Seismic Event Emergency Guidebook for Mass Media

2012

Oregon Office of Emergency Management

Acknowledgments

Many thanks to the Oregon Department of Geology and Mineral Industries, the National Weather Service, and the Federal Emergency Management Administration for their assistance in the production of this media guidebook.

Broadcasters

This guidebook provides a concise overview of the seismic hazards in Oregon. It includes the notification process used to send tsunami alerts to public information broadcasters, local jurisdictions and the public. It includes a Tsunami Warning Flow Chart that shows how information is sent to broadcasters, a contact list of seismic experts who can provide credible information during a seismic event, and Oregon maps of regions most susceptible to seismic events.

Introduction

Oregon is at risk from several different types of seismic events: earthquake, tsunami, and volcanoes. This Mass Media Binder is intended to help you communicate with the public during a seismic event.

- **Earthquakes** occur when rock underground suddenly breaks along a fault. This sudden release of energy causes the seismic waves that make the ground shake.

- **Tsunamis** are generated when geologic events cause large, rapid movements in the sea floor that displace the water column above. These destructive waves can be caused by coastal or submarine landslides or volcanism, but they are most commonly caused by large submarine earthquakes. The Pacific Coast is at risk both from locally and distantly generated tsunamis.

- **Volcanic eruptions** occur only in certain places and do not occur randomly. Mount St. Helens is typical of more than 80 percent of the volcanoes that have formed on land. Known as subduction zone volcanoes, they occur along the edges of continents where one plate dives, or subducts, beneath a second plate. In the Cascade volcanic chain that extends from Lassen Peak in northern California to Meager Mountain in British Columbia, over 3,000 large and small volcanoes have erupted during the past five million years.

There are four types of earthquakes in Oregon

Crustal

- Oregon has had several earthquakes since the 1870's, all shallow crustal.
- The biggest has been a 7.3 magnitude earthquake in the southwest corner of the state in 1873. It caused damage from Northern California to Port Orford to Jacksonville. It was felt as far away as Portland.
- The most recent damaging crustal earthquakes occurred in 1993 in Scotts Mills (5.6M) and Klamath Falls (6.0 and 5.9M).

Deep Intraplate

- Damaging deep earthquakes occur every 10-30 years.
- The most damaging Pacific Northwest deep earthquake occurred in Olympia, Washington in 1949 and was a 7.1 magnitude.

Volcanic

- Warning signs of a possible volcanic eruption such as earthquakes, swelling, heat flow, tilting, and gas plumes need to be monitored.

Subduction Zone

- Strong shaking will be felt for several minutes.
- The last Cascadia Subduction Zone earthquake occurred on January 26, 1700.
- There is an average of 300 to 600 years between events. There is a 10-14% chance of a Cascadia Subduction Zone earthquake in the next 50 years.
- Injuries and fatalities could number in the thousands, and hundreds of buildings could be destroyed.
- A destructive tsunami will hit the coast from northern California to British Columbia.
- Aftershocks are common, up to M7, increasing the potential for damage.

What is an Earthquake?

An earthquake is caused by a sudden slip on a fault. The tectonic plates are always slowly moving, but they get stuck at their edges due to friction. When the stress on the edge overcomes the friction, there is an earthquake that releases energy in waves that travel through the earth's crust and cause the shaking that we feel. The surface where they slip is called the fault or fault plane. The location below the earth's surface where the earthquake starts is called the hypocenter, and the location directly above it on the surface of the earth is called the epicenter.

The earth has four major layers: the inner core, outer core, mantle and crust. The crust and the top of the mantle make up a thin skin on the surface of our planet. But this skin is not all in one piece – it is made up of many pieces covering the surface of the earth. Not only that, but these pieces keep slowly moving around, sliding past one another and bumping into each other. We call these pieces tectonic plates, and the edges of the plates are called the plate boundaries. The plate boundaries are made up of many faults, and most of the earthquakes around the world occur on these faults. Since the edges of the plates are rough, they get stuck while the rest of the plate keeps moving. Finally, when the plate has moved far enough, the edges unstick on one of the faults and there is an earthquake.

The Cascadia Subduction Zone is actually a 600 mile long earthquake fault stretching from offshore northern California to southern British Columbia. This fault builds up stress for hundreds of years as the Juan de Fuca and North America Plates push against each other. Eventually, the two plates rip apart, creating some of the largest earthquakes and tsunamis on earth. Where the Juan de Fuca oceanic plate and the North American continental plate meet is called a subduction zone, because the denser Juan de Fuca Plate is being pulled under North America. The Juan de Fuca Plate is moving to the northeast at about an inch a year as the North American Plate moves west. The Oregon coastline is actually bulging upward from the two plates pushing against each other.

Who is at risk?

Earthquake risk is the probable building damage, and number of people that are expected to be hurt or killed if a likely earthquake on a particular fault occurs. Earthquake risk and earthquake hazard are occasionally incorrectly used interchangeably.

Most crustal earthquakes in Oregon are small in size, but can produce significant damage at a local level. It's not just people in western Oregon who are at risk: the last earthquake-related deaths were in Klamath Falls, and there have been several swarms of small earthquakes in eastern Oregon in the last few years.

Most injuries and deaths in earthquakes are from falling buildings. Some communities are doing inventories of their buildings to see how much damage they might expect. In general, wood-frame houses withstand earthquakes reasonably well, while unreinforced brick buildings do poorly.

In the event of a Cascadia Subduction Zone earthquake, the devastation would extend from the coast to the Cascade Range, from northern California to British Columbia. The resulting earthquake could be similar to the magnitude 9 earthquake and tsunami that struck Japan in March 2011.

Why are earthquakes dangerous?

The strong shaking produced by the earthquake spreads out from the epicenter, causing the ground to move violently up and down and side to side. The strength of the shaking dies away with increasing distance from the epicenter, and larger earthquakes produce stronger shaking over a larger area than small earthquakes. Earthquake shaking alone is often sufficiently strong to damage buildings, bridges and other structures. However the interaction of the shaking with the geologic materials of the landscape can greatly enhance the damage.

Steep slopes can be particularly hazardous during and after earthquakes. Any unstable or marginally stable slope is at risk of a landslide when shaken strongly by an earthquake. In dry areas, rock fall can be deadly; one death in the 1993 Klamath Falls earthquake was from rock fall.

What to do During a Strong Earthquake

- Drop, cover, and hold on until the shaking stops.

- If you are on the coast, IMMEDIATELY move to higher ground, inland, or up a tall sturdy building and STAY there.

Liquefaction

Earthquakes can turn soil to quicksand, a process called liquefaction. This typically happens along river channels, or former river channels. Liquefied soil loses most of its ability to support structures, and can flow on gentle slopes, collapse along river banks and cause buried gas and water lines to break.

Ground shaking

Many types of soft soil, like alluvium along rivers or the windblown silt in the Portland Hills cause ground shaking amplification. In the Willamette Valley, the area of amplification is several miles wide in general. Small, deep earthquakes near Woodburn in the past several years have been felt in an anomalously large area; this is probably attributable to the amplification properties of the valley alluvium. DOGAMI earthquake hazard maps include outlines of specific areas that are susceptible to landslides, liquefaction, and amplification.

Along coastal areas, tsunamis can be the most devastating part of an earthquake. Computer models suggest a tsunami would follow a subduction zone earthquake in just a few minutes, and could produce waves 30-100 feet high. Research has shown that in events where the population did not know how to respond to a tsunami, up to 60 percent of the population died. In areas such as Japan where the populace knows what to do, fatalities were less than 20 percent.

Destructive fires

Earthquakes and tsunamis are often followed by fires because gas lines may break, electrical shorts cause sparks, damaged water tanks and broken pipes limit water for firefighting, and damaged roads prevent firefighter access.

Surface rupture

Fault movements can break the ground surface, damaging buildings and other structures and breaking pipelines.

Hazardous material releases

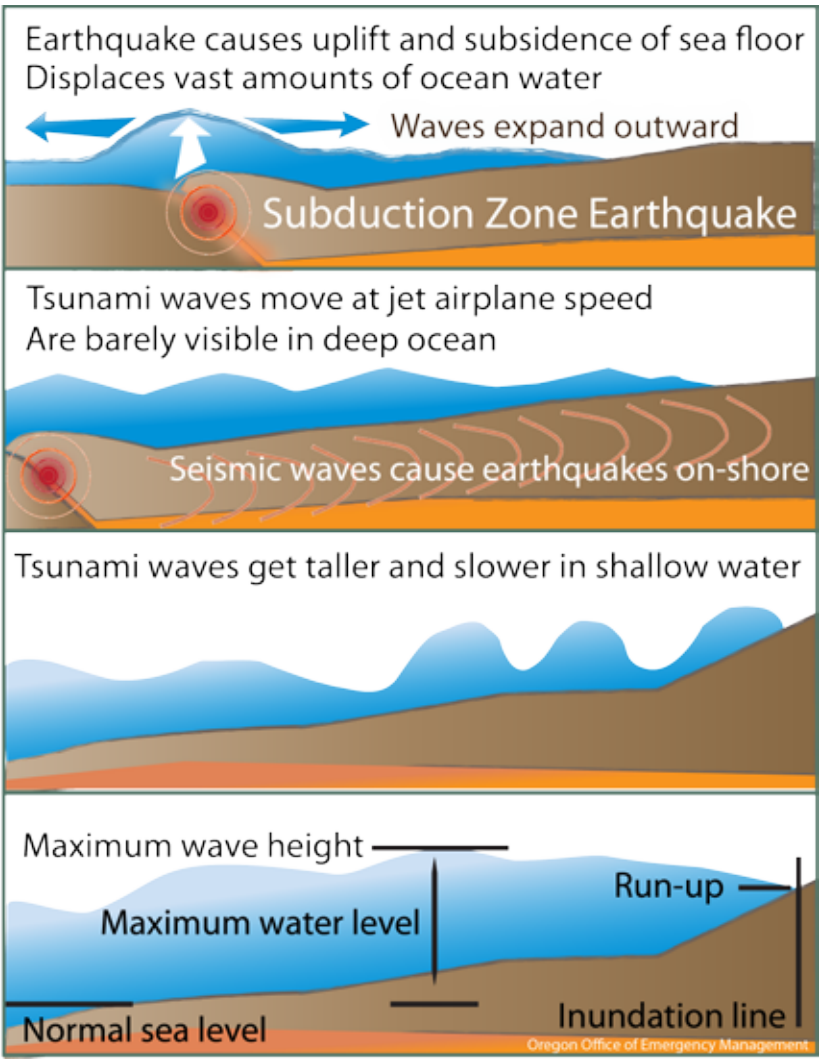
Chemicals, pesticides, and other hazardous materials can be released when industrial plants, laboratories, and other facilities are damaged in an earthquake.

Dam failures

Earthquake shaking and fault rupture can sometimes cause dams to fail, potentially creating catastrophic downstream flooding, reduced water supply, and contamination. Having an emergency plan that deals with an upstream dam is a good idea.

Damaged infrastructure

Earthquakes often damage roads and bridges, which can hinder rescue and recovery efforts and may cause accidents. Ruptured pipelines result in water loss and can cause "sinkholes" that undermine roads and buildings. Damage to gas and electrical systems can cause fires, as well as major service outages. Communications can also be disrupted for long periods of time.


Earthquake causes uplift and subsidence of sea floor
Displaces vast amounts of ocean water
Waves expand outward
Subduction Zone Earthquake
Tsunami waves move at jet airplane speed
Are barely visible in deep ocean
Seismic waves cause earthquakes on-shore
Tsunami waves get taller and slower in shallow water
Maximum wave height
Run-up
Maximum water level
Normal sea level
Inundation line
Oregon Office of Emergency Management

What is a Tsunami?

A tsunami:

- Is a series of waves caused by a sudden, large displacement of water most often caused by earthquakes, but also by landslides; volcanic eruptions; and comet or meteorite impacts in the ocean.
- Is like a fast rising flood tide, storm surge or an advancing wall of water and strikes with devastating force.
- Moves faster than you can run.
- The first wave is not the largest nor the most dangerous, and surges may arrive 10 hours or more after the initial wave.

Who is at Risk?

All U.S. coasts can be impacted by tsunamis, though based on proximity to tsunami sources and seafloor configurations, some areas are at much greater risk than others. Within the last 150 years, destructive and deadly tsunamis have struck Hawaii, Alaska, California, Oregon, Washington, American Samoa, Puerto Rico, and the U.S. Virgin Islands.

How are Tsunamis Generated?

Tsunamis are generated when geologic events cause large, rapid movements in the sea floor that displace the water column above. This swift change creates a series of high energy waves that radiate outward from the source. Locations nearest to the source, such as a large earthquake, will be impacted within minutes. Locations farther away may not see impacts for hours. All coasts can be impacted by tsunamis. Some areas are at a much greater risk than others due to the proximity to tsunami sources and sea floor configurations. For example, the Pacific Northwest coast (Vancouver Island to Cape Mendocino) is right on top of the Cascadia Subduction Zone (CSZ), so tsunamis from the CSZ strike the coast 10-30 minutes after a CSZ earthquake. Impacts also vary widely from site to site depending on the shape of the seafloor and coastline.

Why are Tsunamis Dangerous?

As the tsunami crosses the deep ocean, it may be only a few feet or less in height. Unlike wind-generated waves that affect the surface of the ocean, tsunamis move the entire water column. As the waves move toward shore, the wave energy is compressed in a smaller water column, and the tsunami grows in height and current strength. There is usually little time to forecast the severity of a tsunami after one is generated and entire coastlines can be inundated by a large tsunami.

Two Ways to Find out a Tsunami is Coming

Natural Warning

Strong ground shaking, a loud roar from the ocean, or the water receding unusually far and exposing the sea floor or surging in faster than a normal tide, are all Nature's warning signs that a tsunami may be coming. If you observe any of these signs, immediately move to higher ground or inland. A dangerous tsunami may arrive within minutes. Stay away from low areas until told by officials that the danger has passed. Waves may impact the coast at irregular intervals for ten hours or longer and other hazards like fires or hazardous spills may be present.

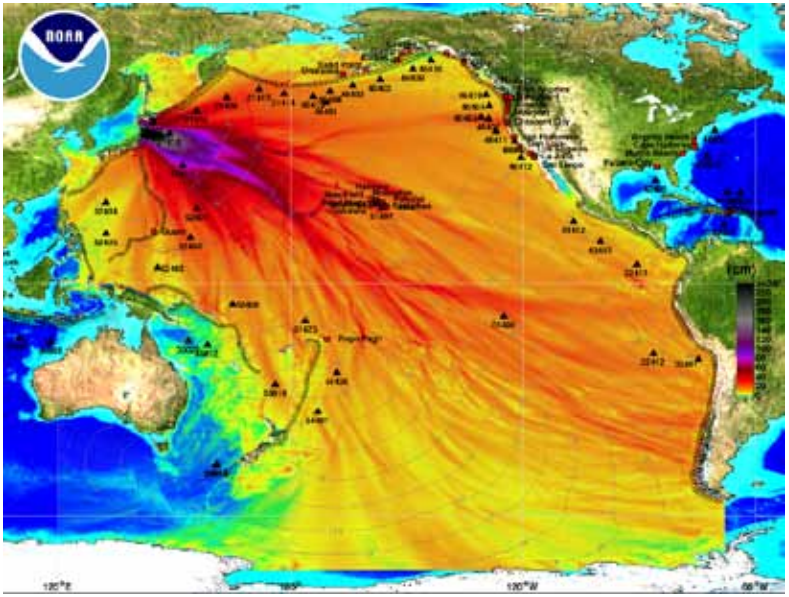
Official Warning

You may learn that a Tsunami Warning has been issued by listening to TV and radio stations, alerts from NOAA Weather Radio, or in some cases by announcements from emergency officials, airplanes, or outdoor sirens. Move away from beaches or harbor areas (if possible to higher ground) and seek more information without using a phone. Tune into local radio or television stations for more information. Follow instructions of emergency personnel.

Both Natural and Official Warnings are equally important. Respond to whatever you hear or observe first!

Tsunami Warning Centers in the U.S.

When an earthquake that might generate a tsunami for the U.S. coast is detected, the West Coast/Alaska Tsunami Warning Center and Pacific Tsunami Warning Center calculate the danger for coastal locations within their respective areas of responsibility. The West Coast/Alaska Tsunami Warning Center in Palmer, Alaska is responsible for providing tsunami warnings, advisories, watches, and information statements for Alaska, the U.S. west, east, and Gulf of Mexico coasts, Puerto Rico, the U.S. Virgin Islands, and Canada. The Pacific Tsunami Warning Center in Ewa Beach, Hawaii is responsible for providing tsunami warnings, advisories, watches, and information statements for Hawaii, U.S. Pacific Territories, Pacific Ocean, Indian Ocean, and Caribbean Sea nations.



Tsunami Warning Flowchart

How the U.S. Tsunami Warning System Works

7.0 or greater undersea earthquake/landslide occurs

Tsunami potential evaluated using seismic measuring equipment, tide & sea level gauges, and NOAA DART buoys

Pacific Tsunami Warning Center and/or West Coast/ Alaska Tsunami Warning Center issue a Tsunami warning/advisory/watch/information message.

This message is received by the National Weather Service (NWS) Forecast Offices, state/provincial, county, local emergency services, offices, broadcasters, Emergency Alert System, other federal agencies, international partners, and the public.

County/Local officals issue county/local tsunami or evacuation (when needed) message

The message is received by local jurisdictions, broadcasters, and the public. Action is taken, if needed.

Levels of Tsunami Alert

Warning: A tsunami warning is issued when a potential tsunami with significant widespread inundation is imminent or expected. Warnings alert the public that widespread, dangerous coastal flooding accompanied by powerful currents is possible and may continue for several hours after the arrival of the initial wave. Appropriate actions to be taken by local officials may include the evacuation of low-lying areas. People in the warned areas need to move to higher ground or inland and stay in a safe area until local officials indicate that the danger is over.

Advisory: A tsunami advisory is issued due to the threat of a potential tsunami that may produce strong currents or waves dangerous to those in or near the water. The threat may continue for several hours after the arrival of the initial wave, but significant widespread inundation is not expected for areas under the advisory. Appropriate actions to be taken by local officials may include the closing of beaches and the evacuation of harbors and marinas. People in the advisory area should heed local official's instructions to leave affected areas until the danger is over.

Watch: A tsunami watch is issued when a potentially dangerous, distant seismic event has occurred which may later impact the watch area with a tsunami. Be ready to take action if a tsunami warning or advisory is later issued.

Information Statement: A tsunami information statement is issued when an earthquake has occurred or a tsunami warning, advisory, or watch has been issued for another part of the ocean. In most cases, tsunami information statements are issued to indicate there is not threat of a destructive tsunami for the area.

Tsunami Safety

What to do During a Tsunami Warning

- Keep calm
- Immediately move to your local tsunami assembly area using defined tsunami evacuation routes. If none defined, then move to higher ground (at least 100 feet elevation), a mile inland, or up a tall, sturdy building (at least the 3rd floor) and stay there.
- If you are already in a safe location, stay there.
- Do not drive – keep roads open for emergency vehicles.
- Pay attention to NOAA Weather Radio and/or local broadcasts for changes in tsunami alerts.
- Stay away from the coast and low-lying areas until officials say emergency is over.

What to do During a Tsunami Advisory

- Keep calm
- Move out of beach areas, marinas, and harbors.
- Stay away from beach areas, marinas, and harbors until officials say emergency is over.
- Pay attention to NOAA Weather Radio and local broadcasts for changes in tsunami alerts.

Be prepared before a Tsunami strikes

- Know which areas are safe and which are not.
- Know the hazard zones, evacuation route(s), and locations of the nearest high ground, tsunami shelter and/or assembly area where you live, work, and visit by contacting your local or state emergency management organization.
- Learn and practice the safe walking route to shelter and assembly areas.
- Create and practice a family emergency plan.
- Have a portable disaster supplies kit with three days' supply of food, water, and medication. Keep the kit in a location where you can access it quickly.
- Be sure you understand the evacuation plans of your children's school.
- Purchase a NOAA All Hazards Weather Radio to receive all tsunami, weather and water warnings.
- Sign up for Tsunami Warning Center email or text messages.

Tsunami Bulletin Example

From the West Coast/Alaska Tsunami Warning Center

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WEPA41 PAAQ 110851
TSUWCA

BULLETIN
TSUNAMI MESSAGE NUMBER 4
NWS WEST COAST/ALASKA TSUNAMI WARNING CENTER PALMER AK
1251 AM PST FRI MAR 11 2011

THE WARNING AND ADVISORY STATUS REGIONS HAVE CHANGED IN THIS
MESSAGE.

...THE TSUNAMI WARNING CONTINUES IN EFFECT FOR THE COASTAL
   AREAS OF CALIFORNIA AND OREGON FROM POINT CONCEPCION
   CALIFORNIA TO THE OREGON-WASHINGTON BORDER...

...THE TSUNAMI WARNING CONTINUES IN EFFECT FOR THE COASTAL
   AREAS OF ALASKA FROM AMCHITKA PASS ALASKA/125 MILES W OF
   ADAK/ TO ATTU ALASKA...

...THE TSUNAMI ADVISORY CONTINUES IN EFFECT FOR THE COASTAL
   AREAS OF CALIFORNIA FROM THE CALIFORNIA-MEXICO BORDER TO
   POINT CONCEPCION CALIFORNIA...

...THE TSUNAMI ADVISORY CONTINUES IN EFFECT FOR THE COASTAL
   AREAS OF WASHINGTON - BRITISH COLUMBIA AND ALASKA FROM THE
   OREGON-WASHINGTON BORDER TO AMCHITKA PASS ALASKA/125 MILES
   W OF ADAK/...

RECOMMENDED ACTIONS
 A TSUNAMI HAS BEEN GENERATED WHICH IS EXPECTED TO CAUSE DAMAGE
 TO THE WARNING AND/OR ADVISORY REGIONS LISTED IN THE HEADLINE.
 PERSONS IN LOW-LYING COASTAL AREAS SHOULD BE ALERT TO
 INSTRUCTIONS FROM THEIR LOCAL EMERGENCY OFFICIALS. EVACUATIONS
 ARE ONLY ORDERED BY EMERGENCY RESPONSE AGENCIES.
 - PERSONS IN TSUNAMI WARNING COASTAL AREAS SHOULD MOVE INLAND TO
   HIGHER GROUND.

 - PERSONS IN TSUNAMI ADVISORY COASTAL AREAS SHOULD MOVE OUT OF
   THE WATER... OFF THE BEACH AND OUT OF HARBORS AND MARINAS.

MEASUREMENTS OR REPORTS OF TSUNAMI ACTIVITY

 LOCATION                  LAT    LON     TIME        AMPL
 ------------------------  -----  ------  -------     -----------
 TOSASHIMIZU  JAPAN        32.8N  132.9E  0747UTC   00.9FT/00.27M
 TOKAI  JAPAN              33.8N  137.6E  0645UTC   00.8FT/00.25M
 OFUNATO  JAPAN            39.0N  141.8E  0605UTC   10.8FT/03.29M
 HANASAKI  JAPAN           43.3N  145.6E  0643UTC   09.3FT/02.82M
 BOSO  JAPAN               34.8N  140.8E  0609UTC   02.6FT/00.78M
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TIME - TIME OF MEASUREMENT
AMPL - TSUNAMI AMPLITUDES ARE MEASURED RELATIVE TO NORMAL SEA LEVEL.
IT IS ...NOT... CREST-TO-TROUGH WAVE HEIGHT.
VALUES ARE GIVEN IN BOTH METERS(M) AND FEET(FT).

DEEP OCEAN SENSORS INDICATE A LARGE TSUNAMI HAS BEEN GENERATED.

PRELIMINARY EARTHQUAKE PARAMETERS
MAGNITUDE - 8.9
TIME - 2046 AKST MAR 10 2011
2146 PST MAR 10 2011
0546 UTC MAR 11 2011
LOCATION - 38.3 NORTH 142.4 EAST
- NEAR EAST COAST OF HONSHU JAPAN
DEPTH - 12 MILES/20 KM

TSUNAMI WARNINGS MEAN THAT A TSUNAMI WITH SIGNIFICANT WIDESPREAD INUNDATION IS IMMINENT OR EXPECTED. WARNINGS INDICATE THAT WIDESPREAD DANGEROUS COASTAL FLOODING ACCOMPANIED BY POWERFUL CURRENTS IS POSSIBLE AND MAY CONTINUE FOR SEVERAL HOURS AFTER THE INITIAL WAVE ARRIVAL.

TSUNAMI ADVISORIES MEAN THAT A TSUNAMI CAPABLE OF PRODUCING STRONG CURRENTS OR WAVES DANGEROUS TO PERSONS IN OR VERY NEAR THE WATER IS EXPECTED. SIGNIFICANT WIDESPREAD INUNDATION IS NOT EXPECTED FOR AREAS UNDER AN ADVISORY. CURRENTS MAY BE HAZARDOUS TO SWIMMERS... BOATS... AND COASTAL STRUCTURES AND MAY CONTINUE FOR SEVERAL HOURS AFTER THE INITIAL WAVE ARRIVAL.

PACIFIC COASTAL REGIONS OUTSIDE CALIFORNIA/ OREGON/ WASHINGTON/ BRITISH COLUMBIA AND ALASKA SHOULD REFER TO THE PACIFIC TSUNAMI WARNING CENTER MESSAGES FOR INFORMATION ON THIS EVENT AT WWW.WEATHER.GOV/PTWC.

THIS MESSAGE WILL BE UPDATED IN 60 MINUTES OR SOONER IF THE SITUATION WARRANTS. THE TSUNAMI MESSAGE WILL REMAIN IN EFFECT UNTIL FURTHER NOTICE. REFER TO THE INTERNET SITE WCATWC.ARH.NOAA.GOV FOR MORE INFORMATION.

PZZ530-CAZ034-035-529-530-006-505>509-002-001-ORZ021-022-002-001-111021-
/O.CON.PAAQ.TS.W.0006.000000T0000Z-000000T0000Z/
COASTAL AREAS BETWEEN AND INCLUDING POINT CONCEPCION CALIFORNIA TO THE OREGON-WASHINGTON BORDER
1251 AM PST FRI MAR 11 2011

...THE TSUNAMI WARNING CONTINUES IN EFFECT FOR THE COASTAL AREAS OF CALIFORNIA AND OREGON FROM POINT CONCEPCION CALIFORNIA TO THE OREGON-WASHINGTON BORDER...

PERSONS IN TSUNAMI WARNING COASTAL AREAS SHOULD MOVE INLAND TO HIGHER GROUND.

TSUNAMI WARNINGS MEAN THAT A TSUNAMI WITH SIGNIFICANT WIDESPREAD INUNDATION IS IMMINENT OR EXPECTED. TSUNAMIS ARE A SERIES OF

WAVES POTENTIALLY DANGEROUS SEVERAL HOURS AFTER INITIAL ARRIVAL
TIME. ESTIMATED TIMES OF INITIAL WAVE ARRIVAL FOR SELECTED
SITES IN THE WARNING ARE PROVIDED BELOW.

CHARLESTON-OR 0715 PST MAR 11 SEASIDE-OR 0724 PST MAR 11
CRESCENT CITY-CA 0723 PST MAR 11 SAN FRANCISCO-CA 0808 PST MAR 11

FOR ARRIVAL TIMES AT ADDITIONAL LOCATIONS SEE
WCATWC.ARH.NOAA.GOV

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AKZ191-111021-
/O.CON.PAAQ.TS.W.0006.000000T0000Z-000000T0000Z/
COASTAL AREAS BETWEEN AND INCLUDING AMCHITKA PASS
ALASKA/125 MILES W OF ADAK/ TO ATTU ALASKA
1251 AM PST FRI MAR 11 2011

...THE TSUNAMI WARNING CONTINUES IN EFFECT FOR THE COASTAL
AREAS OF ALASKA FROM AMCHITKA PASS ALASKA/125 MILES W OF
ADAK/ TO ATTU ALASKA...

PERSONS IN TSUNAMI WARNING COASTAL AREAS SHOULD MOVE INLAND TO
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WAVES POTENTIALLY DANGEROUS SEVERAL HOURS AFTER INITIAL ARRIVAL
TIME. ESTIMATED TIMES OF INITIAL WAVE ARRIVAL FOR SELECTED
SITES IN THE WARNING ARE PROVIDED BELOW.

SHEMYA-AK 0013 AKST MAR 11

FOR ARRIVAL TIMES AT ADDITIONAL LOCATIONS SEE
WCATWC.ARH.NOAA.GOV

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CAZ042-043-040-041-087-039-111021-
/O.CON.PAAQ.TS.Y.0006.000000T0000Z-000000T0000Z/
COASTAL AREAS BETWEEN AND INCLUDING THE CALIFORNIA-MEXICO
BORDER TO POINT CONCEPCION CALIFORNIA
1251 AM PST FRI MAR 11 2011

...THE TSUNAMI ADVISORY CONTINUES IN EFFECT FOR THE COASTAL
AREAS OF CALIFORNIA FROM THE CALIFORNIA-MEXICO BORDER TO
POINT CONCEPCION CALIFORNIA...

PERSONS IN TSUNAMI ADVISORY COASTAL AREAS SHOULD MOVE OUT OF
THE WATER... OFF THE BEACH AND OUT OF HARBORS AND MARINAS.

TSUNAMI ADVISORIES MEAN THAT A TSUNAMI CAPABLE OF PRODUCING
STRONG CURRENTS OR WAVES DANGEROUS TO PERSONS IN OR VERY NEAR
WATER IS IMMINENT OR EXPECTED. SIGNIFICANT WIDESPREAD INUNDATION
IS NOT EXPECTED FOR AREAS IN AN ADVISORY. TSUNAMIS ARE A SERIES OF
WAVES POTENTIALLY DANGEROUS SEVERAL HOURS AFTER INITIAL ARRIVAL

TIME. ESTIMATED TIMES OF INITIAL WAVE ARRIVAL FOR SELECTED
SITES IN THE ADVISORY ARE PROVIDED BELOW.

SANTA BARBARA-CA 0817 PST MAR 11 LA JOLLA-CA 0841 PST MAR 11
SAN PEDRO-CA 0832 PST MAR 11

FOR ARRIVAL TIMES AT ADDITIONAL LOCATIONS SEE
WCATWC.ARH.NOAA.GOV

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WAZ001-021-510-514>517-BCZ130-230-250-260-280-160-142-141-
150-121-122-220-210-922-912-921-911-110-AKZ026>029-023-024-
019>022-025-017-131-135-125-121-171-181-185-187-111021-
/O.CON.PAAQ.TS.Y.0006.000000T0000Z-000000T0000Z/
COASTAL AREAS BETWEEN AND INCLUDING THE OREGON-WASHINGTON
BORDER TO AMCHITKA PASS ALASKA/125 MILES W OF ADAK/
1251 AM PST FRI MAR 11 2011

...THE TSUNAMI ADVISORY CONTINUES IN EFFECT FOR THE COASTAL
AREAS OF WASHINGTON - BRITISH COLUMBIA AND ALASKA FROM THE
OREGON-WASHINGTON BORDER TO AMCHITKA PASS ALASKA/125 MILES
W OF ADAK/...

PERSONS IN TSUNAMI ADVISORY COASTAL AREAS SHOULD MOVE OUT OF
THE WATER... OFF THE BEACH AND OUT OF HARBORS AND MARINAS.

TSUNAMI ADVISORIES MEAN THAT A TSUNAMI CAPABLE OF PRODUCING
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WAVES POTENTIALLY DANGEROUS SEVERAL HOURS AFTER INITIAL ARRIVAL
TIME. ESTIMATED TIMES OF INITIAL WAVE ARRIVAL FOR SELECTED
SITES IN THE ADVISORY ARE PROVIDED BELOW.

ADAK-AK	0110 AKST MAR 11	VALDEZ-AK	0435 AKST MAR 11
DUTCH HARBOR-AK	0220 AKST MAR 11	LANGARA-BC	0535 PST MAR 11
SAND PT.-AK	0257 AKST MAR 11	CORDOVA-AK	0445 AKST MAR 11
COLD BAY-AK	0329 AKST MAR 11	HOMER-AK	0508 AKST MAR 11
KODIAK-AK	0351 AKST MAR 11	CRAIG-AK	0526 AKST MAR 11
SEWARD-AK	0416 AKST MAR 11	TOFINO-BC	0658 PST MAR 11
ELFIN COVE-AK	0418 AKST MAR 11	NEAH BAY-WA	0710 PST MAR 11
YAKUTAT-AK	0425 AKST MAR 11	WESTPORT-WA	0725 PST MAR 11
SITKA-AK	0425 AKST MAR 11		

FOR ARRIVAL TIMES AT ADDITIONAL LOCATIONS SEE
WCATWC.ARH.NOAA.GOV

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How Tsunamis are Detected and Observed

NOAA's Tsunami Warning Centers monitor the earth 24x7 through a tsunami detection system consisting of seismic, coastal sea-level, and Deep Ocean Assessment and Reporting of Tsunamis (DART) networks.

Seismic Networks –

Most damaging tsunamis are caused by earthquakes. Seismic data are collected at hundreds of seismic sensors, called seismometers, around the world. The scientists at the Tsunami Warning Centers use seismic data to determine the location and magnitude of earthquakes. The location and magnitude of an earthquake determine whether or not scientists will issue a tsunami warning, advisory, or watch.

Coastal Sea-Level Networks –

These networks consist of coastal sea-level gauges that measure the ocean height at specific coastal locations. When a tsunami arrives at a gauge, the water level will vary from its normal tide cycle. The scientists use data from these gauges to both detect a tsunami and estimate its impact at the coast.

DART Network –

DART stations sense water level changes in the deep ocean resulting from the formation and propagation of tsunamis. A DART station consists of a pressure sensor, located on the sea floor, and a data transmission buoy, located on the surface. As a tsunami passes, the depth of the water changes as does the pressure on the sensor. This pressure change is transmitted acoustically to the surface buoy and then via satellite to the Tsunami Warning Centers.

Tsunami Warning Centers –

Once an earthquake or tsunami is detected and the information is received at the Tsunami Warning Center, an earthquake and tsunami investigation begins:

- locate and size the earthquake (automated);
- analyze the earthquake or tsunami data;
- analyze the sea-level data to verify the existence of a tsunami and to calibrate models;
- send the appropriate warning, watch, advisory or information message.

If the source of the earthquake is under or near the ocean, not too deep within the earth, and if the magnitude is sufficiently large, then a tsunami may have been generated. On the basis of this seismic evidence, the appropriate Tsunami Warning Center issues a tsunami warning, advisory, or watch (see Tab 3) to threatened areas near the epicenter. The warning, advisory, or watch may be extended to areas located further from the epicenter if the magnitude of the earthquake is so large there is a possibility of a long-range destructive tsunami. All remaining areas will be notified that an event has occurred.

Tsunami bulletins are initially issued based solely on earthquake parameters – magnitude, location, and depth. Initial messages are issued as soon as this information has been determined.

After the initial message has been issued, the Tsunami Warning Center monitors the nearest tide gauges and DARTs to confirm

the existence or nonexistence of a tsunami and its degree of severity, and issues supplementary information or cancels the initial message. Tsunami history, forecast models, and observed tsunami amplitudes are taken into account when determining the extent of danger for the area of responsibility.

The time it takes for a Center to issue an alert is dependent on the seismic network density and distribution around the epicenter. In regions of high seismic network density, Centers can provide alerts within 5 minutes. In areas of lower seismic network density, response time increases to 10-15 minutes.

If a potentially destructive, long-range tsunami is detected, the Tsunami Warning Center will issue an ocean-wide tsunami warning to advise designated national authorities. Such a warning alerts all warning system participants to the approach of a potentially destructive tsunami and provides estimated tsunami arrival times for key locations. Tsunami forecasts or estimated wave heights may be included if there is enough data and the model results are judged by Tsunami Warning Center staff to be reasonable.

Typically, during a tsunami, bulletins containing updated information are issued at least hourly, until the tsunami has crossed the entire ocean or additional data is received to indicate there is no further threat. Tsunami warnings are canceled when the Tsunami Warning Center judges that the tsunami is no longer dangerous. However, even when the warning is canceled, that does not mean it is safe for the public to return to any evacuated coastline areas. Due to structural damage, debris, and other safety concerns, the "all-clear" may not be issued by the local authorities for hours or even days after the event.

How Tsunamis are Forecast

Tsunami Warning Centers utilize Tsunami Forecast Models to provide wave height, arrival time, and inundation forecasts for coastal areas potentially impacted by the tsunami. These models utilize the seismic and sea-level data provided by detection networks to forecast impacts at specific locations throughout the ocean basin.

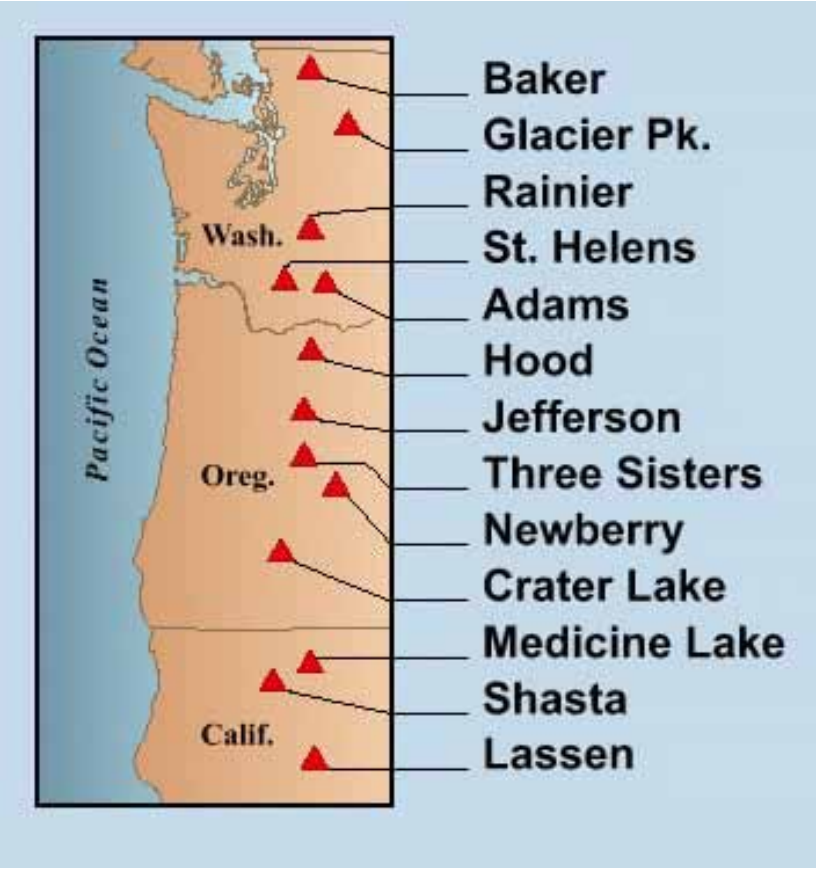
These forecasts help scientists at the Tsunami Warning Centers determine the level of alert (warning, advisory, information statement, or watch) to issue for specific areas of the coast. The forecasts assist local emergency management in determining whether or not to issue evacuation orders during an event.

This determination is critical as emergency managers not only want to ensure that communities who will experience destruction during a tsunami are evacuated, but also to ensure that communities that are not threatened during a tsunami event do not have to undergo needless evacuation.

What is a Volcano?

- Volcanoes are mountains, but they are very different from other mountains; they are not formed by folding and crumpling or by uplift and erosion.
- Instead, volcanoes are built by the accumulation of their own eruptive products -- lava, bombs (crusted over lava blobs), ashflows, and tephra (airborne ash and dust).
- A volcano is most commonly a conical hill or mountain built around a vent that connects with reservoirs of molten rock below the surface of the Earth.
- The term volcano also refers to the opening or vent through which the molten rock and associated gases are expelled.

The molten rock, which is lighter than the surrounding solid rock is driven by buoyancy and gas pressure, and forces its way upward and may ultimately break through zones of weaknesses in the Earth's crust. If so, an eruption begins, and the molten rock may pour from the vent as non-explosive lava flows, or it may shoot violently into the air as dense clouds of lava fragments. Larger fragments fall back around the vent, and accumulations of fallback fragments may move downslope as ash flows under the force of gravity. Some of the finer ejected materials may be carried by the wind only to fall to the ground many miles away. The finest ash particles may be injected miles into the atmosphere and carried many times around the world by stratospheric winds before settling out.


Pacific Ocean
Wash.
Oreg.
Calif.
Baker
Glacier Pk.
Rainier
St. Helens
Adams
Hood
Jefferson
Three Sisters
Newberry
Crater Lake
Medicine Lake
Shasta
Lassen

The roots of Mount St. Helens are 100 to 330 kilometers (70 to 200 miles) below the Earth's surface. Here in the Earth's mantle temperatures are hot enough to melt rock and form a thick, flowing substance called magma. Lighter than the solid rock that surrounds it, magma is buoyant much like a cork in water; being buoyant, it rises. As the magma rises, some of it collects in large reservoirs, or magma chambers that fuel volcanoes. As the rising magma nears the Earth's surface, pressure decreases, which causes the gases in the magma to expand. This expansion propels the magma through openings in the Earth's surface: a volcanic eruption occurs. Once magma is erupted, it is called lava.

The Cascade Range of the Pacific Northwest has more than a dozen potentially active volcanoes. Cascade volcanoes tend to erupt explosively, and on average two eruptions occur per century—the most recent were at Mount St. Helens, Washington (1980–86 and 2004–8), and Lassen Peak, California (1914–17).

On May 18, 1980, after 2 months of earthquakes and minor eruptions, Mount St. Helens, Washington, exploded in one of the most devastating volcanic eruptions of the 20th century. Although less than 0.1 cubic mile of molten rock (magma) was erupted, 57 people died, and damage exceeded $1 billion. Coming more than 60 years after the last eruption in the Cascades (Lassen Peak), the explosion of St. Helens was a spectacular reminder that the millions of residents of the Pacific Northwest share the region with live volcanoes.

The volcanoes of the Cascade Range, which stretches from northern California into British Columbia, have produced more than 100 eruptions, most of them explosive, in just the past few thousand years. However, individual Cascade volcanoes can lie dormant for many centuries between eruptions, and the great risk posed by volcanic activity in the region is therefore not always apparent.

Because the population of the Pacific Northwest is rapidly expanding, the volcanoes of the Cascade Range in Washington, Oregon, and northern California are some of the most dangerous in the United States.

Who is at risk?

The risk from volcanoes, geographically, is well known. Several areas in the world contain active and dormant volcanoes. The Pacific Rim contains several active volcanoes. Almost all events have been confined to the Pacific states. The most recent explosion of significance was the eruption of Mt. St. Helens in Washington State.

Mitigation strategies in volcanoes include early warning systems and evacuation. Today, there generally are several investigations regarding the dormancy status of volcanoes. These are undertaken to identify any changes that may warrant preventive action.

More than 50 volcanoes in the United States have erupted one or more times in the past 200 years. The most volcanically active regions of the Nation are in Alaska, Hawaii, California, Oregon, and Washington. Volcanoes produce a wide variety of hazards that can kill people and destroy property. Large explosive eruptions can endanger people and property hundreds of miles away and even affect global climate. Some of the volcano hazards, such as landslides, can occur even when a volcano is not erupting.

Why are volcanoes dangerous?

Eruption Columns and Clouds

An explosive eruption blasts solid and molten rock fragments (tephra) and volcanic gases into the air with tremendous force. The largest rock fragments (bombs) usually fall back to the ground within 2 miles of the vent. Small fragments (less than about 0.1 inch across) of volcanic glass, minerals, and rock (ash) rise high into the air, forming a huge, billowing eruption column.

Eruption columns can grow rapidly and reach more than 12 miles above a volcano in less than 30 minutes, forming an eruption cloud. Ash from the May 18, 1980, eruption of Mount St. Helens, Washington, fell over an area of 22,000 square miles in the Western United States. Heavy ash fall can collapse buildings, and even minor ash fall can damage crops, electronics, and machinery.

Volcano Landslides

A landslide or debris avalanche is a rapid downhill movement of rocky material, snow, and (or) ice. Volcano landslides range in size from small movements of loose debris on the surface of a volcano to massive collapses of the entire summit or sides of a volcano. Steep volcanoes are susceptible to landslides because they are built up partly of layers of loose volcanic rock fragments. Some rocks on volcanoes have also been altered to soft, slippery clay minerals by circulating hot, acidic ground water. Landslides on volcano slopes are triggered when eruptions, heavy rainfall, or large earthquakes cause these materials to break free and move downhill.

At least five large landslides have swept down the slopes of Mount Rainier, Washington, during the past 6,000 years. The largest volcano landslide in historical time occurred at the start of the May 18, 1980, Mount St. Helens eruption.

Lahars

Mudflows or debris flows composed mostly of volcanic materials on the flanks of a volcano are called lahars. These flows of mud, rock, and water can rush down valleys and stream channels at speeds of 20 to 40 miles per hour and can travel more than 50 miles. Some lahars contain so much rock debris (60 to 90% by weight) that they look like fast-moving rivers of wet concrete. Close to their source, these flows are powerful enough to rip up and carry trees, houses, and huge boulders miles downstream. Farther downstream they entomb everything in their path in mud.

Historically, lahars have been one of the deadliest volcano hazards. They can occur both during an eruption and when a volcano is quiet. The water that creates lahars can come from melting snow and ice (especially water from a glacier melted by a pyroclastic flow or surge), intense rainfall, or the breakout of a summit crater lake. Large lahars are a potential hazard to many communities downstream from glacier-clad volcanoes, such as Mount Rainier.

Pyroclastic Flows

High-speed avalanches of hot ash, rock fragments, and gas can move down the sides of a volcano during explosive eruptions or when the steep side of a growing lava dome collapses and breaks apart. These pyroclastic flows can be as hot as 1,500°F and move at speeds of 100 to 150 miles per hour. Such flows tend to follow valleys and are capable of knocking down and burning everything in their paths. Lower-density pyroclastic flows, called pyroclastic surges, can easily overflow ridges hundreds of feet high. The climactic eruption of Mount St. Helens on May 18, 1980, generated a series of explosions that formed a huge pyroclastic surge. This so-called "lateral blast" destroyed an area of 230 square miles. Trees, six feet in diameter, were mowed down like blades of grass as far as 15 miles from the volcano.

Volcanic Gases

Volcanoes emit gases during eruptions. Even when a volcano is not erupting, cracks in the ground allow gases to reach the surface through small openings called fumaroles. More than 90% of all gas emitted by volcanoes is water vapor (steam), most of which is heated ground water (underground water from rainfall and streams). Other common volcanic gases are carbon dioxide, sulfur dioxide, hydrogen sulfide, hydrogen, and fluorine. Sulfur dioxide gas can react with water droplets in the atmosphere to create acid rain, which causes corrosion and harms vegetation. Carbon dioxide is heavier than air and can be trapped in low areas in concentrations that are deadly to people and animals. Fluorine, which in high concentrations is toxic, can be absorbed into volcanic ash particles that later fall to the ground. The fluorine on the particles can poison livestock grazing on ash-coated grass and also contaminate domestic water supplies.

Lava Flows and Domes

Molten rock (magma) that pours or oozes onto the Earth's surface is called lava and forms lava flows. The higher a lava's content of silica (silicon dioxide, SiO_2), the less easily it flows. For example, low-silica basalt lava can form fast-moving (10 to 30 miles per hour) streams or can spread out in broad thin sheets as much as several miles wide. Flows of higher-silica andesite and dacite lava tend to be thick and sluggish, traveling only short distances from a vent. Dacite and rhyolite lavas often squeeze out of a vent to form irregular mounds called lava domes. Between 1980 and 1986, a dacite lava dome at Mount St. Helens grew to about 1,000 feet high and 3,500 feet across.

Volcanoes in Oregon

Mt. Hood

Mount Hood last erupted about 200 years ago, producing pyroclastic flows, lahars, and a prominent lava dome (Crater Rock) near the volcano's summit. Most recently, a series of steam blasts occurred between 1856 and 1865.

Mt. Jefferson

Mount Jefferson last erupted more than 20,000 years ago. However, eruptions nearby have produced several lava flows and small volcanic cones in the past 10,000 years.

Three Sisters

Three Sisters Volcanic Center in central Oregon includes five large volcanoes—North Sister, Middle Sister, South Sister, Broken Top, and Mount Bachelor. About 2,000 years ago, eruptions occurred on South Sister, as well as from several small volcanoes north of North Sister. Since 1997, a broad area centered 3 miles west of South Sister has domed upward by more than 8 inches. Scientists think that this doming reflects the ongoing accumulation of magma at a depth of 3 to 4 miles. The outcome of this activity is uncertain, but there is no evidence that an eruption is imminent. The USGS and its partners have increased monitoring efforts in the area to detect any changes that might warrant more concern.

Newberry Volcano

Newberry Volcano, a broad shield covering more than 500 square miles, is capped by Newberry Crater, a large volcanic depression (caldera) 5 miles across. Its most recent eruption was about 1,300 years ago.

Crater Lake

Crater Lake occupies a 6-mile-wide caldera formed 7,700 years ago when the summit of an ancient volcano (referred to as Mount Mazama) collapsed during a huge explosive eruption. More than 10 cubic miles of magma were erupted, 10 times as much as in any other eruption in the Cascades during the past 10,000 years. Smaller eruptions ending about 5,000 years ago formed Wizard Island and several submerged cones and lava domes on the lake floor.

Roles and Responsibilities of Federal, State, and Local Governments

Federal agencies:

National Oceanic and Atmospheric Administration (NOAA):

NOAA's role is to provide tsunami detection, forecasting and warnings for the Pacific and Arctic regions and the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico [The Tsunami Warning and Education Act of 2006, 33 U.S.C. § 3201, et seq., (P.L. 109-479)]. NOAA's Tsunami Warning Centers (TWC) provide tsunami warning services for the Caribbean Sea and Pacific, Indian, and parts of the Atlantic Ocean.

The mission of NOAA's Tsunami Warning Centers is to protect lives and property from tsunami hazards by providing timely, accurate, reliable, and effective tsunami information to coastal populations and emergency management within the area of responsibility; and by advancing other aspects of tsunami hazard mitigation such as community preparedness and public education.

U.S. Geological Survey (USGS):

The USGS is a science organization that provides impartial information on the health of our ecosystems and environment, the natural hazards that threaten us, the natural resources we rely on, the impacts of climate and land-use change, and the core science systems that help us provide timely, relevant, and useable information. USGS' role is to provide seismic data to NOAA's TWCs, conduct tsunami research and risk assessments, and conduct independent seismic analysis of potential tsunamigenic earthquakes at its National Earthquake Information Center (NEIC). Thus USGS, along with other partners, supports the Global Seismic Network (GSN). The GSN provides high-quality seismic data to assist earthquake detection (including tsunamigenic earthquakes).

Federal Emergency Management Agency (FEMA):

FEMA's responsibility includes tsunami hazard mitigation and response. As part of its mitigation efforts, FEMA becomes the lead Federal agency in managing the emergency response once a tsunami, earthquake, or volcano has caused damage to a U.S. community.

Subject Matter Expert Contacts

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State Government:

The purpose of the Office of Emergency Management (OEM) is to execute the Governor's responsibilities to maintain an emergency services system as prescribed in ORS 401 by planning, preparing and providing for the prevention, mitigation and management of emergencies or disasters that present a threat to the lives and property of citizens of and visitors to the State of Oregon.

The agency is responsible for coordinating and facilitating emergency planning, preparedness, response and recovery activities with the state and local emergency services, agencies, and organizations.

The Oregon Department of Geology and Mineral Industries (DOGAMI) was created in 1937 as an independent state agency. It has evolved from its early focus on mining to become Oregon's major source of information to help Oregonians understand and prepare for the vast array of natural hazards that accompany the state's spectacular geology. Mapping the state's varied geology and natural hazards is a primary function of the agency. These hazards include earthquakes, tsunamis, landslides and coastal erosion.

Subject Matter Expert Contacts

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Tsunami Fact Sheet

What is a tsunami?

Tsunamis are ocean waves generated by a sudden change of the ocean water level, most often caused by earthquakes, but also by landslides; volcanic eruptions; comet or meteorite impacts in the ocean.

Why are tsunamis dangerous?

As the tsunami crosses the deep ocean, it may be only a few feet or less in height. As the tsunami approaches the shore, the wave height increases and associated currents intensify, becoming a threat to life and property. There is usually little time to forecast the severity of a tsunami after one is generated and entire coastlines can be inundated by a large tsunami.

How often do tsunamis occur?

On average, two tsunamis occur per year throughout the world which inflict damage near the source. Approximately every 15 years, a destructive ocean-wide tsunami occurs somewhere in the world.

A tsunami:

- A series of waves.
- Like a fast rising flood tide, storm surge or an advancing wall of water and strikes with devastating force.
- Moves faster than you can run.
- Will continue for many hours.
- First wave is not the largest nor the most dangerous, and surges may arrive 10 hours or more after the initial wave
- Can strike anywhere along an ocean coast.
- Has no season; they can strike at any time of year; day or night.
- Can reach the coast within minutes of a local subduction zone earthquake.
- Disturbs the entire water column while storms only disturb the uppermost section.

Note: A small tsunami at one beach may be a giant tsunami a few miles away.

Earthquake Fact Sheet

There are four types of earthquakes in Oregon

- Crustal
- Deep Intraplate
- Volcanic
- Subduction Zone

What is an Earthquake?

An earthquake is caused by a sudden slip on a fault. The tectonic plates are always slowly moving, but they get stuck at their edges due to friction. When the stress on the edge overcomes the friction, there is an earthquake that releases energy in waves that travel through the earth's crust and cause the shaking that we feel.

The Cascadia Subduction Zone is actually a 600 mile long earthquake fault stretching from offshore northern California to southern British Columbia. This fault builds up stress for hundreds of years as the Juan de Fuca and North America Plates push against each other. Eventually, the two plates rip apart, creating some of the largest earthquakes and tsunamis on earth. The Oregon coastline is actually bulging upward from the two plates pushing against each other.

Who is at risk?

Earthquake risk is the probable building damage, and number of people that are expected to be hurt or killed if a likely earthquake on a particular fault occurs. Earthquake risk and earthquake hazard are occasionally incorrectly used interchangeably.

Why are earthquakes dangerous?

- Destructive fires
- Liquefaction
- Surface rupture
- Hazardous material releases
- Dam failures
- Damaged infrastructure
- Landslides

Volcano Fact Sheet

What is a Volcano?

- Volcanoes are mountains, but they are very different from other mountains; they are not formed by folding and crumpling or by uplift and erosion.
- Instead, volcanoes are built by the accumulation of their own eruptive products -- lava, bombs (crusted over lava blobs), ashflows, and tephra (airborne ash and dust).
- A volcano is most commonly a conical hill or mountain built around a vent that connects with reservoirs of molten rock below the surface of the Earth.
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Who is at risk?

The risk from volcanoes, geographically, is well known. Several areas in the world contain active and dormant volcanoes. The Pacific Rim contains several active volcanoes. Almost all events have been confined to the Pacific states. The most recent explosion of significance was the eruption of Mt. St. Helens in Washington State.

Mitigation strategies in volcanoes include early warning systems and evacuation. Today, there generally are several investigations regarding the dormancy status of volcanoes. These are undertaken to identify any changes that may warrant preventive action.

Why are volcanoes dangerous?

- Eruption Columns and Clouds
- Volcanic Gases
- Lava Flows and Domes
- Pyroclastic Flows
- Volcano Landslides
- Lahars

Volcanoes in Oregon

Mt. Hood

Mt. Jefferson

Three Sisters

Newberry Volcano

Crater Lake

Websites

Oregon Department of Geology and Mineral Industries
http://www.oregongeology.org

Oregon Office of Emergency Management
http://www.oregon.gov/OMD/OEM/

USGS- Cascades Volcano Observatory
http://vulcan.wr.usgs.gov/

USGS - Latest earthquakes in the world
http://earthquake.usgs.gov/earthquakes/recenteqsww/

Pacific Northwest Seismic Network
http://www.pnsn.org/earthquakes/recent

NOAA Tsunami Website
http://www.tsunami.noaa.gov/

West Coast and Alaska Tsunami Warning Center
http://wcatwc.arh.noaa.gov/

Pacific Tsunami Warning Center
http://ptwc.weather.gov/