CITY OF MANHATTAN BEACH
EMERGENCY RESPONSE PLAN
FOR TSUNAMI OPERATIONS

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EMERGENCY RESPONSE PLAN
FOR TSUNAMI OPERATIONS

SITUATION

a. **The Threat:** (See Annex 1, The Threat, for a full description of the Tsunami threat to the City of Manhattan Beach:

A tsunami is a series of sea waves most commonly caused by an earthquake beneath the ocean floor. In the open ocean, tsunami waves travel at speeds of up to 600 miles per hour. As the waves enter shallow water, they may rise rapidly. The first wave is not always the largest; successive waves may be spaced many minutes apart and continue for several hours.

Southern California has several faults near the coastline as well as several off-shore canyons that could experience an underwater landslide triggered by a local earthquake. The rupture of any of these coastline faults could result in a local tsunami which would be ashore in 10 minutes or less, providing almost no time for a warning to evacuate to higher ground.

The tsunami threat for Manhattan Beach is simple. Immediate coastline structures are threatened west of Highland Ave. There is no siren system for early warning. The City of Manhattan Beach would be notified by the Alaska/Hawaii warning network within minutes of an event that could remotely have an effect on this area, but getting the warning out to the population will take time.

While historic and geologic evidence suggests a threat of tsunami is greater in Alaska, Hawaii and the northern coastal areas of California, the same evidence indicates a potential for events impacting Southern California. A near field or near shore tsunami (local) is one that can hit the coast within minutes following an offshore geological event. This type of locally generated tsunami is possible at many points along the Southern California coast and provides little time for warning the population and less time for evacuation. Studies have identified the Palos Verdes, Santa Cruz Island and Santa Rosa Island faults as active and potentially tsunami-genic.

A USC study concludes that the Southland would experience "grave economic consequences," with losses reaching $43 billion, from a tsunami-caused landslide off the Palos Verdes Peninsula. The USC study estimates that a submarine landslide off the Peninsula could generate a wave ranging from about 15 feet to 60 feet in height that would reach land in less than a minute. The study examines four different scenarios of increasing severity. Depending on the scenario, economic losses ranged from $7 billion to $43.5 billion, according to the newspaper. In the worst case, both the ports of Los Angeles and Long Beach would be out of commission for a year. Losses in the Harbor Area, Carson, Rancho Palos Verdes and Palos Verdes Estates alone could exceed $450 million.

"We're not talking about the replacement cost (of homes, roads and other infrastructure) that would come about as a result of this catastrophe," James Moore II, professor and chair of the Daniel J. Epstein Department of Industrial and Systems Engineering at USC, said in remarks quoted by the *Breeze.* "We're talking about the cost of not being able to produce because of damage to facilities." The costs also do not include damage caused by a potential earthquake. The study, published in the April issue of Civil Engineering magazine, is the first effort by scientists to try to quantify economic losses from a tsunami, according to the *Breeze.*

b. **Federal, State and County response**.

(1) In 1994, the United States Senate Appropriations Committee directed the National Oceanic and Atmospheric Administration (NOAA) to formulate a plan for reducing tsunami risks to the nation's coastal residents. Subsequent studies have indicated the potential for a local or distant source tsunami affecting the pacific shoreline states. Subsequent studies and workshops sponsored or supported by NOAA, the Federal Emergency Management Agency, and the Governor's Office of Emergency Services have raised the consciousness of public disaster services agencies, and led to the development of tsunami action plans in some of the most endangered localities.

(2) The County Board of Supervisors has recognized the criticality of the tsunami threat and has directed the preparation of a County Operational Area Tsunami Emergency Response Plan.

(3) Given the above conditions, and the recent activities of Federal, State and County agencies in defining the issues, a tsunami element would be a prudent addition to the City's overall disaster planning efforts. Integration of a tsunami element into existing plans will provide for coordinated and supported activities, maximize available resources, provide a strong foundation of expertise, and contain any additional elements which may be necessary to affect appropriate preparation and response.

c. **Assumptions**: While the city is not considered the most threatened area for a tsunami event, prudent planning will allow for a worst-case scenario. If a distant or local event has occurred and generated a tsunami, it might be expected that the following could occur depending on the size and scope of the undersea disruption:

(1) The activation of the City EOC if the event is large enough to trigger a tsunami of potentially dangerous proportion

(2) There may be loss of life.

(3) Properties located west of Highland Ave. may be severely damaged or destroyed.

(4) Local evacuations may be necessary causing the need for local shelter sites to be opened.

(5) Power and water outages will occur and communication systems may be damaged.

(6) Economic losses can occur that will require business resumption planning.

(7) Losses to the tourist industry.

2. **MISSION**: The mission of the City of Manhattan Beach is to reduce the potential for loss of life and property from actions caused by a tsunami. City planning will be led by the City Manager supported by designated City departments, agencies and representatives from potentially impacted areas. Execution will be directed by the Director of Emergency Services or by the City EOC Director.

3. CONCEPT OF OPERATIONS:

a. **Lead responsibilities**. The Emergency Preparedness Coordinator is responsible for developing and maintaining this plan. Execution of the plan will be directed by The City Manager, or designee. Assigned departments and agencies will work under the umbrella of the City EOC using the Standardized Emergency Management System (SEMS). In order to successfully accomplish the mission, different City departments and agencies must work cooperatively. Multi-agency, multi-disciplined coordination will be used in response to a tsunami threat or event.

b. **Phases of operational activities**. The sequence of operational activities for a tsunami event is categorized below:

(1) **Alert Phase.** Potential tsunamis are monitored by the West Coast/Alaska Tsunami Warning Center (WC/ATWC) in Palmer, Alaska. The information is received by the Office of Emergency Services (OES) Warning Center via the National Warning System (NAWAS). All information received from the WC/ATWC is passed directly to the local operational areas via the California Law Enforcement Telecommunications System (CLETS), California Warning System (CALWAS) and Emergency Digital Information System (EDIS). The Operational Area disseminates the information to the local jurisdiction through the Sheriff's Department. If the first wave is expected to reach the coast with enough time for evacuation, the decision to make a complete, immediate evacuation may be necessary. However, if the wave is expected in 3-6 hours, a phased evacuation is possible with the closing of beaches and removal of emergency equipment and personnel from coastal areas. It should be noted that the decision to evacuate populations and to close businesses may be questioned if the tsunami does not occur. In order to reduce individual liability, the City may elect to declare a local emergency.

(2) **Warning Phase.** The County will use the Emergency Alert System (EAS), and Emergency News Network (ENN) to warn the public about an anticipated tsunami. The City will utilize the Reverse 911 telephone advisory system. Additionally the City will use its Cable TV channel, Hazard Advisory Radio System, Emergency Alert E-mail system, website and telephone Hotline.

(3) **Evacuation Phase.** The County Operational Area is responsible for developing evacuation plans to be implemented in response to local or distant events. A local tsunami requires immediate self-evacuation possibly through areas damaged by earthquake and at risk of after-shocks. Distant events may allow several hours to implement emergency procedures and evacuation. Evacuation routes must take into account potential earthquake damage. The City Emergency Preparedness Department, in association with the Police Department, will establish proposed evacuation routes and coordinate these routes with the Public Works department, and Fire department.

(4) **Damage Assessment Phase.** Damage and Safety Assessment will be performed by City staff in association with auxiliary trained personnel as available. All reports will be received by the Operations Section in the City EOC. Completed reports will be forwarded to the Los Angeles County EOC via OARS computer, or if OARS is not functional, to Lennox Sheriff Station for forwarding to the County EOC.

(5) **Emergency Public Information (all phases).** All official Emergency Public Information emanating from the City of Manhattan Beach will be handled by the Public Information Officer under the direction of the Director of Emergency Services or EOC Director. Information will be disseminated via Manhattan Beach's Cable TV channel, Hazard Advisory Radio System, Emergency Alert E-mail system, website and telephone Hotline. In an emergency, the Emergency Alert System (EAS) may be utilized by Los Angeles County to interrupt normal radio and television broadcasts for special announcements.

c. **Public awareness/education campaigns.** Los Angeles County Office of Emergency Management (OEM), in cooperation with other departments and agencies, will establish public education materials to prepare the public for tsunamis. This material will be available to the City in camera-ready copy for us to customize to meet our needs. The City of Manhattan Beach's Emergency Preparedness Coordinator will work with Los Angeles County's Earthquake Survival Program's (ESP) public education campaign, to provide preparedness information to all residents throughout the city on the dangers of tsunamis and the actions to take before, during and after an event. A sample of the ESP Focus and Public Information Sheet for Tsunami Preparedness are attached at Annex 4.

4. **EXECUTION.** Implementation of this plan will be directed by the Director of Emergency Services for the City of Manhattan Beach, or designee. Response operations will be consistent with those described in the Los Angeles County Operational Area Emergency Response Plan.

a. **RESPONSIBILITIES:** In addition to their normal responsibilities, City departments are responsible for the following specific actions:

- DIRECTOR OF EMERGENCY SERVICES (City Manager)
  - Reports to the City Council;
  - Warning the public;
- EMERGENCY PREPAREDNESS COORDINATOR:
  - Plan development and maintenance;
  - Emergency Operations Center (EOC) coordination
  - Warning the public;
- CITY EOC OPERATIONS SECTION
  - Managing Emergency Operations;
  - Coordination With the Operational Area;
  - Assessing damage to City facilities;
  - Coordinating evacuation transportation needs;
  - Coordination with Utility companies;
  - Coordination with County Public Health on health impacts;
  - Coordination with the Red Cross on sheltering needs;
- CITY EOC PLANS & INTEL SECTION
  - Evacuation planning;
  - Initial recovery planning;
- CITY EOC LOGISTICS SECTION
  - Expedite requests for tsunami-related purchases of goods and services
  - Procurement assistance and Mutual Aid assistance can be provided by the County EOC for issues that cannot be resolved through normal means.
- CITY EOC ADMIN/FINANCE SECTION
  - Will establish guidelines for identifying emergency-related expenditures for City departments.
  - Tracks and documents associated costs

b. **UPDATES AND MAINTENANCE OF THE PLAN:** The Emergency Preparedness Coordinator is responsible for updates and maintenance of this plan. The plan will be reviewed and exercised yearly in conjunction with the Los Angeles County Tsunami Task Force.

c. EMERGENCY STATUS: There are three levels of emergency status:

1. Case "A": Tsunami Warning: Tsunami is imminent or has occurred (Warning and evacuation).
2. Case "B": Tsunami Watch: A potentially hazardous situation is developing. (precautionary alert to prepare to evacuate inundation area).
3. Case "C": Tsunami Watch/Warning has been cancelled.

d. EMERGENCY ACTIONS

1. CASE "A" EVENT; Tsunami Warning: Reports from responsible authority indicate that TSUNAMI INUNDATION IS IMMINENT OR HAS OCCURRED.

a. County Actions (typically):

1. Staff Duty Officer(SDO) will verify that tsunami inundation is imminent or has occurred
2. County EOC will activate
3. SDO will make designated initial notifications
4. Coordinate information with Sheriff's Office, CHP and appropriate Police departments concerning evacuation from the inundation areas, including designated Critical Infrastructure.
5. Alert American Red Cross for Mass Care Shelters.
6. Make contact with City of Manhattan Beach City Manager or Emergency Services Coordinator for status report and designated shelter area locations.
7. Broadcast Emergency Alert System (EAS) evacuation notices indicating inundation areas and locations of mass care shelters.
8. Activate RACES, DCS etc for communications support to Command Posts and mass care Shelters.
9. Monitor situation and assess damages, casualties and number of homeless.
10. Coordinate mutual aid, if necessary.
11. Keep State OES informed of situation.
12. Assist in re-entry, recovery operations and planning with other agencies as requested.

a. The primary concern of the Manhattan Beach Fire Department is rescue of victims and saving lives. The Manhattan Beach Police Department is primarily concerned with perimeter control and the prevention of looting within the City of Manhattan Beach. Law enforcement agencies are responsible for ensuring transportation for the disabled, the elderly and persons without vehicles.

b. City Actions:

1. Verify the situation with Sheriff's department or County EOC.
2. Make emergency notifications to the public.

3. Alert City emergency response staff
4. Alert City Council
5. Declare a State of Emergency
6. Establish on-going communications with County via EMIS
7. Open a City EOC to help manage the emergency.
8. Ensure safety & logistical support for City staff.
9. Send a representative to Unified Command Post as a Liaison
10. Alert CERT volunteers for additional support if necessary
11. Anticipate and provide for Mutual Aid requirements
12. Begin planning for the Recovery phase
13. Continue public notifications

2. **CASE "B" EVENT;** Tsunami Watch: Reports from responsible authority indicate that a TSUNAMI WATCH HAS BEEN ISSUED.
   a. County Actions:
      1. Verify the Information
      2. Activate EOC
      3. Make designated notifications
      4. Ensure all county resources are moving to safety

   b. City Actions:
      1. Verify the situation, and anticipated landfall.
      2. Alert City emergency response staff
      3. Alert City Council
      4. Make preliminary "Watch" notifications to the public
      5. Monitor media for confirmation of landfall
      6. Move available resources to pre-designated higher ground
      7. Open a City EOC to help manage the emergency

3. **CASE "C" EVENT;** Stand Down: Reports from responsible authority indicate that the tsunami threat no longer exists.
      1. Notify staff members and Council
      2. Make necessary public notifications
      3. Ensure documentation of all actions taken, for future reference
      4. Return all resources that were relocated to their original locations
      5. IF OARS was used, ensure system is properly logged off

5. CONTACTS AND NOTIFICATIONS

Notifications of an emergency (made to the City of Manhattan Beach):
(See “Alert Phase”; page 6)
Tsunami Watches, Warnings and Cancellation Notices for California are generated by the National Weather Service’s WEST COAST AND ALASKA TSUNAMI WARNING CENTER, a division of the National Oceanic and Atmospheric Administration (NOAA). These messages are transmitted in a variety of different ways by several sources and agencies.

It is possible to sign-up to receive these advisories directly by e-mail or via pager or cellular phone. However, the official notification system mandated by the State of California Governor’s Office of Emergency Services (OES) is a system called CLETS, the California Law Enforcement Telecommunications System. CLETS is used by law enforcement agencies and also by the Operational Area in the L.A. County EOC.

It is the Operational Area who will make Official notification of any messages received via CLETS to the City of Manhattan Beach, regardless of whether that information had already been received by staff via another delivery system on their cell phones or pagers. From the legal standpoint, City staff should understand that any messages received from sources other than the Operational Area should be taken as advisory in nature, and do not constitute an Official warning from the Operational Area.

Notifications to be made by City of Manhattan Beach:

- City Manager
- Fire Chief
- Police Chief
- Public Works Director
- Manhattan Beach Unified School District
- RCC Dispatch Center

6. INUNDATION ZONE

An official of the California Tsunami Safety Committee reported that a Southern California tsunami generated by a landslide off Palos Verdes could be as big as 42 feet tall and 25 miles wide. Assuming a worst-case scenario of a tsunami run-up of 42 feet, the inundation area would include:

- All beach-front property west of Highland Ave. from the northern city border to the southern city border.

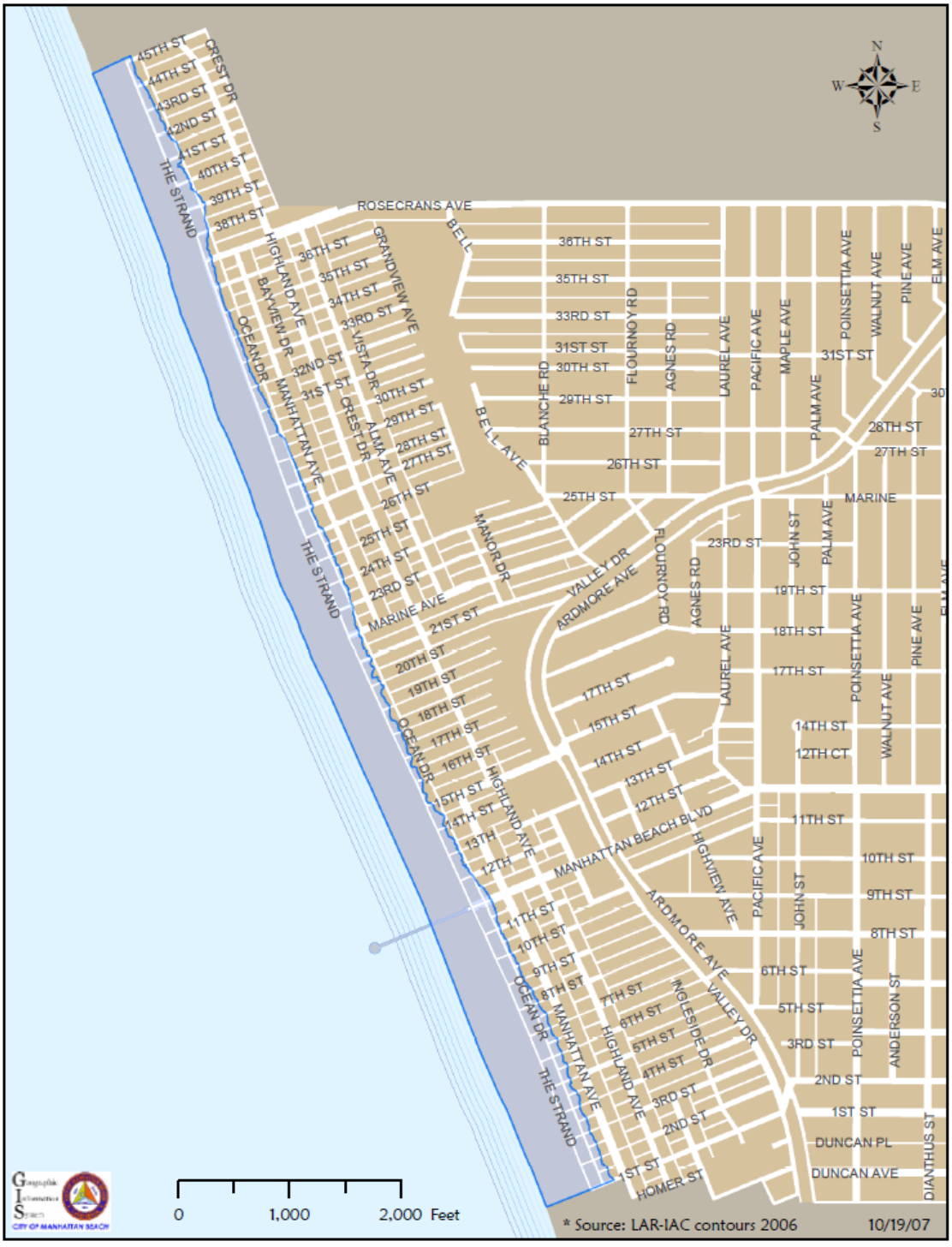
CRITICAL FACILITIES IN THE INUNDATION ZONE

- Manhattan Beach Pier
- Sewage Pump Station 27th St / Strand
- Beach Parking Lots

City of Manhattan Beach

Potential Tsunami Inundation Area

(elevation < 50' above sea level*)



The primary objective for persons within the Inundation Zone in the event of a Tsunami Warning is to move uphill and inland, away from the potential inundation area. It is important to note that any area that is 90' above sea level may be considered an area safe from tsunami upsurge.

A. Public Notification: Once the order to evacuate has been given, announcements will be made on all broadcast media using the Emergency Alert System (EAS). In addition to this, the City will employ the Reverse 911 system to notify by telephone every household located in the threatened area.. The Sheriff's Department will order helicopters to over-fly the coastal areas and provide announcements via loudspeaker. No door-to-door notifications are anticipated. On the beaches, the Life Guards will be responsible for evacuations on the sand; the Police Department would be responsible for evacuations from the parking lots.

B. Evacuation Routes & Safe Areas: Evacuation is coordinated by the Police Department.

C. Traffic Control: In order that the flow of traffic coming from areas west of Highland Ave. roadblocks will be established as needed.

POTENTIAL SHELTER SITES FOR THE PUBLIC

NOTE: The need for activation of Mass Care Centers will be as recommended by the City of Manhattan Beach and as designated by the City and the American Red Cross. Announcements will be made on all broadcast media of the shelter locations.

1. Manhattan Beach Middle School
2. Mira Costa High School

INITIAL COMMAND POST

1. City of Manhattan Beach EOC

POTENTIAL STAGING AREAS FOR EMERGENCY RESPONDERS

1. 15th Street between Highland Ave. and Valley Dr.
2. Live Oak Park

SIGNAGE

Standardized signs have been developed to delineate tsunami safe areas or evacuation routes nation-wide. Currently there are no signs posted in Manhattan Beach to indicate tsunami safe areas or evacuation routes. The City of Manhattan Beach is working with the County of Los Angeles to implement a signage program.

Examples of Warning Signs currently in use:

.

Tsunami Hazard Zone

Tsunami Evacuation Route

ANNEX 1: Tsunami Threat to the West Coast

1. A tsunami is a series of sea waves most commonly caused by an earthquake beneath the sea floor or generated by submarine volcanic eruptions or an underwater landslide. As the waves enter shallow water, they may rise rapidly and inundate coastal areas with the potential of endangering lives and creating significant property damage. The first wave is often not the largest, and waves may continue arriving for a number of hours.

2. A far field or tele-tsunami (distant) is one that may be generated by a very large earthquake in remote areas of the Pacific Ocean, such as the Cascadia Subduction Zone near Eureka which is considered by experts as the most threatening. Since distant tsunamis, such as from Cascadia, may take several hours to reach the Southern California coast following the event, they allow time for warnings to be issued to give coastal residents time to evacuate.

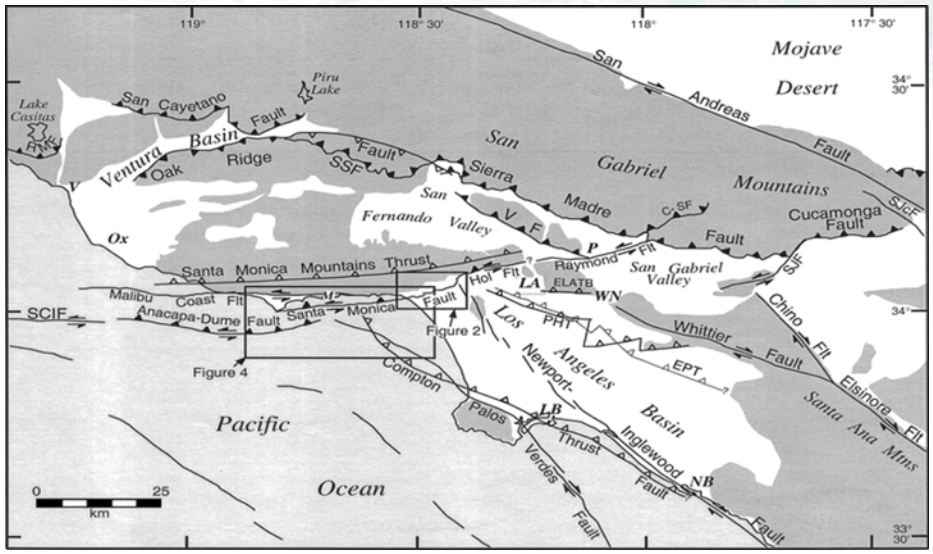
3. A near field or near shore tsunami (local) is one that can hit the coast within minutes following an offshore geological event. This type of locally generated tsunami is possible at many points along the Southern California coast and provides little time for warning the population and less time for evacuation. Studies have identified the Palos Verdes, Santa Cruz Island and Santa Rosa Island faults as active and potentially tsunami-genic.

4. "Tsunami events affecting the United States an its territories have been responsible for approximately 470 fatalities and hundreds of millions of dollars in property and infrastructure damage.

5. "Since 1770, more than 46 remote-source generated and 18 local tsunamis have been observed along the west coast". (FEMA Multi-Hazard Risk Assessment, 1988).

6. "The orientation and bathymetry of the west coast of the United States tend to protect it from the full effects of many tsunamis". (American Institute of Professional Geologists, 1983).

7. On May 22, 1960, a tsunami generated in Chile struck Crescent City CA, causing $500,00 in damages. On March 27, 1964 a tsunami generated in Prince William Sound, Alaska struck Crescent City, this time killing 10 and causing $7 million in damage.



Regional neotectonic map for metropolitan southern California showing major active faults. The Santa Monica fault is a 40-km-long active fault within the 215-km-long Transverse Ranges Southern Boundary fault system (TRSBFS), which encompasses the Raymond, Hollywood, Santa Monica, Manhattan Beach Coast, Anacapa-Dume, Santa Cruz Island, and Santa Rosa Island faults as well as several blind thrust faults

ANNEX 2: Historic Tsunamis in California:

The chart below shows data from some of the tsunamis recorded in central and southern California from 1812 to 2000 (from http://www.ngdc.noaa.gov/nndc/servlet/ShowDatasets):

year	month	day	travel time (hours)	travel time (minutes)	tsunami location	height (meters)	source location	source event	source magnitude (Ms)	source magnitude (Mw)
1812	12	21			EL REFUGIO (GAVIOTA)	3.4	CA	Purisima	7.7	
1812	12	21			SANTA BARBARA	2	CA	Purisima	7.7	
1812	12	21			VENTURA	2	CA	Purisima	7.7	
1856	9	24			SAN DIEGO	3.6	Japan	Tokaido		
1859	9	24			HALF MOON BAY	4.6	N. CA			
1862	5	27			SAN DIEGO	1.2	S. CA		5.8	
1868	10	21			SAN FRANCISCO BAY	4.5	SF area		6.8	
1868	8	13			SAN PEDRO	1.8	N. Chile		8.5	
1868	8	13			WILMINGTON	1.8	N. Chile		8.5	
1877	4	16			ANAHEIM LANDING	1.8	CA			
1877	4	16			CAYUCOS	3.6	CA			
1877	5	10			GAVIOTA	1.8	N. Chile		8.3	
1877	5	10			SAN PEDRO	1	N. Chile		8.3	
1877	5	10			WILMINGTON	1.7	N. Chile		8.3	
1878	11	22			WILMINGTON	1	S. CA			
1896	12	17			SANTA BARBARA	2.5	S. CA			

1896	6	15		SANTA CRUZ	1.5	Japan	Sanriku	7.6	
1927	11	4		SURF	1.8	CA		7.3	
1930	8	31		SANTA MONICA	6.1	S. CA		5.2	
1930	8	31		VENICE	6.1	S. CA		5.2	
1934	8	21		NEWPORT BEACH,	12	S. CA			
1946	4	1		ARENA COVE	2.4	Alaska	E. Aleutian Islands	7.3	
1946	4	1	5 36	AVILA BEACH	1.3	Alaska	E. Aleutian Islands	7.3	
1946	4	1		DRAKES BAY	2.6	Alaska	E. Aleutian Islands	7.3	
1946	4	1		HALF MOON BAY	2.6	Alaska	E. Aleutian Islands	7.3	
1946	4	1		MORRO BAY	1.5	Alaska	E. Aleutian Islands	7.3	
1946	4	1	5 36	SAN LUIS OBISPO	1.3	Alaska	E. Aleutian Islands	7.3	
1946	4	1		SANTA CATALINA ISLAND	1.8	Alaska	E. Aleutian Islands	7.3	
1946	4	1		SANTA CRUZ	1.5	Alaska	E. Aleutian Islands	7.3	
1952	11	4	8 36	AVILA BEACH	1.4	Russia	Kamchatka	8.2	9
1960	5	22		MONTEREY	1.1	Chile	Central Chile		9.5
1960	5	22		PACIFICA	1.2	Chile	Central Chile		9.5
1960	5	22		PISMO BEACH	1.4	Chile	Central Chile		9.5
1960	5	22	14 4	PORT HUENEME	1.3	Chile	Central Chile		9.5
1960	5	22	14 12	SANTA MONICA	1.4	Chile	Central Chile		9.5

1960	5	22		STINSON BEACH	1.5	Chile	Central Chile		9.5
1960	5	22	13 43	WILSON COVE	1.2	Chile	Central Chile		9.5
1964	3	28		ARENA COVE	1.8	Alaska	Gulf of Alaska		9.2
1964	3	28	5 10	AVILA BEACH	1.6	Alaska	Gulf of Alaska		9.2
1964	3	28		CAPITOLA	2.1	Alaska	Gulf of Alaska		9.2
1964	3	28		MARTINS BEACH	3	Alaska	Gulf of Alaska		9.2
1964	3	28		MONTEREY	1.4	Alaska	Gulf of Alaska		9.2
1964	3	28		MOSS LANDING	1.4	Alaska	Gulf of Alaska		9.2
1964	3	28		PACIFICA	1.4	Alaska	Gulf of Alaska		9.2
1964	3	28	5 6	SAN FRANCISCO	1.1	Alaska	Gulf of Alaska		9.2
1964	3	28		SAN RAFAEL	1.5	Alaska	Gulf of Alaska		9.2
1964	3	28		SANTA CRUZ	1.5	Alaska	Gulf of Alaska		9.2
1964	3	28	5 39	SANTA MONICA	1	Alaska	Gulf of Alaska		9.2
1964	3	28		SAUSALITO	1.2	Alaska	Gulf of Alaska		9.2
1964	3	28		SEA VIEW	3.8	Alaska	Gulf of Alaska		9.2
1964	3	28		TOMALES BAY	1	Alaska	Gulf of Alaska		9.2
1975	11	29		SANTA CATALINA ISLAND	1.4			7.2	
1989	10	18		MOSS	1	CA	Loma	7.1	

			LANDING			Prieta
2000	11	4	POINT ARGUELLO	5	CA	Pt. Arguello

Tsunami Terminology

Amplitude: The rise above or drop below the ambient water level as read on a tide gage.

Arrival time: Time of arrival, usually of the first wave, of the first wave of the tsunami at a particular location.

Bore: Traveling wave with an abrupt vertical front or wall of water. Under certain conditions, the leading edge of a tsunami wave may form a bore as it approaches and runs onshore. A bore may also be formed when a tsunami wave enters a river channel, and may travel upstream penetrating to a greater distance inland than the general inundation.

CREST: Consolidated Reporting of EarthquakeS and Tsunamis, a project funded through the Tsunami Hazard Mitigation Federal/State Working Group to upgrade regional seismic networks in AK, WA, OR, CA, and HI and provide real-time seismic information from these networks and the USNSN to the tsunami warning centers.

ETA: Estimated Time of Arrival. Computed arrival time of the first tsunami wave at coastal communities after a specific earthquake has occurred.

First motion: Initial motion of the first wave, a rise in the water level is denoted by R, a fall by F.

free field offshore profile: A profile of the wave measured far enough offshore so that it is unaffected by interference from harbor and shoreline effects.

Harbor resonance: The continued reflection and interference of waves from the edge of a harbor or narrow bay which can cause amplification of the wave heights, and extend the duration of wave activity from a tsunami.

Horizontal inundation distance: The distance that a tsunami wave penetrates onto the shore, measured horizontally from the mean sea level position of the water's edge. Usually measured as the maximum distance for a particular segment of the coast.

ICG/ITSU: The International Coordination Group for the Tsunami Warning System in the Pacific, a United Nations organization under UNESCO responsible for international tsunami cooperation.

IDNDR: International Decade for Natural Disaster Reduction, a United Nations sponsored program for the 1990's.

inundation: The depth, relative to a stated reference level, to which a particular location is covered by water.

Inundation area: An area that is flooded with water.

ITIC: International Tsunami Information Center established in 1965. Monitors international activities of the Pacific Tsunami Warning Center and assists with many of the activities of ICG/ITSU.

Inundation: The depth, relative to a stated reference level, to which a particular location is covered by water.

Inundation area: An area that is flooded with water.

Inundation line (limit): The inland limit of wetting measured horizontally from the edge of the coast defined by mean sea level.

Leading-depression wave: Initial tsunami wave is a trough, causing a draw down of water level.

Leading-positive wave: Initial tsunami wave is a crest, causing a rise in water level. Also called a leading-elevation wave.

Local/regional tsunami: Source of the tsunami within 1000 km of the area of interest. Local or near-field tsunami has a very short travel time (30 minutes or less), mid-field or regional tsunami waves have travel times on the order of 30 minutes to 2 hours. Note: " Local" tsunami is sometimes used to refer to a tsunami of landslide origin.

Maremoto: Spanish term for tsunami.

Marigram: Tide gage recording showing wave height as a function of time.

Marigraph: The instrument which records wave height.

Mean Lower Low Water (MLLW): The average low tide water elevation often used as a reference to measure runup.

Ms: Surface Wave Magnitude. Magnitude of an earthquake as measured from the amplitude of seismic surface waves. Often referred to by the media as "Richter" magnitude.

Mw: Moment Magnitude. Magnitude based on the size and characteristics of the fault rupture, and determined from long-period seismic waves. It is a better measure of earthquake size than surface wave magnitude, especially for very large earthquakes. Calibrated to agree on average with surface wave magnitudes for earthquakes less than magnitude 7.5.

NOAA: National Oceanic and Atmospheric Administration, the federal agency responsible for tsunami warnings and monitoring. Part of the Department of Commerce.

NWS: National Weather Service, the branch of NOAA which operates the tsunami warning centers and disseminates warnings.

Normal earthquake: An earthquake caused by slip along a sloping fault where the rock above the fault moves downwards relative to the rock below.

Pacific Disaster Center (PDC): An information processing center to support emergency managersin the Pacific region. Funded by the U.S. Department of Defense.

PTWC: Pacific Tsunami Warning Center. Originally established in 1948 as the SSWWS, located in Ewa Beach near Honolulu. Responsible for issuing warnings to Hawaii, to U.S. interests in the Pacific other than the west coast and Alaska, and to countries located throughout the Pacific.

Period: The length of time between two successive peaks or troughs. May vary due to complex interference of waves. Tsunami periods generally range from 5 to 60 minutes.

Runup: Maximum height of the water onshore observed above a reference sea level. Usually measured at the horizontal inundation limit.

Seiche: A standing wave oscillating in a partially or fully enclosed body of water. May be initiated by long period seismic waves, wind and water waves, or a tsunami.

Strike-slip earthquake: An earthquake caused by horizontal slip along a fault.

SSWWS: Seismic Sea Wave Warning System, the original tsunami warning center established in 1948 after the April 1, 1946 tsunami killed 159 in Hawaii.

Teletsunami: Source of the tsunami more than 1000 km away from area of interest. Also called a distant-source or far-field tsunami.

THRUST: The project for Tsunami Hazard Reduction Using System Technology, sponsored by the Office for U.S. Foreign Disaster Assistance/Agency for International Development. A comprehensive program to mitigate tsunami hazards in developing countries.

Thrust earthquake: An earthquake caused by slip along a gently sloping fault where the rock above the fault is pushed upwards relative to the rock below. The most common type of earthquake source of damaging tsunamis.

Tidal wave: Common term for tsunami used in older literature, historical descriptions and popular accounts. Tides, caused by the gravitational attractions of the sun and moon, may increase or decrease the impact of a tsunami, but have nothing to do with their generation or propagation. However, most tsunamis (initially) give the appearance of a fast-rising tide or fast-ebbing as they approach shore and only rarely as a near-vertical wall of water.

TIME: The Center for the Tsunami Inundation Mapping Effort, to assist the Pacific states in developing tsunami inundation maps.

Travel time: Time (usually measured in hours and tenths of hours) that it took the tsunami to travel from the source to a particular location.

Tsunami: A Japanese term derived from the characters “tsu” meaning harbor and “nami” meaning wave. Now generally accepted by the international scientific community to describe a series of raveling waves in water produced by the displacement of the sea floor associated with submarine earthquakes, volcanic eruptions, or landslides.

Tsunami earthquake: A tsunamigenic earthquake which produces a much larger tsunami than expected for its magnitude.

Tsunamigenic earthquake: Any earthquake which produces a measureable tsunami.

Tsunami magnitude: A number which characterizes the strength of a tsunami based on the tsunami wave amplitudes. Several different tsunami magnitude determination methods have been proposed.

TWS: Tsunami Warning System, organization of 26 Pacific Member States which coordinates international monitoring and warning dissemination. Operates through ICG/ITSU

USNSN: United States National Seismic Network, operated by the USGS. Monitors, in real-time, magnitude (M)>5 earthquake activity worldwide and M>3 in conterminous US.UTC Universal Coordinated Time, international common time system, formerly GMT (Greenwich Mean Time).

UTC: Universal Coordinated Time, international common time system (formerly GMT, Greenwich Mean Time).

WC/ATWC: West Coast/ Alaska Tsunami Warning Center, established in 1967 originally to issue warnings to Alaska of local tsunami events. WC/ATWC is now responsible for issuing warnings for any event likely to impact either Alaska, the west coast of the US, or the Pacific coast of Canada.

WCM: Warning Coordination Meteorologist, regional weather service person responsible for providing information on the tsunami warning system to local agencies.

Source: www.pmel.noaa.gov/tsunami-hazard/terms.html

Annex-4

TSUNAMI PREPAREDNESS

General information:

Contrary to popular belief, a tsunami isn't one giant wave. It is a series of waves most commonly generated by an earthquake below the ocean floor. Ocean landslides offshore also can cause tsunamis.

Tsunamis can travel at speeds up to 600 miles per hour in the open sea and reach heights of up to 100 feet in shallow coastal waters. Usually, however, tsunamis that cause damage average nine to 10 feet in height and peak in the 21-45 foot range. The first wave almost never is the highest. Waves might continue to arrive for several hours, with several hours passing between each wave. In fact, the dozen residents of Crescent City who died as a result of the 1964 tsunami were killed when they went to the ocean to see the impacts of the earlier waves and a subsequent wave struck.

The time it takes for the waves to reach their destinations depends on where the earthquake occurs. A tsunami caused by an earthquake a few miles off the coast is called a "near field" or "locally generated" tsunami. Residents of coastal communities probably will feel such an earthquake. The first wave might reach shore in only a few minutes.

Tsunamis caused by large earthquakes centered near Alaska and other distant parts of the Pacific Ocean are called "far field" or "distant source" tsunamis. The first waves from these events take several hours to reach the California coastline. More than a dozen tsunamis with waves three feet high or more have struck California since 1812. Six caused damage. The tsunami generated by the 1964 Alaskan earthquake killed a dozen Crescent City residents and caused more than $34 million in damages.

The tsunami risk is greater along the north coast than in Southern California because more faults capable of generating tsunamis lie off the coast of Northern California. The threat in Northern California also is higher because of its proximity to Alaska, where most tsunamis that are damaging to California originate.

Southern California is not immune from the threat, however. Three tsunamis flooded Santa Barbara during the 1800s; a tsunami resulting from a Chilean earthquake damaged the pier in San Diego Harbor in 1960; and one-foot waves resulting from the 1992 Cape Mendocino earthquake were detected near Santa Barbara.

Terms to remember:

TSUNAMI WATCH: This means that a significant distant earthquake has occurred. Tsunami approach is not confirmed but is possible. Stay tuned to local radio and TV stations for information. Prepare for a possible Tsunami Warning.

TSUNAMI WARNING: This means that a tsunami approach has been confirmed. Stay tuned to local radio and TV stations for information and be prepared to evacuate if advised to do so by local authorities.

TSUNAMI EVACUATION: Those within the evacuation advisory area should immediately make their way to higher ground. Tsunami “Safe Areas” may be indicated by signs placed along roads at elevations of 90’ or more above sea level. Stay tuned to local radio and TV stations for information about local Evacuation Centers.

Steps you should take:

- If you feel an earthquake, duck, cover and hold until the shaking stops. Count how long the shaking lasts. If severe shaking lasts 20 seconds or more, a tsunami might follow.
- If you are at the beach and you notice the water has pulled back or run out, creating a vast expanse of exposed beach; this is a warning that a tsunami may be imminent.
- Move inland two miles or to land that is at least 90 feet above sea level immediately. Don’t wait for officials to issue a warning. Walk quickly, rather than drive, to avoid traffic, debris and other hazards.
- Stay away from coastal or low-lying areas. Waves might continue for several hours and travel several times faster than you can walk, run or drive.
- Use common sense. Do not endanger yourself by trying to surf a tsunami. Because they are not like regular waves, they are impossible to surf. They are much faster, higher and can come onshore filled with debris.
- Follow any evacuation notices.
- Listen to the radio or watch television for emergency information and instructions about re-entry from local officials.

NEVER GO TO THE BEACH TO WATCH FOR, OR TO SURF, A TSUNAMI WAVE!
When you are that close, you will probably not escape the waves. Remember that a tsunami is a series of waves. Often the first wave may be the least dangerous. The waves may get progressively worse.

ANNEX-5: DEFINITIONS

Tsunami: A series of traveling waves of extremely long length and period, usually generated by disturbances associated with earthquakes occurring below or near the ocean floor. (Also called seismic sea wave and, popularly, tidal wave.) Also, a series of ocean waves produced by a submarine earthquake, landslide, or volcanic eruption. These waves may reach enormous dimensions and travel across entire ocean basins with little lost of energy. They proceed as ordinary gravity waves with a typical period between 5 and 60 minutes. Tsunamis become steeper and increase in height on approaching shallow water (creating one or more waves that sweep inland like a flash flood), inundating low-lying areas. Where local submarine topography causes extremely steep waves, they may break and cause great damage. Tsunamis have no connection with tides; the popular name is entirely misleading.

Tsunami Information Bulletin: Message issued by the West Coast Alaska Tsunami Warning Center (WCATWC) to advise participants of the occurrence of a major earthquake in the Pacific or near-Pacific area, with the evaluation that a potentially destructive Pacific-wide tsunami was not generated.

Tsunami Warning Bulletin: Warning message issued throughout the Pacific based on confirmation that a tsunami has been generated that poses a threat to the population in part or all of the Pacific coast regions. A **Tsunami Warning** will be followed by additional bulletins with updated information until it is cancelled.

Regional Tsunami Warning/Watch Bulletin: Message issued initially by West Coast Alaska Tsunami Warning Center (WCATWC) based only on seismic information to alert all participants of the possibility of a tsunami and advise them that a tsunami investigation is underway. Those areas that are within 0 to 3 hours from the estimated time of arrival of the first wave are placed in a **Tsunami Warning** status. Those areas within 3 to 6 hours are placed in a Tsunami Watch status. It will be followed by additional bulletins until it is either upgraded to a Pacific-wide Tsunami Warning or until it is cancelled. The following is an example of a Regional Warning/Watch Bulletin issued by the PTWC.

Pacific-wide tsunami: A tsunami capable of widespread destruction, not only in the immediate region of its generation, but across the entire Pacific Ocean. These occur when the disturbance that generates the tsunami is sufficiently great. Usually starting as a local tsunami that causes extensive destruction near the source, these waves continue to travel across the entire ocean basin with sufficient energy to cause additional casualties and destruction on shores more than a thousand km from the source. In the last two hundred years, there have been at least seventeen destructive Pacific-wide tsunamis.

The most destructive Pacific-wide tsunami of recent history was generated by a massive earthquake off the coast of Chile on May 22, 1960. All Chilean coastal towns between the 36th and 44th parallels were either destroyed or heavily damaged by the action of the tsunami and the quake. The combined tsunami and earthquake toll included 2,000 killed, 3,000 injured, 2,000,000 homeless, and $550 million damage. Off the coastal town of Corral, Chile, the waves were estimated to be 20 meters (67 feet) high. The tsunami caused 61 deaths in Hawaii, 20 in the Philippines, and 100 or more in Japan. Estimated damages were US$50

million in Japan, US$24 million in Hawaii and several more millions along the west coast of the United States and Canada. Distant wave heights varied from slight oscillations in some areas to 12 meters (40 feet) at Pitcairn Island; 11 meters at Hilo, Hawaii; and 6 meters at some places in Japan. A Pacific-wide tsunami today, similar in size to the May 1960 event, could easily have catastrophic consequences.

Near-field Tsunami (Also Known As Local Tsunami): A tsunami from a nearby source, generally less than 200 km away. A local tsunami is generated by a small earthquake, a landslide or a pyroclastic flow. This is the most serious tsunami hazard for Los Angeles County, because the wave heights are likely to be highest and the forces are likely to be the strongest (due to proximity to the precipitating event), because these tsunami waves can arrive in as little as 3 to 15 minutes of the event, and because they may occur after a disastrously damaging coastal earthquake, creating another layer of disaster, threatening the public and personnel responding to the earthquake, and complicating search, rescue, treatment, firefighting, and hazardous materials management.

Tele-tsunami (also known as distant-source Tsunami): A tsunami originating from a distant source, generally more than 1000 km away.

Estimated time of arrival (ETA) of Tsunami : Time of tsunami arrival at some fixed location, as estimated from modeling the speed and refraction of the tsunami waves as they travel from the source. ETA is estimated with very good precision if the bathymetry and source are well known (less than a couple of minutes).

Tsunami Evacuation Map: A drawing or representation that outlines danger zones and designates limits beyond which people must be evacuated to avoid harm from tsunami waves.

Tsunami Travel Time: Time required for the first tsunami wave to propagate from its source to a given point on a coastline.

Tsunami Travel Time Map: Map showing isochrons or lines of equal tsunami travel time calculated from the source outwards toward terminal points on distant coastlines.

Inundation Line: Inland limit of tsunami inundation, measured horizontally from the mean sea level (MSL) line.

Run-up: Difference between the elevation of maximum tsunami penetration (inundation line) and the sea-level at the time of the tsunami attack.

ANNEX 6: EXAMPLE OF TSUNAMI WATCH MESSAGE

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PKZ032-031-042-034-033-035-041-036-AKZ023-024-025-026-028-
029-027-150456-
COASTAL AREAS FROM THE NORTH TIP OF VANCOUVER I.-BC. TO
SITKA-AK.

...A TSUNAMI WATCH IS IN EFFECT FOR THE COASTAL AREAS FROM
   THE NORTH TIP OF VANCOUVER I.-BC. TO SITKA-AK...

ESTIMATED TIMES OF INITIAL WAVE ARRIVAL
LANGARA-BC       2244 PDT JUN 14   KETCHIKAN-AK     2257 ADT JUN 14
SITKA-AK         2227 ADT JUN 14
$$
PKZ176-175-172-170-171-155-150-132-136-138-137-130-141-140-
120-121-129-127-125-126-128-052-051-053-022-012-043-013-
011-021-AKZ191-185-181-171-145-111-101-121-125-131-135-017-
020-018-019-021-022-150456-
COASTAL AREAS FROM SITKA-AK. TO ATTU-AK.

...TSUNAMI INFORMATION STATEMENT...

NO - REPEAT NO - TSUNAMI WATCH OR WARNING IS IN EFFECT FOR
   THE COASTAL AREAS FROM SITKA-AK. TO ATTU-AK.

FOR INFORMATION ONLY - ESTIMATED TIMES OF INITIAL WAVE ARRIVAL
YAKUTAT-AK       2317 ADT JUN 14   CORDOVA-AK       0007 ADT JUN 15
KODIAK-AK        2332 ADT JUN 14   DUTCH HARBOR-AK  0013 ADT JUN 15
JUNEAU-AK        2334 ADT JUN 14   COLD BAY-AK      0034 ADT JUN 15
SEWARD-AK        2339 ADT JUN 14   ADAK-AK          0038 ADT JUN 15
VALDEZ-AK        2357 ADT JUN 14   HOMER-AK         0044 ADT JUN 15
SAND PT.-AK      2358 ADT JUN 14   SHEMYA-AK        0119 ADT JUN 15
$$

THE PACIFIC TSUNAMI WARNING CENTER AT EWA BEACH HAWAII WILL
ISSUE BULLETINS FOR OTHER AREAS OF THE PACIFIC.

BULLETINS WILL BE ISSUED HOURLY OR SOONER IF CONDITIONS
WARRANT. THE TSUNAMI WATCH/WARNING WILL REMAIN IN EFFECT
UNTIL FURTHER NOTICE. REFER TO THE INTERNET SITE
WCATWC.ARH.NOAA.GOV FOR MORE INFORMATION AND ETA SITES.
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ANNEX 7: EXAMPLE OF TSUNAMI WARNING

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WEPA41 PAAQ 150256
TSUWCA

TO      - TSUNAMI WARNING SYSTEM PARTICIPANTS IN
          ALASKA/BRITISH COLUMBIA/WASHINGTON/OREGON/CALIFORNIA
FROM    - WEST COAST AND ALASKA TSUNAMI WARNING CENTER/NOAA/NWS
SUBJECT - TSUNAMI WARNING BULLETIN - INITIAL
BULLETIN NUMBER 1
ISSUED 06/15/2005 AT 0256 UTC

...A TSUNAMI WARNING IS IN EFFECT FOR THE COASTAL AREAS
   FROM THE CALIFORNIA-MEXICO BORDER TO THE NORTH TIP OF
   VANCOUVER I.-BC. INCLUSIVE...

...A TSUNAMI WATCH IS IN EFFECT FOR THE COASTAL AREAS FROM
   THE NORTH TIP OF VANCOUVER I.-BC. TO SITKA-AK...

...AT THIS TIME THIS BULLETIN IS FOR INFORMATION ONLY FOR
   OTHER AREAS OF ALASKA...

EARTHQUAKE DATA
 PRELIMINARY MAGNITUDE - 7.4
 LOCATION -  41.3N  125.7W -  90 MILES NW OF EUREKA-CA.
                             300 MILES NW OF SAN FRANCISCO-CA.
 TIME     - 1851 ADT 06/14/2005
            1951 PDT 06/14/2005
            0251 UTC 06/15/2005

EVALUATION
 IT IS NOT KNOWN - REPEAT NOT KNOWN - IF A TSUNAMI EXISTS BUT A
 TSUNAMI MAY HAVE BEEN GENERATED.  THEREFORE PERSONS IN LOW
 LYING COASTAL AREAS SHOULD BE ALERT TO INSTRUCTIONS FROM THEIR
 LOCAL EMERGENCY OFFICIALS. PERSONS ON THE BEACH SHOULD MOVE TO
 HIGHER GROUND IF IN A WARNED AREA. TSUNAMIS MAY BE A SERIES OF
 WAVES WHICH COULD BE DANGEROUS FOR SEVERAL HOURS AFTER THE
 INITIAL WAVE ARRIVAL.

$$
PZZ130-131-133-134-132-135-150-153-156-110-250-210-255-350-
353-356-450-455-550-530-535-555-670-673-650-655-750-WAZ001-
002-021-022-CAZ001-002-005-007-006-075-074-009-034-035-039-
040-046-041-042-043-150456-
COASTAL AREAS FROM THE CALIFORNIA-MEXICO BORDER TO THE
NORTH TIP OF VANCOUVER I.-BC. INCLUSIVE.

...A TSUNAMI WARNING IS IN EFFECT FOR THE COASTAL AREAS
   FROM THE CALIFORNIA-MEXICO BORDER TO THE NORTH TIP OF
   VANCOUVER I.-BC. INCLUSIVE...

ESTIMATED TIMES OF INITIAL WAVE ARRIVAL
CRESCENT CITY-CA 2029 PDT JUN 14   ASTORIA-OR       2154 PDT JUN 14
CHARLESTON-OR    2044 PDT JUN 14   TOFINO-BC        2157 PDT JUN 14
SAN FRANCISCO-CA 2123 PDT JUN 14   SAN PEDRO-CA     2200 PDT JUN 14
SEASIDE-OR       2126 PDT JUN 14   LA JOLLA-CA      2214 PDT JUN 14
NEAH BAY-WA      2148 PDT JUN 14
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