City of Capitola

Coastal Climate Change Vulnerability Report

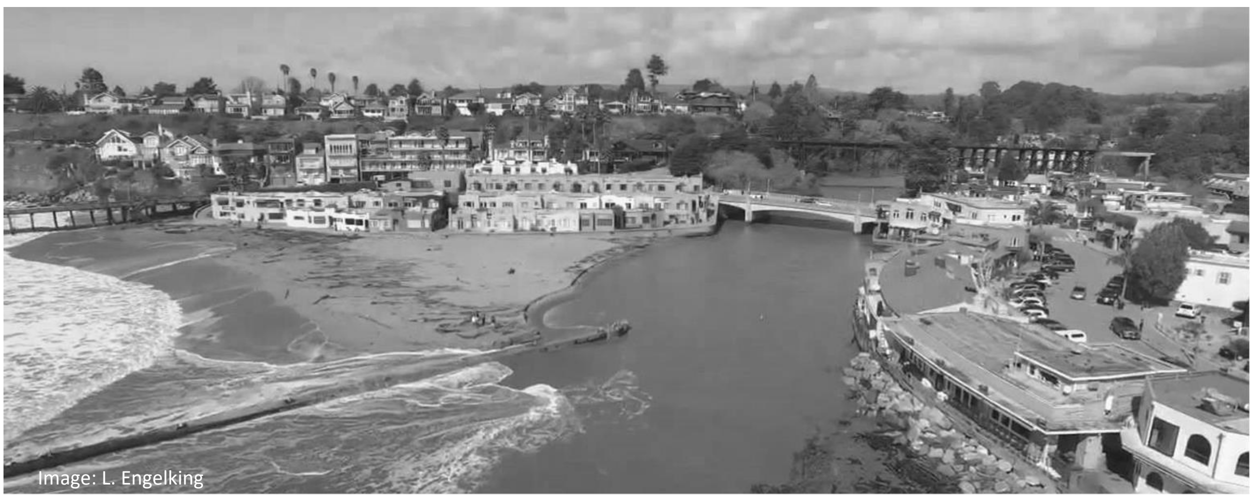

Image: L. Engelking

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CENTRAL COAST WETLANDS GROUP

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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).

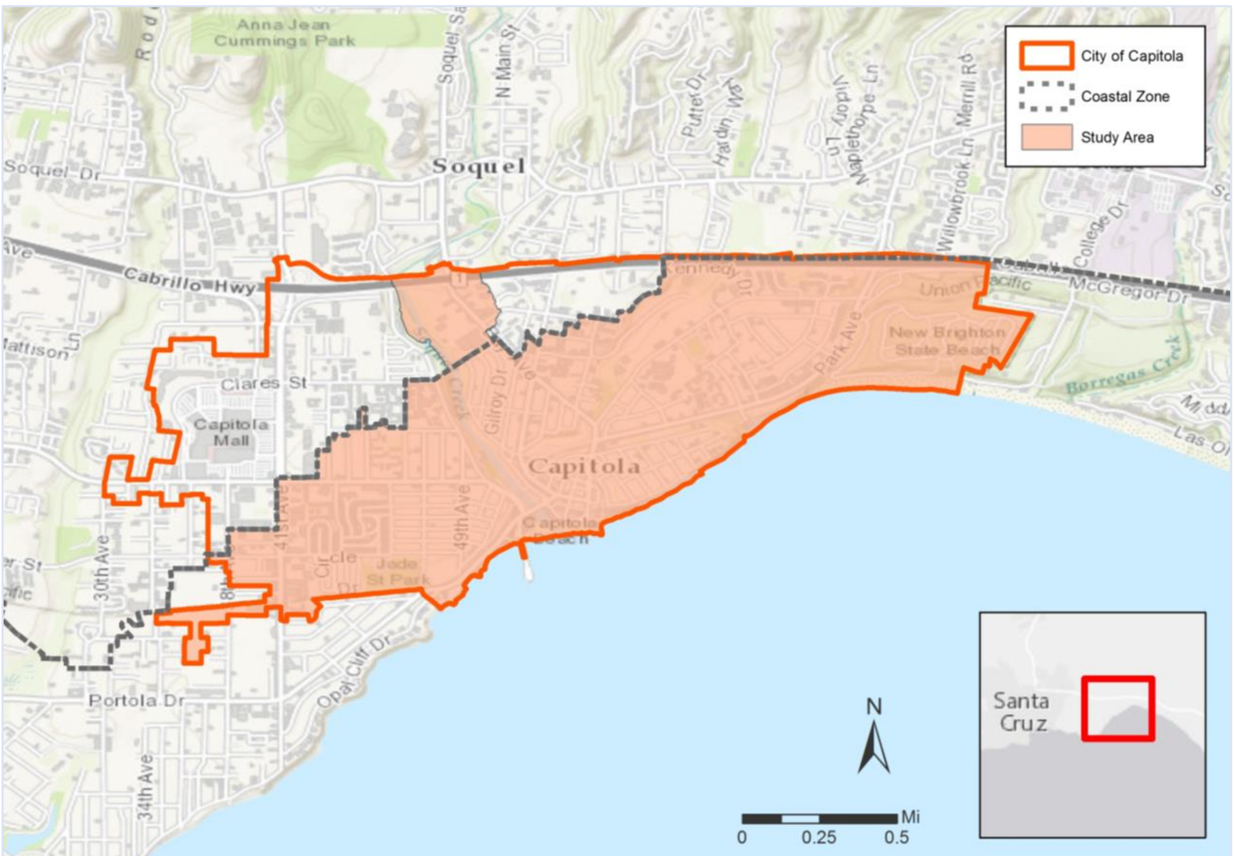

Figure 1. City of Capitola Vulnerability Assessment Study Area with Soquel Creek floodplain

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.

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

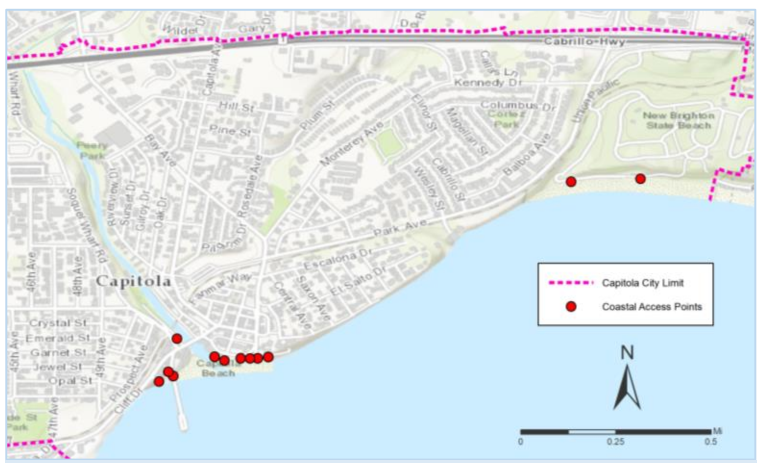

Figure 2. Coastal access points within the City of Capitola

[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.

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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,

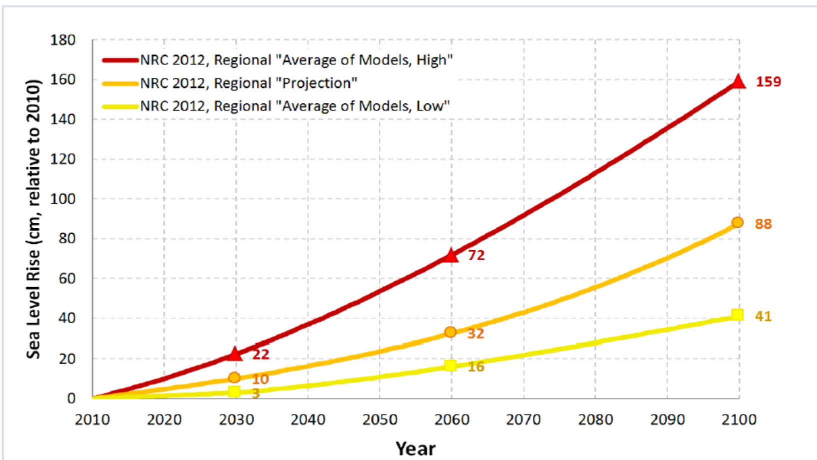


Figure 5. Sea Level Rise scenarios for each time horizon
(Figure source: ESA PWA 2014)

[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

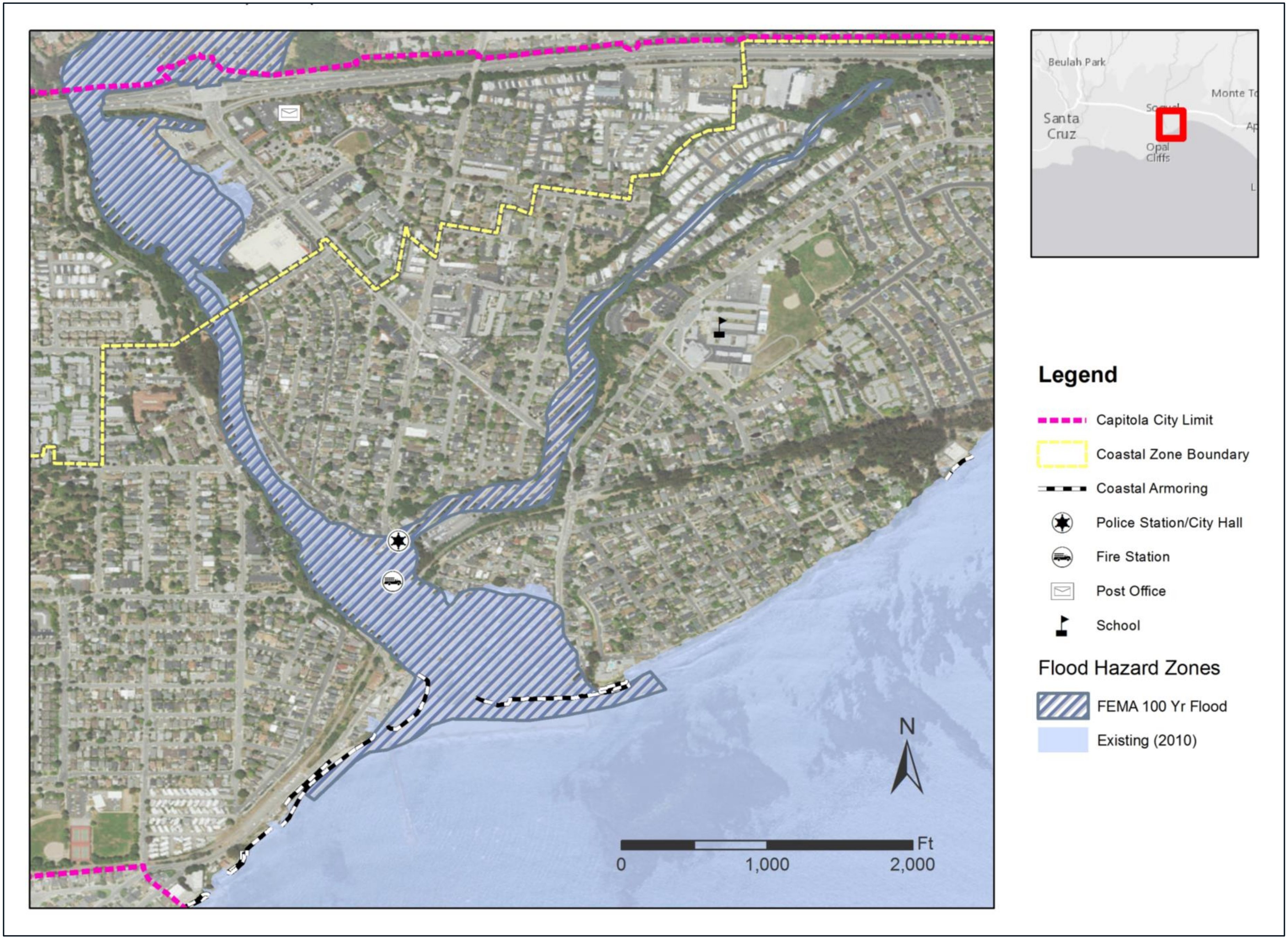


Table 5. Existing Conditions Comparison between FEMA and Existing (2010) hazard layers.

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)

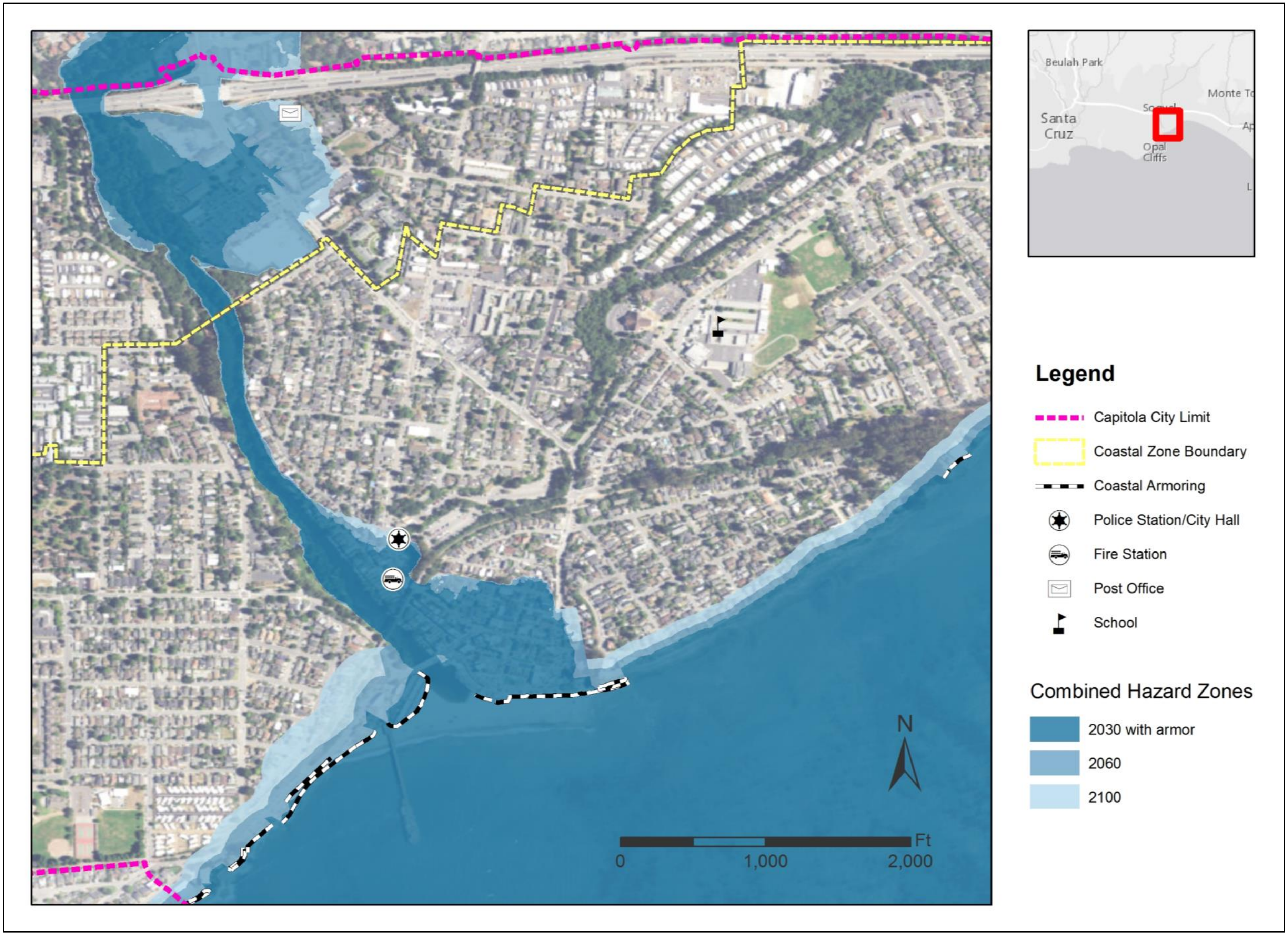
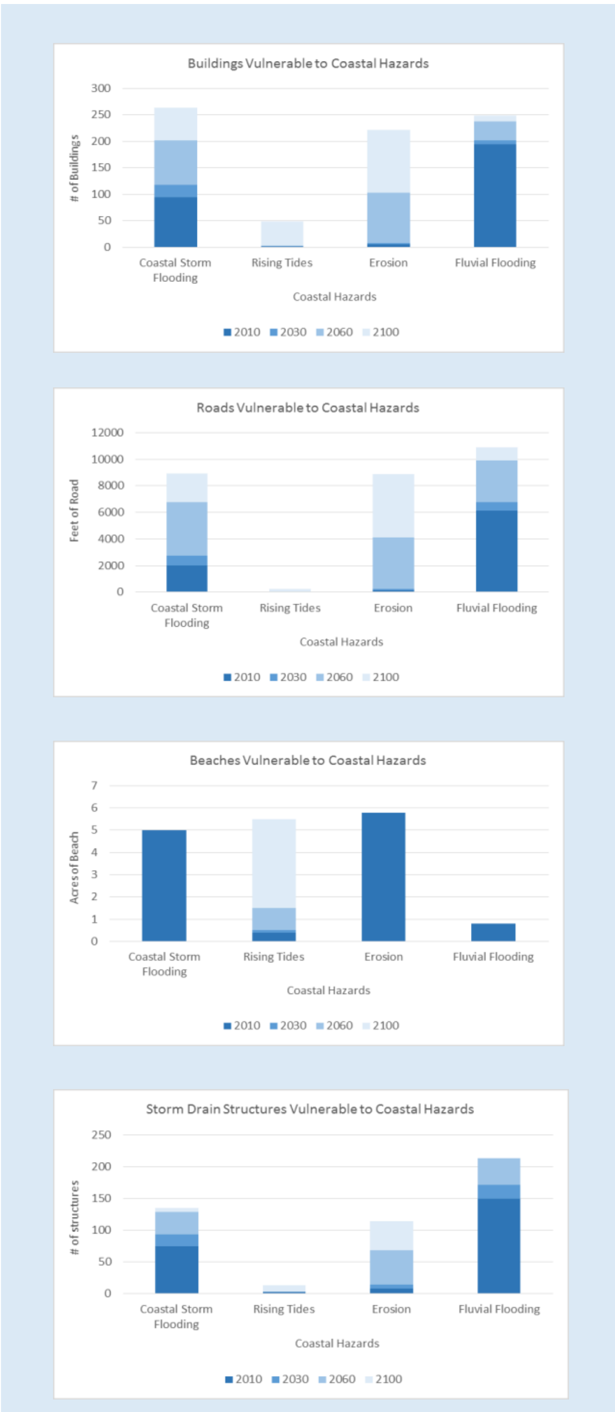


Table 6. Summary of Assets Vulnerable to all Coastal Hazards at 2030, 2060, and 2100

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

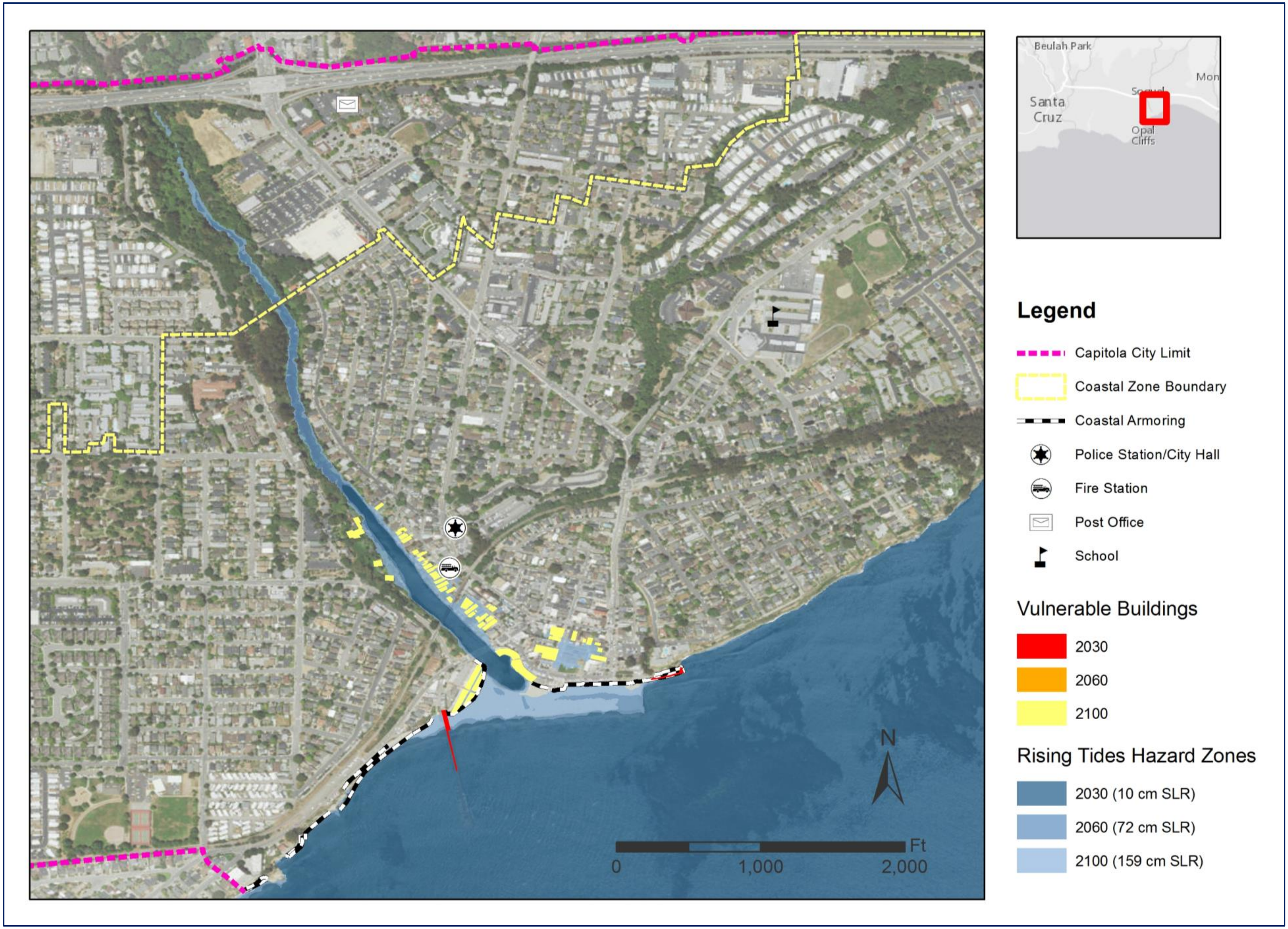


Table 7. Summary of Assets Vulnerable to Impacts by Rising Tides

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

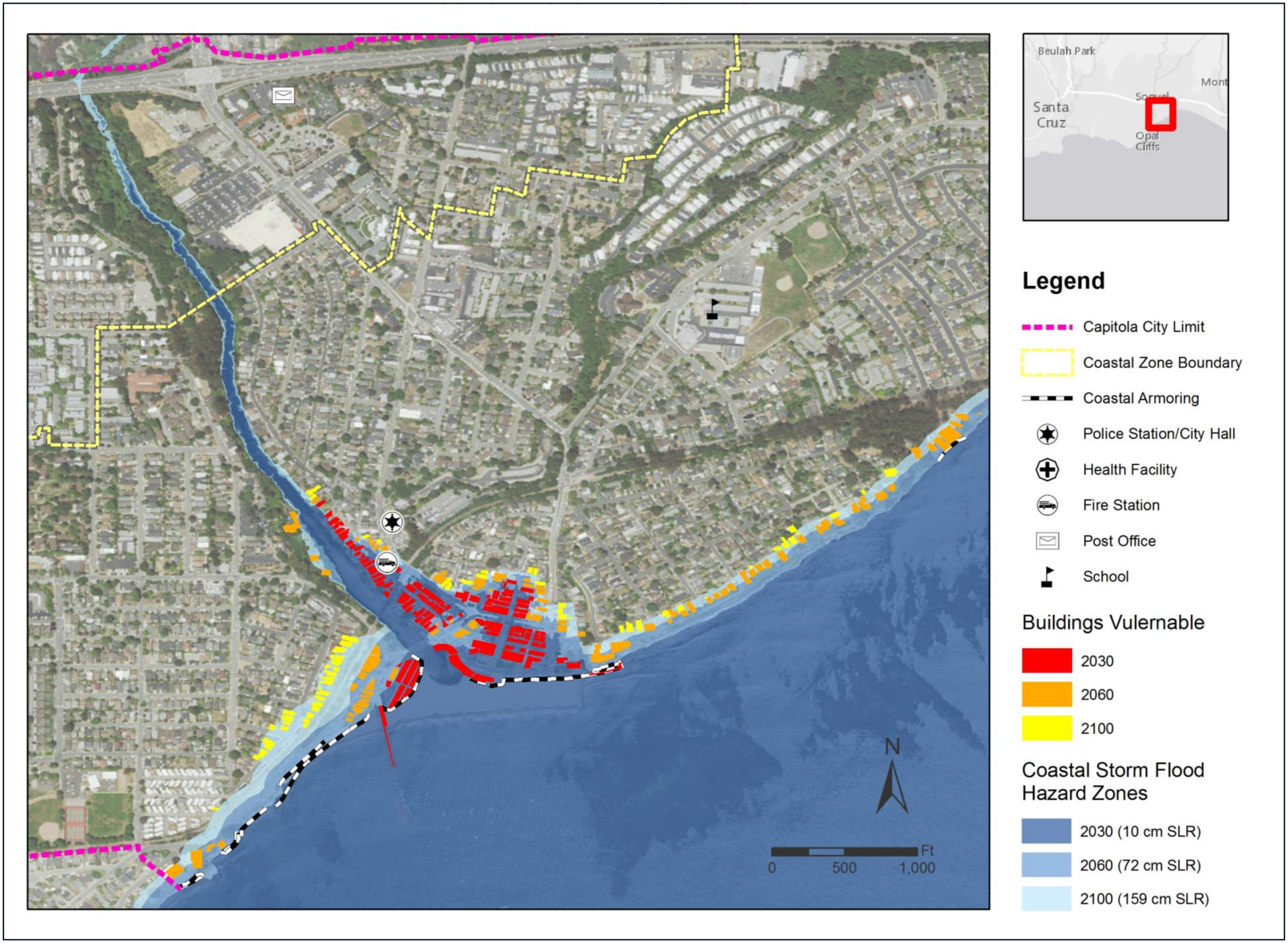


Table 8. Summary of Assets Vulnerable to Coastal Storm Flooding

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

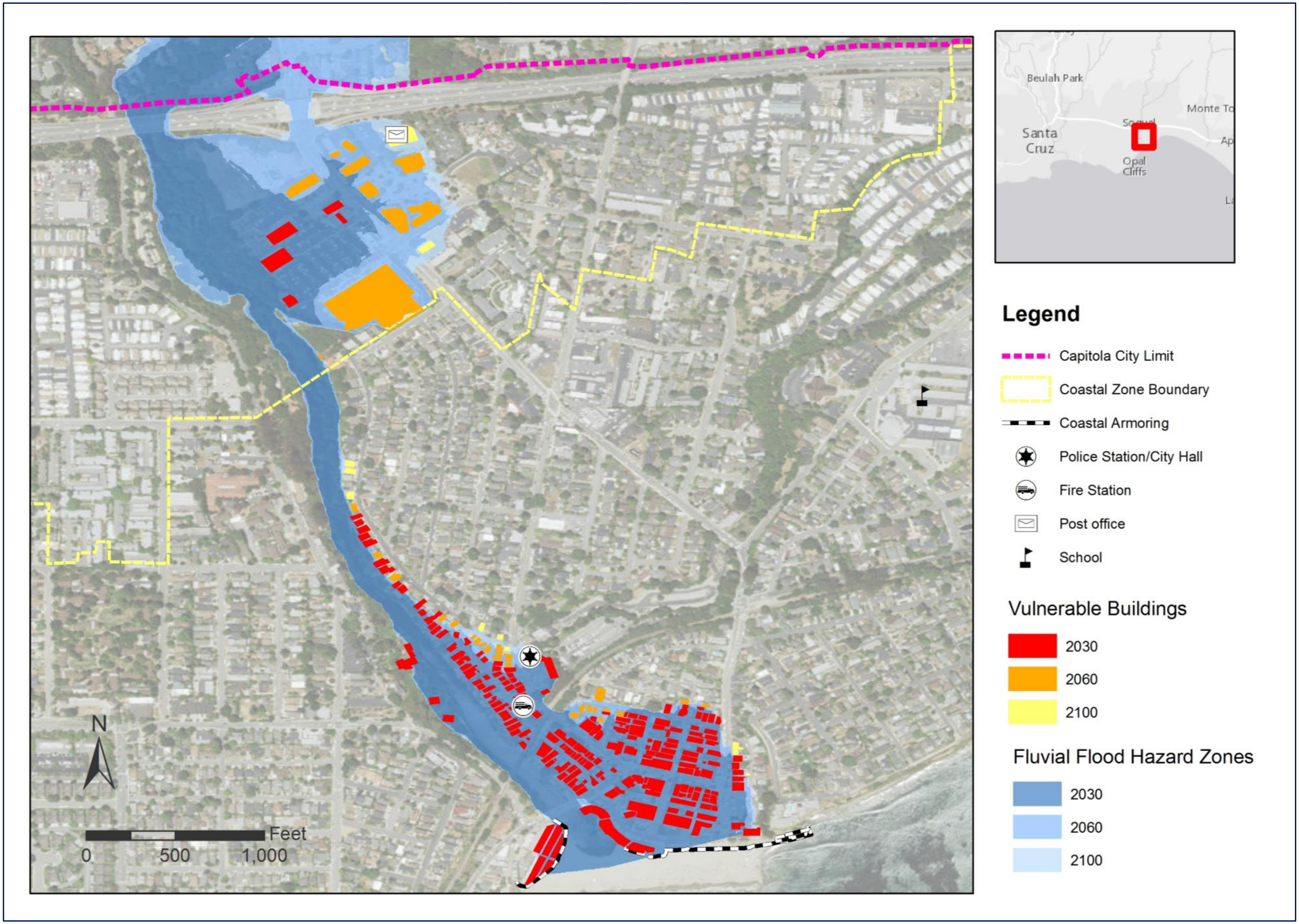


Table 10. Summary of Assets Vulnerable to River (Fluvial) Flooding

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

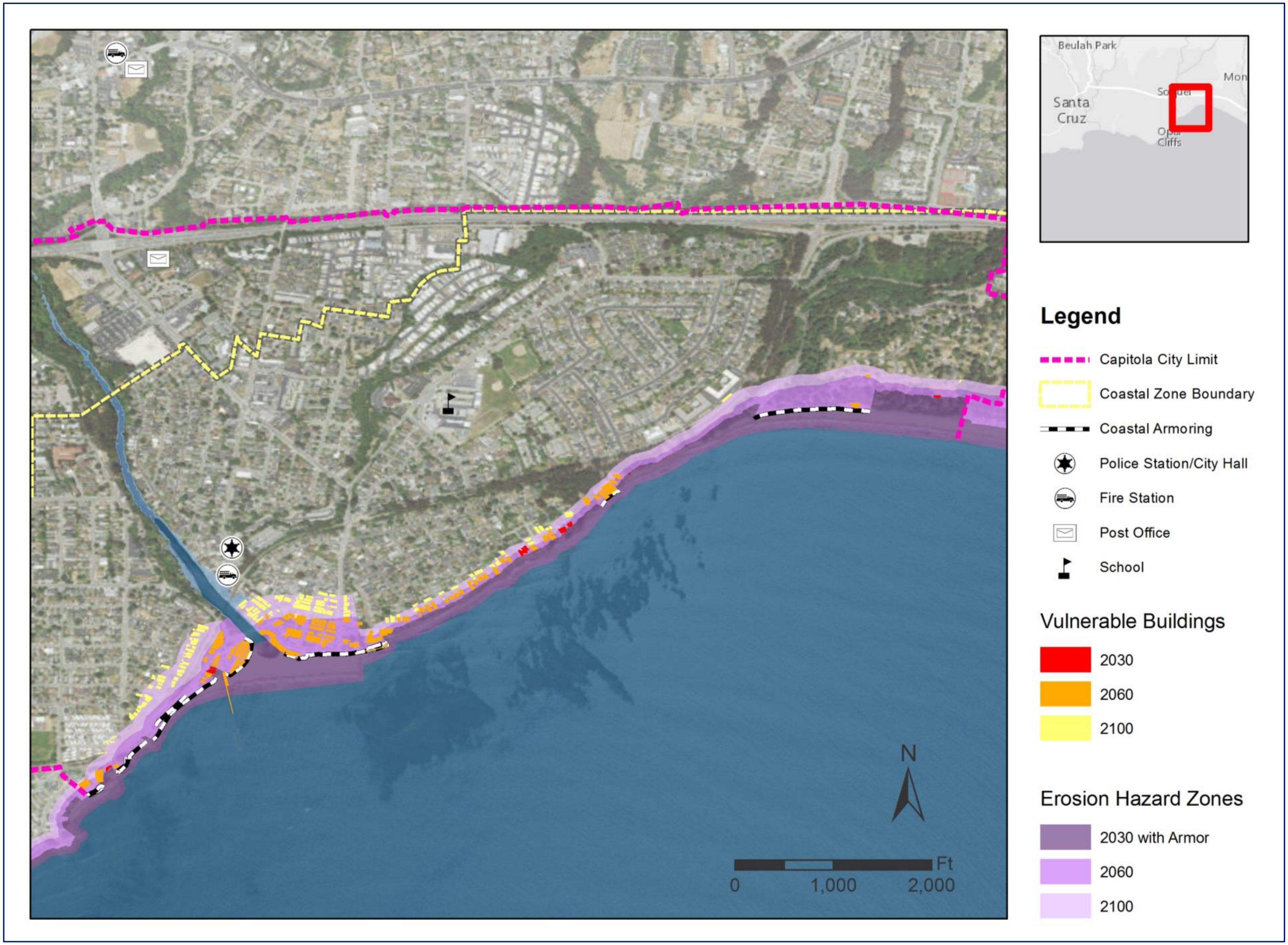


Table 11. Summary of Assets Vulnerable to Erosion

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.

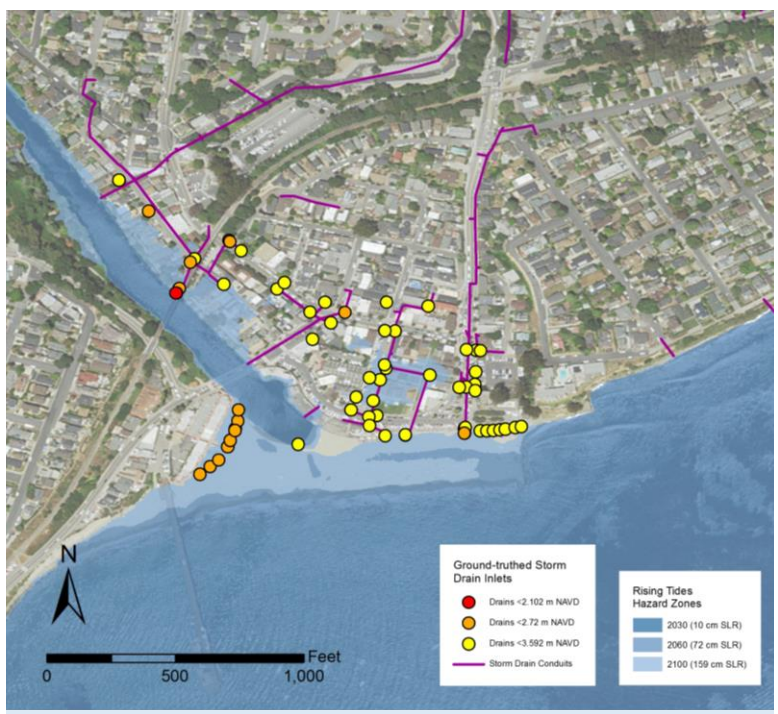


Figure 13. Storm drains with elevations within the projected tidal range for each time horizon

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

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[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)