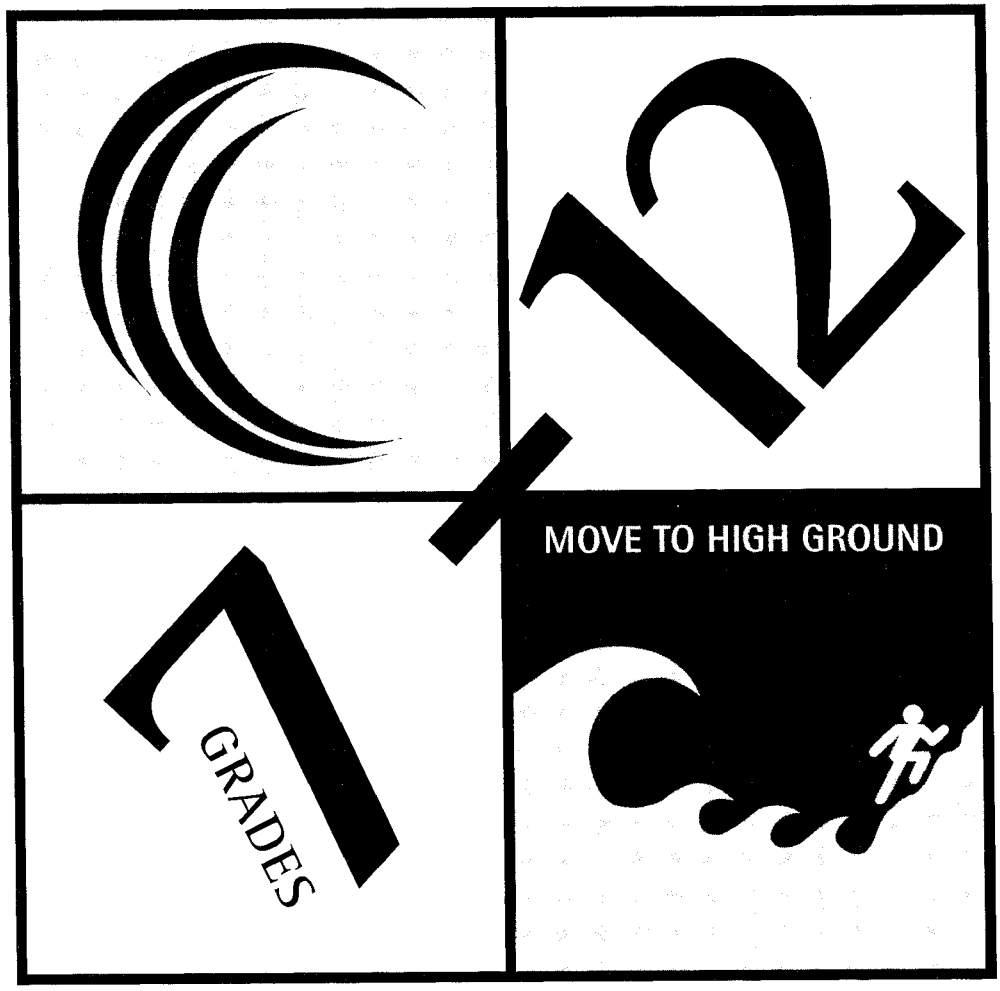
SURVIVING GREAT WAVES OF DESTRUCTION

TSUNAMI



CURRICULUM

WASHINGTON MILITARY DEPARTMENT / EMERGENCY MANAGEMENT DIVISION

George Crawford, Earthquake Program Manager
Barbara Everette Thurman, Public Education Coordinator

Laurie Dent-Cleveland, M.Ed., Author

Acknowledgements

Portions of this document are based on the FEMA Seismic Sleuths Curriculum.
This publication was designed by Lenore Doyle, Communication By Design.

Table of Contents

TEACHER'S GUIDE

Tsunami

This publication is an interdisciplinary set of lesson plans for grades 7-12.

Contents of this packet

- Color Tsunami Poster
- Teaching Guide (including a glossary of terms and resource bibliography)
- Surviving A Tsunami – Lessons from Chile, Hawaii, and Japan
- Tsunami – The Great Waves
- Four Lesson Plans with Activities
- References to Relevant Internet Web Sites

Lesson Plans

Lesson includes:

- Background Information
- Learning Activities
- Reproducible Master Sheets for making overhead transparencies or photographs (where applicable)
- Reproducible Activity Sheet for students (where applicable)

The lesson plans were created to be taught independently. However, it is recommended that Lesson 1, Tsunami, Definition and Cause, be taught first. Lesson five, Tsunami Preparedness – Move to Higher Ground, is a life safety unit that can stand alone.

GLOSSARY OF TERMS

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

Bore:
A bore is a 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.

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

First Motion:
Initial motion of the first wave.

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

Horizontal Inundation Distance:
The distance that a tsunami wave penetrates onto the shore.

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.

Local/RegionalTsuanmi:
A local- or near-field tsunami has a very short travel time (30 minutes or less). A regional or mid-field tsunami has travel times of between 30 minutes and 2 hours.

Marigraph:
The instrument which records wave height.

NOAA – National Oceanic and Atmospheric Administration:
The Federal Agency responsible for tsunami warnings and monitoring.

NWS – National Weather Service:
NWS is a branch of NOAA that operates the tsunami warning centers and disseminates tsunami warnings.

PTWC – Pacific Tsunami Warning Center:
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. Tsunami periods generally range from 5 to 60 minutes.

GLOSSARY OF TERMS

Runup:
The maximum height of the water onshore.

Seiche:
A standing wave oscillating in a partially or fully enclosed body of water.

Teletsunami:
Also referred to as a distant-source or far-field tsunami. Travel time is greater than 2 hours.

Tidal Wave:
Common, although incorrect, term for tsunami. 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.

Travel-time:
The time it takes for a 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. A series of traveling ocean waves of extremely long length generated by disturbances associated primarily with earthquakes occurring below or near the ocean floor. Underwater volcanic eruptions and landslides can also generate tsunamis.

RESOURCES

Tsunami Web-site Information

International Tsunami Information Center
http://www.nws.noaa.gov/pr/itic/

U.S. Geological Survey
http://www.usgs.gov/

National Oceanic & Atmospheric Administration
www:/www.pmel.noaa.gov/tsunami-hazard

The Tsunami Page
http://www.geocities.com/CapeCanaveral/Lab/1029/TsunamiFAQ.html

"Tsunami! An On-Line Interactive Resource of Tsunami Information," sponsored by the University of Washington
http://www.geophys.washington.edu/tsunami

Waves of Destruction: Tsunamis – a PBS Special
http://www.pbs.org/wnet/savageearth/tsunami/index.html

The International Journal of Tsunami Society - Tsunami Links
http://www.ccalmr.ogi.edu/STH/links.html

Western States Seismic Policy Council Tsunami Hazard Mitigation Committee
http://www.wsspc.org/tsunami/tsunami.html

Tsunami Video List

Aonae Tsunami Animation
Produced by Dr. Vasily Titov, NOAA/PMEL; can be downloaded from website:
http://www.pmel.noaa.gov/tsunami-hazard/vasily.mpg

Tsunami: Killer Waves
Extensive photos and footage documenting the disastrous results of lethal waves that struck Hawaii in 1946 and 1960, killing hundreds of people and causing hundreds of millions of dollars in damage. Available at the Channel Store, 800-408-4842 for $19.95.

Killer Wave: Power of the Tsunami
Part of the 3-video set, "Nature Strikes," including, "Volcano: Nature's Inferno," and "Asteroids: Deadly Impact." The three-video set is available from the National Geographic Society Store at a cost of $49.95.
http://www.ngstore.com/ngstore/ngsstore.htm

Waves of Destruction: Tsunamis
From remote Okushiri Island, off the coast of northern Japan, to Hawaii, survivors give first-hand reports of the devastating power of tsunami and tell how they managed to escape. The final program of the PSB series "Savage Earth" is available for $19.95 from WNET Video Distribution, PO Box 2284, South Burlington, VT 05407.
http://www.pbs.org/wnet/savageearth/programs/html/videos.html

RESOURCES

Fire on the Rim, Episode 3 – the Prediction Problem

Available from Ambrose Video Publishing, 28 West 44th St., Suite 2100, New York, NY 10036. Phone 1-800-526-4663, Ext. 224, Fax 212-768-9282. Cost is $99.95.

http://www.ambrosevideo.com

The Wave: A Japanese Folktale

Item PE 501 (Grades K-3), available from the Nature of the Northwest Information Center, 800 NE Oregon St., Suite 177, Portland, OR 97232. Phone 503-872-2750. Cost $10.00 plus shipping.

Tsunami! Surviving the Killer Waves

Item PE 502 (Grades 4-12), produced by the Oregon Dept. of Geology and Miners, RT 13.35 min., available from the Nature of the Northwest Information Center, 800 NE Oregon St., Suite 177, Portland, OR 97232. Phone 503-872-2750. Item PE 503 (General Public), Cost $10.00 plus shipping.

Raging Planet: Tidal Wave

Imagining an unstoppable wall of water, 500 mph, reaching heights of nearly 100 feet. Tidal Wave is the store of defiant humans. Join scientists who struggle to predict the unpredictable. RT 50 min. Item 707091, available from The Discovery Channel for $19.95 plus shipping.

http://shopping.discovery.com/product/70791.html

Tsunami—Born of Fire

Available from NOAA/PMEL, 206-526-6810 for cost of duplication. RT 9:37 min., features tsunami destruction and fires on Okushiri Island, Japan. Good graphics, explanations and safety information.

Sea Tek: Tsunami

Excerpt from Sea Tek TV series produced in 1996. Includes historic tsunami footage, inundation, and damage scenes from Peru, Alaska, and Japan. Information: Eddie Bernard, 206-526-6800.

Raging Sea

Thirty minute special on tsunami preparedness focused in Hawaii; produced by KGMB TV. Information: Delores Clark, 808-532-6411.

Tsunami

B-roll showing Papua New Guinea simulations and tsunami buoy deployment. Cost is $9-$25, depending on format. Available from Video Transfer, 301-881-0270. Email: vidtans@erols.com.

International Tsunami Information Center

Two videos available, each with multiple tsunami sections. These videos can be used for educational purposes. Contact VideoLab, 401 Kamakee St., 3rd Floor, Honolulu, HI 96814. Phone 808-593-0400, Fax 808-593-1841. Cost is $15.00, plus Blue Label shipping, approx. $15.00.

TSUNAMI AND EARTHQUAKE CURRICULUM

Essential Academic Learning Requirements and Components

Upon completion of the following curriculum, the following Essential Academic Learning Requirements and Components (EALRS) will have been covered.

Reading

2. **The student understands the meaning of what is read.**
   To meet this standard, the student will:
   - 2.1 comprehend important ideas and details
   - 2.2 expand comprehension by analyzing, interpreting, and synthesizing information and ideas
   - 2.3 think critically and analyze author's use of language, style, purpose, and perspective

3. **The student reads different materials for a variety of purposes.**
   To meet this standard, the student will:
   - 3.2 read to perform a task

Writing

1. **The student writes clearly and effectively.**
   To meet this standard, the student will:
   - 1.1 develop concept and design
   - 1.2 use style appropriate to the audience and purpose

2. **The student writes in a variety of forms for different audiences and purposes.**
   To meet this standard, the student will:
   - 2.1 write for different audiences
   - 2.2 write for different people

TSUNAMI AND EARTHQUAKE CURRICULUM

Communication

1. **The student uses listening and observation skills to gain understanding.**
   To meet this standard, the student will:
   1.1 focus attention

2. **The student communicates ideas clearly and effectively.**
   To meet this standard, the student will:
   2.1 communicate clearly to a range of audiences for different purposes
   2.2 develop content and ideas
   2.3 use effective delivery

3. **The student uses communication strategies and skills to work effectively with others.**
   To meet this standard, the student will:
   3.2 work cooperatively as a member of a group

Mathematics

3. **The student uses mathematical reasoning.**
   To meet this standard, the student will:
   3.1 analyze information
   3.2 predict results and make inferences
   3.3 draw conclusions and verify results

4. **The student understands how mathematical ideas connect within mathematics, to other subject areas, and to real-life situations.**
   To meet this standard, the student will:
   5.2 relate mathematical concepts and procedures to other disciplines
   5.3 relate mathematical concepts and procedures to real-life situations

TSUNAMI AND EARTHQUAKE CURRICULUM

Science

1. **The student understands and uses scientific concepts and principles.**
   To meet this standard, the student will:
   1.3 understand how interactions within and among systems cause changes in matter and energy

2. **The student knows and applies the skills and processes of science and technology.**
   To meet this standard, the student will:
   2.3 apply science knowledge and skills to solve problems or meet challenges

Social Studies: Geography

1. **The student uses maps, charts, and other geographic tools to understand the spatial arrangement of people, places, resources, and environments on Earth's surface.**
   To meet this standard, the student will:
   1.1 use and construct maps, charts, and other resources

3. **The student observes and analyzes the interaction between people, the environment and culture.**
   To meet this standard, the student will:
   3.2 analyze how the environment and environmental changes affect people
   3.3 examine cultural characteristics, transmission, diffusion and interaction

LESSON 1

Tsunami: Definition and Cause

The phenomenon we call "tsunami"

Tsunami *(soo-NAH-mee)* is a series of ocean waves of extremely long length generated by disturbances associated primarily with earthquakes occurring below or near the ocean floor. Underwater volcanic eruptions and landslides can also generate tsunamis. The waves radiate outward in all directions from the disturbance, and can propagate across entire ocean basins.

River wave in Hilo, Hawaii, 1946.

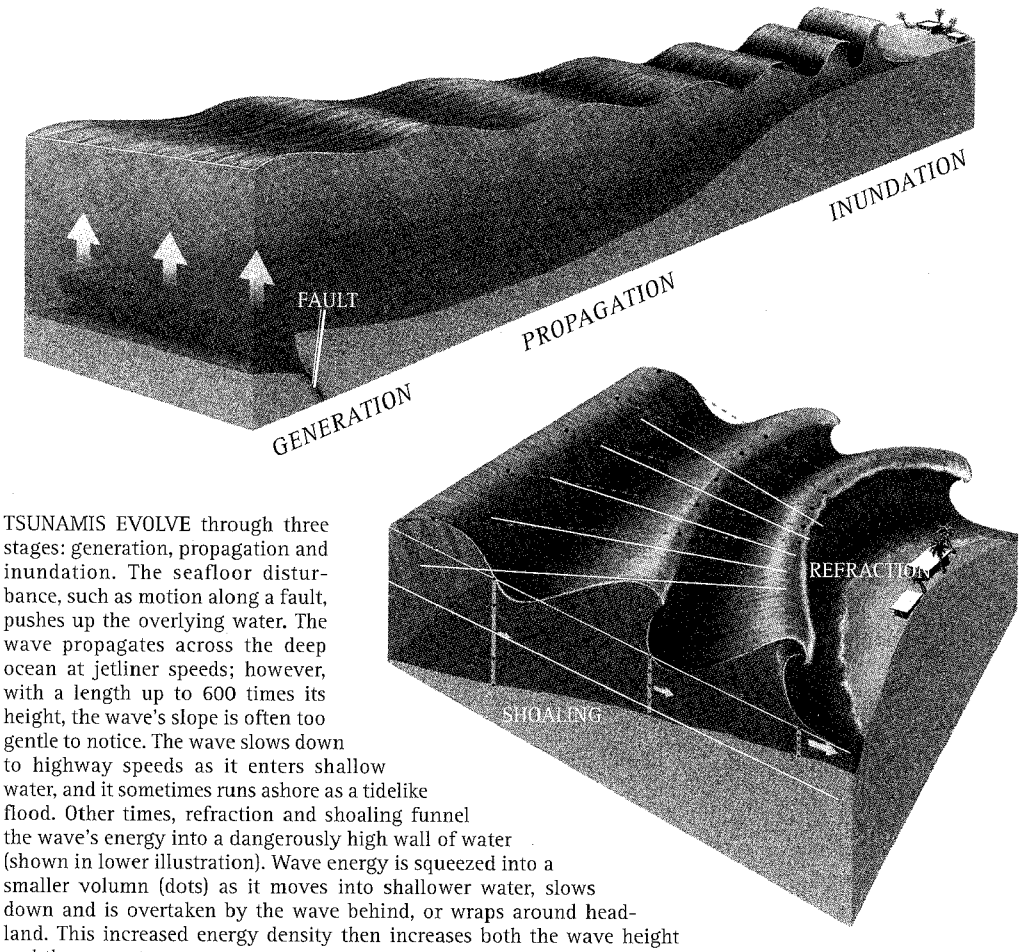
Tsunamis have been erroneously called "tidal waves." However, it should be understood that these waves have nothing to do with the attraction of the Moon or the Sun. Therefore, scientists prefer the Japanese word "tsunam," which means, "wave in the harbor," or the English term "seismic sea wave."

Twenty-four tsunamis have caused damage in the United States and its territories during the last 204 years. Just since 1946, six tsunamis have killed more than 350 people and caused a half billion dollars of property damage in Hawaii, Alaska, and the West Coast. A tsunami can occur during any season of the year and at any time, day or night.

Most strong earthquakes, representing 80 percent of the total energy released worldwide by earthquakes, happen in subduction zones where an oceanic plate slides under a continental plate or another younger oceanic plate.

Not all earthquakes generate tsunamis. To generate a tsunami, the fault where the earthquake occurs must be underneath or near the ocean, and create a vertical movement (up to several meters) of the sea floor over a large area (up to a hundred thousand square kilometers.)

Shallow focus earthquakes (depth less than 70 kilometers) along subduction zones are responsible for most destructive tsunamis. The amount of vertical and horizontal motion of the sea floor, the area over which it occurs, the simultaneous occurrence of slumping of underwater sediments due to the shaking, and the efficiency with which energy is transferred from the earth's crust to the ocean water are all part of the tsunami generation mechanism.



TSUNAMIS EVOLVE through three stages: generation, propagation and inundation. The seafloor disturbance, such as motion along a fault, pushes up the overlying water. The wave propagates across the deep ocean at jetliner speeds; however, with a length up to 600 times its height, the wave's slope is often too gentle to notice. The wave slows down to highway speeds as it enters shallow water, and it sometimes runs ashore as a tidelike flood. Other times, refraction and shoaling funnel the wave's energy into a dangerously high wall of water (shown in lower illustration). Wave energy is squeezed into a smaller volumn (dots) as it moves into shallower water, slows down and is overtaken by the wave behind, or wraps around headland. This increased energy density then increases both the wave height and the currents.

Tsunami waves can be distinguished from ordinary surf waves by their great length, often exceeding 100 miles in the deep ocean, and by the long amount of time between successive peaks, 5 minutes to an hour. The speed at which tsunamis travel depends upon the ocean depth. A tsunami can exceed 500 mph in the deep ocean but slows to 20 or 30 mph in the shallow water near land. In less than 24 hours, a tsunami can cross the entire Pacific Ocean.

Tsunamis evolve through three stages: generation, propagation and inundations. A seafloor disturbance, such as motion along a fault, pushes up the overlying water. The wave propagates across the deep ocean at jetliner speeds; however, with a length up to 600 times its height, the wave's slope is often too gentle to notice. The wave slows down to highway speeds as it enters shallow water, and it sometimes runs ashore as a tidelike flood. Other times, refraction and shoaling funnel the wave's energy into a dangerously high wall of water (above). Wave energy is squeezed into a smaller volume (shown as white lines above) as it moves into shallower water,

slows down and is overtaken by the wave behind, or wraps around a headland. This increased energy density then increases both the wave height and the currents.

Scotch Cap Lighthouse before (above) and after a tsunami in 1946.

In the deep ocean, a tsunami is barely noticeable and will only cause a small and slow rising and falling of the sea surface as it passes. A tsunami becomes a hazard only as it approaches land. In the open ocean, tsunamis would not be felt by ships because the wavelength would be hundreds of miles long, with an amplitude of only a few feet. This would also make them unnoticeable from the air. As the tsunami approaches land and shallow water, the tsunami waves slow down and become compressed, causing them to grow in height. In the best of cases, the tsunami comes onshore like a quickly rising tide and causes a gentle flooding of low-lying coastal areas. In the worst of cases, a bore will form. A bore is a wall of turbulent water that can be several meters or more high, and can rush onshore with great destructive power. Behind the bore is a deep and fast-moving flood that can pick up and sweep away almost anything in its path. Minutes later the water will drain away as the trough of the tsunami wave arrives, sometimes exposing great patches of sea floor. But then the water will rush in again, causing additional damage. This destructive cycle may repeat many times before the hazard has finally passed. Persons caught in the path of a tsunami have little chance to survive. They can easily be crushed by debris or they may simply drown. Children and the elderly are particularly at risk, since they have less mobility and endurance.

Tsunamis typically cause the most severe damage and casualties very near their source. In fact, most tsunamis are only destructive near their source. There the waves are highest because they haven't yet lost much energy to friction or spreading. In addition, the nearby coastal population, often disoriented from the violent earthquake shaking, has little time to react before the tsunami arrives. The largest tsunamis, however, can cause destruction and casualties over a wide area, sometimes as wide as the entire Pacific basin. These types of Pacific-wide tsunamis may happen only a few times each century.

TSUNAMI ACTIVITY

What Do You Know About Tsunamis?

Rationale

This pre-assessment activity is designed to focus your students on what they are about to learn, assess their current knowledge, and later provide them and you with a gauge of what they have learned from this tsunami curriculum.

Focus

What do you know about tsunamis?

Objectives

Students will:

1. Use various writing styles to describe a hypothetical tsunami.
2. Anticipate what they will learn from this study of tsunamis.

Materials

- Writing Paper
- Student copies of Writing Outlines (see page 18)
- Pictures or slides of tsunami damage

Procedure

Introduction

Show students images of tsunami damage. Tell students they are going to imagine themselves in a tsunami. Distribute copies of the writing outline (see page 18). Ask students to note the date and time of their tsunami, its location, how much damage it caused and other basic information at the top of the page.

Lesson Development

Tell the students that they are to write about his or her hypothetical tsunami from three different points of view: that of a news reporter, a scientist, and an individual directly affected by the tsunami. The three accounts will describe the same tsunami, but the styles will vary.

News Reporter: A short, article describing the who, what, where, and when of the tsunami. Provide information the public needs.

Include:

- A lead sentence – must be catchy, attention-grabbing.
- Rest of paragraph – answer what, where, when, who and how many were affected.
- One or more body paragraphs – provide background.
- Final sentence – the clincher; end the story with a punch.

Scientist: A scientific account stating what is objectively known about the tsunami, its causes, its effects, its magnitude and/or intensity, and the likelihood of its recurrence.

Include:

- Lead paragraph – answer what, where, when and who was affected. May be heavy with data.
- Body paragraph or paragraphs – provide background and analysis.

Eyewitness: A personal letter to a friend telling about being in the tsunami. Describe what happened to buildings, your family, friends, pets and your home. Describe any preparedness activities you had taken before the tsunami, and what you wish you had done. The student should keep the facts accurate from story to story.

Include:

- Informal account intended for a friend. May include humor or exaggeration.
- Write in letter format.

Conclusion

Ask students to talk about the experience of writing the accounts. Ask?

- Did you feel you had enough information to do the job in each case?
- Was one point of view more comfortable than the others?

Writing Outline

Name: _____

Just the Facts – Use these same facts in each of the variations.

Date and time of the hypothetical tsunami: _____

Location (city, state, country): _____

Size of the wave: _____

Deaths: _____

Injuries: _____

Amount of property damage: _____

LESSON 2

Pacific Coast and Regional Tsunamis

The 1960 Chilean Tsunami

In 1960 a large tsunami caused widespread death and destruction throughout the Pacific. The tsunami was generated by an earthquake located off the coast of Chile. The tsunami radiated outward from a subduction zone along the coast of Chile. Its waves reached Hawaii in 15 hours and Japan in 22 hours.

Aftermath of Chilean tsunami i Hilo, Hawaii, in 1960.

The earthquake and tsunami took more than 2,000 lives and caused property damage estimated at $550 million dollars. The tsunami radiated outward and killed 61 people in Hawaii and 122 in Japan.

There was plenty of time for evacuation in Hilo, Hawaii, on May 22, 1960, as the tsunami was racing across the Pacific Ocean. An official warning was issued that waves would hit Hilo sometime around midnight. That evening coastal sirens sounded in Hilo and continued to sound every 20 minutes.

The first wave that hit Hilo was only a few feet high, arriving shortly after midnight. Hundreds of people had failed to heed the warning and remained in their homes. Those that had left thought the danger was over after the initial wave and returned home. At 1:04 a.m. the highest wave of the tsunami hit Hilo. The wave grew in height as it moved toward the city and the noise became deafening. Finally, the 20 foot high, nearly vertical wave, hit Hilo, killing 61 people and injuring 282 badly.

The warning system was unclear to people and interpreted in different ways. One must always remember to play it safe, even if warnings seem ambiguous or you think the danger has passed, choosing to err on the side of safety.

The Great Alaskan Earthquake/Tsunami of 1964

The Great Alaskan Earthquake/Tsunami occurred March 28, 1964. This was the largest earthquake to hit the northern hemisphere in recorded history. The earthquake was a magnitude 8.3, it affected an area that was almost one thousand miles long and more than two hundred miles wide.

For additional information, visit

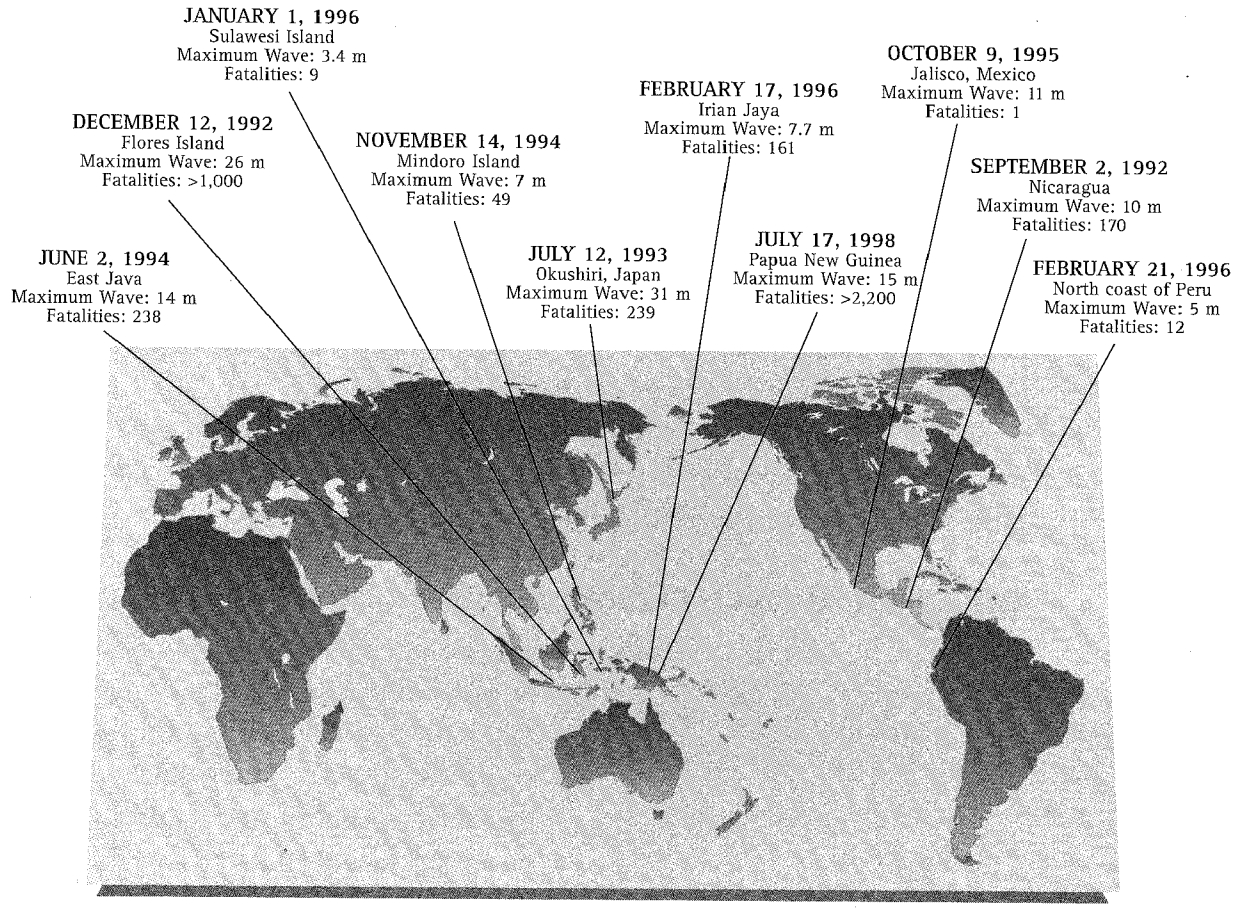
www.geophys.washington.edu/tsunami

The earthquake generated a great tsunami, which was extremely damaging. The area of damage extended from Alaska, along Vancouver Island, and in Northern California and Hawaii. In Crescent City, California eleven people were killed by the tsunami. Wave heights were reported between 7 and 21 feet. At Santa Cruz Harbor, the tsunami wave reached as high as 11 feet. The damage in San Francisco Bay was largely to pleasure boats. Damage also occurred in Los Angeles and Long Beach Harbors. Damage in California was between 1.5 and 2.3 million dollars while in Crescent City the damage was estimated at 7.4 million.

In Crescent City the first of the four tsunami waves caused no significant damage other than flooding. The second and third waves were very similar to

---

TEN TSUNAMIS have claimed more than 4,000 lives since 1990. Last year's Papua New Guinea disaster, which claimed more than 2,200 lives, is the most recent in this string of killer waves generated by earthquakes along colliding tectonic plates of the Pacific Rim.



Resurrection Bay in Seward, Alaska, after 1964 tsunami.

the first. It was the fourth wave that was the largest. The fourth wave was preceded by a withdrawal of water, leaving the harbor almost entirely dry. Finally, the fourth wave hit the city damaging piers, fishing boats and pleasure boats. Approximately 30 blocks of Crescent City was destroyed. Automobiles, lumber and other objects were carried away by waves that destroyed a good portion of the buildings in the area.

Papua New Guinea Tsunami of 1998

On Friday evening July 17th at 6:49 p.m., a Richter magnitude 7.1 earthquake initiated the Papua New Guinea tsunami. The general consensus is that the earthquake triggered an underwater landslide and that in turn generated the giant sea waves. At least 2,500 people were confirmed dead. Over 713 were admitted to hospitals, and thousands left homeless.

Within minutes the tsunami struck hard along a 30-mile stretch of coast near Sissano lagoon, completely destroying several coastal villages, and taking a staggering toll in human life. The tsunami waves that came ashore in Papua were reported to be as much as 24 to 30 feet high. Debris hung from the palm trees indicating that the waves were taller than a four-story building.

TSUNAMI ACTIVITY

Tsunami Waves Research

Rationale

Underwater earthquakes can cause powerful seismic sea waves commonly called tsunamis. These waves can devastate a coastal community because of the tremendous amount of energy they carry.

Focus

- How do earthquakes cause seismic sea waves?
- What precautions can people take to limit tsunami damage?

Objectives

Students will:

- Prepare and present a class report that reflects their own research on tsunamis.
- Describe, through research, the characteristics of an average tsunami wave in terms of speed, wavelength, and period, and predict its effects on a coastal community.

Materials

- Copies of Seismic Sea Wave Research and Report form (see page 23).

Procedure

Invite students to do some research on actual tsunamis. Hand out one Seismic Sea Waves Research and Report form to every two students. Explain that each team is to research a specific topic and report what they learn to the class. Two students may research and report on a specific tsunami, two others on tsunami warning systems, others preventive measure that can be taken to minimize tsunami damage, etc.

Conclusion

Students will present their reports.

Seismic Sea Wave Research and Report

Name _____ **Date** _____

Event: _____

_____

_____

Cause: _____

_____

_____

Characteristics of the tsunami: _____

_____

_____

Damage: _____

_____

_____

What could have been done to prevent the damage?: _____

_____

_____

_____

Information Source:

Title: _____

Author: _____

Publisher and place of publication: _____

Internet Site: _____

Other: _____

Date: _____

LESSON 3

Pacific Tsunami Warning System

The Tsunami Warning System in the Pacific

The West Coast/Alaska Tsunami Warning Center (WC/ATWC) is responsible for tsunami warnings for California, Oregon, Washington, British Columbia, and Alaska.

The Pacific Tsunami Warning Center (PTWC) is responsible for providing warnings to international authorities, Hawaii, and U.S. territories within the Pacific basin. The two Tsunami Warning Centers coordinate the information being disseminated.

The IOC also maintains an International Tsunami Information Center (ITIC) which works closely with the Pacific Tsunami Warning Center (PTWC) located near Honolulu, Hawaii. PTWC is operated by the United States National Weather Service (NOAA).

PTWC operates more than 50 seismic stations in cooperation with the National/Regional Tsunami Warning Centers and other international sources. If the location and criteria for the generation of a tsunami is determined, a tsunami warning is issued. Tsunami watches, warnings, and information bulletins are disseminated to appropriate emergency officials and the general public by a variety of communication methods.

The Tsunami Watch

When an earthquake of sufficient magnitude occurs in the Pacific Ocean area, PTWC personnel determine the location of the earthquake epicenter – the point on the earth's surface above the subterranean focus of the earthquake. If the epicenter is under or near the ocean, tsunami generation is possible. On the basis of seismic evidence, the center issues a tsunami watch, which tells participants that an earthquake has occurred, and where and when, and that the possibility of a tsunami exists. Because tsunamis move through the water in accordance with known physical laws, accurate estimated times of arrival can be given for each location in the Pacific.

Tsunami time charts have been prepared for different locations in the Pacific.

The Tsunami Warning

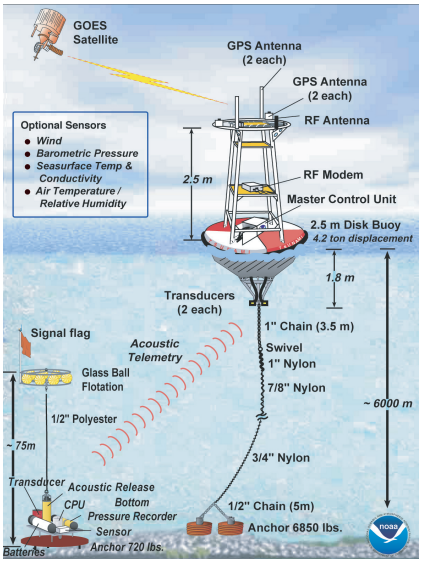
The first positive indication of the existence of a tsunami usually comes from tide stations nearest the disturbance. When confirmation is received, the PTWC issues a tsunami warning, alerting warning system participants to the approach of a potentially destructive tsunami and repeating tsunami times of arrival for all locations.

Tsunami watches, warnings, and advisory bulletins are disseminated throughout the Pacific to the member states in accordance to procedures outlines in the communications plan for the Tsunami Warning System. The primary purpose of this plan is to serve as the communications operating manual for the PTWC and for participants. Dissemination agencies in the participating member states have the continuing responsibility for educating the pubic concerning the dangers of tsunamis and for developing safety measures that must be taken to avoid loss of life and to reduce property damage.

Tsunami Detectors

Tsunami warnings will be improved through the installation of an array of deep ocean tsunami detectors (see graph this page) and a major upgrade of existing earthquake detection networks. The locations of the oceanic sensors and land-based seismic sensors are identified on the map that follows (see page 27). These sensors will provide faster, more accurate estimates of tsunamis.

The deep-ocean detectors depend on high tech sensors stationed on the seafloor. When one of the instruments senses a tsunami wave overhead, it will send acoustic signals to a buoy at the surface, which will then relay the warning via satellite to the officials who are responsible for sounding an alarm.



Deep-ocean tsunami detectors, as depicted in this illustration, are being designed by the U.S. to take the suprise out of tsunami attacks. The detectors depend on sensors stationed on the seafloor. When one of the instruments senses a tsunami wave overhead, it will send acoustic signals to a buoy at the surface, which will relay the warning via satellite to officials who will sound an alarm. The detectors are scheduled for installation within two years.

Tsunami Safety Rules

- All earthquakes do not cause tsunamis, but many do. When you hear that an earthquake has occurred, stand by for a tsunami emergency.
- An earthquake in your area is a natural tsunami warning. Do not stay in low-lying coastal areas after a strong earthquake has been felt.

- A tsunami is not a single wave, but a series of waves. Stay out of danger areas until the authorities issue an "all clear."
- Approaching tsunamis are sometimes preceded by a noticeable rise or fall of coastal water. This is nature's tsunami warning and should be heeded.
- A small tsunami at one point on the shore can be extremely large a few kilometers away.
- The PTWC does not issue false alarms. When a tsunami warning is issued, a tsunami exists.
- All tsunamis are potentially dangerous, even though they may not damage every coastline they strike.
- Never go down to the shore to watch for a tsunami. When you see the wave you are too close to escape it.
- Sooner or later tsunamis strike every coastline in the Pacific. Warnings apply to you if you live in any Pacific Coastal area.
- During a tsunami give local authorities your fullest cooperation.

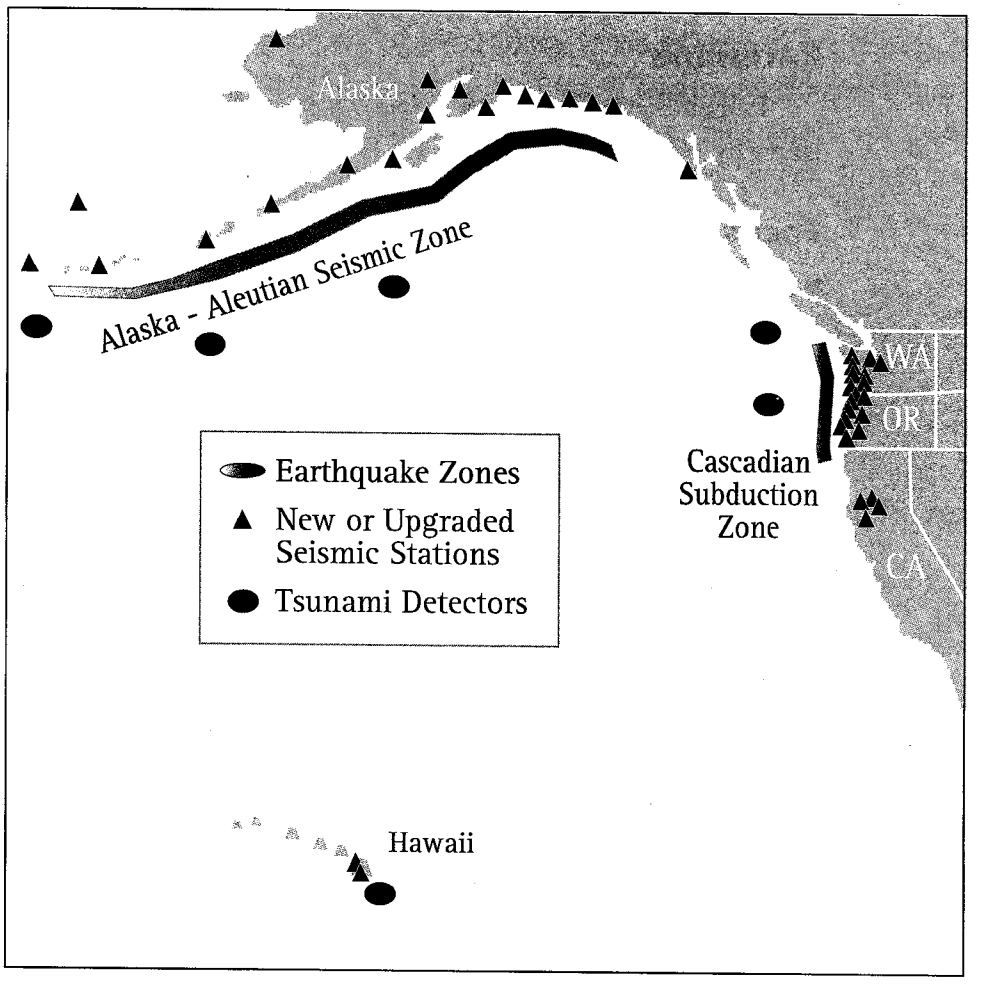
Local Tsunamis — The Immediate Threat

When a large subduction zone earthquake occurs, the first tsunami waves may reach nearby coastal communities within 10 minutes of the event. Communities must know in advance what areas are likely to flood in order to establish evacuation routes. Communities on coastlines bordering subduction zones are at the greatest risk of significant local tsunamis. However, other Pacific Coast communities must also consider the local tsunami hazard, since large, nonsubducting, earthquakes may trigger local submarine landslides that can generate destructive tsunamis.

Distant Tsunamis — The Silent Threat

All of the U.S. coastline bordering the Pacific Ocean is exposed to distant tsunami dangers and has experienced major damage and loss of life from tsunamis originating near Chile, Japan, Russia, and Alaska. NOAA tsunami warning center operations have greatly reduced the loss of life from distant tsunamis. Monitoring earthquakes gives a good estimate of the potential for a tsunami.

Tsunami Warning Guidance



Tsunami warnings will be improved through the installation of deep ocean tsunami detectors and a major upgrade of existing earthquake detection networks. The locations of the oceanic sensors and land-based seismic sensors are identified in this map.

TSUNAMI ACTIVITY

Tsunami in a Box!

Rationale

Tsunamis are a series of ocean waves created by the sudden displacement of water by seismic movement of the ocean floor.

Focus

- How are tsunamis generated?
- Do earthquakes occur underwater?

Objectives

Students will be able to:

1. Generate a tsunami and observe the results on a model shoreline.
2. Relate the analogy of the motion of the lid to the motion of the ocean floor during an earthquake as a means of water displacement and subsequent tsunami generation.
3. Explain that not all underwater earthquakes will generate a tsunami.

Materials

- Glass or metal baking pan or plastic shoe box
- One liter of water
- Plastic lid of the type used to re-close coffee or margarine containers
- Punching tool or drawing compass
- Scissors
- String
- Sand
- Erasers, toothpicks, popsicle sticks, and other small object to represent shoreline features
- Book or block of wood to serve as a wedge
- Metric ruler

Procedure

1. Explain to the students:
   All tsunamis are generated by a sudden displacement of water. Landslides, submarine slumps, or earthquakes can displace water. It usually requires an earth-

quake with a magnitude greater than 7 on the Richter scale to generate a significant tsunami. Tsunamis travel from the point of origin at a speed of 300-350 miles an hour. Earthquake (seismic) waves travel 50 times faster than tsunamis, thus seismographs would provide a warning of a potential tsunami within minutes after a large earthquake occurred. This often gives time to prepare for a tsunami after the tsunami warning has been issued.

2. Ask the students:
   a. Do earthquakes occur underwater? (yes)
   b. How could earthquakes under the ocean ever affect people? (Accept all reasonable answers)
   c. What is a tsunami?

3. Begin the class discussion with what the students have already learned from the tsunami curriculum.

4. Divide the students into groups, distribute materials, and give the following directions:
   a. Use the wedge to tilt the box or pan at an angle of about 20 degrees.
   b. Pour water into the box or pan to cover the lower end, leaving about a third of the box or pan at the upper end dry.
   c. Pack a layer of sand 2-3cm thick on the dry end of the box or pan to simulate a beach or coastline. Use your hands to mold dunes or drifts. Draw roads parallel to the shore with a stick or your fingers. Build docks and other small, lightweight structures to complete the shore environment. Be creative.
   d. Punch the plastic lid on one end near the rim to make a hold, and thread it with a piece of string 20cm long. Tie knots to hold the string in place.
   e. Gently (in order not to make waves) place the plastic onto the bottom at the deep end of the box or pan. Trim to fit if necessary. The string should be next to the low side of the box or pan.
   f. Have one student use several fingers to hold the plastic down tightly on the shallow end, while another student pulls the string up at the deep end with a rapid movement. Tsunami!

Conclusion

Ask the students:

1. What does the sudden motion of the lid represent? (The sudden motion of the ocean floor.)
2. Using the lid as an analogy, explain that like the lid, a sudden release of energy as the upward motion of the ocean floor literally pushes the water away in the form of waves, thus a tsunami.
3. Remember that not all earthquakes generate tsunamis, only those that significantly displace the ocean floor.

LESSON 4

Tsunami Preparedness — Move To Higher Ground

Life Saving Knowledge — What You Should Know

If you think a tsunami may be coming, the ground shakes under your feet or you hear there is a warning, tell your relatives and friends, and move quickly to higher ground.

Earthquakes often generate tsunamis that strike coastal locations in the Pacific Ocean. These earthquakes might occur far away or near where you live. The tsunami generated by the earthquake may be very large. In coastal areas their height can be as great as 30 feet or more (100 feet in extreme cases), and they can move inland several hundred feet.

Tsunami damage at Aonae, Okushiri Island in 1993.

Tsunamis consist of a series of waves. Often the first wave is not the largest. It is important to remember that a tsunami can last for several hours after the arrival of the first wave.

Tsunamis can move faster than a person can run. Remember, the force of the tsunami is enormous. Large rocks weighing several tons along with boats and other debris can be moved inland hundreds of feet by tsunami wave activity. Homes and other buildings may be destroyed. All of this material and water move with great force and can kill or injure people.

Tsunamis can occur at any time, day or night. The following are preparedness facts that everyone should know.

For additional information, visit

www.tsunami.org/

If You Are At School

Schools in Washington State have emergency evacuation plans. If you are at school and hear there is a tsunami warning, you should follow the advice of teachers and other school personnel. You will be directed to a place of safety.

The Great Wave Off Kanagawa (Japan) by Katsushika Hokusai (1760-1846)

If You Are At Home

If you are at home and hear there is a tsunami warning, you should make sure your entire family is aware of the warning. Your family should evacuate your house if you live in a tsunami evacuation zone. Move in an orderly, calm and safe manner to the evacuation site or to any safe place outside your evacuation zone. Follow the advice of local emergency law enforcement authorities.

If You Are At the Beach

If you are at the beach or near the ocean and you feel the earth shake, move immediately to higher ground. DO NOT wait for a tsunami warning to be announced. Stay away from rivers and streams that lead to the ocean, as you would stay away from the beach and ocean if there were a tsunami. A regional tsunami from a local earthquake could strike some areas before a tsunami warning could be announced. Tsunamis generated in distant locations will generally give people enough time to move to higher ground. For locally generated tsunamis, where you might feel the ground shake, you may only have a few minutes to move to higher ground.

High, multi-story, reinforced concrete hotels are located in many low-lying coastal areas. The upper floors of these hotels can provide a safe place to find refuge should there be a tsunami warning and you cannot move quickly inland to higher ground. Local authorities, however, may not allow this type of evacuation in your area. It is important to always follow the directions of local emergency authorities. Homes and small buildings located in low-lying coastal areas are not designed to withstand tsunami impacts. Do not stay in these structures if there is a tsunami warning. Stay away from all low-lying areas when there is a tsunami warning.

If You Are On a Ship or Boat

Since tsunami wave activity is imperceptible in the open ocean, do not return to port if you are at sea and a tsunami warning has been issued for your area. Tsunamis can cause rapid changes in water level and unpredictable dangerous currents in harbors and ports.

If there is time to move your boat or ship from port to deep water (after you know a tsunami warning has been issued), you should weigh the following considerations:

- Most large harbors and ports are under the control of a harbor authority and/or a vessel traffic system. These authorities direct operations during periods of increased readiness (should a tsunami be expected), including the forced movement of vessels if deemed necessary. Keep in contact with the authorities should a forced movement of vessels be directed.
- Smaller ports may not be under the control of a harbor authority. If you are aware there is a tsunami warning and you have time to move your vessel to deep water, then you may want to do so in an orderly manner, in consideration of other vessels. Owners of small boats may find it safest to leave their boat at the pier and physically move to higher ground, particularly in the event of a locally generated tsunami. Concurrent severe weather conditions (rough seas outside of safe harbor) could present a greater hazardous situation to small boats, so physically moving yourself to higher ground may be the only option.
- Damaging wave activity and unpredictable currents can affect harbors for a period of time following the initial tsunami impact on the coast. Contact the

harbor authority before returning to port making sure to verify that conditions in the harbor are safe for navigation and berthing.

Plan Ahead of Time For Earthquakes and Tsunamis

What can you do ahead of time to protect yourself and your family in an earthquake or tsunami?

- **Make Disaster Plans Beforehand.** Be prepared to be on your own, without outside assistance for at least three days.
- **Contact your local emergency management office** to find out what areas are vulnerable to tsunami hazards, and which routes have been designated as evacuation routes. Discuss the earthquake hazard in your community and have a plan ahead of the quake.
- **Create a Disaster Plan.** Meet with your family and discuss why you need to prepare for disaster. Discuss the dangers of an earthquake and/or tsunami. Learn earthquake safe procedures, especially the "Drop, Cover and Hold" procedure. Discuss the approved evacuation route for your area. Establish an out-of-area phone contact, and don't forget to make plans for your pets, they are family too!
- **Put Your Plan into Action.** Take a first aid class. Prepare your disaster supply kit. Have a kit available in your car, at home and at work. You kit should include a portable radio with extra batteries, water (1 gallon per person per day), first aid supplies, flashlight, with extra batteries, non-perishable food, your prescription medications, copies of your insurance papers, a small amount of cash, extra clothing, heavy duty gloves, heavy shoes, sanitation supplies, and tools, such as a non-electric can opener and utensils.
- **Practice and Maintain Your Plan.** Review your plans every six months. Conduct drills with your family on a regular basis. Replace water and food in your disaster kit every six-month.

Life Saving Facts

- Protect yourself during the earthquake. "Drop, Cover and Hold" until the earth stops shaking. Remember, an earthquake is a natural tsunami warning.
- Move to higher ground immediately. Leave possessions behind. A tsunami may be coming in minutes. Go on foot if at all possible. If there is no high ground, move inland away from the coastline.

- If you feel the ground shake, DO NOT wait for an official warning. Move to higher ground immediately.
- Listen to your radio for information from the emergency authorities. Use a NOAA Weather Radio with a tone-alert feature to keep you informed of local watches and warnings. The tone alert feature will warn you of potential danger even if you are not currently listening to local radio or television stations.
- Stay away from the coast. Remember, there may be more than one wave. The later wave may be higher than the first! Damaging waves may continue to arrive even hours later.
- Listen to your radio. Wait for an official "all clear" signal before returning to low-lying areas.
- Never go to the coast to watch for a tsunami if you hear that a warning has been issued. Tsunamis move quicker than a person can run.
- Talk to your insurance agent. Homeowner policies do not cover flooding from a tsunami. Ask about the National Flood Insurance Program.
- Remember that tsunamis are very rare. The Washington coast is certainly vulnerable, but tsunamis are infrequent. It is important to understand the hazard and learn how to protect yourself, but don't let the threat of tsunamis ruin your enjoyment of the beach.

Evacuation Signs and What They Mean

Tsunami evacuation routes were developed to assist coastal residents and visitors find safer locations in case of an earthquake and tsunami. Evacuation signs have been placed along roadways to indicate the direction inland or to higher ground. In some places, there may be more than one direction available to reach safer areas. These routes may be marked with several signs showing additional options for evacuation. You will need to know the evacuation routes for your area.

Community Plans

Every attempt has been made by local Emergency Management offices to locate evacuation routes and public congregation areas that are safe, within a reasonable distance for foot or vehicle traffic, and accessible within a short period of time. These are difficult criteria to meet in some geographic areas, primarily as a result of private property issues. For that reason, residents who may be impacted by tsunami activity, but do not have an "official" route or congregation area within a reasonable distance, are urged to work together to develop an evacuation plan within their neigh-

borhood or community. A plan should address property access issues, evacuation routes, and what might be expected in terms of numbers of people needing to access a locally organized congregation area.

What To Do After A Tsunami

- Continue listening to a NOAA Weather Radio, Coast Guard emergency frequency station, or other reliable source for emergency information. The tsunami may have damaged roads, bridges, or other places that may be unsafe.
- Help injured or trapped persons. Give first aid where appropriate. Call for help. Do not move seriously injured persons unless they are in immediate danger of further injury.
- Help a neighbor who may require special assistance – infants, elderly people, and people with disabilities. Elderly people and people with disabilities may require additional assistance. People who care for them or who have large families may need additional assistance in emergency situations.
- Use the telephone only for emergency calls. Telephone lines are frequently overwhelmed in disaster situations. They need to be clear for emergency calls to go through.
- Stay out of buildings if waters remain around them. Tsunami waters, like flood waters, can undermine foundations, causing buildings to sink, floors to crack, or walls to collapse.
- When re-entering buildings or homes, use extreme caution. Tsunami-driven flood waters may have damaged buildings where you least expect it. Carefully watch every stop you take.
- Wear sturdy shoes. The most common injury following a disaster is cut feet.
- Use battery-powered lanterns or flashlights when examining buildings. Battery-powered lighting is the safest and easiest, preventing fire hazard for the user, occupants, and building.
- Examine foundations, walls, floors, doors, staircases, and windows to make sure that the building is not in danger of collapsing. Cracks and damage to a foundation can render a building uninhabitable.
- Look for fire hazards. There may be broken or leaking gas lines, flooded electrical circuits, or submerged furnaces or electrical appliances. Flammable or explosive materials may come from upstream. Fire is the most frequent hazard flowing floods.

- Check for gas leaks. If you smell gas or hear a blowing or hissing noise, open a window and quickly leave the building. Turn off the gas using the outside main valve if you can, and call the gas company. If you turn off the gas for any reason, it must be turned back on by a professional.
- Look for electrical system damage. If you see sparks or broken or frayed wires, or if you smell burning insulation, turn off the electricity at the main fuse box or circuit breaker. If you have to step in water to get to the fuse box or circuit breaker, call an electrician first for advice. Electrical equipment should be checked and dried before being returned to service.
- Check for sewage and water line damage. If you suspect sewage lines are damaged, avoid using the toilets and call a plumber. If water pipes are damaged, contact the water company and avoid using water from the tap. You can obtain safe water from undamaged water heaters, or by melting ice cubes.
- Use tap water if local health officials advise it is safe.
- Watch out for animals. Use a stick to poke through debris. Tsunami flood waters flush snakes and animals out of their homes.
- Watch for loose plaster, drywall, and ceilings that could fall.
- Take pictures of the damage, both of the building and its contents, for insurance claims.

TSUNAMI ACTIVITY

Could It Happen Here?

Rationale

Students will consider their needs and the state of their personal preparedness for an emergency.

Focus Questions

- What do people need to survive?
- What kinds of natural events can prevent people from meeting their basic needs?

Objectives

Students will:

- Distinguish between luxuries and necessities.
- Describe their own experience with natural disasters, and how they and their families fared.
- Explain why preparedness can help individuals and families cope effectively in the event of a tsunami or other natural disaster.

Materials

- Chart paper
- Felt markers
- Student copies of the "Three-Day Survival Pack" (see page 41)

Procedure

Introduction

- Ask the students to consider which of all the things they use and consume every day are really essential to their survival. Discuss, and develop a class listing on chart paper. (Answers may include variations on water, food, clothing, and shelter.)
- Ask the students how they would meet the needs listed above? (Answers will include faucets, restaurants, grocery stores, the refrigerator, school cafeterias, clothing stores, parents' home.)

Lesson Development

1. Elicit a definition of natural hazards from the class. Emphasize that earthquakes, volcanoes, tsunamis, and similar events are the result of natural processes. Be sure students understand the difference between natural events and those caused by human activity.
2. Ask: If a natural disaster occurs in an uninhabited region, and has no impact on human beings or human property, is it a disaster? (Not for humans but it may be for farm animals, wildlife, and other life forms.) Are we able to control natural events, or accurately predict when they will occur? (No, we cannot accurately predict earthquakes, but we can issue warnings for tsunamis.)
3. Ask students how they and their families coped with any destructive events they have experienced. Were their homes equipped with everything they needed? Did they have to leave their homes? Were the roads open? Were the stores open? Who provided help? (If personal experiences are lacking, discuss recent news accounts of earthquakes, tsunamis, etc.).
4. Look at the list of vital necessities and widen the discussion to include the needs of communities as well as individuals. Ask if a tsunami occurred in or near your community, what necessities would have to be added to the first list? (Answers may include medical care, electrical power and other utilities, and essential transportation – for hospital workers, police, firefighters, and people who supply food, water, and other necessities.)

   Emphsize that a major tsunami would disrupt all or most of the communities lifelines – its supplies of water and power and its transportation and communications systems. Emergency services, such as police, fire departments, and emergency medical technicians, would be severely taxed and unable to answer all calls for assistance.

   For these reasons, individuals, families, and neighborhoods must be prepared to be self-sufficient for at least three days.

Conclusion

- Distribute copies of the "Three-Day Survival Pack" (see page 41). Explain that the Federal Emergency Management Agency (FEMA) recommends that every family assemble a pack like this and keep it handy in their home for emergencies, checking it periodically to keep it up to date. (Batteries may need replacing, family needs may have changed.) Compare this list with the lists students have developed.
- Ask the students to take the supply list home and encourage their families to prepare a container with supplies in it. Remember the goal is to be prepared to be on your own for at least three days.

BE PREPARED

Three Day Supply Kit

Assemble a 3-day minimum supply for your home. Modify this list for your car and office.

Medical and special needs equipment

- First aid handbook
- First aid kit: gauze, bandages, aspirin, tape, scissors, disinfectants, antiseptics, and non-prescription medications
- Medications for at least 7 days
- Personal hygiene supplies
- Plastic zip-close bags, chlorine

Household inventory and important documents

- Copies of important documents
- Household inventory, pictures of contents
- List of credit cards and account numbers
- Banking information
- Wills, durable power of attorney, legal documents
- Copy of driver's licenses
- Photos of household members
- School emergency information

Food and water

- Non-perishable food for 3 days
- Special dietary needs
- 1 gallon of water per person per day
- Manual can opener
- Cooking utensils

Safety equipment

- Fire extinguisher
- Smoke detectors and fire alarm
- Whistle
- Tools

Special equipment

- Dust masks and eye protection
- Masking tape to seal areas
- Plastic wrap to protect equipment
- Battery-operated radio
- Extra batteries
- Flashlights
- Cleaning supplies
- Small amount of cash
- Quiet games and activities for children

Miscellaneous

- Tent and waterproof tarp
- Extra blankets
- Warm clothing
- Sturdy shoes
- Work gloves
- Infant specialty items
- Items for the elderly
- Pet items – medicines, food and water

TSUNAMI ACTIVITY

Hey, Look At Me Now!

Rationale

This activity is designed to serve students and teachers as a gauge of what they have learned from this curriculum.

Focus Question

- What have you learned about tsunami preparedness?
- What will you do differently as a result of these lessons?

Objective

Students will correct, elaborate, and refine their earlier writings by applying information they have gained from this curriculum.

Materials

- Writing paper and pens or computers and printers.

Procedure

Introduction

- Explain that in the post-assessment activity each student is to complete the same task he or she did in the pre-assessment activity. In rewriting each of the three passages, however, students are urged to draw upon what they have learned from the unit. Remind the students to focus on how their new knowledge has changed their way of thinking about tsunamis and tsunami preparedness.

Lesson Development

- As they did in the pre-assessment activity, the students will invent a tsunami. Each of their three accounts will describe the same tsunami, but the styles of the three will vary (see Writing Outline on page 18).

  News Reporter: A short, concise article describing the who, what, where, why, and when of the tsunami.

  Scientist: A scientific account stating what is objectively known about the tsunami.

  Eyewitness: A personal story or letter to a friend telling about being in a tsunami. This will describe what happened during the tsunami to the student, his or her family, pet, home, school, etc. Describe what you had done before the tsunami to be prepared, how effective your preparations were, and what you would do differently in preparation for the next tsunami. Also describe what life was like in the two weeks following the tsunami.

Conclusion

After collecting the papers, pair each student's post-assessment writings with the same student's pre-assessment writings, and hand them out to a different student. Assign students the task of reading both sets and commenting on what the writer has learned from the unit. Follow with a class discussion of these comparisons, either the same day or the next.

TSUNAMI ACTIVITY

Simulation and Roleplay

Putting Plans Into Action — Group Activity

Rationale

When natural disasters occur, coordinated planning is essential if the stricken community is to return to a normal state of affairs. Each community should have a comprehensive emergency management plan to direct their planning, mitigation, response and recovery efforts.

Focus Question

What information needs to be in place to serve a community in the event of a natural disaster?

Objectives

Students will:

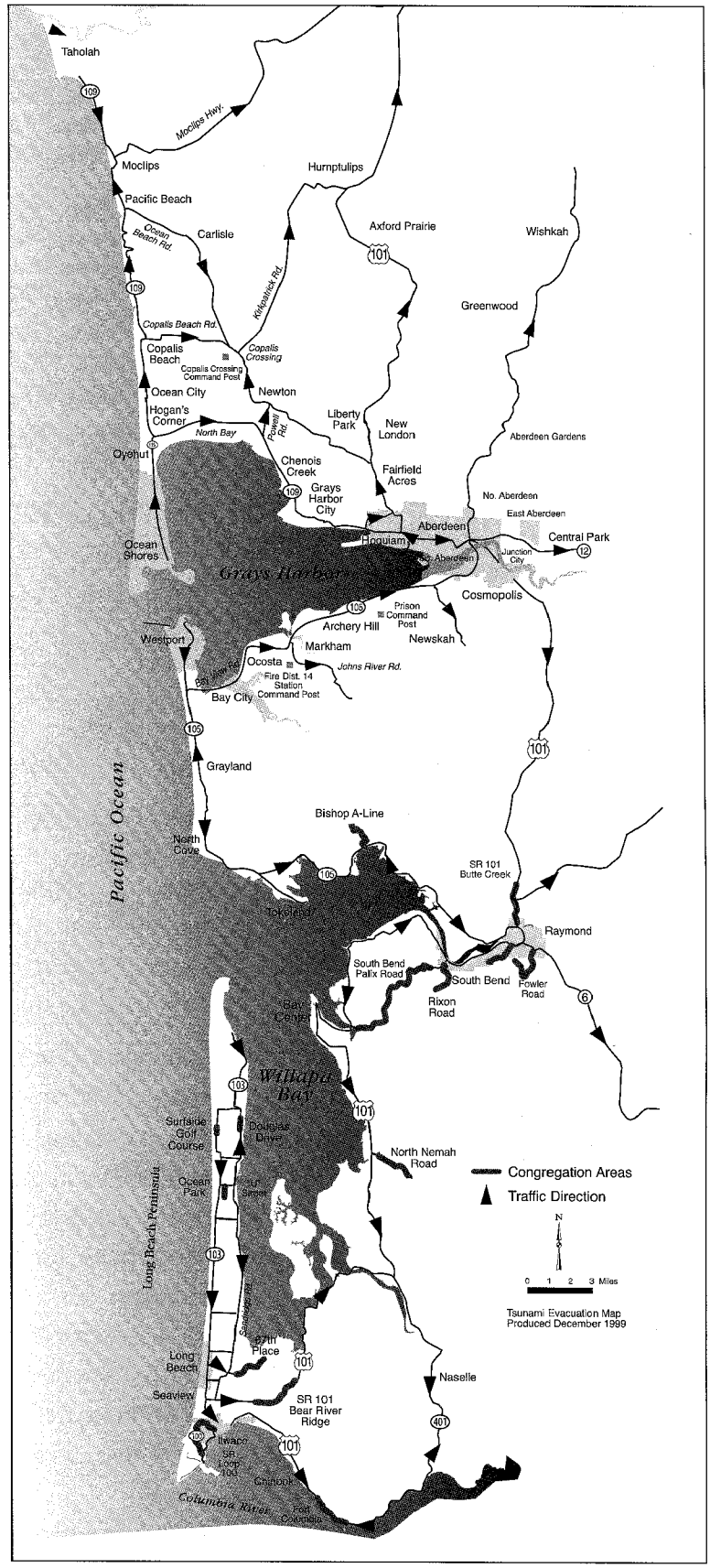
- Recognize the importance of advance planning for a community's emergency response.
- Understand how a community government works and how it responds to emergencies.
- Evaluate their locality's tsunami preparedness plan.
- Suggest changes in their existing emergency preparedness plan to reflect what has been learned.
- Develop a personal tsunami emergency response.

Guest Emergency Management Director/Coordinator

Invite the county or city emergency management director or coordinator to the classroom to address the class and participate in the simulation and debriefing.

Grays Harbor and Pacific Counties Evacuation Map

This evacuation map was produced jointly by Grays Harbor and Pacific Counties in Washington state to assist residents and visitors move to safer ground following an earthquake. Arrows in the map show routes designated by tsunami evacuation route signs. Students may use their own local maps to evaluate or create evacuation plans.



Materials

- Map of their community
- Tsunami Scenario
- Job descriptions for simulation
- Self-adhesive name tags, for each student to designate position
- Transparencies
- Color markers

Procedure

Introduction — Group Discussion

Begin by asking the students what they would do if a tsunami struck the area where their school was located. Help them recognize that the most important immediate response is not to panic and to follow the directions of emergency and school authorities.

Now expand the discussion to determine what students think would happen in their community if the tsunami was powerful enough to cause both loss of life and major property damage. (Draw on the knowledge of the emergency manager who is present).

- How would the community respond?
- Who would be in charge of managing the rescue operation?
- Who would be in charge of managing long-term recovery?
- What plans are already in place to assure that the emergency would be responsibly managed?

Lesson Development

1. Explain the purpose of the simulation and tell students that they will be playing the roles of community leaders charged with developing an outline for emergency management in the event of a disaster resulting from a natural or man-made hazard. They are meeting to develop a system to manage the effects of an emergency (tsunami), preserve life and minimize damage, provide necessary assistance, and establish a recovery system in order to return the city to its normal state of affairs as quickly as possible. Their plan must define clearly who does what, when, where, and in what order to deal with the community crisis.
2. Each student will assume a role in county government. Distribute job descriptions (see pp 49-51).
3. Governmental positions for a fictitious "Evergreen County" include:

Chief of Police
Fire Chief
Director of Public Works
Director of Health
Coordinator of Community Transportation Services
Public Information Officer
Superintendent of Schools
City Manager or Mayor
Members of the City Council (as many as are needed)

4. Display the county map and discuss or have the guest emergency manager describe vulnerable areas within the county and what can be expected when a tsunami hits.
5. Have the student playing the role of city manager mark the transparency as indicated, using a different color for each type of information.
   - Areas where you can expect the tsunami to come ashore.
   - Area where you expect concentrated building damage, both commercial and residential.
   - Major facilities, such as hospitals, schools, government buildings, etc.
   - Highway roads, bridges and overpasses that might be impassable.

   Ask each student to assume the role they have been assigned.
6. Have the city manager or mayor convene the Evergreen County Emergency Management Planning Committee and call the meeting to order. The city manager will remind the group that every plan must have three parts:
   - **Before:** preparations to be made before an emergency strikes, such as purchasing safety equipment, upgrading building codes, and educating the public.
   - **During:** strategies for emergency response during a tsunami or other crisis. Lines of communication will be particularly critical in this phase.
   - **After:** recovery plans for returning the community to conditions as normal as possible.

   Have the students discuss these three areas and determine what they would find in each area.
7. Students work together to formulate an emergency management plan for Evergreen County.

8. When the group has completed its emergency management plan, provide time for students to report the details of their plan. Help them to evaluate their plan by asking these questions:
   - Is the plan realistic and timely?
   - Is it comprehensive?
   - Is it cost-effective?
   - Do we have the resources to implement it? If not, how might we obtain additional resources?
   - Does the plan address tsunami as well as other hazards in Evergreen County?

Conclusion

Discuss the plan with the guest emergency management director and see how their plan compares to the actual Comprehensive Emergency Management Plan for the county the guest emergency management director represents.

Designate someone in the class to prepare a thank you letter to be sent to the emergency management director from their jurisdiction.

Tsunami Activity Job Planning Roles

Chief of Police

The police chief is responsible for protecting lives and property in the area served. Specific responsibilities include preserving the peace, preventing criminal acts, enforcing the law, and arresting violators. The chief is under oath to uphold the law 24 hours a day. He or she makes many of the final decisions dealing with budgets and services provided by the police force.

Fire Chief

This official is responsible for protecting lives and property from the hazards of fire. Responsibilities include fighting fires, rescuing trapped individuals, conducting safety inspections, and conducting fire drills and fire safety education. The fire chief also assists in other types of emergencies and disasters in community life. He or she makes many of the final decisions dealing with budgets and services provided by the fire department. The fire chief usually comes through the ranks, starting as a firefighter.

Director of Public Works

This official is responsible for the maintenance of systems built at public expense for the common good, such as highways and dams. In some communities these responsibilities may be dealt with separately by officials responsible for highway safety and community transportation services, water and sewage, and other areas; in some, they may be combined in one office.

Director of Public Health

This official, usually a physician, is responsible for controlling the spread of communicable disease in the community and for mitigating any threats to the public safety, such as the contamination of public water supplies. He or she also engages in proactive education and advocacy to encourage positive behaviors, such as proper nutrition, and discourage negative ones, such as smoking and the abuse of alcohol and other drugs.

Coordinator of Community Transportation Services

This official is responsible for the safety of public transportation and both public and private vehicles. He or she arranges for registration, licensing, and state inspections. The coordinator inspects public vehicles and coordinates operation and maintenance of equipment, storage facilities, and repair facilities. She or he directs the

recording of expenses and controls purchasing and repair spending. This official also helps plan and direct transportation safety activities.

Public Information Officer

This official supervises a staff of public relations workers, directs publicity programs designed to inform the public, and directs information to appropriate groups. He or she clarifies the local government's points of view on important issues to community or public interest groups and responds to requests for information from new media, special interest groups, and the general public. In an emergency, this function assumes added importance.

Superintendent of Schools

This official is responsible for managing the affairs of an entire public school district. He or she oversees and coordinates the activities of all the schools in the district in accordance with standards set by the board of education. Responsibilities include selecting and hiring staff, negotiating contracts with union employees and settling labor disputes. He or she creates and implements plans and policies for educational programs, and, when necessary, interprets the school system's programs and policies. The superintendent is also responsible for the development and administration of a budget, the maintenance of school buildings, and the purchase and distribution of school supplies and equipment, and oversees the school's transportation system and health services.

City Manager or Mayor

This professional in public administration has general responsibility for the overall operation of the city. All department heads answer to this official, who serves as the city's chief executive officer. A city manager is hired by the city council and serves at its discretion. A mayor is elected by the voters, but holds many of the same responsibilities.

Emergency Management Director

The emergency management director is responsible for coordinating the plans and operations of the various components of the emergency management system – fire and police, emergency medical services, public works, volunteers, and other groups contributing to the management of emergencies. The director manages the application of resources during a disaster. The director must balance the duties authorized and required by law with the moral obligation of the public employee to do everything possible to protect and preserve the safety of citizens, and protect property within the jurisdiction.

Members of the City Council

Each member determines the needs of the ward or district he or she represents by seeking out interviews, responding to constituents' phone calls and letters, and referring persons to specific agencies for services. The member speaks before neighborhood groups to establish communication and rapport between the members of the community and the service agencies available. The members of the council also have the responsibility to help resolve problems facing the community at large, in such areas as housing, urban renewal, education, welfare, unemployment, disaster response, and crime prevention.

Tsunami Scenario

It is 10:13 in the morning in Evergreen County, school is in session. Approximately 20 minutes ago Cape Hazard experienced an earthquake, magnitude 7.4. An official tsunami warning was issued warning that waves were expected to reach Sandy Pointe Beach at approximately 10:45. The tsunami reached Evergreen Beach just north of Sandy Point about 15 minutes later with waves about one foot. The tsunami reached Sandy Pointe Beach, where we all reside, about 45 minutes later. Coastal sirens were sounded and continued to sound intermittently for 20 minutes.

1. The first wave arrived and was only a few feet high. Many citizens of Sandy Pointe thought the danger was passed and went back into their homes and businesses. Approximately 30 minutes later the highest wave of the tsunami reached Sandy Pointe. Many people had not observed the warning and 32 were killed along with extensive property damage. The downtown area was hardest hit, as it is closest to the ocean.

2. The hospital reports flooding and a major crack in its foundation. There is disruption of power to the hospital. At the time of the tsunami there were 152 people in the hospital – 126 patients and 26 staff members. The hospital is at 50% operational capacity.

3. One of the three fire stations have remained operational. The downtown fire station is destroyed and the equipment is trapped inside.

4. Water mains are broken, power is out to a large part of the city, utility lines are down, sewers are backing up, and animals run throughout the streets. Ambulances are having difficulty moving through the streets.