved inland or raised.[80] As was discussed for Capitola, an overlay zone could provide notice to the owners of vulnerable properties and restrict building and redevelopment in the area, as deemed appropriate. Furthermore, a moratorium on development could be imposed for some certain time period, while proactive coastal planning is pursued.

Moss Landing has a large amount of surrounding undeveloped and agricultural land.[81] Accordingly, some of these open spaces may be appropriate, stable sites for managed retreat of buildings in the area. Buyouts might be necessary in certain areas where planning is not able to sufficiently address increasingly rising seas.[82] Transfers of development rights might also be appropriate in certain similar circumstances.[83]

Barriers and Considerations

This area of the coastline is dominated by water, protected areas and sensitive ecosystems. The abundance of seawater and wetland areas might pose challenges for coastal adaptation for several reasons. For instance, the abundance of inland waterways and wetlands means that there is not much land immediately upland to move vulnerable buildings via managed retreat. Additionally, while this area features many coastal dependent facilities that might be protected or raised, there are drawbacks to pursuing these strategies. For instance, raising structures might bring additional regulatory requirements, such as those imposed by the Americans with Disabilities Act.[84]

Developing coastal adaptation strategies for coastal dependent structures carries with it its own set of unique challenges. Coastal dependent structures are prioritized for coastal land use under the Coastal Act.[85] Coastal dependent structures are not a high priority to move upland because of their dependence on water, but they need to be protected from rising seas nonetheless. Leaving these coastal dependent assets where they are makes them more susceptible to massive storm events than slowly rising seas. However, protecting these structures by armoring with seawalls would exacerbate erosion around these protective structures. If these coastal dependent structures are armored in the short term, long-term plans should be made to remove the armoring and move the structures.

Moving or raising Highway 1 presents issues as well. While raising Highway 1 in place is a possible short-term solution, Highway 1 may eventually need to be moved inland due to rising seas and repeated storm events. Moving Highway 1 immediately landward of its current location also presents drawbacks. Inland relocation would put it right in the middle of protected areas such

[80] The issues with this proposition are discussed *infra* in the Barriers and Considerations section.
[81] *See* Figure 7.
[82] *See, e.g.*, New York's Recreate NY Smart Home Buyout Program.
[83] *See, e.g.,* Penn Central Transportation Co. v. New York City, 438 U.S. 104 (1978).
[84] 42 U.S.C. §§12101-12213.
[85] CAL. PUB. RES. CODE §§ 30235 & 30255.

as Elkhorn Slough[86] and could restrict coastal access.[87] Moving Highway 1 would also require CalTrans to exercise its eminent domain authority, which can be controversial. Finally, moving Highway 1 to upland areas, such as those currently used for agriculture, will introduce additional complexities because of how these lands are currently prioritized in the current LCP.[88]

Managed retreat faces several challenges in this area. While Moss Landing is surrounded by open area, much of the region comprises wetlands or otherwise sensitive or protected areas. For instance, the area features Elkhorn Slough State Marine Conservation Area, Elkhorn Slough State Marine Reserve, Moro Cojo Slough State Marine Reserve, Moss Landing State Beach, and the Moss Landing Wildlife Area. The abundance of state lands and conservation lands creates challenges for managed retreat. On the other hand, public and open spaces might be well-suited for conservation easements such that they are set aside to become inundated and form new wetland and marsh areas. Section 30240 of the Coastal Act protects environmentally sensitive habitat areas (ESHAs), and further complicates using any of the areas surrounding these protected areas in Moss Landing for managed retreat.[89]

Another issue is possible challenges to zoning changes in the area. Property owners affected by new regulations sometimes claim that these regulations impermissibly "take" their property without just compensation. As was the case for Capitola, local governments should be weary of enacting regulations that possibly deprive property of all of its economic value and of instituting moratoria that do not specify end dates.

<u>Summary</u>

Communities in the Monterey Bay region, like many areas of California and the nation, are actively planning for a changing climate. Rising sea levels and increasingly damaging storm events are expected to cause increased erosion and inundation, which will further threaten people, property, infrastructure and coastal habitats. If these habitats are lost, degraded or unable to adapt by migrating inland, then local communities also lose the beneficial services they provide, including carbon sequestration, improving water quality, buffering ocean chemistry, providing nursery or nesting grounds, and protecting from erosion and inundation.

Proactive adaptation planning that takes into account the role of coastal habitats—coupled with advanced construction designs and technologies—and policy pathways for implementation, will allow local communities to proceed from planning to implementation more effectively. Ultimately, this approach—in concert with similar coastal adaptation decisions throughout California—can lead to coastal management processes that are consistent for statewide needs and flexible for local needs while ensuring a vibrant coastline for future generations.

[86] *See* list of protected areas in region *supra* note 15.
[87] The Coastal Act seeks to protect and maximize public coastal access. CAL PUB. RES. CODE. § 30211.
[88] MONTEREY COUNTY, NORTH COUNTY LAND USE PLAN 45-49 (1982).
[89] CAL. PUB. RES. CODE § 30240.

Habitat Type	Relative Protective Role*	Protective Attributes	Additional Ecosystem Services	Management Options
Kelp Forests	Relatively Low Role	Kelp forests attenuate low-energy wave action and have a dimished protective role as wave power increases.	Habitat for commercially viable fish and invertebrate species	Maintain healthy water conditions for kelp growth and reproduction.
			Vegetation harvested for commercial abalone aquaculture	
			Nutrient and vegetation export to local beach ecosystems	
			Integral ecosystem for culturally important species	
Wetlands	Relatively Moderate Role	Wetland ecosystems absorb water to reduce inundation and also serve to dissipate wave energy.	Flood control from inland inundation	Consider conservation of key areas of vegetation and soils before allowing development.
			Nutrient and sediment retention for improved water quality	
			Habitat for diverse species including marine mammals	Provide space for habitat to migrate inland as sea level rises.
			Carbon sequestration	
Seagrass	Relatively Low Role	Eelgrass beds attenuate low-energy waves which help decrease erosion of loose soils.	Wave attenuation	Provide space for habitat to migrate inland as sea level rises.
			pH buffer	Conserve existing habitat and restore damaged submerged aquatic vegetation.
			Nursery and essential habitat for fish and invertebrate species	
			Carbon sequestration	Maintain healthy water conditions and limit habitat degradation.
High Dune Systems**	Relatively High Role	Large dune systems dissipate high-energy waves and resist runup from powerful storms.	Cultural and aesthetic attachment	Maintain dune structure and vegetation.
			Location for recreation	
			Habitat for important bird and plant species	Regulate and/or limit dune sediment extraction.
Low Dunes & Beaches**	Relatively Moderate to High Role	Low dune systems and beaches dissipate low and moderate energy waves.	Habitat for important bird and plant species	Limit the implementation of built structures that impede migration of beach systems.
			Location for recreation	
			Cultural and aesthetic attachment	Maintain beach structure and access to continued sediment supply.

Table 1: Compilation of Ecosystem Services

*Protective role is based on model outputs created for and relative to the full study area (Año Nuevo to Wharf 2).
**Dunes were classified as “high dune” if their crest was higher than five meters. High dunes are less likely to lead to overwash and inundation from coastal storms.

Adaptation Strategy	Definition*	Example**	Potential Applications	Role of Natural System
Protection: *Hold the Line*	Employ built measure to defend development in current location	Wetland Restoration	Elkhorn Slough; northern section of Moss Landing Harbor; potentially in creeks near Capitola	Enhances extent of ecologically important natural areas
		Dune Restoration	North and south of Moss Landing on outer coast; southern Monterey Bay	Enhances extent of ecologically important natural areas
		Beach Nourishment	Soquel Creek Lagoon; outer coast of Moss Landing	Adds to natural system; requires thorough environmental monitoring
		Hard Protection	Near coastal-dependant or critical infrastructure such as power plant or critical transportation routes	Often limits natural habitat migration and increases erosion at edges of armoring
Accommodation: *Adjust to the line*	Modify existing or new development to decrease hazard risks	Overlay Zones	Existing flood zones or areas expected to be impacted by rising sea levels	N/A
		Limit Redevelopment	Locations that encounter repetitive loss or in (newly delineated) sea level rise overlay zones	May facilitate migration of natural systems or allow them to reestablish themselves
		Mobile Structures	Structures that are location dependent yet also encounter large episodic flood events	N/A
		Conservation Easement	Open and undeveloped areas in existing flood plain and areas adjacent to flood plains	Keeps natural system intact
Retreat: *Get away from the line*	Relocate existing development out of hazard areas and/or limit construction of new development in vulnerable areas	Planned Retreat	Highly vulnerable areas or locations with suitable upland areas available nearby	Removes structures allowing corridor for habitats to naturally migrate inland
		Buyout Programs	Lands suitable for becoming open areas	Can help promote natural system to replace previously developed area
Hybrid: *Maintain a flexible line*	Using strategies from multiple categories that may need to change over time	Accommodate over short term; relocate over long term	Hybrid adaptation options could be designed with enough flexibility to be applied across many different areas as needed	Provides pathway for taking actions that allow habitat to migrate and may provide opportunities for nature-based solutions
		Update land use designations and zoning ordinances		
		Redevelopment restrictions		
		Permit conditions		

Table 2: Compilation of Adaptation Strategies

* Definitions of adaptation strategies are distilled explanations derived from chapter seven of the California Coastal Commission's Sea Level Rise Guidance (Guidance).

** Many examples are summarized descriptions from figure 17 of the Guidance.

Analysis, Methodology, and Assumptions

This assessment involved a combination of ecosystem service modeling and adaptation policy research in an effort to identify and map priority locations for nature-based strategies that reduce vulnerability of critical assets using feasible land use policy methods.

To map and value the goods and services from natural habitats, we used the InVEST (Integrated Valuation of Environmental Services and Tradeoffs) free and open-source suite of software models created by the Natural Capital Project at Stanford University. The InVEST Coastal Vulnerability model incorporates a scenario-based approach to evaluate the role of natural habitats in reducing exposure to coastal impacts. [90] The InVEST Coastal Vulnerability model produces a qualitative estimate of coastal exposure. The Exposure Index differentiates areas with relatively high or low exposure to erosion and inundation during storms.

Data inputs included: 1) **Geomorphology**: Polyline representing coastal geomorphology based on the National Oceanic and Atmospheric Administration (NOAA) Environmental Sensitivity Index; 2) **Coastal habitat**: Polygons representing the location of natural habitats (e.g., seagrass, kelp, wetlands, etc.) from the Department of Fish and Wildlife website created for Marine Life Protection Act process; 3) **Wind and wave exposure**: Point shapefile containing values of observed storm wind speed and wave power across an area of interest using Wave Watch III data provided by NOAA; 4) **Surge potential**: Depth contour that can be used as an indicator for surge level default contour is the edge of the continental shelf. In general, the longer the distance between the coastline and the edge of the continental shelf at a given area during a given storm, the higher the storm surge; 5) **Relief**: A digital elevation model (DEM) representing the topography and (optionally) the bathymetry of the coastal area—this analysis includes a five meter bathymetric and topographic merge from US Geologic Survey for the California coast; 6) **Sea-level rise**: Rates of (projected) net sea-level change derived from the National Research Council 2012 report (highest range for 2030: 12" of sea level change);[91] 7) **Hard Armoring**: Data set inventory of man-made structures and natural coastal barriers that have the potential to retain sandy beach area in California. This armoring dataset is a compilation of the UC Santa Cruz Sand Retention Structures, Monterey County Barriers, and US Army Corps of Engineers Coastal Structures.

One main limitation with this modeling approach is that the dynamic interactions of complex coastal processes occurring in a region are overly simplified into the geometric mean of seven variables and exposure categories. InVEST does not model storm surge or wave field in nearshore regions. More importantly, the model does not take into account the amount and quality of habitats, and it does not quantify the role of habitats for reducing coastal hazards. Also, the model does not consider any hydrodynamic or sediment transport processes: it has been assumed that regions that belong to the same broad geomorphic exposure class behave in a similar way. In addition, using this model we assume that natural habitats provide protection to regions that are protected against erosion independent of their geomorphology classification (e.g., rocky cliffs). This limitation artificially deflates the relative vulnerability of these regions, and inflates the relative vulnerability

---

[90] INTEGRATED VALUATION OF ECOSYSTEM SERVICES AND TRADEOFFS, http://www.naturalcapitalproject.org/models/coastal_vulnerability.html (last visited Aug. 30, 2016).

[91] NATIONAL RESEARCH COUNCIL (NRC) COMMITTEE ON SEA LEVEL RISE IN CALIFORNIA, OREGON, AND WASHINGTON, SEA-LEVEL RISE FOR THE COASTS OF CALIFORNIA, OREGON, AND WASHINGTON: PAST, PRESENT, AND FUTURE (2012).

of regions that have a high geomorphic index. Based on these limitations and assumptions, the InVEST Coastal Vulnerability tool is an informative approach to investigate *relative exposure* for a coastline and identify locations where coastal habitats play a relatively significant role in reducing exposure. However, for local scale decisions regarding locally specific geomorphic conditions, further analysis is needed (e.g., the InVEST Nearshore Wave and Erosion model).

Results can help evaluate tradeoffs between climate adaptation strategy approaches. In this assessment, we compared the InVEST Exposure Index results both with and without the protective services provided by natural habitats. This approach (computing the difference between exposure indices) provides a priority index for locations in which coastal habitats play the largest relative role in reducing exposure to erosion and inundation. These locations can then be further investigated for nature-based strategies to reduce vulnerability.

We began our policy research by exploring academic and practitioner guidance on potentially appropriate coastal adaptation strategies for sea-level rise. We reviewed a number of guidance documents that outline land use planning and regulatory options that should be considered in coastal areas. Next, we identified how priority or high-risk locations align with various land-use or zoning designations in Monterey and Santa Cruz Counties using land use zoning layers provided by Monterey and Santa Cruz Counties as well as from planning staff from the City of Capitola. The zoning designations and population density in the various high-risk areas guided our determination of the strategies most feasible in each location. For example, high-density zoning designations—in most cases—reduce the feasibility of habitat restoration or retreat options. We also researched relevant state- and county-level laws and policies on acceptable strategies for near- and long-term adaptation to rising sea levels. We identified the limitations these policies place on adaptation options in the Monterey Bay Region and explored potential changes to the existing policies that may increase adaptive capacity. Ultimately, these prioritized policy considerations may be relevant to both Santa Cruz and Monterey Counties—as well as local jurisdictions—through the development of the Local Coastal Program update process.

In addition to this specific engagement in the Monterey Bay Region, the Center for Ocean Solutions is also involved in Local Coastal Program updates throughout the state. The Center is playing a key role in compiling, distilling, and distributing information on incremental adaptation actions with current county partners (i.e., Sonoma, Marin, Santa Cruz, and Monterey Counties) as well as with the State Coastal Conservancy and California Coastal Commission through the development of the California Coastal Adaptation Network. By developing a transferable methodology that incorporates the role of natural capital into county-level coastal adaptation planning, the Center for Ocean Solutions is scaling these best practices to a statewide prioritization of adaptation strategies that preserve the integrity of natural systems. The Center's work advances the state's efforts for flexible consistency in accordance with the California Coastal Commission's Sea Level Rise Policy Guidance.

Appendix B.

Climate Change Impacts to Combined Fluvial and Coastal Hazards (ESA, 2016)

MONTEREY BAY SEA LEVEL RISE

Climate Change Impacts to Combined Fluvial and Coastal Hazards

Prepared for
Moss Landing Marine Labs with Funding from the
California Ocean Protection Council

May 13, 2016

ESA

MONTEREY BAY SEA LEVEL RISE

Climate Change Impacts to Combined Fluvial and Coastal Hazards

Prepared for
Moss Landing Marine Labs with Funding from the
California Ocean Protection Council

May 13, 2016

ESA

550 Kearny Street
Suite 800
San Francisco, CA 94108
415.262.2338
www.esassoc.com

Los Angeles

Oakland

Olympia

Petaluma

Portland

San Francisco

San Diego

Seattle

Tampa

Woodland Hills

D130523.00

ESA

TABLE OF CONTENTS

Page

1 Introduction 1

2 Climate Analysis 3

2.1 Emissions Scenarios 3
2.2 Extreme Fluvial Streamflow Analysis 4
2.3 Extreme Coastal Water Level Analysis 10

2.3.1 Reclamation Ditch Extreme Tide Levels 10
2.3.2 Soquel Creek Extreme Tide Levels 10

3 Hydraulic and Hydrodynamic Modeling Analysis 12

3.1 Reclamation Ditch Unsteady Modeling 12

3.1.1 Model Geometry Development 12
3.1.2 Model Hydrology Inputs 14
3.1.3 Model Validation 14
3.1.4 Model Limitations 15

3.2 Soquel Creek Steady State Modeling 16

3.2.1 Model Geometry Development 16
3.2.2 Model Hydrology Inputs 18
3.2.3 Model Limitations 18

4 Model Results and Flood Hazard Mapping 19

5 Discussion 22

6 References 23

7 List of Preparers 24

8 Disclaimer and Use REstrictions 25

List Of Tables

Table 1 Subsets for Time Periods Used in Flood Frequency Analysis 4
Table 2 Change in 100-year Discharge for Both Systems RElative to Historic Period (1950-2000) 9
Table 3 Extreme Tide Conditions for Reclamation Ditch System 10
Table 4 Coastal Storm Surge and Wave Setup for Events on Soquel and Aptos Creeks 11

List of Figures

Figure 1. Comparison between SRES and RCP emissions scenarios. Reproduced from Figure 1-4 of IPCC AR5, WGII, Chapter 1 3
Figure 2. Log Pearson III flood frequency curve for historic time period (1950-2000) for GCM ACCESS 1-0 for the RCP4.5 emissions scenario. The black dots show peak annual flow from routed GCM hydrology, the blue line shows the fitted LP-III curve, and the red lines show the 95- and 5-percent confidence intervals. 5
Figure 3. Percent change in peak annual flow relative to 1950-2000 average for all GCMs under RCP 4.5 emissions, blue lines show individual GCM trajectories and blue dots show result at year 2030 (top), and (bottom) histogram of total number of models for given ranges of percent change in peak annual flow 6
Figure 4. Distribution of change in Q_{100} for each GCM for 2030, 2060, and 2100 for RCP 4.5 on the Reclamation Ditch System 7
Figure 5. Distribution of change in Q_{100} for each GCM for 2030, 2060, and 2100 for RCP 8.5 on the Reclamation Ditch 8
Figure 6. Distribution of change in Q_{100} for each GCM for 2030, 2060, and 2100 for RCP 4.5 on Soquel Creek 8
Figure 7. Distribution of change in Q_{100} for each GCM for 2030, 2060, and 2100 for RCP 8.5 on Soquel Creek 9
Figure 8. Reclamation Ditch hydraulic model layout 13
Figure 9. Comparison of Modeled 100-year flowpaths and observed flowpaths during December 2014 flood 15
Figure 10. Soquel Creek hydraulic model layout 17
Figure 11. Flood inundation hazard maps for multiple climate scenarios on the Reclamation Ditch system19
Figure 12. Flood inundation hazard maps for multiple climate scenarios on Soquel Creek 20

1 INTRODUCTION

As part of the Sea Level Rise study for the Monterey County Local Coastal Program (LCP) ESA simulated and mapped the potential inundation from extreme coastal and fluvial conditions for multiple scenarios of future climate conditions. Two fluvial systems were analyzed for this effort (1) the Reclamation Ditch watershed which includes Gabilan Creek and Tembladero Slough the and drains to the Moss Landing Harbor, and (2) Soquel Creek which runs through the City of Capitola in Santa Cruz County. The Reclamation Ditch watershed is mostly agricultural while the lower reaches on Soquel Creek are mostly urbanized. These two systems were selected to enable risk assessment for a range of natural and manmade resources.

Climate data analysis was conducted to evaluate future extreme rainfall-runoff events and extreme coastal tide and wave events. For the rainfall-runoff and fluvial climate change analysis ESA used public climate model data to develop medium and high estimates of 100-year discharge for 2030, 2060, and 2100 time periods. ESA also developed estimates of extreme tide conditions with sea level rise for medium and high climate change scenarios for the three future periods. The flood levels and extents were then estimated for these scenarios using hydraulic modeling driven by combined watershed and coastal water level conditions under climate stress.

The study developed geospatial datasets for the extent and depth of inundation under flooding for existing conditions and future climate scenarios. The key products and findings for this study include:

- **Key products developed**
    - GIS layers of flood inundation extent for the Moss Landing Harbor and surrounding areas, and Soquel Creek in Capitola, for six scenarios (1) existing conditions 100-year flood, (2) future conditions 100-year flood under high emissions for 2030, (3 and 4) medium and high emissions for 2060, and (5 and 6) medium and high emissions for 2100.
    - GIS depth rasters for both systems and the six scenarios listed above.
    - Amendments to previously developed coastal flooding layers based on newly surveyed structural information in flooded areas in Monterey Bay.
    - Technical metadata and reporting contained herein
- **Key analysis findings**
    - Analysis of existing hydrologic climate data indicates an increase in peak flow for the 100-year discharge of 337 cfs (25%) for high emissions by 2100 on the Reclamation

Ditch system and by 1660 cfs (95%) for Soquel Creek for the same emissions and time horizon scenario.

- Analysis of existing sea level rise trends and anticipated coastal flood levels indicate an increase in downstream water level of 5.2 ft for high emissions by 2100.
- As anticipated the increase in rainfall intensity and 100-year discharge combined with the increase in sea level under climate change increases flood extent on both systems. In comparing the 100-year event under existing conditions with the year 2100 high-emissions scenario, the increase in flood extent for the Reclamation Ditch system is approximately 1736 acres (95%) and the change in flood depth is approximately 2.6 feet (36%). The same comparison for Soquel Creek, which is more topographically constrained, shows a total increase in flood extent of 65 acres (65%) and an increase in flood depth of 3.01 feet (29%).

The following four report sections lay out the technical analysis methodologies, flood hazard mapping results, and applications for the resulting information in planning and adaptation assessments. Specifically Section 2 describes the climate analysis conducted to develop boundary conditions for the hydraulic model for several scenarios representing change in 100-year discharge due to increased precipitation intensity and depth with climate change and the change in extreme ocean level coincident with the 100-year flow. Section 3 describes the model development process for both the Reclamation Ditch and Soquel Creek systems. Section 4 summarizes the flood hazard mapping analysis conducted to develop the geospatial datasets of flood hazard for the climate scenarios analyzed. Section 5 summarizes the applicability of the datasets to planning and adaptation efforts for the communities that may be at risk of additional flooding under stress by climate change.

2 CLIMATE ANALYSIS

2.1 Emissions Scenarios

The goal of the climate change data analysis was to review existing climate model data to estimate changes in extreme rainfall, coastal water level, and the resulting extent of flood hazards. The changes in extreme rainfall conditions were used to drive the inflow boundary for the hydraulic models of the two systems. Climate model data were evaluated for the latest set of General Circulation Models (GCMs) developed for the IPCC's fifth Assessment Report (AR5). The GCM data produced for AR5 has been aggregated by the World Climate Research Programme under the Coupled Model Intercomparison Project Phase 5 (CMIP5). The emissions scenarios used to drive the GCMs for CMIP5 are referred to as Representative Concentration Pathways (RCPs). The highest scenario, RCP 8.5, reflects a track with little mitigative measures to reduce greenhouse gas emissions resulting in a net increase in radiative forcing of 8.5 W/m^2 by 2100 relative to pre-industrial conditions. A medium level emissions scenario, RCP 4.5, reflects a future wherein changes in technology and energy usage stabilize the increase in net radiative forcing to 4.5 W/m^2 by 2100. These emissions scenarios, RCP 4.5 and RCP 8.5, were used to reflect respectively medium and high emissions trajectories for this study. Existing conditions was also modeled which is representative of a low emissions scenario thus the scenarios selected effectively span low, medium, and high climate change conditions.

These emissions scenarios supersede the scenarios developed in the Special Report on Emissions Scenario (SRES) utilized for the IPCC's fourth Assessment Report (AR4) and used to drive GCMs for CMIP Phase 3 (CMIP3). In general, the RCP4.5 emissions scenario tracks closely with the prior SRES B1 scenario, while RCP8.5 tracks slightly above SRES A2. The following figure (Figure 1) compares the change in mean surface temperature for the SRES and RCP emissions scenarios.

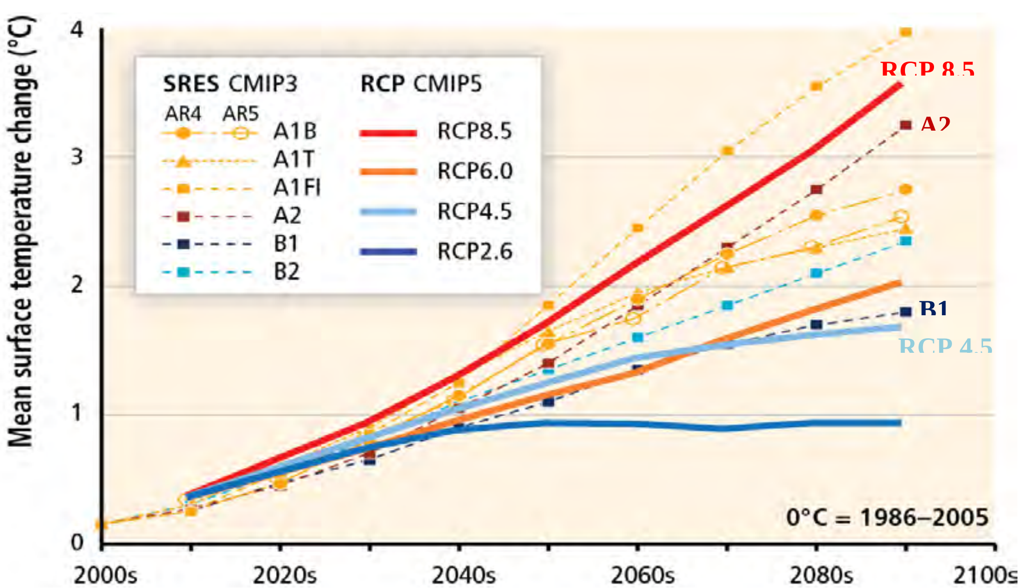


Figure 1. Comparison between SRES and RCP emissions scenarios. Reproduced from Figure 1-4 of IPCC AR5, WGII, Chapter 1

2.2 Extreme Fluvial Streamflow Analysis

Model output from GCMs driven by the RCP emissions scenarios was downscaled by CMIP5 institutions to regionalize the data from a global scale to higher resolution local scale. The downscaled data were then used to drive hydrologic models and estimate runoff for a daily timestep on a 12km x 12km grid from 1950-2100 in a study conducted by the USBR (2014). ESA used the resulting data from the USBR study to route baseflow and surface runoff and generate a time series of daily streamflow at the outlet of the two systems. The routing routine used is a component of the Variable Infiltration Capacity (VIC) model used in the USBR study to develop the runoff datasets.

The resulting daily streamflow time series from 1950-2100 was used to conduct flood frequency analysis to estimate 100-year discharge (Q_{100}) for medium and high emissions for 2030, 2060, and 2100. From the daily time series, peak annual flows were extracted for each year from 1950- 2100. A frequency curve was then fit to subsets of the peak annual flows using the Log Pearson III (LP-III) fitting method outlined in the USGSs Bulletin 17b (USGS, 1982). The USGS conducted a 2011 study updating many of the elements of Bulletin 17b based on updated gage records through water year 2006 for California gages (USGS, 2011). Two significant elements that were updated were the methods for estimating values for generalized skew (G_{gen}) and mean square error for generalized skew (MSE-G_{gen}) based on the average elevation of the basin. The average elevation of the basin is 479 feet for the Reclamation Ditch system and 1,141 feet for Soquel Creek. Based on the non-linear model for G_{gen} and the relationship between MSE-G_{gen} and average basin elevation summarized in USGS, 2011 Tables 7 and 8 respectively, the values estimated for G_{gen} and MSE-G_{gen} for the Reclamation Ditch watershed are -0.613 and 0.14, respectively, and -0.581 and 0.14 respectively for Soquel Creek.

Using these updated values in the LP-III method, we computed 100-year discharge for each GCM and each emissions scenario for an historical period, and three future time periods—2030, 2060 and 2100. A sample figure for the flood frequency curve for the historic time period for a single GCM for RCP4.5 is shown in Figure 2. Subsets of the data were selected for the time periods as summarized in Table 1.

TABLE 1
SUBSETS FOR TIME PERIODS USED IN FLOOD FREQUENCY ANALYSIS

Time period	Years for which peak annual flow was used in flood frequency analysis	Emissions scenario	GCM percentile	Resulting 100-year flow variable
2030	2015-2045	RCP 4.5 (medium)	50^{th}	Q_{100}-2030-medium
		RCP 8.5 (high)	90^{th}	Q_{100}-2030-high
2060	2045-2075	RCP 4.5 (medium)	50^{th}	Q_{100}-2060-medium
		RCP 8.5 (high)	90^{th}	Q_{100}-2060-high
2100	2070-2100	RCP 4.5 (medium)	50^{th}	Q_{100}-2100-medium
		RCP 8.5 (high)	90^{th}	Q_{100}-2100-high

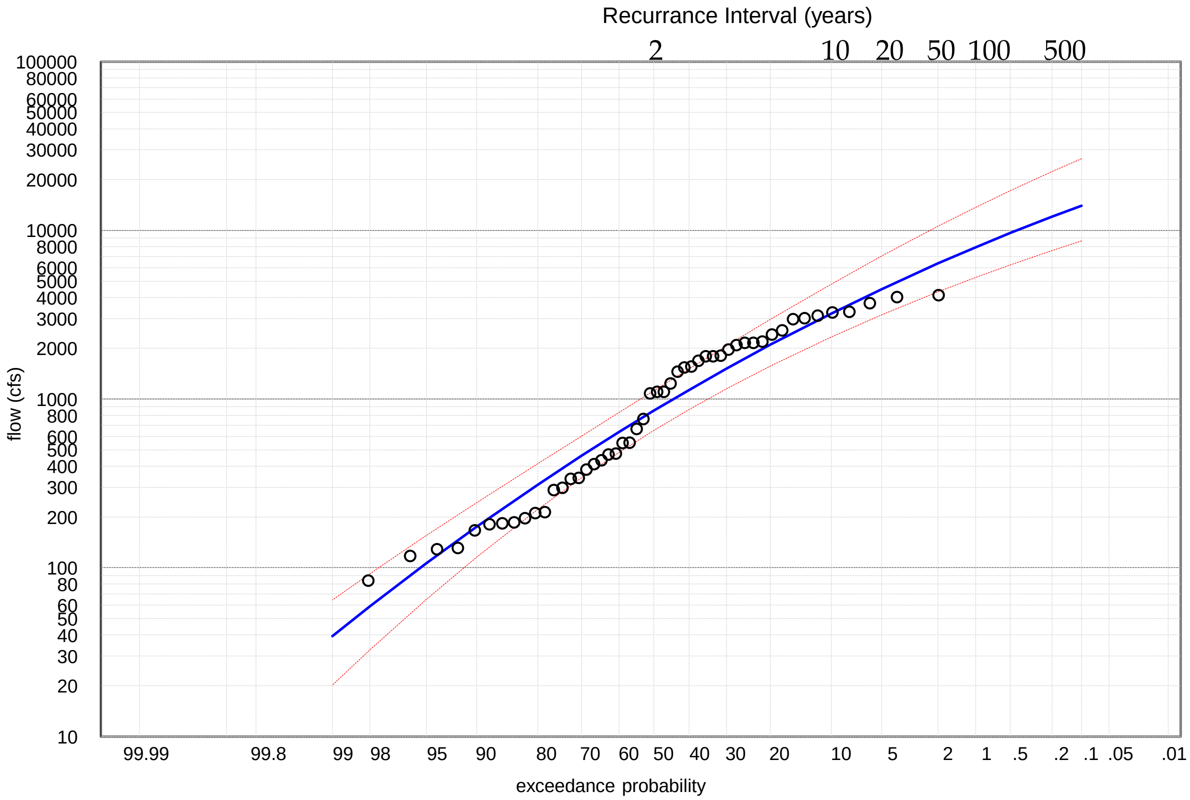


Figure 2. Log Pearson III flood frequency curve for historic time period (1950-2000) for GCM ACCESS[1] 1-0 for the RCP4.5 emissions scenario. The black dots show peak annual flow from routed GCM hydrology, the blue line shows the fitted LP-III curve, and the red lines show the 95- and 5-percent confidence intervals.

Because this analysis was conducted for each individual GCM, a distribution of GCMs can be created. The distribution highlights the discrepancy between individual models and the need to select a representative percentile for characterizing climate risk on any system. An example of the distribution of all models considered for a single emissions scenario and selected percentiles within the model distribution is shown for change in peak annual flow in Figure 3.

[1] Australian Community Climate and Earth-System Simulator (ACCESS)

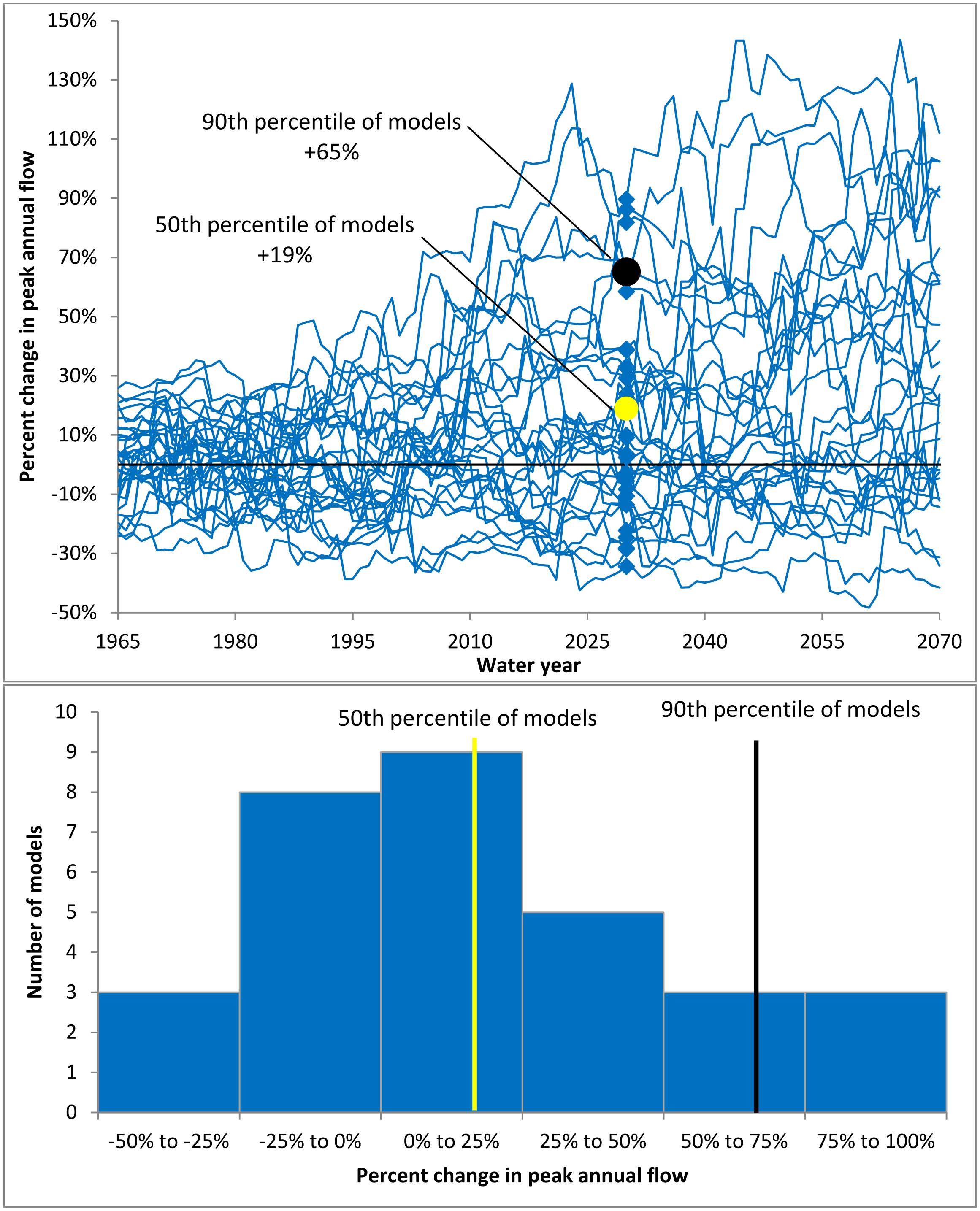


Figure 3. Percent change in peak annual flow relative to 1950-2000 average for all GCMs under RCP 4.5 emissions, blue lines show individual GCM trajectories and blue dots show result at year 2030 (top), and (bottom) histogram of total number of models for given ranges of percent change in peak annual flow

The 100-year discharge and the change in 100-year discharge for the three future time periods relative to the historic time period was calculated for each GCM based on the following equation:

$$\Delta Q_{100} = Q_{100-year-emissions} - Q_{100-hist}$$

Where ΔQ_{100} is the change in Q_{100} in cfs

$Q_{100\text{-year-emissions}}$ is the Q_{100} for a given GCM at a specific time horizon and emissions scenario

$Q_{100\text{-hist}}$ is the Q100 for the historical time period based on the GCM data

The distribution of GCMs for the change in Q_{100} on the Reclamation Ditch is shown for RCP 4.5 in Figure 4 and for RCP 8.5 in Figure 5. The distribution of GCMs for the change in Q100 on the Soquel Creek is shown for RCP 4.5 in Figure 6 and for RCP 8.5 in Figure 7.

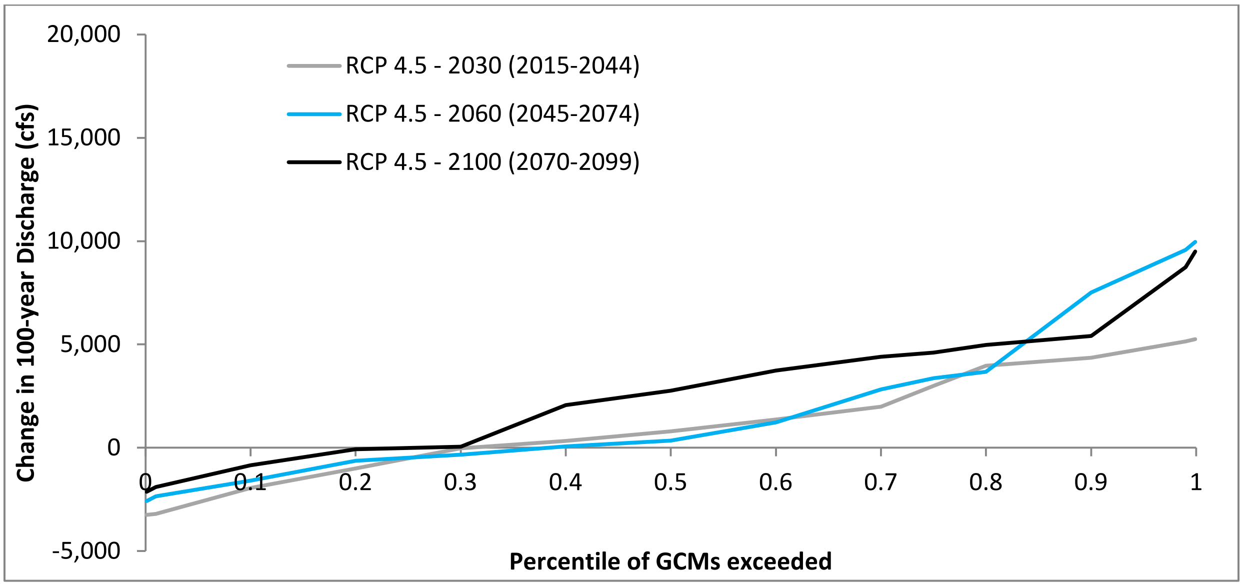


Figure 4. Distribution of change in Q_{100} for each GCM for 2030, 2060, and 2100 for RCP 4.5 on the Reclamation Ditch System

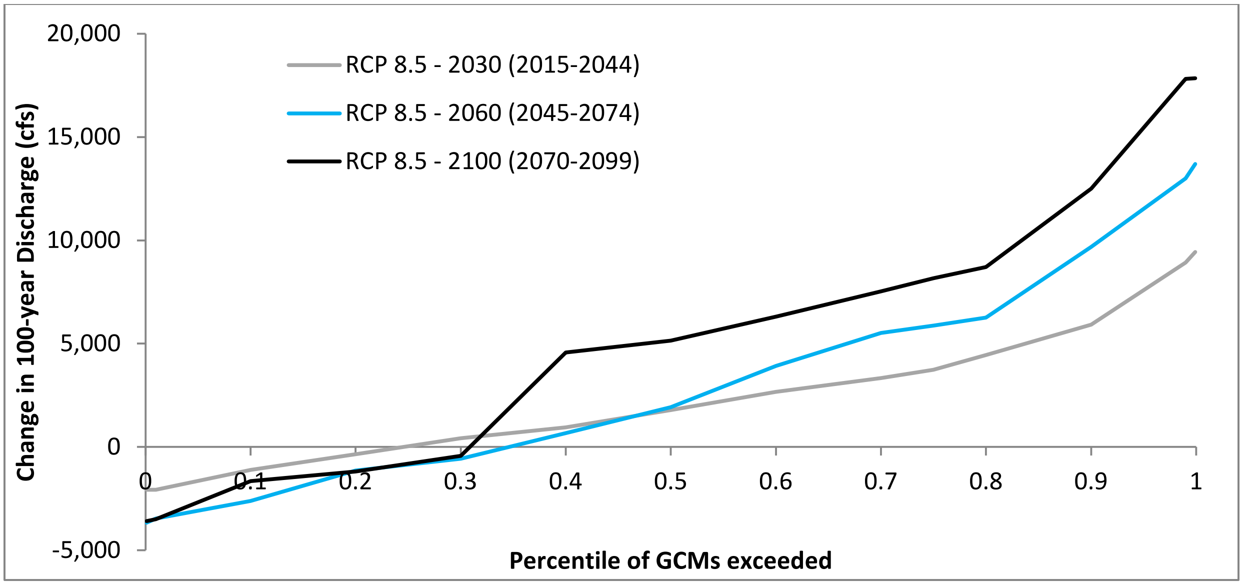


Figure 5. Distribution of change in Q_{100} for each GCM for 2030, 2060, and 2100 for RCP 8.5 on the Reclamation Ditch

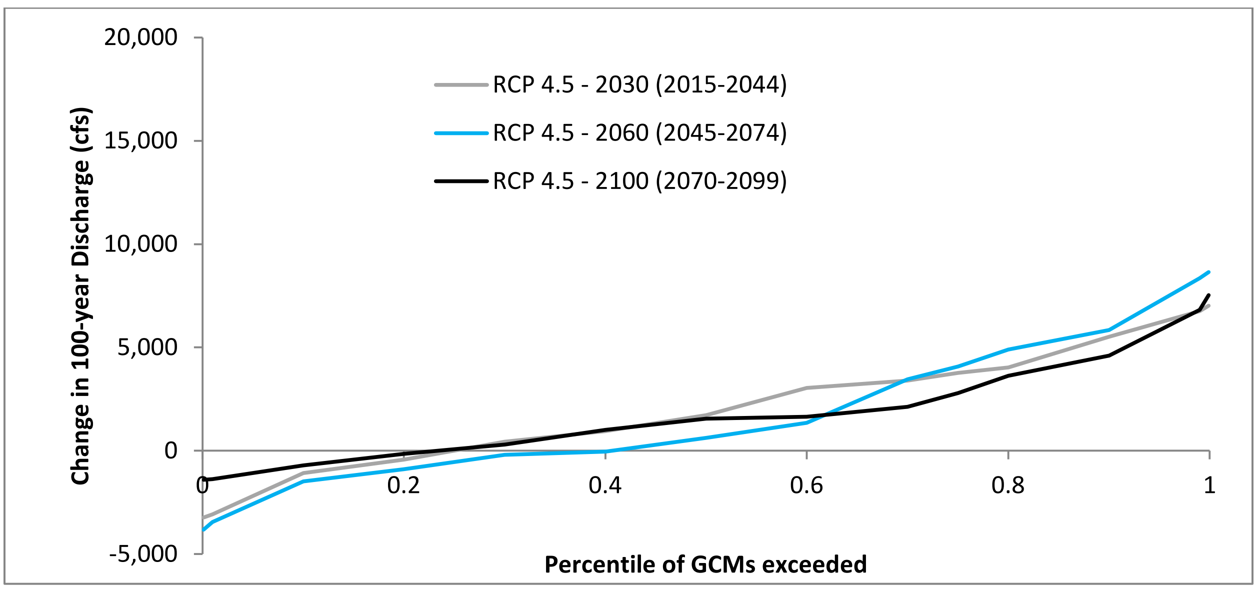


Figure 6. Distribution of change in Q_{100} for each GCM for 2030, 2060, and 2100 for RCP 4.5 on Soquel Creek

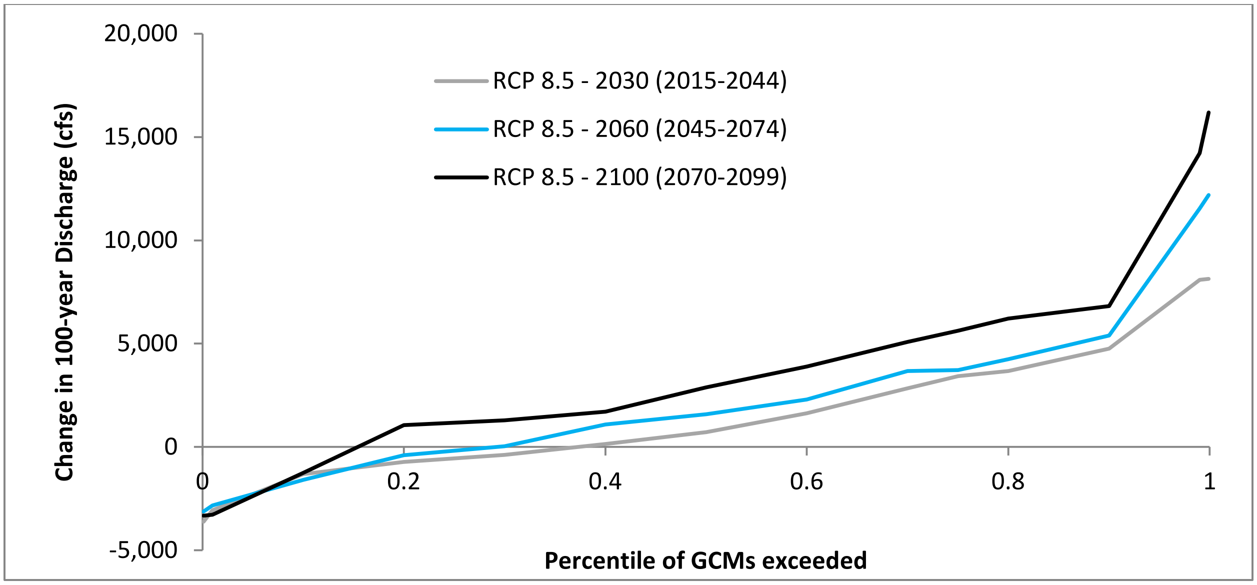


Figure 7. Distribution of change in Q_{100} for each GCM for 2030, 2060, and 2100 for RCP 8.5 on Soquel Creek

These figures indicate that for RCP 4.5, the emissions scenarios are grouped fairly closely for each future time period. The 'medium' emissions scenario was estimated from approximately the 50th percentile for the three time periods for RCP 4.5. It was determined that the 90th percentile of the models for RCP 8.5 for each individual year would be used to represent the 'high' emissions scenario. The changes estimated for 100-year discharge for both systems are summarized in Table 2.

TABLE 2
CHANGE IN 100-YEAR DISCHARGE FOR BOTH SYSTEMS RELATIVE TO HISTORIC PERIOD (1950-2000)

	Reclamation Ditch system			Soquel Creek		
Emissions scenario	**2030**	**2060**	**2100**	**2030**	**2060**	**2100**
Medium (RCP 4.5 50th percentile)	20%	40%	60%	13%	15%	20%
High (RCP 8.5 90th percentile)	140%	210%	275%	62%	68%	95%

The flows estimated in the extreme streamflow analysis were used to drive the hydraulic models which, in turn, were used to map inundation extents for existing conditions and the five future climate conditions (2030 high, 2060 and 2100 medium and high emissions). In addition to the extreme streamflow change, the downstream coastal water levels are influenced by sea level rise. The following section describes the analyses conducted to characterize the extreme coastal water level that would be coincident with the 100-year flood.

2.3 Extreme Coastal Water Level Analysis

2.3.1 Reclamation Ditch Extreme Tide Levels

The ocean boundary condition from the existing unsteady HEC-RAS hydraulic model consisted of a repeated tide cycle that peaked at about MHHW. To represent extreme tide conditions we used a 10-year tide as the ocean boundary for existing conditions. Given that the mouth of this system (the mouth to Moss Landing Harbor) is relatively deep we assumed that the mouth would not support wave setup, and therefore no additional water level increase was added for wave setup. The input ocean stage hydrograph was scaled up to peak at the 10-year water level (7.69 ft NAVD, from Monterey NOAA Buoy 9413450).

For future conditions the 10-year tide was increased at the rate of sea level rise based on the CA Coastal Commission guidance document (CCC, 2013). The total amount of SLR added for each scenario was estimated by fitting curves to the NRC 2012 SLR values, following this guidance. The peak tide elevation for each scenario is summarized in Table 3. These are the same water levels used by ESA for the Monterey Bay hazard mapping (ESA PWA, 2014).

TABLE 3
EXTREME TIDE CONDITIONS FOR RECLAMATION DITCH SYSTEM

	Sea level rise (ft)		10-year tide level + SLR (ft NAVD)	
Time period	Medium	High	Medium SLR	High SLR
2015	-	-	7.69	
2030	0.3	0.7	8.0	8.4
2060	1.1	2.4	8.8	11.0
2100	2.9	5.2	10.6	12.9

2.3.2 Soquel Creek Extreme Tide Levels

The Soquel Creek model is steady state thus there is no time dimension to the peak coastal water level. Recognizing this, it was deemed not representative to use the 10-year peak water level to represent extreme tide levels given that this elevation is only reached for a brief period during the 10-year event. We selected the 1-year recurrence interval as a tide level that would have a long enough time dimension to be considered credibly steady-state during an extreme tide event. Based on the Monterey Bay tide gauge (NOAA# 9413450), the 99% exceeded (1-year recurrence) tide elevation is 6.87 ft NAVD. Additionally, given the geomorphic configuration of this system, we added an additional increase in the steady state boundary to account for storm surge and wave setup. We selected 2-feet to account for these factors based historic data and previous studies of joint probability between coastal storm surge and high intensity rainfall as described below.

The steady downstream water surface boundary condition for Soquel Creek was chosen based on review of traditional practice and consideration of past analyses of joint probability of peak river discharges with elevated ocean water levels. A past study on San Lorenzo Creek by (USACE 2011) showed a correlation between peak discharges and storm surges, with average tidal residuals during river flood events ranging from 0.4 to 1.5 feet and wave setup ranging from 0.2 to 2 feet. We also examined historic data for Soquel Creek and nearby Aptos Creek for coastal storm events based on USGS stream gauge, CDIP buoy, and NOAA tide gauge records to estimate the wave setup during past events. We found similar patterns in the tide residuals, wave setup, and tide peak elevation during the storm. The wave setup and tide peak for a set of extreme tide and flow events is summarized in Table 4. The tidal peak water level that occurred around the time of the peak river discharge was found to be near the 1-year recurrence elevation with an average residual 0.5 feet and average estimated wave runup of 1.2 feet.

TABLE 4
COASTAL STORM SURGE AND WAVE SETUP FOR EVENTS ON SOQUEL AND APTOS CREEKS

Creek	Date	Approximate peak flow (cfs)	Ocean Residual ft (1-day average)	Offshore Wave Height, H (ft) approx	Wave Setup hsetup (ft)[1]	Total ocean water anomaly (wave setup + residual) ft	Tide Peak During Storm (ft NAVD)
Aptos	2/6/1983	210	0.74	16	1.6	2.38	6.1
Aptos	2/25/1983	210	0.43	11	1.1	1.58	6.9
Aptos	2/23/2009	280	-0.04	7	0.7	0.7	5.6
Aptos	1/20/2010	210	1.17	21	2.1	3.3	6
Aptos	12/21/2010	310	0.65	10	1	1.63	7
Aptos	12/29/2010	140	0.23	16	1.6	1.87	6.3
Aptos	2/25/2011	n/a	0.12	8	0.8	0.94	5.6
Soquel	10/13/2009	4000	0.85	7	0.7	1.51	6.1

[1]steady (average) setup ~= 0.1*H

The future conditions 100-year discharge combined with the future conditions extreme coastal tide level were used as boundary conditions for the hydraulic modeling analysis. The modeling analysis is described in the following section.

3 HYDRAULIC AND HYDRODYNAMIC MODELING ANALYSIS

3.1 Reclamation Ditch Unsteady Modeling

The basis for the unsteady HEC-RAS hydraulic model was a model provided by the Monterey County Water Resources Agency (MCWRA) to ESA in 2014. The model is an updated version of the HEC-RAS model originally developed by Schaaf & Wheeler (1999) for flood analysis. The model has been periodically updated for flood mapping studies. However, the original channel data dates back to the original study. The existing conditions 100-year hydrology was also developed by Schaaf & Wheeler in 1999 using a HEC-1 hydrologic model for the Gabilan Creek watershed. This formed the basis for the existing conditions 100-year unsteady hydrograph boundary conditions used in the model. Updates to the model geometry required including positioning the model in real geospatial coordinates and updating overbank areas with LiDAR topography are described in the following section.

3.1.1 Model Geometry Development

Hydraulic Roughness – The parameter representing the resistance to flow within a channel or floodplain due to vegetation, bedform, and bed material is known as the manning's roughness or 'n' value. The manning's n values were adopted from the existing model. The values are 0.025 for channel roughness and 0.065 for floodplain roughness.

Georeferencing – The original model provided by Monterey County required georeferencing to spatially orient the model input and output. The original mode was shifted to correctly orient the confluence of the Tembladero Slough and drainage canal from Merritt Lake (just upstream of Castroville). Tembladero Slough was digitized from Moss Landing up the Reclamation Ditch to the Hwy 101 crossing in Salinas using the HEC-GeoRAS toolbar in ArcGIS and then imported to the HEC-RAS model. Cross section spacing was then adjusted in HEC-RAS to align known bridge crossings with their spatial location. The model layout is shown in Figure 8.

Figure 8. Reclamation Ditch hydraulic model layout

Update with LiDAR – Because the overbank representation of the existing model was limited, it was necessary to update the overbank topography from new sources. This was accomplished by first extending the channel cross sections to include the full floodplain and then updating the cross section station-elevation data with topography from the 2009-2011 CA Coastal Conservancy Coastal Lidar Project: Hydro-flattened Bare Earth DEM that was downloaded from http://coast.noaa.gov/dataviewer/. This was only done for cross sections downstream of the railroad crossing west of Hwy 183, as the focus was primarily on flood behavior downstream. We determined that the elevations of the existing model were vertically referenced to an old vertical datum NGVD29. We thus converted the elevations to NAVD88 using the conversion factors listed in the FIS (+2.7 ft for Tembladero Slough, +2.77 ft for Reclamation Ditch). The model was also expanded into the Moro Cojo Slough and historic slough area between the Tembladero and Moro Cojo to represent alternate flood pathways that became apparent during the December 2014 flood.

Incorporation of MLML data – Hydraulic structure data was provided by Ross Clark, Charlie Endris, that was used to develop preliminary geometry for hydraulic structures located in the expanded portions of the model including:

1. Cabrillo Hwy crossing over Moro Cojo Slough
2. Moss Landing Rd tide gates at Moro Cojo

Other minor structure crossings in the model area were not accounted for due to lack of data. One improvement to the model would be to survey these crossings and add them into the model geometry to improve the representation of flow routing in the system.

3.1.2 Model Hydrology Inputs

Future flows determined in the future Q_{100} climate analysis were simulated by scaling the existing unsteady 100-year hydrographs that came with the HEC-RAS model provided by Monterey County. Base flow was maintained for the input hydrographs by only scaling the peak of each input hydrograph (flows > ~75% of the existing peak discharge). Within each hydrograph peak, a polynomial scaling function was used to produce smooth transitions between the existing rising and falling limbs and the future hydrograph peaks.

Inflow hydrographs were developed for Moro Cojo Slough and the unnamed canals/historic slough watershed. Area was determined for each watershed using USGS streamstats online tools. Then hydrographs were scaled from nearby subwatersheds analyzed by Schaff and Wheeler that possessed similar attributes (drainage area, relief, and impervious percentage) using watershed area as the scaling factor. These were scaled for future conditions using the method described above.

The downstream boundary was driven by an unsteady tide as described in the extreme coastal tide level section for the Reclamation Ditch.

3.1.3 Model Validation

The results of the updated hydraulic model run with the existing conditions 100-year hydrology and MHHW tailwater were compared to flooding extent and hydraulic flowpaths from a flood event that occurred in December 2014. The MLML provided a map of estimated extents and observed flow directions during this event. One key observation for this event was that flow backing up at the Moss Landing tide gates overtopped adjacent farm fields contributing additional water into Moro Cojo Slough which routes water to the harbor through the culverts under Moss Landing Road. The model reproduced this observed pattern for the 100-year flow as shown in Figure 9.

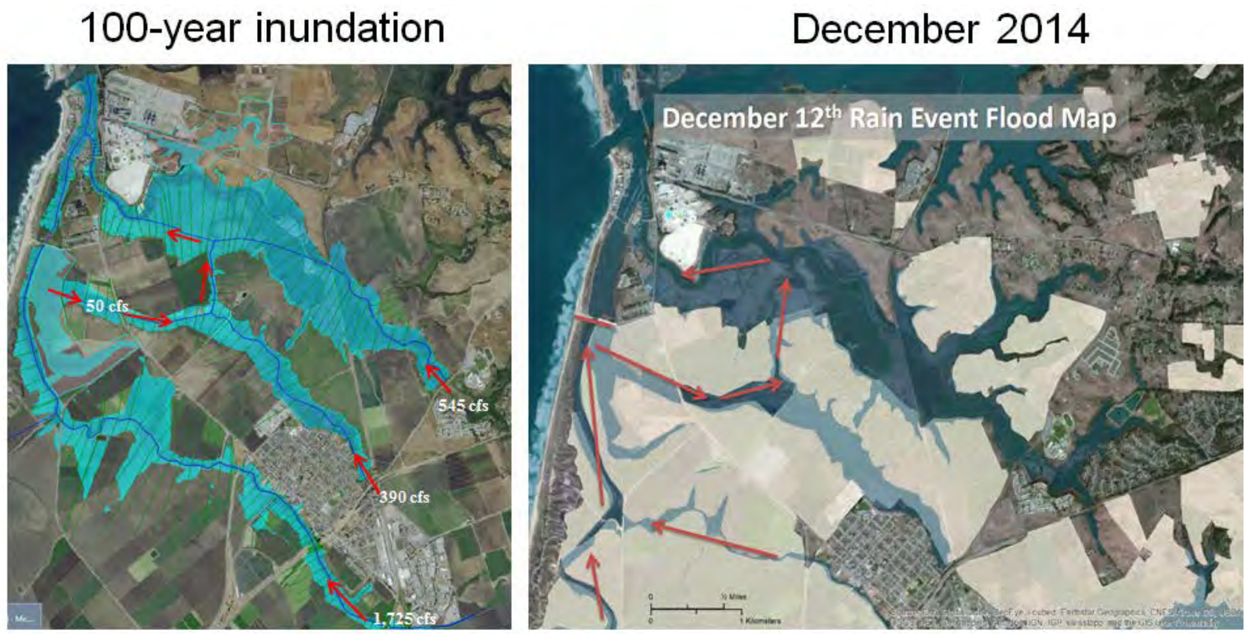


Figure 9. Comparison of Modeled 100-year flowpaths and observed flowpaths during December 2014 flood

3.1.4 Model Limitations

Flood mapping was truncated for Tembladero Slough at the Cabrillo Hwy, Moro Cojo up to the Railroad, and the historic slough in between. From the Tembladero up to the City of Salinas, the cross sections are limited to in channel portions, and floodplains were not mapped for any of the model coverage upstream. Given the uncertainty regarding the location of cross-sections an improvement to the model would be collecting new channel cross-sections and channel bathymetry in the model domain. Additionally, replacing the overbank areas with 2D flow elements would improve the routing of flow once it escapes the channel and goes out of bank. Lastly, the main Salinas River channel is not represented in the model. There are known interactions with the Salinas River and the Reclamation Ditch system including breakout flows from upstream entering the Reclamation Ditch and a water control structure connection between the mouth of the Salinas River and the old Salinas River alignment. The model could be improved significantly by combining the model with a model of the Salinas River and replacing the overbank areas with 2D flow elements.

3.2 Soquel Creek Steady State Modeling

3.2.1 Model Geometry Development

Hydraulic Roughness – The manning's n values were adopted from the existing FEMA model to maintain consistency. The channel and floodplain n values are 0.1 and 0.4 respectively.

Georeferencing – The existing conditions model for Soquel Creek came from the effective FEMA model for the system which was provided by FEMA as HEC-2 data-the precursor to HEC-RAS. The model was converted to HEC-RAS and georeferencing was performed to geospatially orient the model cross-sections and flood results. The georeferencing was accomplished by digitizing the length of Soquel Creek from the Pacific Ocean upstream to the limit of existing model coverage with HEC-GeoRAS tools in ArcGIS. Once the new stream centerline was imported to HEC-RAS, cross section spacing was adjusted to align bridge crossings with the known locations determined by the Terrain or aerial imagery. The model cross-section layout is shown in Figure 10.

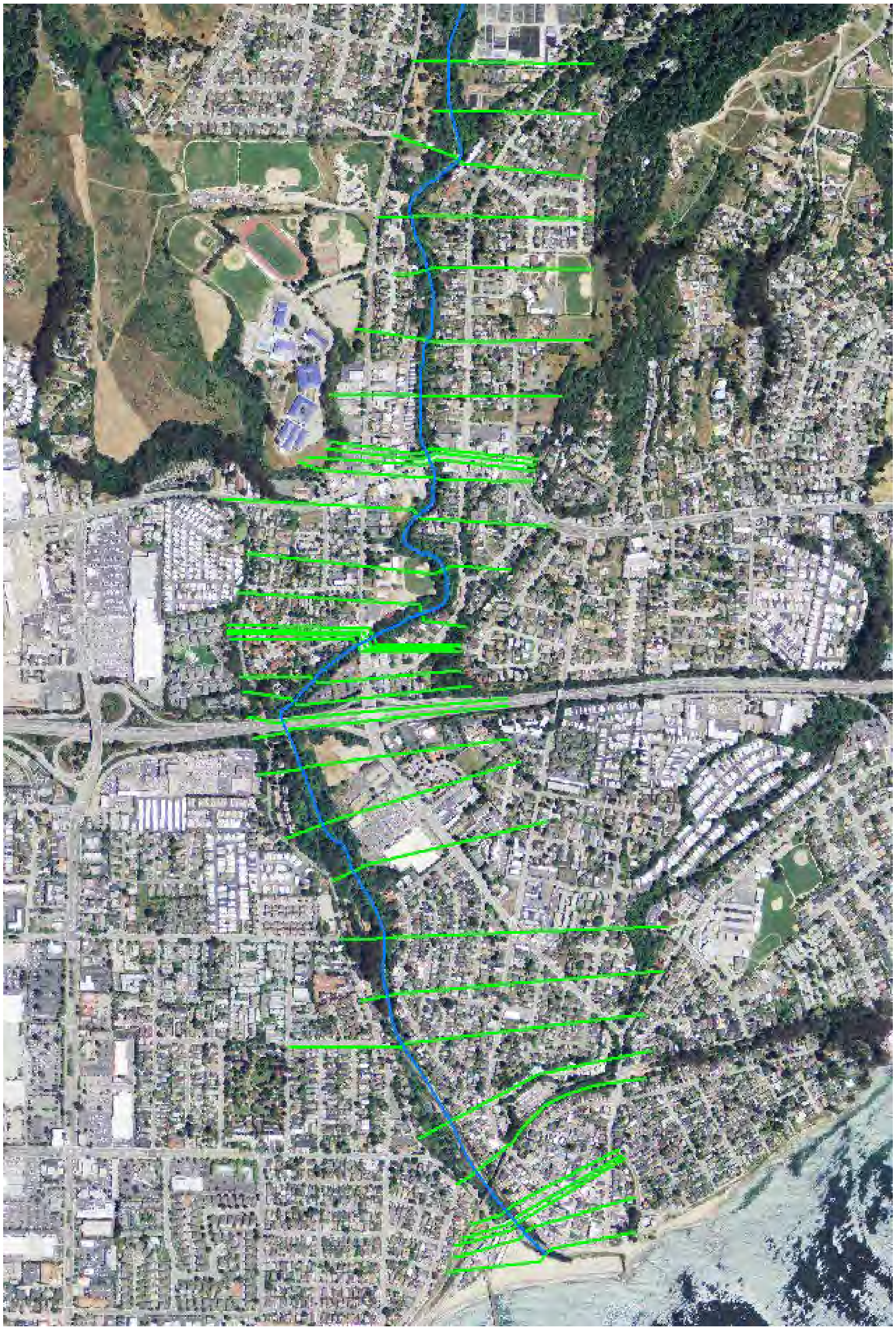


Figure 10. Soquel Creek hydraulic model layout

Update with LiDAR – Channel cross sections were extended to include the full floodplain and the cross section station-elevation data was updated with topography from the 2009 - 2011 CA Coastal Conservancy Coastal Lidar Project: Hydro-flattened Bare Earth DEM (downloaded here: http://coast.noaa.gov/dataviewer/). This was only done for cross sections downstream of Soquel Nursery Growers Plant Nursery. In-channel bathymetry and hydraulic structure data were maintained, and were shifted from NGVD29 to NAVD88 using the datum conversion factor from the FIS (+2.75 ft).

Incorporation of MLML data – Hydraulic structure data (stormdrains, manholes, etc.) were provided by Ross Clark, Charlie Endris, but were not used in the model. These data can (are going to) be used to update flood connectivity of previously mapped coastal flooding hazards (ESA 2014), and would serve to improve fluvial flood mapping from an unsteady model of Soquel Creek.

3.2.2 Model Hydrology Inputs

Future peak flows determined in the future Q_{100} climate analysis were modeled in steady state. Flows were increased by the percent change calculated for the medium and high emissions scenarios and the three future time horizons. The downstream boundary was driven by a steady tide as described in the extreme coastal tide level section for Soquel Creek.

3.2.3 Model Limitations

The geometry information in the model, including hydraulic structures and in-channel bathymetry, are out of date and may not be representative of current channel conditions. These should be updated to better represent the current conditions in Soquel Creek. Because the model is steady state, overbank flooding is potentially overestimated. Flooding extents could be improved by switching to an unsteady model.

4 MODEL RESULTS AND FLOOD HAZARD MAPPING

The hydraulic model results include water elevations in each cross-section which were translated into geospatial datasets of flood extent and depth for each of the scenarios modeled. This flood hazard mapping process was accomplished using the HEC-GeoRAS toolbar for ArcGIS which enables data transfer between GIS and HEC-RAS. Water surface profiles from the model results were exported to GIS and differenced against the underlying NOAA LiDAR topography to map flood extent. This topographic dataset does not include bathymetry below the water line thus flow depths in the channel are representative of depth above the water line at the time during which the LiDAR data were surveyed. Though some channel bathymetry for Tembladero Slough and the Reclamation Ditch was present in the original HEC-RAS model, no clear geospatial information was available for precisely locating these data. Thus the bathymetry from the cross-sections was not integrated into the topographic surface. The results of the inundation mapping are shown for the Reclamation Ditch system in Figure 11 and for Soquel Creek in Figure 12.

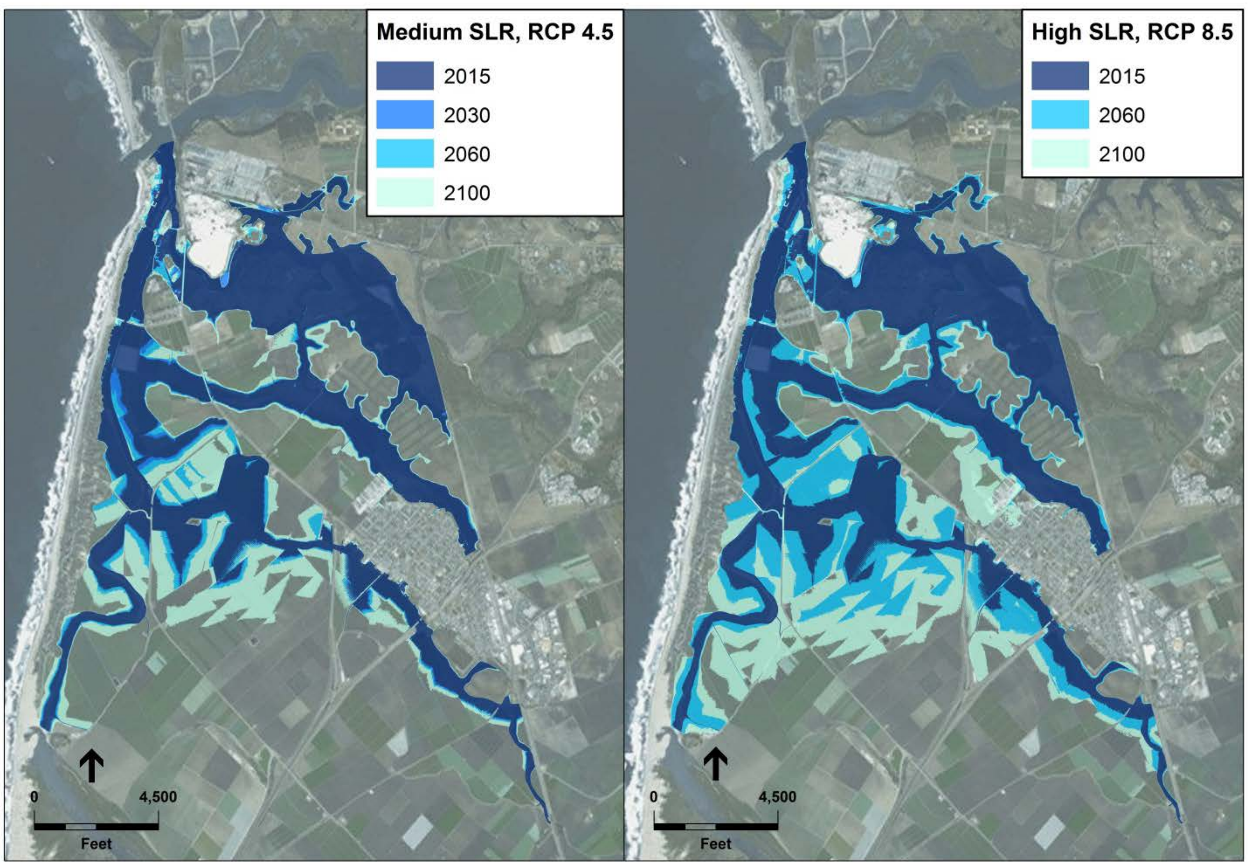


Figure 11. Flood inundation hazard maps for multiple climate scenarios on the Reclamation Ditch system

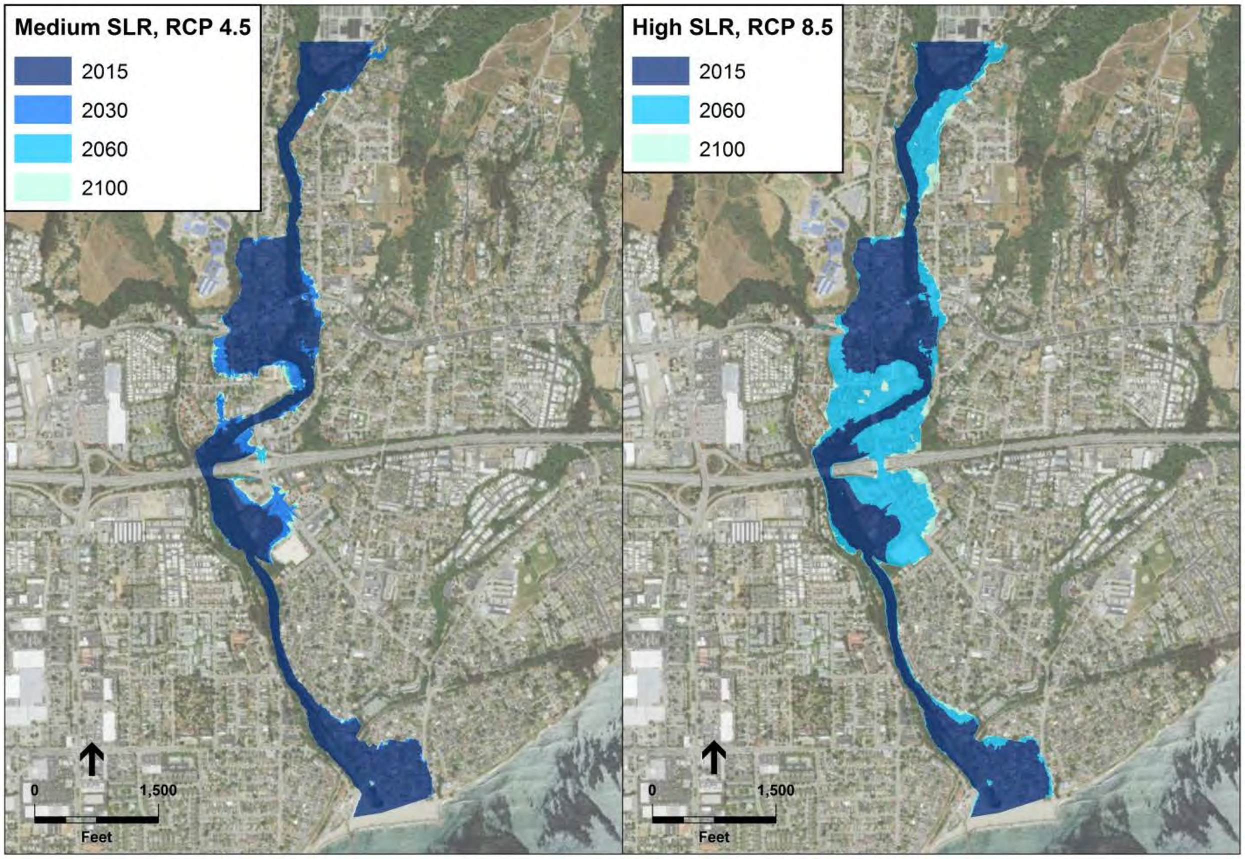


Figure 12. Flood inundation hazard maps for multiple climate scenarios on Soquel Creek

As Figure 11 shows, the flood extent increases significantly from existing conditions to 2100 on the Reclamation Ditch system. The majority of additional flooding is on the agricultural properties adjacent to Tembladero Slough and the Old Salinas River channel. The increase is exacerbated by the flatness of the terrain which results in a large increase in flooding for small increases in discharge. The additional flooded area is approximately 960 and 1740 acres for the Medium and High scenarios respectively, and the increase in flood depth is approximately 1.1 and 2.6 feet respectively. Depth measurements were sampled just upstream of the Hwy 156 crossings on Tembladero Slough.

For Soquel Creek, the change in 100-year discharge is less significant than on the Reclamation Ditch system. Additionally, the topography is more constrained in areas that are already flooded by the existing conditions 100-year flood. Thus the extent of flooding does not change as significantly on this system. The additional flooded area is approximately 18 and 65 acres for the Medium and High scenarios respectively, and the increase in flood depth is approximately 0.8 and 3.0 feet respectively.

In addition to the fluvial flood hazard mapping analysis, coastal storm flooding hazard zones were provided for the purposes of updating flooding connectivity in the Capitola and Salinas-Elkhorn areas. Coastal storm flooding hazards were previously mapped for the Monterey Bay Sea Level Rise Vulnerability Study (ESA PWA 2014) prepared for The Monterey Bay Sanctuary Foundation, and were provided in shapefile format for these two areas.

For the Capitola area (Soquel Creek), ESA provided MLML with intermediate coastal hazards shapefiles that contained separate polygons for the various hazards modeled. Equipped with the separated hazards and by using GIS data of storm drain networks and other flood management infrastructure, staff at MLML can make any warranted flood connectivity updates to the coastal flooding hazard layers provided in the MBSLR study (ESA PWA 2014). Described in the shapefile metadata, the separated versions of the coastal flooding hazards include layers for wave overtopping, wave runup, event tide flooding (100-yr tide), and erosion layers depicting eroded conditions of cliffs and dune areas (which would be considered as flooded in the future). Elevations associated with each flooding mechanism (except the erosion layers) are provided as attributes for each mechanism ("Method" in the attributes table).

As a part of a subsequent study "Economic Impacts of Climate Adaptation Strategies for Southern Monterey Bay" by ESA, The Nature Conservancy and others, flood connectivity was updated to reflect known water control structures in the area. The main structures considered are the tide gates on Tembladero Slough at Potrero Road, the Cabrillo Hwy road crest separating low lands from backwatering from the Moro Cojo Slough, and the water control structure between the Salinas Lagoon and Old Salinas channel to the north. In this update, flooding methods and associated flooding elevations for the Salinas River were altered to produce more accurate flood extents:

- Beach berm flooding – the elevation of flooding behind the beach berm at the Salinas River lagoon mouth was lowered from 4.88 m NAVD to 3.66 m NAVD (from 16ft to 12 ft) to represent the hydraulic control structure that diverts water north to the old Salinas River channel. These flooding layers also assume a 15 ft crest elevation for the levee on the north bank of the Salinas River, estimated from LiDAR.

- 100-yr tide flooding – flooding by the 100-year tide was updated to reflect the Potrero Rd tide gates and the road crest at Cabrillo Hwy, which affects primarily farmlands south of the Elkhorn Slough mouth.

The geospatial layers for the flood hazard extent and depths were compiled in an ESRI ArcGIS compatible geodatabase. The geodatabase was provided to MLML on 1/29/2016. Additionally the coastal flooding shapefiles adjusted to incorporate structural information on both systems was provided with this geodatabase. A table of the layers provided is included in Attachment A.

5 DISCUSSION

The climate analysis and hydraulic modeling show how future conditions flooding can change with increased precipitation intensity and higher coastal water levels with extreme coastal flood events. The flood hazard inundation extents can be used to inform planning efforts in the areas that are at risk of increased flooding as climate change puts added pressure on flood parameters. The range of scenarios provided allows for interpretation of potential flood risk given uncertainty in how climate will evolve. Planning efforts can be informed by considering a range of future scenarios and associated vulnerabilities, and the community's tolerance for risk, which should conceptually relate to the community's resilience.

The fluvial flood hazard maps add value to the previous coastal flooding analyses conducted by ESA by incorporating changes to watershed hydrology into the flood potential. This enables an assessment of the flood risk from combined changes in increasing coastal water levels and increased precipitation intensity. This is beneficial to communities at risk of flooding from both coastal and fluvial sources and provides a more complete set of scenarios for planning in those communities.

The resulting hazard maps can be used to assess risk as well as plan for future adaptation measures. By highlighting areas at risk currently and areas potentially at risk under different climate scenarios, communities can begin to develop and implement specific localized measures for adapting to these future risks. Future study should be considered to develop adaptation plans now that the tools for assessing risk have been developed and are available for further use.

6 REFERENCES

California Coastal Commission (CCC), 2013. California Coastal Commission Draft Sea level Rise Policy Guidance - Public Review Draft. October 14, 2013.

ESA PWA (2014), Monterey Bay Sea Level Rise Vulnerability Study: Technical Methods Report Monterey Bay Sea Level Rise Vulnerability Study. Prepared for The Monterey Bay Sanctuary Foundation, ESA PWA project number D211906.00, June 16, 2014.

National Oceanic and Atmospheric Administration (NOAA) 2009-2011, CA Coastal Conservancy Coastal Lidar Project: Hydro-flattened Bare Earth DEM. Accessed online January 30, 2015 from http://coast.noaa.gov/dataviewer/#

Schaaf & Wheeler, 1999. Zone 9 and Reclamation Ditch Drainage System Operations Study.

USBR, 2014. Downscaled CMIP3 and CMIP5 Hydrology Projections. Release of Hydrology Projections Comparison with Preceding Information and Summary of User Needs.

USGS, 1982, Guidelines for determining flood flow frequency, Bulletin 17-B of the Hydrology Subcommittee: Reston, Virginia, U.S. Geological Survey, Office of Water Data Coordination, [183 p.]. [Available from National Technical Information Service, Springfield VA 22161 as report no. PB 86 157 278 or from FEMA on the World-Wide Web at http://www.fema.gov/mit/tsd/dl_flow.htm]

USGS, 2011, Parrett, C., Veilleux, A., Stedinger, J.R., Barth, N.A., Knifong, D.L., and Ferris, J.C., Regional skew for California, and flood frequency for selected sites in the Sacramento–San Joaquin River Basin, based on data through water year 2006: U.S. Geological Survey Scientific Investigations Report 2010–5260, 94 p.

USGS, 2013. Jin, S., Yang, L., Danielson, P., Homer, C., Fry, J., and Xian, G. 2013. A comprehensive change detection method for updating the National Land Cover Database to circa 2011. *Remote Sensing of Environment*, 132: 159 – 175.

7 LIST OF PREPARERS

This report was prepared by the following ESA staff:

James Gregory, PE, Managing Associate

James Jackson, PE, Senior Associate

Bob Battalio, PE, Chief Engineer, Vice President

8 DISCLAIMER AND USE RESTRICTIONS

Funding Agencies

These data and this report were prepared as the result of work funded by the California Ocean Protection Council (the "funding agency"). The data and report do not necessarily represent the views of the funding agency, its respective officers, agents and employees, subcontractors, or the State of California. The funding agency, the State of California, and their respective officers, employees, agents, contractors, and subcontractors make no warranty, express or implied, and assume no responsibility or liability, for the results of any actions taken or other information developed based on this report; nor does any party represent that the uses of this information will not infringe upon privately owned rights. These study results are being made available for informational purposes only and have not been approved or disapproved by the funding agency, nor has the funding agency passed upon the accuracy, currency, completeness, or adequacy of the information in this report. Users of this information agree by their use to hold blameless the funding agency, study participants and authors for any liability associated with its use in any form.

ESA

This information is intended to be used for planning purposes only. Site-specific evaluations may be needed to confirm/verify information presented in these data. Inaccuracies may exist, and Environmental Science Associates (ESA) implies no warranties or guarantees regarding any aspect or use of this information. Further, any user of these data assumes all responsibility for the use thereof, and further agrees to hold ESA harmless from and against any damage, loss, or liability arising from any use of this information.

Commercial use of this information by anyone other than ESA is prohibited.

Data Usage

These data are freely redistributable with proper metadata and source attribution. Please reference ESA as the originator of the datasets in any future products or research derived from these data.

The data are provided "as is" without any representations or warranties as to their accuracy, completeness, performance, merchantability, or fitness for a particular purpose. Data are based on model simulations, which are subject to revisions and updates and do not take into account many variables that could have substantial effects on erosion, flood extent and depth. Real world results will differ from results shown in the data. Site-specific evaluations may be needed to confirm/verify information presented in this dataset. This work shall not be used to assess actual coastal hazards, insurance requirements or property values, and specifically shall not be used in lieu of Flood insurance Studies and Flood Insurance Rate Maps issued by FEMA.

The entire risk associated with use of the study results is assumed by the user. The Counties of Monterey and Santa Cruz, ESA and all of the funders shall not be responsible or liable for any loss or damage of any sort incurred in connection with the use of the report or data.

Monterey Bay Sea Level Rise

Climate Change Impacts on Combined Fluvial and Coastal Hazards

ATTACHMENT A

GIS Data Layers Provided With Report

Attachment A - Files transmitted via 20150126_fluvialHZ_w_Metadata.zip

Folder	Subfolder	File	Geographic Location	Type	SLR	Emissions
RecDitch_Tembladero_UTMz10						
	area					
		river100yr_floodplain_ec2010.shp	Tembladero Slough	Fluvial flooding extents polygon shapefile	none	none
		river100yr_floodplain_hi2060.shp	Tembladero Slough	Fluvial flooding extents polygon shapefile	High	RCP 8.5
		river100yr_floodplain_hi2100.shp	Tembladero Slough	Fluvial flooding extents polygon shapefile	High	RCP 8.5
		river100yr_floodplain_med2030.shp	Tembladero Slough	Fluvial flooding extents polygon shapefile	Medium	RCP 4.5
		river100yr_floodplain_med2060.shp	Tembladero Slough	Fluvial flooding extents polygon shapefile	Medium	RCP 4.5
		river100yr_floodplain_med2100.shp	Tembladero Slough	Fluvial flooding extents polygon shapefile	Medium	RCP 4.5
	depth					
		MaxDepth_100yr_ec2010.tif	Tembladero Slough	Fluvial flooding max depth raster	none	none
		MaxDepth_100yr_hi2060.tif	Tembladero Slough	Fluvial flooding max depth raster	High	RCP 8.5
		MaxDepth_100yr_hi2100.tif	Tembladero Slough	Fluvial flooding max depth raster	High	RCP 8.5
		MaxDepth_100yr_med2030.tif	Tembladero Slough	Fluvial flooding max depth raster	Medium	RCP 4.5
		MaxDepth_100yr_med2060.tif	Tembladero Slough	Fluvial flooding max depth raster	Medium	RCP 4.5
		MaxDepth_100yr_med2100.tif	Tembladero Slough	Fluvial flooding max depth raster	Medium	RCP 4.5
SoquelCreek_UTMz10						
	area					
		river100yr_floodplain_ec2010.shp	Soquel Creek	Fluvial flooding extents polygon shapefile	none	none
		river100yr_floodplain_hi2060.shp	Soquel Creek	Fluvial flooding extents polygon shapefile	High	RCP 8.5
		river100yr_floodplain_hi2100.shp	Soquel Creek	Fluvial flooding extents polygon shapefile	High	RCP 8.5
		river100yr_floodplain_med2030.shp	Soquel Creek	Fluvial flooding extents polygon shapefile	Medium	RCP 4.5
		river100yr_floodplain_med2060.shp	Soquel Creek	Fluvial flooding extents polygon shapefile	Medium	RCP 4.5
		river100yr_floodplain_med2100.shp	Soquel Creek	Fluvial flooding extents polygon shapefile	Medium	RCP 4.5
	depth					
		MaxDepth_100yr_ec2010.tif	Soquel Creek	Fluvial flooding max depth raster	none	none
		MaxDepth_100yr_hi2060.tif	Soquel Creek	Fluvial flooding max depth raster	High	RCP 8.5
		MaxDepth_100yr_hi2100.tif	Soquel Creek	Fluvial flooding max depth raster	High	RCP 8.5
		MaxDepth_100yr_med2030.tif	Soquel Creek	Fluvial flooding max depth raster	Medium	RCP 4.5
		MaxDepth_100yr_med2060.tif	Soquel Creek	Fluvial flooding max depth raster	Medium	RCP 4.5
		MaxDepth_100yr_med2100.tif	Soquel Creek	Fluvial flooding max depth raster	Medium	RCP 4.5

Key

SLR	High	high sea level rise (NRC 2012) of 159 cm by 2100, relative to 2010
	Med	medium sea level rise (NRC 2012) of 72 cm by 2100, relative to 2010
Emissions	RCP 8.5	future emissions scenario (IPCC, AR 5)
	RCP 4.5	future emissions scenario (IPCC, AR 5)

100-year fluvial flooding rasters and polygons are projected to UTM Zone 10N coordinates. Raster depths are in Feet.

Attachment A - Files transmitted via 20150129_Draft_UpdatedCoastalFloodHZ

Folder	File	Geographic Location	Type	SLR
coastal_storm_flood_MBSLR_Capitola				
subfolder "combined"	coastal_floodhz_ec2010_dissolved.shp	Capitola / Soquel Creek	Coastal Storm flooding extents	none
	coastal_floodhz_s12030_dissolved.shp	Capitola / Soquel Creek	Coastal Storm flooding extents	Low
	coastal_floodhz_s12060_dissolved.shp	Capitola / Soquel Creek	Coastal Storm flooding extents	Low
	coastal_floodhz_s12100_dissolved.shp	Capitola / Soquel Creek	Coastal Storm flooding extents	Low
	coastal_floodhz_s22030_dissolved.shp	Capitola / Soquel Creek	Coastal Storm flooding extents	Medium
	coastal_floodhz_s22060_dissolved.shp	Capitola / Soquel Creek	Coastal Storm flooding extents	Medium
	coastal_floodhz_s22100_dissolved.shp	Capitola / Soquel Creek	Coastal Storm flooding extents	Medium
	coastal_floodhz_s32030_dissolved.shp	Capitola / Soquel Creek	Coastal Storm flooding extents	High
	coastal_floodhz_s32060_dissolved.shp	Capitola / Soquel Creek	Coastal Storm flooding extents	High
	coastal_floodhz_s32100_dissolved.shp	Capitola / Soquel Creek	Coastal Storm flooding extents	High
subfolder "separated"	coastal_floodhz_ec2010.shp	Capitola / Soquel Creek	Coastal Storm flooding extents, with separate EL and HZ type attributes	none
	coastal_floodhz_s12030.shp	Capitola / Soquel Creek	Coastal Storm flooding extents, with separate EL and HZ type attributes	Low
	coastal_floodhz_s12060.shp	Capitola / Soquel Creek	Coastal Storm flooding extents, with separate EL and HZ type attributes	Low
	coastal_floodhz_s12100.shp	Capitola / Soquel Creek	Coastal Storm flooding extents, with separate EL and HZ type attributes	Low
	coastal_floodhz_s22030.shp	Capitola / Soquel Creek	Coastal Storm flooding extents, with separate EL and HZ type attributes	Medium
	coastal_floodhz_s22060.shp	Capitola / Soquel Creek	Coastal Storm flooding extents, with separate EL and HZ type attributes	Medium
	coastal_floodhz_s22100.shp	Capitola / Soquel Creek	Coastal Storm flooding extents, with separate EL and HZ type attributes	Medium
	coastal_floodhz_s32030.shp	Capitola / Soquel Creek	Coastal Storm flooding extents, with separate EL and HZ type attributes	High
	coastal_floodhz_s32060.shp	Capitola / Soquel Creek	Coastal Storm flooding extents, with separate EL and HZ type attributes	High
	coastal_floodhz_s32100.shp	Capitola / Soquel Creek	Coastal Storm flooding extents, with separate EL and HZ type attributes	High
event_flood_SMB_SalinasElkhorn				
subfolder "combined"	event_flood_AER_ec2010.shp	Salinas River / Elkhorn Sloug	Coastal Storm flooding extents	none
	event_flood_AER_s22030.shp	Salinas River / Elkhorn Sloug	Coastal Storm flooding extents	Medium
	event_flood_AER_s22060.shp	Salinas River / Elkhorn Sloug	Coastal Storm flooding extents	Medium
	event_flood_AER_s22100.shp	Salinas River / Elkhorn Sloug	Coastal Storm flooding extents	Medium
	event_flood_AER_s32030.shp	Salinas River / Elkhorn Sloug	Coastal Storm flooding extents	High
	event_flood_AER_s32060.shp	Salinas River / Elkhorn Sloug	Coastal Storm flooding extents	High
	event_flood_AER_s32100.shp	Salinas River / Elkhorn Sloug	Coastal Storm flooding extents	High
subfolder "separated"	event_flood_AER_ec2010_EL.shp	Salinas River / Elkhorn Sloug	Coastal Storm flooding extents, with separate EL and HZ type attributes	none
	event_flood_AER_s22030_EL.shp	Salinas River / Elkhorn Sloug	Coastal Storm flooding extents, with separate EL and HZ type attributes	Medium
	event_flood_AER_s22060_EL.shp	Salinas River / Elkhorn Sloug	Coastal Storm flooding extents, with separate EL and HZ type attributes	Medium
	event_flood_AER_s22100_EL.shp	Salinas River / Elkhorn Sloug	Coastal Storm flooding extents, with separate EL and HZ type attributes	Medium
	event_flood_AER_s32030_EL.shp	Salinas River / Elkhorn Sloug	Coastal Storm flooding extents, with separate EL and HZ type attributes	High
	event_flood_AER_s32060_EL.shp	Salinas River / Elkhorn Sloug	Coastal Storm flooding extents, with separate EL and HZ type attributes	High
	event_flood_AER_s32100_EL.shp	Salinas River / Elkhorn Sloug	Coastal Storm flooding extents, with separate EL and HZ type attributes	High

Key

SLR	low sea level rise (NRC 2012) of 22 cm by 2100, relative to 2010
	medium sea level rise (NRC 2012) of 72 cm by 2100, relative to 2010
	high sea level rise (NRC 2012) of 159 cm by 2100, relative to 2010

coastal storm flooding rasters and polygons are projected to UTM Zone 10N coordinates

Appendix D – City of Capitola Notice of Availability of Public Review Draft 2020 LHMP

Advance Planning - LHMP Public Comment Period Now Open

ADVANCE PLANNING OVERVIEW

Advance Planning maintains and updates the City's long-range planning documents, including the **General Plan**, **Housing Element**, **Zoning Code**, **Local Coastal Program**, and design guidelines. Advance Planning functions also include policy and ordinance development, coordination with neighboring agencies on regional planning issues, and grant preparation and administration.

ADVANCE PLANNING PROJECTS

Local Hazard Mitigation Plan Update - Public Comment Period Now Open

The City is currently in the process of updating the Local Hazard Mitigation Plan. The public comment period will be open from April 15, 2020 through April 29, 2020. Please submit written comment to planning@ci.capitola.ca.us.

Draft Local Hazard Mitigation Plan for public comment period

The purpose of the LHMP is to develop a comprehensive local public planning process to assess and develop a response to the city's vulnerability to natural hazards. The LHMP identifies critical facilities that are vital to the city's and other local agencies' response during a natural disaster, particularly those that are currently vulnerable or at risk, assesses vulnerability to a variety of natural disasters (earthquake, flood, coastal erosion, etc.) and identifies needed mitigation actions.

Search

Community Development

Planning Applications
- Advance Planning
2014-2023 Housing Element
Capitola General Plan
Climate Action Plan
+ New Zoning Code
+ Affordable Housing
Building
Code Enforcement
+ Current Planning
Applications and Forms