

Chapter 8 Tsunami

8.1 Risk Assessment

8.1.1 Description of Hazards

Requirement §201.6(c)(2)(i): The risk assessment shall include a description of the type location and extent of all natural hazards that can affect the jurisdiction.

A tsunami is a series of waves generated by an impulsive disturbance in a large body of water such as an ocean or large lake. Tsunamis are produced when movement occurs on faults in the ocean floor, usually during very large earthquakes. Sudden vertical movement of the ocean or lake floor by a fault, landslide or similar movement displaces the overlying water, creating a wave that travels outward from the source. The waves can travel across oceans and maintain enough energy to damage distant shorelines. The hazard posed by tsunamis came to the attention of the world during the 2004 Indian Ocean tsunami that killed as many as 300,000 people who lived more than a thousand miles from the source of the earthquake. An earthquake anywhere in the Pacific Ocean can cause tsunamis around the entire Pacific basin, including offshore of Santa Cruz County. Since the Pacific Rim is highly seismically active, tsunamis are not uncommon, but historically have been only a few meters in height. Significant damage occurred in the Santa Cruz Harbor as a result of a 9.0 earthquake in Japan. While the tsunami caused massive damage and casualties in Japan, the Santa Cruz Harbor suffered approximately \$20 million in damage. However, the historic record is short, and may not reflect the true tsunami hazard to the County. The potential outcome of a tsunami could be more significant damage and loss of life.

Santa Cruz County is located on Monterey Bay. Several active and potentially active earthquake faults are located within or near Santa Cruz County. An earthquake occurring in or near any of the nearby faults could result in local source tsunamis from submarine landsliding in Monterey Bay. Additionally, distinct-source tsunamis from the Cascadia Subduction Zone to the north, or teletsunamis from elsewhere in the Pacific Ocean, are also capable of causing significant destruction. Figure 19 is a map of potential tsunami inundation areas in Santa Cruz County.

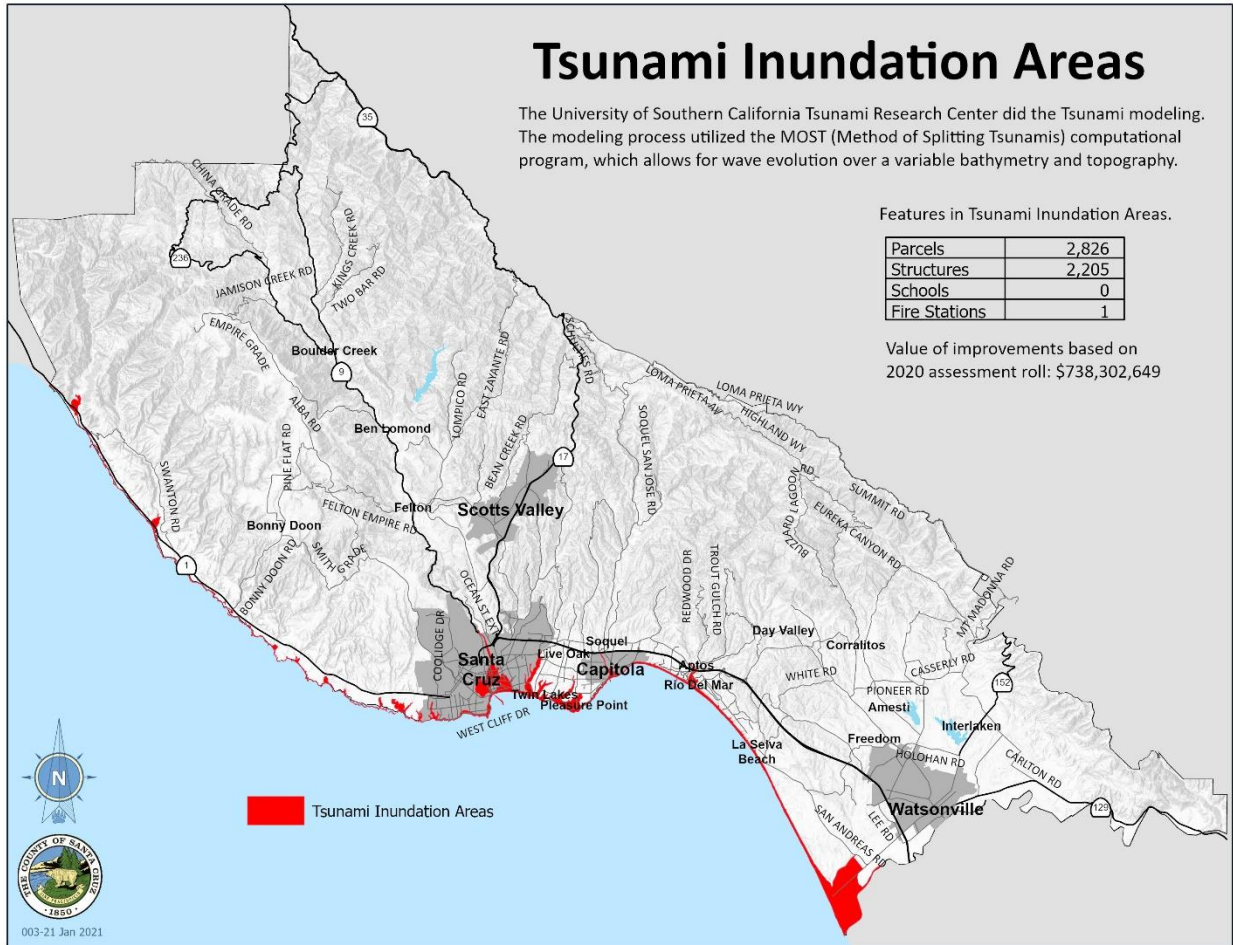


Figure 18 Tsunami inundation map

A local source tsunami generated by an earthquake on any of the faults affecting Santa Cruz County could arrive just minutes after the initial shock. The lack of warning time from such a nearby event would result in higher casualties than if it were a distant tsunami where the Tsunami Warning System for the Pacific Ocean could warn threatened coastal areas in time for evacuation (2011 Santa Cruz Harbor tsunami, for example). Past experience has not resulted in extensive damage from nearby tsunamis, but proximity to faults does create the possibility as a result of future quakes.

8.1.2 Previous Occurrences

Requirement §201.6(c)(2)(i): The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.

Tsunamis have affected Santa Cruz County several times in recorded history. The first recorded tsunami was a tele-tsunami that initiated from an earthquake near Japan on June 15, 1896. In Japan, the death toll was approximately 20,000 people, but in Santa Cruz the tsunami was only a meter and a half high and there is little record of damage. A more significant tsunami occurred on April 1, 1946 when a magnitude 7.8 earthquake in the Aleutian Islands produced a 115-foot wave, which destroyed the Scotch Cap lighthouse killing five Coast Guardsmen. A related tsunami was 56 feet high in Hawaii, killing

173 people. The wave was observed all along the west coast. In Santa Cruz County, a man drowned, and minor damage was done by 10-foot waves. It should be noted that scientific observations place the 1946 Tsunami run up at 1.5 meters. Santa Cruz County was hit by a similar sized tsunami generated by the Good Friday Earthquake of March 27, 1964. Reports vary indicating heights between 1.5 meters and 3.3 meters. After the Loma Prieta Earthquake, a seiche, or oscillating wave in an enclosed or partially enclosed body of water, was observed at the Santa Cruz Harbor. The most recent tsunami occurred as a result of the magnitude 9.0 earthquake in Japan on March 11, 2011. In Japan nearly 16,000 deaths occurred as a result of the earthquake and tsunami, which generated a wave of water up to 113 feet in height travelling inland up to six miles. This tsunami hit the Santa Cruz Harbor with waves estimated to be several feet combined with swift and chaotic currents causing approximately \$20 million in damage.

California is at risk from both local and distant source tsunamis. Eighty-two possible or confirmed tsunamis have been observed or recorded in California during historic times. Most of these events were small and only detected by tide gages. Eleven were large enough to cause damage and four events resulted in deaths.

Anticipating the extent of future tsunami hazard is difficult because the historic record is limited, as is our understanding of the source mechanisms and influence of offshore geometry on the impact of tsunami in Santa Cruz County.

Studies have recently been undertaken by Richard K. Eisner, Jose C. Borrero and Costas E. Synolakis through the Governor's Office of Emergency Services and the Department of Civil Engineering at the University of Southern California, Los Angeles. In Inundation Maps for the State of California, the authors clarify that the results are based on worst-case scenario events and the maps are only to be used for emergency preparedness and evacuation planning. Pre-1994 inundation computations underestimated inundation height. Newer inundation models are now capable of modeling extreme events more accurately. These new inundation models (known as MOST) permit quantitative evaluation of inundation from nearfield tsunamis, provided accurate regional tectonic models and high-resolution bathymetry exist. Even using state of the art inundation prediction tools, California presents unique challenges in assessing tsunami hazards because:

- There is an extremely limited historic record of tsunamis in the state. In California there are no known records before the 19th century. Some paleo-seismic investigations have revealed evidence of pre-historic tsunamis, but not in Santa Cruz County.
- Most of the geologic work in the state has concentrated on identifying the risks associated with onshore faults and there is scant available information on offshore faults or landslide and slump scars suggestive of past submarine mass failures.
- Earlier estimates of tsunami hazards created the impression among planners and the public that the tsunami hazard was small.
- Nearshore seismic events may trigger tsunamis arriving within less than 20 minutes from peroration, allowing little time for evacuation.
- Shorelines and shoreline platforms vary significantly throughout the state, which modify tsunami run up and the corresponding potential damage.

8.1.3 Assessing Vulnerability: Overview

Requirement §201.6(c)(2)(ii): The risk assessment shall include a description of the jurisdiction’s vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description shall include an overall summary of each hazard and its impact on the community.

There are two primary types of tsunami vulnerability in Santa Cruz County. The first is a teletsunami or distant-source tsunami from elsewhere in the Pacific Ocean. This type of tsunami is capable of causing significant destruction in Santa Cruz County. However, this type of tsunami would usually allow time for the Tsunami Warning System for the Pacific Ocean to warn threatened coastal areas in time for evacuation.

The more vulnerable risk to Santa Cruz County is a tsunami generated as the result of an earthquake along one of the many earthquake faults in the region. Even a moderate earthquake could cause a local source tsunami from submarine landsliding in Monterey Bay. A local-source tsunami generated by an earthquake on any of the faults affecting Santa Cruz County would arrive just minutes after the initial shock. The lack of warning time from such a nearby event would result in higher casualties than if it were a teletsunami.

8.1.4 Assessing Vulnerability: Identifying Structures

Requirement §201.6(c)(2)(ii)(A): The plan should describe vulnerability in terms of the types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas.

Among every type of land use within the county, over 2,800 parcels lie within the tsunami inundation zone. The number of structures on these parcels is 2,205. Expected total loss in value would be over \$738 million (Table 20).

8.1.5 Assessing Vulnerability: Estimating Potential Losses

Requirement §201.6(c)(2)(ii)(B): The plan should describe vulnerability in terms of an estimate of the potential dollar losses to vulnerable structures identified in paragraph (c)(2)(ii)(A) of this section and a description of the methodology used to prepare the estimate.

Land Use	Parcels	Structures	Total Assessed Value 2020
Agricultural	28	23	\$1,286,675
Commercial	29	19	\$10,148,786
Government	144	41	\$0
Industrial	3	0	\$1,658,660
Institutional	10	3	\$4,022,180
Miscellaneous	76	11	\$13,656,300

Land Use	Parcels	Structures	Total Assessed Value 2020
Residential	2,529	2,106	\$707,147,912
Utilities	7	2	\$382,136
Total	2,826	2,205	\$738,302,649
Population	4,076		
Population is based on the 2010 Census. Unincorporated Block centroids were selected by the hazard area.			

Table 20 Tsunami potential loss inventory

Valuation of parcels within a hazard area is based on improvement values only as collected by appraisers with the County of Santa Cruz Assessor’s Office. They do not reflect sale value or replacement value. If a parcel intersected a hazard the entire improvement value of that parcel was used. Census population blocks were reduced to center points. If a hazard intersected a center point, that population was counted.

Tsunamis create many risks similar to riverine and coastal flooding and the tsunami and flood inundation areas are similar. However, tsunamis also produce a run up that can be much more extensive than the run up that occurs with typical coastal flooding. In determining the extent of tsunami damage an estimate must be made of the extent of the flooding. Current mapping of tsunami flooding and damage is not meant to be measured against parcel level information and therefore is a rough estimate of damage and loss in a worst-case scenario.

8.1.6 Assessing Vulnerability: Analyzing Development Trends

Requirement §201.6(c)(2)(ii)(C): The plan should describe vulnerability in terms of providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.

As was described previously, Santa Cruz County has compact urban areas as well as large expanses of agricultural and forested land. Most development is now infill or reuse development²², although development of existing rural parcels continues. As discussed under Flood Hazards, new development is not allowed within the 100-year floodway and must meet flood hazard regulations within the remainder of the floodplain. Reconstruction of existing structures within these areas must meet the flood elevation requirements for habitable space dictated by the FEMA guidelines and regulations. Although FEMA flooding regulations may indirectly protect against some tsunamis, these standards are inadequate as tsunamis have a different direction of force and energy and can inundate areas that are not affected by riverine or coastal flooding.

No changes in these development regulation or patterns occurred that would affect the County’s overall vulnerability since the previous plan was adopted in 2016. Although the County does not track the number of residential and commercial structures that have been built in tsunami hazard areas since the last LHMP was adopted in 2016, the number includes the number of new structures built in the flood hazard area in the unincorporated portion of the County. Since the last LHMP in 2016, there has been

twelve new residential structures and one commercial structure built on existing lots of record in flood hazard areas in the County. As stated above, growth management policies prevent new development from occurring where hazards are present. Development on existing lots of record is required to avoid hazards and incorporate appropriate setbacks, structural elevation, floodproofing, and other requirements to mitigate potential impacts from flood hazards. The Environmental Planning Section of the Planning Department, staffed by Resource Planners, one of which is the designated floodplain manager, specialize in reviewing each application for new residential and commercial structures to ensure that new development does not occur in hazard zones and that development on existing lots of record avoid, minimize, and mitigate potential impacts from identified flood hazards.

8.2 Mitigation Strategy

Requirement §201.6(c)(3): The plan shall include a mitigation strategy that provides the jurisdiction’s blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs and resources, and its ability to expand on and improve these existing tools.

The County’s current tsunami mitigation strategy is based upon notification and evacuation (see Appendix I). The strategy also includes continuation of an up-to-date Emergency Management Plan, an effective public information program and continuing collaborative efforts with the cities, agencies, and community organizations to facilitate collaborative efforts in providing up-to-date tsunami mapping, preparation, information, warning dissemination and education.

Mapping of tsunami inundation areas in Santa Cruz County, including the map used in this plan, is inadequate. This map should be viewed as an estimate of a worst-case scenario for planning purposes only. More accurate mapping of potential tsunami outcomes based on simulations of specific geologic events has been identified as an important component in preparing updates to this Hazard Mitigation Plan.

An assessment of this mitigation strategy as part of this 5-year plan update indicates this strategy would be an effective method for reducing potential losses identified in the risk assessment. The earthquake risk has not changed since the previous plan was adopted. No adjustments are needed to address a change in circumstances. The County will seek to update the tsunami mapping during the next five-year update.

8.2.1 Mitigation Goals

Requirement §201.6(c)(3)(i): The hazard mitigation strategy shall include a description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.

Tsunami Goals

Tsunami 1 - Avoid or reduce the potential for life loss, injury, property, and economic damage to Santa Cruz County from tsunami events.

Tsunami 2 - Continue to enhance emergency management systems including a defined public information process that includes an early warning system for evacuation prior to a tsunami event.

Tsunami 3 - Pursue unification of the County of Santa Cruz evacuation plan with those of the cities of Watsonville, Capitola, and Santa Cruz.

8.2.2 Identification and Analysis of Mitigation Actions

Requirement §201.6(c)(3)(ii): The mitigation strategy shall include a section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure.

Tsunami hazard mitigation strategies include the following actions. The alpha-numeric identifiers after each action are further described in Chapter 15 Mitigation Strategy.

- Coordinate a communication system with other agencies and cities, including evacuation operations for homes and businesses within specific areas. (A-10)
- Management of the early warning system including a defined public information process including establishing a reverse 911 system that will notify all homes and businesses within the tsunami inundation areas, and a public address protocol to have local and regional radio, TV and cable outlets announce evacuation notifications to the community. (C-1)
- Update tsunami maps and signage defining evacuation zones. (C-2)
- Encourage investigation of the tsunami threat to Santa Cruz County, and update development regulations based upon this investigation. (C-14)

2021 Progress Report

The integration of the plan into existing planning mechanisms and the implementation of mitigation actions demonstrate progress in risk reduction. An explanation of how the mitigation plan for tsunami hazards has been implemented over the last five years is included in Appendix L and described below for each Mitigation Action related to tsunami hazard reduction.

- Continue to meet quarterly with Long Range Radio Infrastructure Management Planning Group to strategically consider interoperability and coordination of communications systems development and change out. Continue to seek grant funding opportunities for emerging technologies and enhancements. The narrow banding communications project has been completed for all county emergency services partners. (A-10)
- Continue to use Code Red EWS. Also added IPAWS. In addition, Public Works installed tsunami warning signs along the coastal areas in cooperation with Emergency Services. (C-1)
- The County uses the latest tsunami inundation maps referenced in this plan. The existing maps will be updated when new information becomes available. (C-2)
- The County will pursue update of the tsunami inundation maps as better scientific information becomes available. (C-14)

By using these communication and warning systems combined with current maps the County has demonstrated progress in reducing the risk from tsunami hazards. Further explanation of how the previous mitigation plan has been implemented over the last five years is included in Appendix L. The worksheets in Appendix L also describe how the current mitigation strategy, including the goals and hazard mitigation actions, will be implemented over the next five years. The projects described in Mitigation Actions A-10, C-1, C-2, and C-14 are still relevant and will continue to be implemented over the next five years.