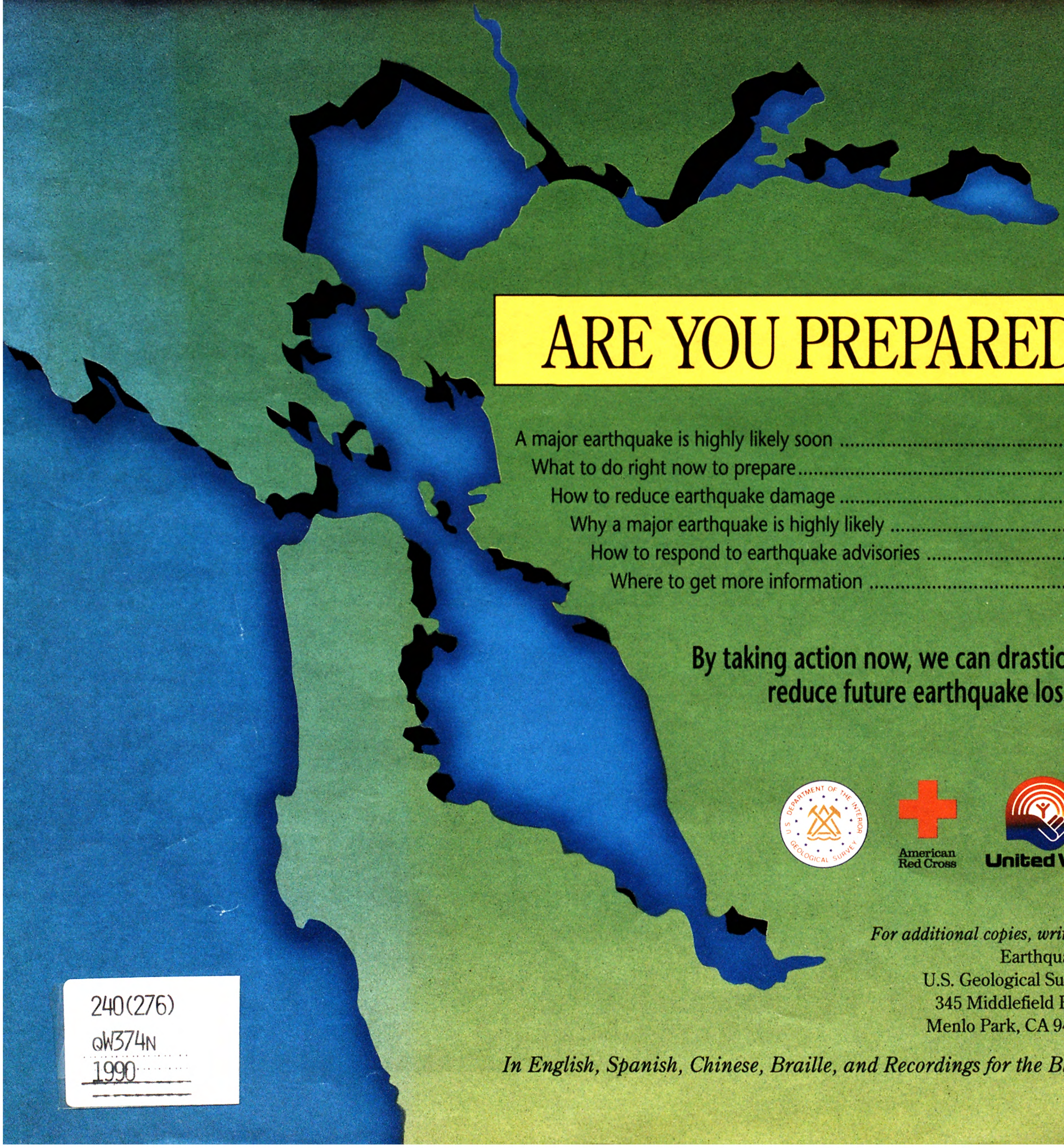
THE

NEXT BIG EARTHQUAKE

IN THE BAY AREA MAY COME SOONER THAN YOU THINK.



ARE YOU PREPARED?

By taking action now, we can drastically reduce future earthquake losses.

U.S. Department of the Interior · Geological Survey

American Red Cross

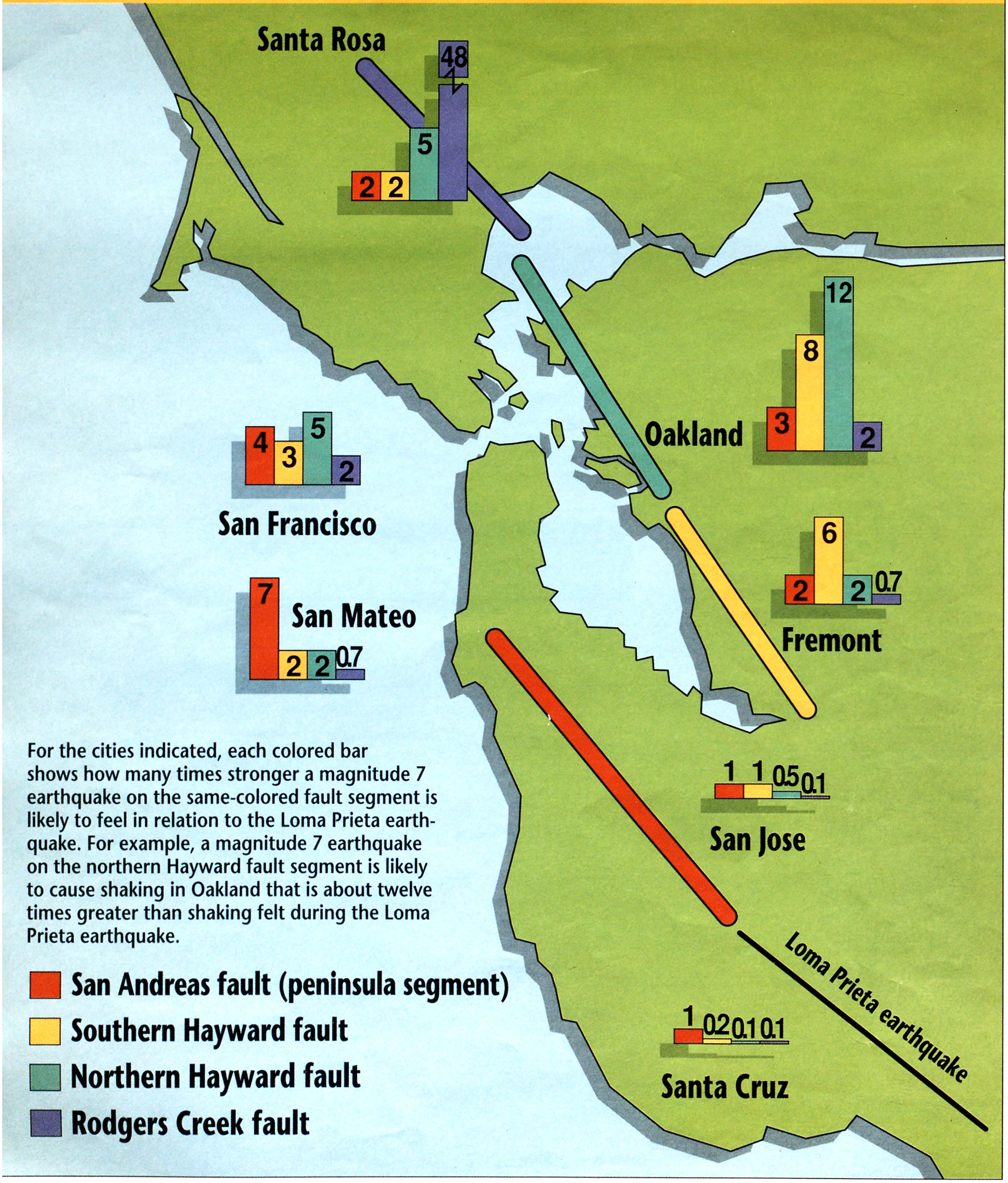
United Way

For additional copies, write to:
Earthquakes
U.S. Geological Survey
345 Middlefield Road
Menlo Park, CA 94025

In English, Spanish, Chinese, Braille, and Recordings for the Blind

HOW MUCH THE GROUND WILL SHAKE

A Comparison with the Loma Prieta Earthquake



For the cities indicated, each colored bar shows how many times stronger a magnitude 7 earthquake on the same-colored fault segment is likely to feel in relation to the Loma Prieta earthquake. For example, a magnitude 7 earthquake on the northern Hayward fault segment is likely to cause shaking in Oakland that is about twelve times greater than shaking felt during the Loma Prieta earthquake.

A MAJOR EARTHQUAKE IS HIGHLY LIKELY SOON

Many of us breathed a little easier after October 17, 1989. The Loma Prieta earthquake, 7.1 on the Richter scale, meant that the big one, talked about for decades, had finally happened. And, bad as it was, we had survived.

There are two things wrong with that.

First, Loma Prieta was not the big one. It was a moderately big one, certainly destructive to some parts of the Bay Area, but nowhere near the size of the great San Francisco earthquake of 1906.

Second, having an earthquake like Loma Prieta has little to do with the likelihood of having another one on a different fault, somewhere else in the area.

The inevitability of a damaging earthquake still confronts everybody in the Bay Area, and we still risk substantial damage. A new study, released in July 1990 by the United States Geological Survey, says that there is a 67 percent chance of another earthquake the size of Loma Prieta during the next 30 years and that the quake could strike at any time, including today. In other words, scientists think that a magnitude 7 or larger earthquake is now twice as likely to happen as not to happen. This is a substantial increase, since in 1988, scientists thought the chance for such an earthquake was 50 percent (just as likely to occur as not to occur) within 30 years.

The new report also says that the next one will most likely strike farther north than Loma Prieta, somewhere between San Jose and Santa Rosa on either side of the Bay. The epicenter of the October 1989 quake was in a sparsely populated area. The next one, according to the study, will likely be centered in a more populated area. During the Loma Prieta earthquake, shaking was so severe in the Santa Cruz Mountains that a van overturned, treetops snapped off, and many people were thrown to the ground. Because the next one is expected to strike closer to an urban area, it will cause much more damage.

Fortunately, there is something we can do about it. By taking actions, such as those described in this booklet, we can drastically reduce the losses and we can make the Bay Area a safer place to live.

Earthquake damage is particularly great in certain locations and in certain buildings. Most locations and most modern buildings are relatively safe. By identifying the greatest hazards, we can set priorities for using our limited resources most effectively to reduce them.

The choice is ours.

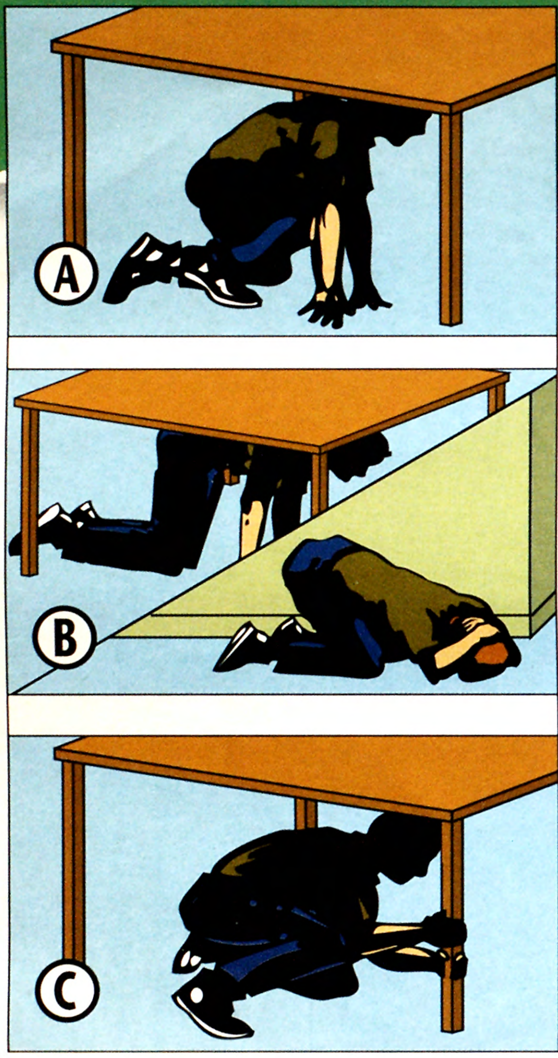
Earthquake Damage

Damage during an earthquake results from several factors:

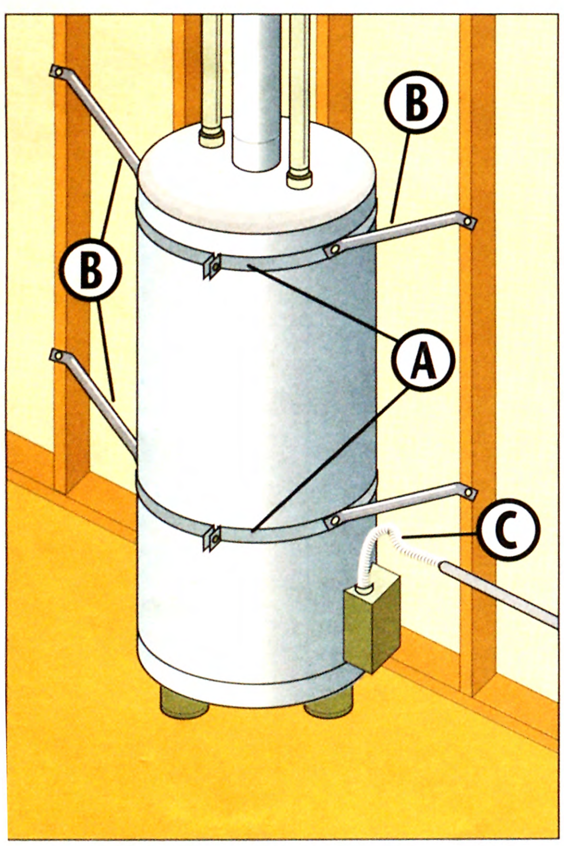
1. **Strength of shaking.** Strength decreases rapidly with distance from the earthquake. The strong shaking along the fault segment that slips during an earthquake becomes half as strong at a distance of 8 miles, a quarter as strong at a distance of 17 miles, an eighth as strong at a distance of 30 miles, and a sixteenth as strong at a distance of 50 miles.
2. **Length of shaking.** Length depends on how the fault breaks during the earthquake. The maximum shaking during the Loma Prieta earthquake lasted only 10 to 15 seconds. During other magnitude 7 earthquakes in the Bay Area, the shaking may last 30 to 40 seconds. The longer buildings shake, the greater the damage.
3. **Type of soil.** Shaking is increased in soft, thick, wet soils. In certain soils the ground surface may settle or slide.
4. **Type of building.** Certain types of buildings, discussed on pages 7 to 9, are not resistant enough to the side-to-side shaking common during earthquakes.

WHAT TO DO RIGHT NOW TO PREPARE

Most people in the San Francisco Bay Area will survive the anticipated earthquake with little loss. Some people will be severely affected. Actions you take now can reduce how much you and your family will lose.



(A) Duck; (B) Cover; (C) Hold



Wrap a 1-1/2-inch-wide, 16-gauge-thick metal strap (A) around the top of the water heater and bolt the ends together. Do the same about 1/3 of the way up the side of the water heater. Take four lengths of EMT electrical conduit, each no longer than 30 inches. Flatten the ends. Bolt one end to the metal strap as shown (B). Screw the other end to a 2-inch by 4-inch stud in the wall using a 5/16-inch by 3-inch lag screw. Be sure a flexible pipe (C) is used to connect the gas supply to the heater.

Protect yourself

❶ Practice "duck, cover, and hold" drills at home with your family and at work.

- Injuries and deaths during earthquakes are caused by falling objects and collapsing structures. Knowing how to protect yourself when the shaking starts may save your life. Duck under a strong table or desk. Cover your head and face to protect them from broken glass and falling objects. Hold onto the table or desk and be prepared to move with it. Hold your position until the shaking stops.
- Do not run outside during the shaking or use the stairways or elevators. Many people are killed just outside of buildings by falling bricks and other debris.
- If you are driving when the earthquake strikes, move to the shoulder of the highway and away from bridges, overpasses, power lines, and large buildings as quickly as is safe. Stay in your car and wait for the shaking to stop.
- If you are riding BART (Bay Area Rapid Transit), the train typically will stop. Remain calm and follow instructions from BART staff members who have been trained to handle earthquake emergencies.

❷ Develop an earthquake plan at home, in your neighborhood, at school, at work.

- If the earthquake hits during the day, family members may be separated for several hours to several days. Consider your family's possible needs.
- Do not use telephones in the first hours after a major quake except for serious emergencies. Completing local telephone calls will be difficult. Communication to points outside northern California may be easier. Choose a relative or friend living outside the Bay Area whom family members may call to report their condition and location. Make sure family members carry this number with them at all times.
- Learn to fight fires, to rescue people trapped under debris, to provide first aid, to find help for dire emergencies, and to assist others, especially the elderly, immobile, or handicapped.
- The most common cause of earthquake-related fires is broken gas lines. Everyone should know how to turn off the gas supply at the meter in case they smell gas after a large earthquake. Now is the time to buy a special wrench that fits your gas turnoff valve and to fasten it next to the valve.
- Find out the policy of your local school concerning release of children after an earthquake. Arrange with neighbors to watch out for your family and property in case you are not at home.
- Make plans with your family, your neighbors, and your co-workers. Every business should have an emergency response plan.

❸ Store emergency supplies.

- After a major earthquake, medical aid, transportation, water, electricity, and communication may be unavailable or severely restricted for several days to weeks throughout the Bay Area. Be prepared to take care of yourself, your family, and your neighbors for at least 3 days.
- At home, at work, and in your car, store flashlights, batteries, an A-B-C rated fire extinguisher, a battery-operated radio, a first-aid kit and handbook, one gallon of water per person per day, food, warm clothes, and sturdy shoes.
- Make sure emergency supplies are located in a safe and readily available place.
- Make sure everyone in your family knows where these supplies are and how to use them. Take a course in first aid.

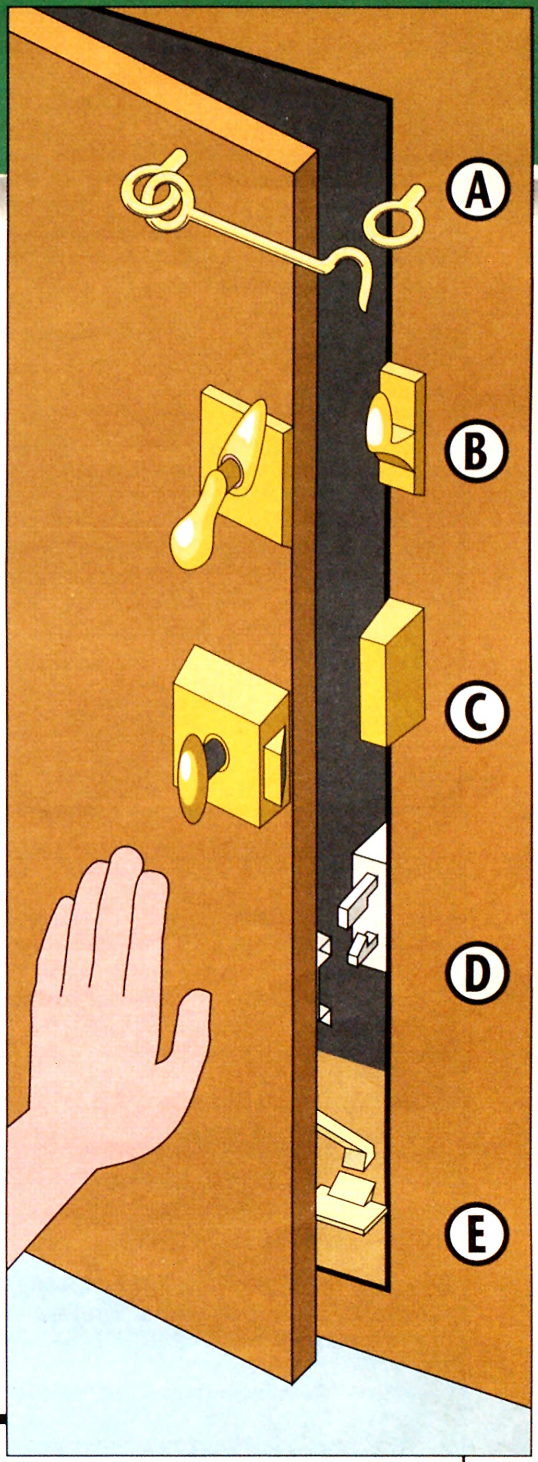
For more information, check the books listed on pages 20-21, and look at the "First Aid and Survival Guide" in the introductory pages of most telephone directories. Your local Office of Emergency Services and American Red Cross Chapter can provide pamphlets, slide shows, video tapes, and/or speakers to help you prepare and to help you organize self-help groups. The local offices are listed on page 19.

Discuss the options and make plans now. Participate in earthquake drills. When the earthquake happens, your family and friends will know better how to deal with the emergency and with the fear and uncertainty until you are all reunited. Making plans is one key to living more safely in earthquake country.

Protect your belongings

Falling objects and toppling furniture present the greatest danger and the biggest potential financial loss for most people. Imagine all of the contents of your kitchen cabinets falling to the floor or on your head! At home, at work, and in schools, building contents should be secured.

- Be sure that no heavy items, such as pictures or mirrors, can fall on your bed, where you typically spend a third of each day.
- Secure tall furniture and bookcases to the wall. Add lips to shelves to prevent costly items from sliding off. Be sure adjustable shelves cannot slide off their supports.
- Put strong latches on cabinet doors, especially at home in your kitchen and at work in laboratories.
- Fasten heavy or precious items to secured shelves or tables. Secure file cabinets, computers, and machinery that may overturn during an earthquake.
- Store potentially hazardous materials such as cleaners, fertilizers, chemicals, and petroleum products in secure containers and in sturdy cabinets fastened to the wall or floor.
- In your office, be sure heavy objects are fastened to the building structure and not just to a movable wall. Have a specialist check to be sure light fixtures and modular ceiling systems are securely supported.
- Be sure your gas hot-water heater is fastened to the wall studs and that all gas heaters and appliances are connected to the gas pipe through a short piece of flexible tubing. If you use propane gas, be sure the storage tank is secured against overturning and sliding.
- Check with your school officials to be sure that they have taken similar precautions.



Latches

For many residents of the Bay Area, a large financial loss during the next severe earthquake will come from the doors of kitchen cabinets being shaken open and most of the contents being hurled to the floor. A few dollars spent now can prevent most of that loss.

In choosing a latch, consider looks and ease of use. The standard hook and eye **(A)** is an inexpensive and secure latch, but you may not close it every time you enter the cabinet because it takes extra effort to do so. A child-proof catch **(E)** prevents a door from opening more than an inch or two. These catches close automatically, but they require an extra action every time you open the door.

Some standard types of secure latches mount on the surface of the door **(B, C)**. Latches are available that mount inside the door **(D)**, hold the door firmly shut, and open by being pushed gently inward. These are marketed under names such as push latch, touch latch, or pressure catch. If you cannot find these latches, ask your hardware dealer to order them for you.

HOW TO REDUCE EARTHQUAKE DAMAGE

Estimate your risk

Earthquakes are a risk that we accept as part of living in the Bay Area. We face many other risks in our lives, and we routinely take precautions to reduce our losses from them; for example, we wear seat belts to reduce the risk of injury during automobile accidents. This is an action that most people have come to accept as a reasonable precaution.

Earthquake hazards can also be reduced significantly by taking appropriate action. Such actions can be taken by individuals, businesses, and governments. The basic actions described on pages 4 and 5 are reasonable precautions that should be taken by all residents of the Bay Area. Other actions – such as strengthening or replacing a dangerous building and choosing to live in a safer building or in a safer part of your city – may involve significant expense and some disruption. Yet, damage to buildings and other structures is the primary cause of death, injury, and financial loss during a large earthquake.

To decide how much action is required to reduce earthquake hazards, you must estimate your risk. Earthquake risk varies from location to location, from structure to structure, from person to person.

- Is there a risk of serious injury or even death for occupants of a specific building?
- What would be the cost of repairing or replacing a building after a large earthquake?
- What would be the cost of not being able to use a building after a large earthquake?
- What are the odds that time and money spent on action today will prove cost-effective within your lifetime and within the lifetimes of existing structures?
- If a structure will be replaced by normal development within 10 years, is strengthening it to resist earthquake damage cost-effective?
- Is such strengthening required by a governmental agency, is it legally reasonable, or is it morally necessary?

These are difficult questions. The sections on the following pages are designed to help you assess your risk from earthquakes and determine how much action is appropriate for you.

We can live more safely with earthquakes by understanding the risks and by taking reasonable precautions.

The 1988 Uniform Building Code

Modern criteria for seismic design and construction have been included in the Uniform Building Code since 1973. The 1988 edition has the most up-to-date requirements. Construction of nearly all new buildings in California complies with this or a similar code.

The code requires greater strength for essential facilities and for sites on soft soil where shaking intensity is increased. The code sets minimum requirements that assure life safety but allow earthquake damage and loss of function. Owners who desire less potential damage and continued use of the building after severe earthquakes should insist on higher standards for design, construction, and inspection. Discuss with an architect or a civil or structural engineer what level of damage will be acceptable.

Earthquake Insurance

The most common type of earthquake insurance is normally added as an endorsement on a standard homeowners insurance policy. Typically, there is a deductible of 5 to 10 percent, and sometimes 15 percent, of the value of the home. This means that for a home currently insured at $200,000, you would have to pay $10,000 to $30,000 on damages before the insurance company would pay anything. Separate deductibles may apply to contents and structure. An important coverage is temporary living expense, which pays for motel and meals if you have to move out of your home. There is usually no deductible on this coverage. The yearly cost of residential earthquake insurance is normally about $1.50 to $3.00 per $1,000 of coverage on the structure.

In the San Francisco Bay Area, 30 to 40 percent of homeowners have purchased earthquake insurance. The percentage drops to about 25 for all of California.

To find out more about earthquake insurance, ask your insurance agent or call the California State Department of Insurance at (800) 233-9045.

Determine the safety of your home and school

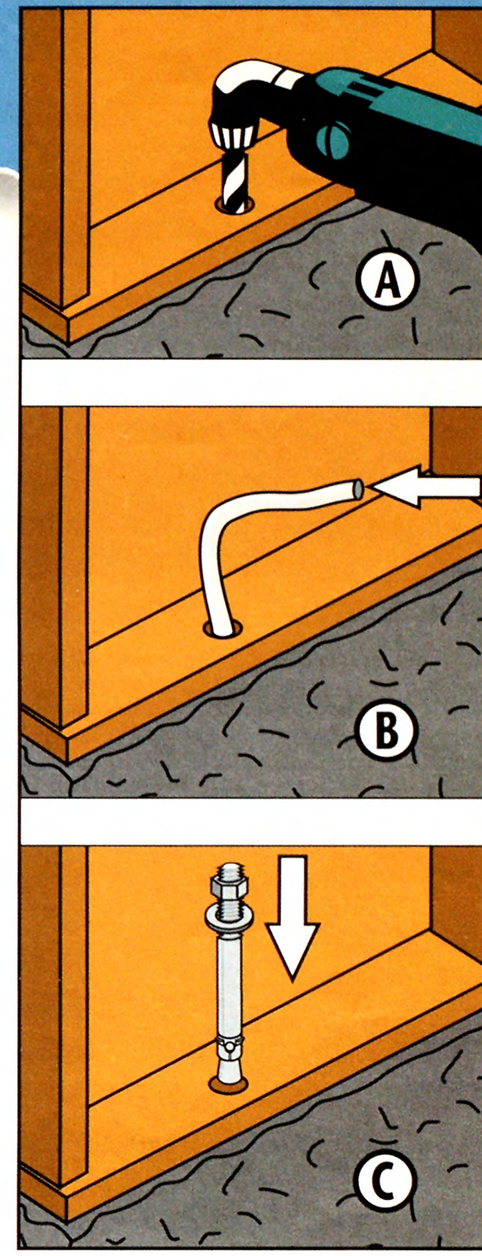
Most people in California are safe at home if they live in a one- or two-story wood-frame building. These buildings are not likely to collapse during earthquakes. The most common damage is light cracking of interior walls, cracking of brick chimneys, and cracking and possible collapse of brick veneer on exterior walls. A cracked chimney should be inspected by a qualified professional before the fireplace is used.

Unfortunately, some one- or two-story wood-frame buildings can be hazardous. Those built before about 1940 can fail at or near ground level if they are not adequately bolted to the foundation or if the short "cripple" walls, often found between the foundation and the first floor, are not adequately braced. Information on adding foundation bolts and bracing cripple walls is available through your local Office of Emergency Services listed on page 19. Correcting these two problems will drastically reduce the earthquake risk for residents in older homes. Bracing of chimneys in older homes may be required to prevent toppling during earthquakes.

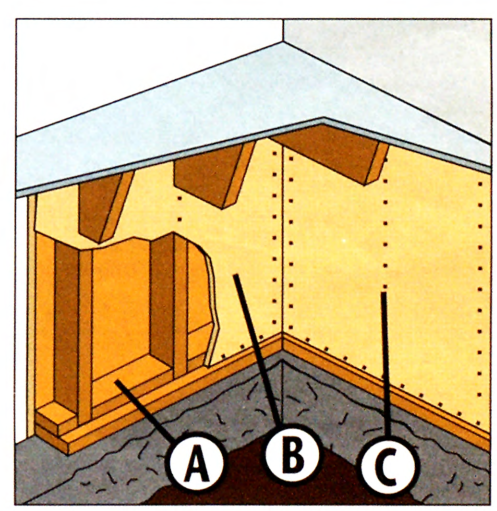
Modern public elementary and high schools and community college buildings have generally performed well during earthquakes. Following severe damage to many schools during the Long Beach earthquake of 1933, the Field Act was passed, requiring special seismic design for public school buildings. However, knowledge about proper seismic design has increased dramatically since then. Older school buildings may need to be reassessed in light of modern building codes.

The provisions of the Field Act do not apply to colleges and private schools. Ask school officials whether the school buildings have been recently evaluated for earthquake resistance.

Mobile homes, portable classrooms, and modular buildings can slide off their foundations during earthquakes. Their supports need to be braced to resist horizontal forces. If portable classrooms are used at your local school, you should ask school officials whether they are properly braced.



Bolting the wood frame of an older house to the concrete foundation can significantly reduce earthquake damage. Every 3 to 4 feet along the foundation, drill a hole using a right-angle drill with a 1/2-inch bit (A), blow the concrete powder out of the hole with a small piece of flexible tubing (B), and hammer in an expansion bolt, 1/2-inch in diameter and about 5-1/2-inches in length (C). Tighten the nut on the expansion bolt.



Reinforcing the "cripple" walls between the foundation and first floor of an older, wood-frame house can significantly reduce earthquake damage. Nail 2 by 4 inch blocks of wood to the mud sill as needed (A). Cut 1/2-inch plywood to fit the inner side of the wall (B). Fasten plywood along all edges and to each stud using 8d nails spaced 3 inches apart.

Getting Your Building Inspected

How do you locate a professional to advise you on the resistance of your building to earthquake shaking?

Civil and structural engineers and architects are trained and licensed to provide such information about structures. Geologists, foundation engineers, and geotechnical engineers are trained and licensed to evaluate the soil conditions and recommend appropriate action.

When hiring such a consultant, you are asking an experienced professional to review a potential problem and possibly to provide plans and specifications for correcting the problem. The amount of work required is not known when you hire the consultant, and thus it is important to select someone you trust and to develop a scope of work as you proceed.

A good place to start is to call a professional organization (see page 21) and ask for information about the different types of work that might be required, for information about how to select an engineer, geologist, or architect, and for a list of members in your area.

Contact several firms or individuals to determine if they do the different types of work you need. Ask for information that explains the type of firms they are and that identifies others whom they have served. Check to see how satisfied other clients were.

Recognize that the quality of the advice given and of the work performed, as well as the price you pay, may depend critically on the care you take in making a selection.

Become informed. Even if you do not understand the technical details, ask enough questions to understand the concepts and relative importance of the issues involved. Do not be afraid to ask questions that you fear might appear stupid. Your money is going to be spent, so you have a right to understand what needs to be done and why.

For projects more complex than inspecting a single-family home, you should meet with the selected firm and discuss the options. In almost every case, there will be a number of approaches for solving any given problem. Get the consultant to explain the pros and cons of each, as well as the dollars and risks involved. Once this is done, you will have defined the work the consultant will do for you. Then a fee can be set and you can discuss how changing the work would change the fee.

State and federal agencies do not inspect individual buildings. Your local building department may be willing to inspect your building, but they are not authorized to recommend actions to be taken.

HOW TO REDUCE EARTHQUAKE DAMAGE

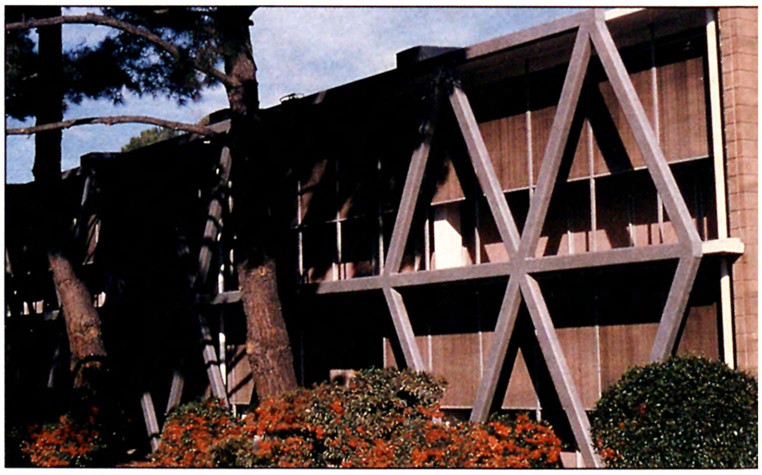
Determine the safety of other buildings you use

Buildings designed and constructed since the mid-1970s and according to modern codes have generally performed very well during earthquakes. Certain types of buildings, especially older ones, are potentially hazardous.

Many masonry buildings can be made more resistant to earthquakes by adding an internal frame, such as the one shown here, and bolting the walls to the frame.

Unreinforced brick buildings pose a particular hazard even in moderate earthquakes. Unbraced parapets and walls inadequately tied to the floors and roof can topple onto sidewalks or adjacent buildings. Many such buildings are currently used for low-income housing and commercial space in the Bay Area. The Unreinforced Masonry Building Law required all local governments to conduct an inventory of existing unreinforced masonry buildings and to develop a mitigation plan by January 1990. If you are concerned about these buildings, contact your local building department to see what is being done with this inventory.

Concrete-frame structures built before 1976 will likely pose a hazard, even during moderate earthquakes. This design was commonly used for mid-rise office and commercial buildings in our cities. These structures are readily damaged by repeated earthquake shaking and can collapse catastrophically. The collapse of a single mid-rise structure of this type in a California earthquake could result in more deaths than the total loss of life during all earthquakes in California since 1906.



This diagonal steel frame effectively braces a concrete frame building housing U.S. Geological Survey employees.

"Tilt-up" buildings built before the local adoption of the stricter 1976 Uniform Building Code are another type of concrete structure that has proven particularly vulnerable to damage during moderate or larger earthquakes. These buildings have concrete walls precast on the ground and then tilted vertically into place. They often fail at the connections between the walls, the floor, and the roof. Strengthening the connections is a relatively inexpensive procedure. These buildings house many of the major industrial activities of the Bay Area; their collapse could cause severe economic loss and release of hazardous materials.

Major damage often occurs in buildings with a "soft" first story. Usually, soft stories consist of an open space with stand-alone columns rather than interior walls supporting the building above. Such spaces are usually used as garages, stores, or large offices. The first floor does not have enough strength to resist the horizontal shaking force of the upper parts of the building. Similarly, rooms added over garages of private homes or older split-level homes may not be adequately supported.

This "soft"-first-story building failed partially during the Loma Prieta earthquake. In some buildings nearby, the first floor was totally destroyed.

Damage to all of these types of buildings poses a threat to both life and property during earthquakes. These losses can be significantly reduced by strengthening structures before the earthquakes. Investment in strengthening offices and commercial buildings will reduce structural and nonstructural damage and may allow continuation of business after severe earthquakes.

If you believe a structure that you or your family uses is hazardous, check the books listed on page 21. Ask the building owner what consideration has been given to seismic design and strengthening. Many civil and structural engineers and architects are trained and licensed to investigate the strength of a structure and to recommend appropriate action to reduce earthquake risk.

For single-family homes, ask an engineer or architect to look at your home while you are present and to discuss the seismic issues with you. This typically involves less than 4 hours of work, including travel. A written report or plans and specifications for corrective action may involve more time. You may want to ask for such an inspection before buying a new home.

Extra ties can readily be added to strengthen older tilt-up buildings.

Finding a Contractor

A contractor has to implement the detailed plans and specifications prepared by an architect or engineer. Contact at least three potential contractors. Discuss your objective and the steps they think are necessary to accomplish that objective. Check on the experience and reliability of the potential contractor. Ask if the individuals involved are members of a professional or trade association and check to see if that association has a code of ethics or standards for their trade.

Ask them for names of customers who have had similar work done. Ask these customers not only whether they would recommend this specific individual or company, but also what experiences they had in accomplishing similar objectives, what problems occurred, and how these problems were resolved. Decide if each potential contractor has the experience and training necessary for your particular job.

Ask for bids from at least three potential contractors. If the bids vary significantly, try to determine why. An unusually low bid may signal potential problems.

Check with the Better Business Bureau. Ask the Contractors State License Board whether a contractor's license is current. You can apply in writing to obtain detailed information about the contractor's record. In California, any contractor performing a job in which the total cost of the project, including labor and materials, is more than $300 must be licensed by the CSLB.

Determine how disputes will be handled. Inserting an arbitration clause in your contract may be a reasonable precaution. Is the contractor bonded?

Do not sign a contract until you understand and feel comfortable with the details.

Get a copy of the free booklet entitled **What you should know before you hire a contractor** from the Contractors State License Board. Send a mailing label to CSLB, P.O. Box 26000, Sacramento, CA 95826, or visit a local office:

Oakland, 1700 Broadway, 2nd Floor, (415) 464-0964
Pleasant Hill, 367 Civic Drive, Suite 10, (415) 671-9899
San Francisco, 301 Junipero Serra Blvd., Room 206, (415) 469-6200
San Jose, 100 Paseo de San Antonio, Room 319, (408) 277-1244
Santa Rosa, 50 D St., Room 105, (707) 576-2192

Understand how earthquake risk varies by location

Earthquake damage is typically concentrated in locations that can be identified in advance:

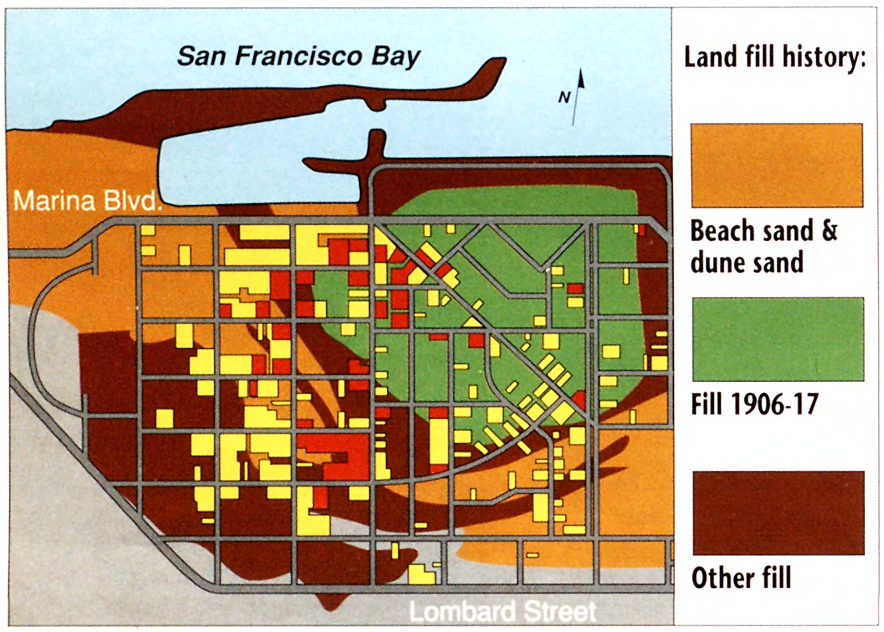
- Areas nearest to the fault segments that are likely to move.
- Areas of soft soils where shaking is increased.
- Areas where the ground may settle or slide.

Failure of the ground during an earthquake can happen in many ways. Cracks commonly rupture the ground near the slipped segment of the earthquake fault. Landslides are likely on steep slopes, especially if an earthquake hits during the rainy season. Soft ground — like that around the margins of San Francisco Bay — may settle during shaking. This settling will add to the hazard already posed by shaking.

Damage in the Marina District of San Francisco during the Loma Prieta earthquake of October 17, 1989, illustrates well the problems aggravated by soft soil. This area sustained major damage even though it was more than 50 miles north of the fault segment that slipped in the Santa Cruz Mountains. The damage was unusually high primarily because the shaking was increased by the soft soil, and the ground failed. Furthermore, many buildings in the Marina District had "soft" first stories (see page 9) and other design details that are hazardous during earthquakes. During the great San Francisco earthquake of 1906, the shores along the lagoon that later became the Marina District experienced some of the strongest shaking observed in San Francisco. Shaking during the Loma Prieta earthquake was 3 to 4 times stronger in the Marina District than on bedrock at Fort Mason, just a few blocks to the east, because the Marina is underlain by mud nearly 100 feet thick.

But there is another reason for the severe damage in the Marina District. In 1912, the original lagoon was filled with sand to prepare for the Panama-Pacific International Exposition. Sand was an unfortunate choice because, when wet, it can flow like a liquid during the shaking of an earthquake. This process, called liquefaction, deforms streets, sidewalks, pipelines, and buildings. The filled ground in the Marina settled during the Loma Prieta earthquake as much as 5 inches. Seventy-three percent of the buildings in the Marina District that became unsafe for occupancy or entry after the quake were located on the filled land. Techniques have been developed in the past few decades to engineer landfills so as to reduce the chance of liquefaction and ground failure during earthquakes.

This detailed map of the Marina District shows the areas underlain by sandy fill and the distribution of damaged structures. Land that liquefies during one earthquake has been observed to liquefy again in subsequent earthquakes. Special engineering techniques are available to minimize the effect of liquefaction, but they involve significant costs.



In the Marina District of San Francisco, maximum ground subsidence of as much as 5 inches was centered in the land filled between 1906 and 1917. Damage to buildings was greatest where filled land overlaps old beach sands. Demolished or severely damaged buildings are shown in red. Less damaged but uninhabitable buildings are shown in yellow.

Land Use Planning

Earthquake hazards vary throughout your community depending on the closeness to active faults, the type of soil, the potential for ground failure, and the age and design of structures. Recognizing these differences can provide a basis for guiding future development to minimize earthquake hazards. Clearly, new facilities such as hospitals and fire stations would best be located in the safest sites, and the most hazardous regions would best be designated for parks or other low-density uses. Often, however, even hazardous areas are too valuable not to be used, and special design procedures are needed.

In the early 1970s, each California county and city was required to develop a Seismic Safety Element for its General Plan that included consideration of earthquake hazards. Citizens interested in the future development of their community may wish to consult this plan at their local planning office and to encourage updates of this plan in the near future.

Determine if you live or work in particularly hazardous areas

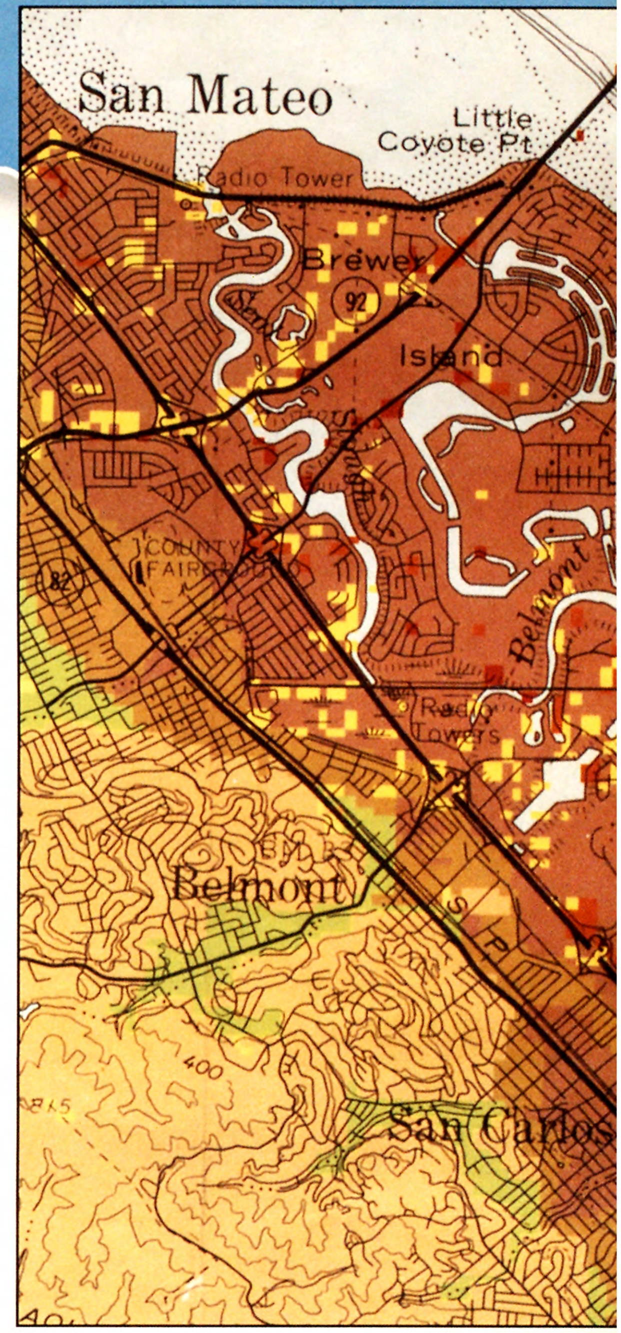
The map of the Marina District illustrates how earthquake risk can vary within a small area. Unfortunately, such detailed studies are not available for most regions. A set of maps does exist for San Mateo County, listed on page 22. On the right is a portion of one map for San Mateo County that shows the potential for liquefaction during an earthquake. Less detailed maps are currently available for other Bay Area counties.

Even reasonably detailed maps give only an overview of potential for shaking, liquefaction, landsliding, faulting, and damage. To be sure about a particular building site, you should consult an engineering geologist, geotechnical engineer, or foundation engineer (see page 21).

Particularly severe damage is likely where structures are built directly on top of active faults. The Alquist-Priolo Special Study Zones Act of 1972 required the California Department of Conservation's Division of Mines and Geology to map all known active faults in California and to designate areas within 500 feet of these faults as Special Study Zones. Buildings for human occupancy must be at least 50 feet away from an active fault trace. Significant development in these zones can proceed only after geologic studies are done to ensure that structures are not placed directly on top of ground likely to rupture during major earthquakes. The Special Study Zones are shown on the map on pages 12 to13. Most realtors have maps showing these fault zones, and they are required to inform you if you are considering buying land within a Special Study Zone. You can learn more about these zones and how to obtain detailed maps by ordering Special Publication 42 from the Division of Mines and Geology (see top of page 22). You may also be able to examine these maps at your local government planning office or building department.

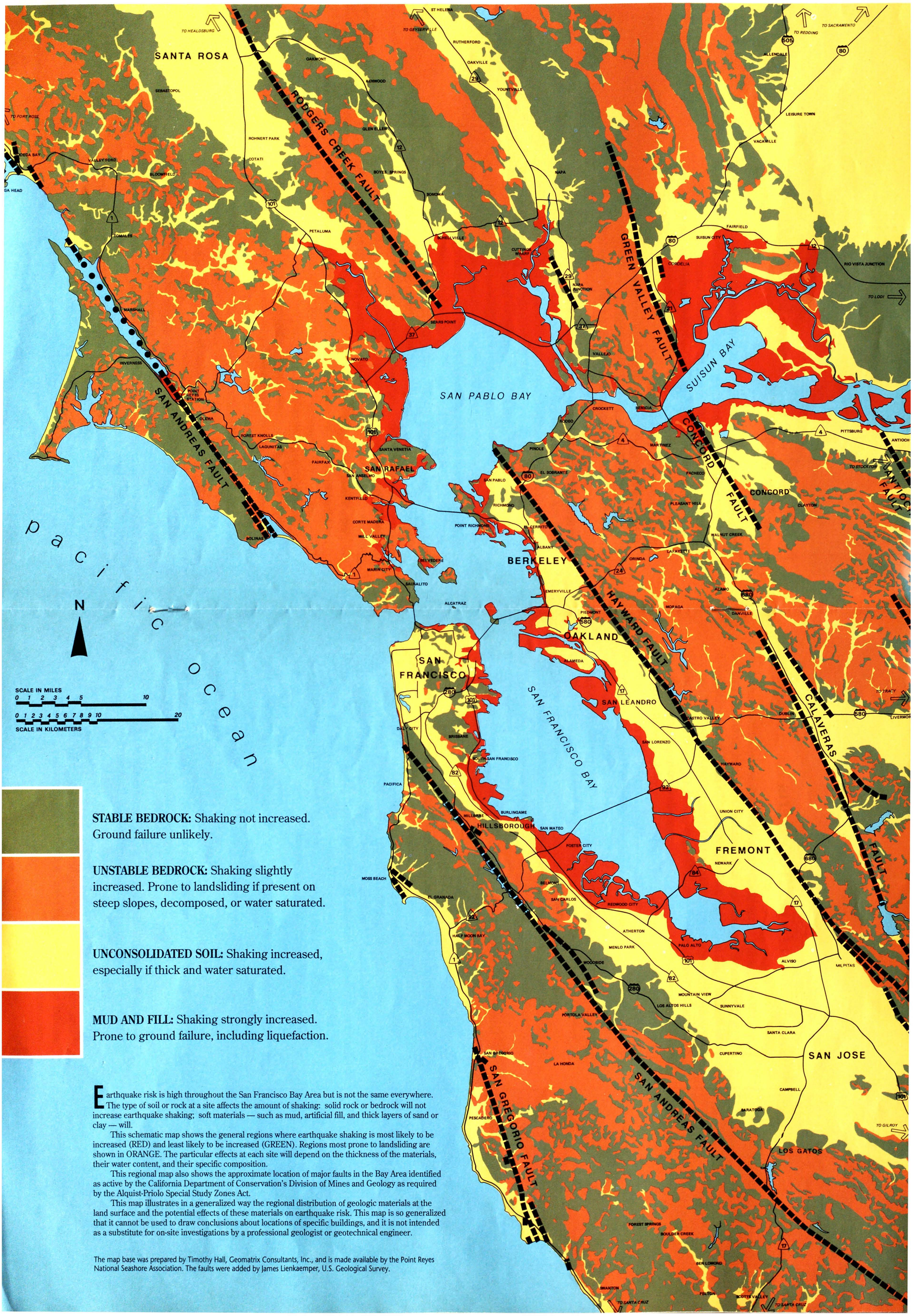
Earthquake risk is high throughout the Bay Area, but the risk is particularly high in regions with steep slopes prone to landsliding, on soft soils, and near faults. The map on pages 12 to 13 provides a regional overview of the general areas where the greatest hazards exist. The four types of geologic conditions shown are simplified, and the boundaries are imprecise, but the map can alert you to potential problems in your area. If you are concerned, you may be able to get more detailed information from maps listed on page 22 and from your local government planning office or building department. None of the available maps can substitute for an examination of your particular site by a geologist or geotechnical engineer.

Building new structures and reinforcing older structures throughout the Bay Area should involve careful attention to seismic-resistant design and construction. If surveys show that your site is at higher risk than typical, you will probably be required by your building department to provide for the specific hazards of your site in your design and construction practices even though such provisions may increase the costs. Given the high probability of earthquake damage in the next few decades, it is prudent for all residents to learn more about whether they may face particularly high risks because of location.



This portion of U.S. Geological Survey Map I-1257-G shows the potential for liquefaction during an earthquake. The broad, dark-reddish area shows where there is a potential for liquefaction. Where holes have been drilled into the soils, the sites are shown as bright red if a liquefiable layer was found and yellow if no liquefiable layer was found. This map demonstrates how it is possible to determine risk on a site-by-site basis.

THE EFFECT OF SOIL TYPE ON EARTHQUAKE RISK



Earthquake risk is high throughout the San Francisco Bay Area but is not the same everywhere. The type of soil or rock at a site affects the amount of shaking: solid rock or bedrock will not increase earthquake shaking; soft materials — such as mud, artificial fill, and thick layers of sand or clay — will.

This schematic map shows the general regions where earthquake shaking is most likely to be increased (RED) and least likely to be increased (GREEN). Regions most prone to landsliding are shown in ORANGE. The particular effects at each site will depend on the thickness of the materials, their water content, and their specific composition.

This regional map also shows the approximate location of major faults in the Bay Area identified as active by the California Department of Conservation's Division of Mines and Geology as required by the Alquist-Priolo Special Study Zones Act.

This map illustrates in a generalized way the regional distribution of geologic materials at the land surface and the potential effects of these materials on earthquake risk. This map is so generalized that it cannot be used to draw conclusions about locations of specific buildings, and it is not intended as a substitute for on-site investigations by a professional geologist or geotechnical engineer.

The map base was prepared by Timothy Hall, Geomatrix Consultants, Inc., and is made available by the Point Reyes National Seashore Association. The faults were added by James Lienkaemper, U.S. Geological Survey.

WHY A MAJOR EARTHQUAKE IS HIGHLY LIKELY

About Probabilities

We do not know what will happen in the future, but with the information we now have, we can estimate the likelihood that something will happen. We express the likelihood by using probabilities.

- A probability of 50 percent means that it is just as likely to happen as not to happen.
- A probability of 67 percent means that it is twice as likely to happen as not to happen.
- A probability of 75 percent means that it is 3 times more likely to happen than not to happen.

Conclusions of a panel of experts

In 1987, the National Earthquake Prediction Evaluation Council convened a panel of experts for the first time to evaluate the likelihood for future earthquakes in California. In a report published in 1988, the panel concluded that there was a 50 percent probability for an earthquake of magnitude 7 or larger within the San Francisco Bay Area in 30 years or less. The panel also said there was a 30 percent probability for a 6.5 to 7 magnitude earthquake in the Santa Cruz Mountains within 30 years. This was the highest probability they assigned to any single fault segment in the Bay Area. The 7.1 Loma Prieta earthquake struck in the Santa Cruz Mountains only one year later in 1989.

After the Loma Prieta earthquake, the panel of experts was again convened to determine whether they should change the estimate of the probabilities of future large earthquakes in the San Francisco Bay Area because of the earthquake and other new data. Their report, issued in July 1990, was endorsed by the National Earthquake Prediction Evaluation Council and the California Earthquake Prediction Evaluation Council.

The panel identified four fault segments in the Bay Area along which they now believe large earthquakes are most likely (see map on page 2): the peninsula segment of the San Andreas fault between Los Gatos and Hillsborough; the Hayward fault between Fremont and San Leandro; the Hayward fault between San Leandro and San Pablo Bay; and the Rodgers Creek fault between San Pablo Bay and Santa Rosa. They estimated that the probability is about 25 percent for a large earthquake on each one of these fault segments within 30 years.

More importantly, when the probabilities of earthquakes on all of these segments are combined mathematically, **there is a 67 percent chance for at least one earthquake of magnitude 7 or larger in the San Francisco Bay Area between 1990 and 2020. Such an earthquake could strike at any time, including today.**

The panel also concluded that:

- There could be more than one earthquake of magnitude 7 or larger in this 30-year period.
- Major earthquakes on all four fault segments are likely within the next 100 to 150 years.
- Each earthquake is likely to be of magnitude 7. If two fault segments slip during the same earthquake, for example along the Hayward fault, then the anticipated magnitude could be as large as 7.5.
- Earthquakes of magnitude 7 are considered possible, but not as likely, on other Bay Area faults such as the Calaveras, Concord, and San Gregorio (see map on pages 12 to 13).
- A repeat of the magnitude 8.3 San Francisco earthquake of 1906, which broke several segments of the San Andreas fault from south of San Jose to Cape Mendocino (a distance of more than 270 miles), is not likely during the next few decades.
- Numerous earthquakes with magnitudes of about 6 are also likely; these smaller earthquakes could cause some damage, especially near their epicenters.

Working Group on California Earthquake Probabilities

Members of the panel of experts convened in 1989 by the National Earthquake Prediction Evaluation Council:

James H. Dieterich, Chairman
U.S. Geological Survey
Clarence R. Allen
California Institute of Technology
Lloyd S. Cluff
Pacific Gas & Electric Co.
C. Allin Cornell
Stanford University
William L. Ellsworth
U.S. Geological Survey
Lane R. Johnson
University of California, Berkeley
Allan G. Lindh
U.S. Geological Survey
Stuart P. Nishenko
U.S. Geological Survey
Chris H. Scholz
Lamont-Doherty Geological Observatory, Columbia University
David P. Schwartz
U.S. Geological Survey
Wayne Thatcher
U.S. Geological Survey
Patrick L. Williams
Lawrence Berkeley Laboratory

Some scientists believe that the 67 percent probability estimate may be too low. They have noted several instances of pairs of earthquakes of magnitude 6.5 or larger in northern California, and they are concerned that the Loma Prieta earthquake could be the first quake of such a pair. An earthquake in 1865, similar to the earthquake of October 17, 1989, was followed 3 years later in 1868 by a major earthquake on the Hayward fault. Other pairs struck in 1836 and 1838, in 1892 and 1898, and in 1906 and 1911. Scientists do not understand the reason for such pairing, which may be due only to random chance.

Scientists are also concerned over an increase in the number of magnitude 5 earthquakes along the southern part of the Calaveras fault east of San Jose since 1979. A similar pattern of activity apparently preceded the Hayward fault earthquake of 1868.

The 67 percent probability does not include these additional pieces of information. Nor does it include the information suggesting that other fault segments in northern California might also be capable of producing large earthquakes. Therefore it seems prudent to consider the 67 percent chance of a large Bay Area earthquake within the next 30 years as a **minimum** estimate.

The increase in estimated probability from 50 percent to 67 percent between 1988 and 1990 was not because of the Loma Prieta earthquake. The increase resulted from new data on rates of strain accumulation on the Hayward fault and from new data that showed that a magnitude 7 earthquake was possible along the Rodgers Creek fault.

Ongoing and future studies are also likely to produce additional data that will result in changes in probability estimates, and details about calculated probabilities are still being debated by scientists. The major conclusions reached by the panel, however, are not likely to change. Most importantly, scientists agree that:

- Earthquakes of magnitude 7 and larger are highly likely within the Bay Area during the next several decades.
- Each of these events can cause much more damage than the earthquake of October 17, 1989, because each will likely be located closer to densely populated areas.
- Actions can be taken now to reduce the amount of damage and the number of deaths that are likely to result from future major earthquakes.

Why Earthquakes are Inevitable in the San Francisco Bay Area

Geologists know that the surface of the earth is made up of a dozen or so large plates, most of which cover millions of square miles and each of which is at least 40 miles thick. These plates are in continual motion. The San Francisco Bay Area lies in the boundary between two of these plates, the North American plate to the east and the Pacific plate to the west.

The North American and Pacific plates are sliding by each other at an average rate of about 2 inches per year, as the Pacific plate moves to the northwest. Most of this sliding motion in the San Francisco Bay Area takes place along the San Andreas fault west of the Bay and along faults east of the Bay, including the Hayward, Calaveras, and Rodgers Creek faults.

This sliding motion is neither smooth nor constant. The motion of the plates strains or deforms the rocks along the plate boundaries until the rocks can no longer withstand the strain. Then, a sudden slip along the faults releases energy that causes earthquake shaking.

Sudden slip during earthquakes occurs on different parts or segments of faults at different times. For example, in the magnitude 8.3 San Francisco earthquake of 1906, the San Andreas fault slipped as much as 15 feet along a 270-mile segment from south of San Jose northwestward to Cape Mendocino. During the magnitude 7.1 Loma Prieta earthquake of 1989, a 25-mile segment of the San Andreas fault southwest of San Jose slipped about 7 feet.

By matching up similar rocks on either side of the San Andreas fault, geologists have shown that land west of the fault has moved nearly 200 miles to the northwest relative to land east of the fault during the last several million years. This motion has been producing major earthquakes for millions of years and will most likely continue to do so for millions of years to come.

The average rate of strain buildup and the amount of slip during earthquakes has been measured by precise surveying between mountaintops in the San Francisco Bay Area. Accurate surveys since 1851 show that the total average slip on the San Andreas, Hayward, Calaveras, and related Bay Area faults is approximately 1.5 inches per year. Additional movement of about 0.5 inches per year occurs on still other faults, including some in eastern California and western Nevada. The strain builds steadily, but the slipping occurs infrequently.

WHY A MAJOR EARTHQUAKE IS HIGHLY LIKELY

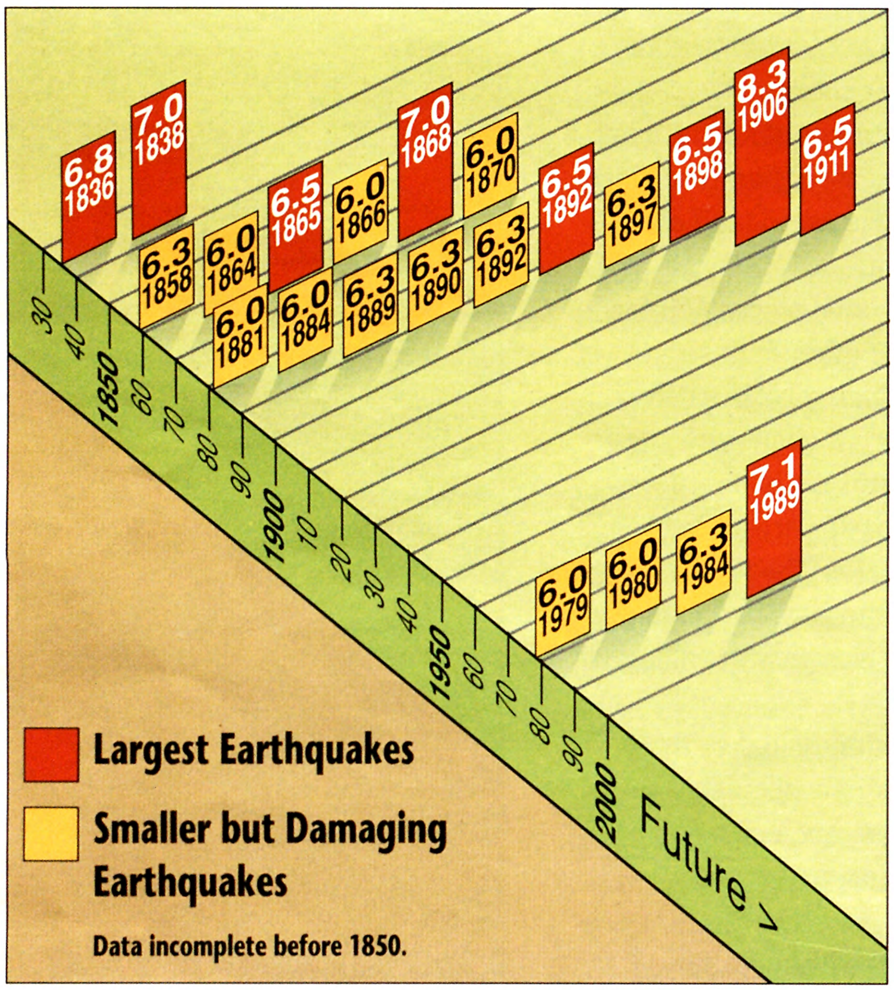
How scientists estimate earthquake probability

Probabilities based on frequency

One way to determine the likelihood of future large earthquakes is to study the past frequency of such earthquakes. Since 1836, there have been five earthquakes in the San Francisco Bay Area with a magnitude of 6.75 or higher. If earthquakes struck randomly over time, the region would expect another earthquake of this same magnitude in the next 30 years with about a 50 percent probability.

But scientists know that earthquakes do not always occur randomly over time. In some regions, such as the Bay Area, large earthquakes are more frequent at some times than others. An example of this clustering can be seen in the timeline to the left: there were 18 earthquakes of magnitude 6 or larger in the Bay Area during the 75 years between 1836 and 1911; yet there were no events of this magnitude during the 68 years between 1911 and 1979. Apparently, the amount of movement during the great San Francisco earthquake of 1906 was large enough to reduce strain throughout the region, so that only one large earthquake followed.

Since 1979, however, there have been four earthquakes of magnitude 6 or greater, leading up to the recent 7.1 Loma Prieta earthquake. It seems likely that in 1979 we began a new era of major earthquake activity similar to the era before 1911. Geologists are now concerned that the strain along the faults has built up again and that more large earthquakes are possible. If the level of earthquake activity during the next few decades is similar to activity between 1836 and 1911, then the probability of a magnitude 7 earthquake in the next 30 years is about 75 percent.



Between 1836 and 1911 earthquakes of magnitude 6 or greater were common throughout the Bay Area. Between 1911 and 1979, however, there were no earthquakes of this magnitude. We may have begun a new period of high earthquake activity in 1979. The magnitude and year of occurrence of each earthquake are shown.

Probabilities based on strain accumulation

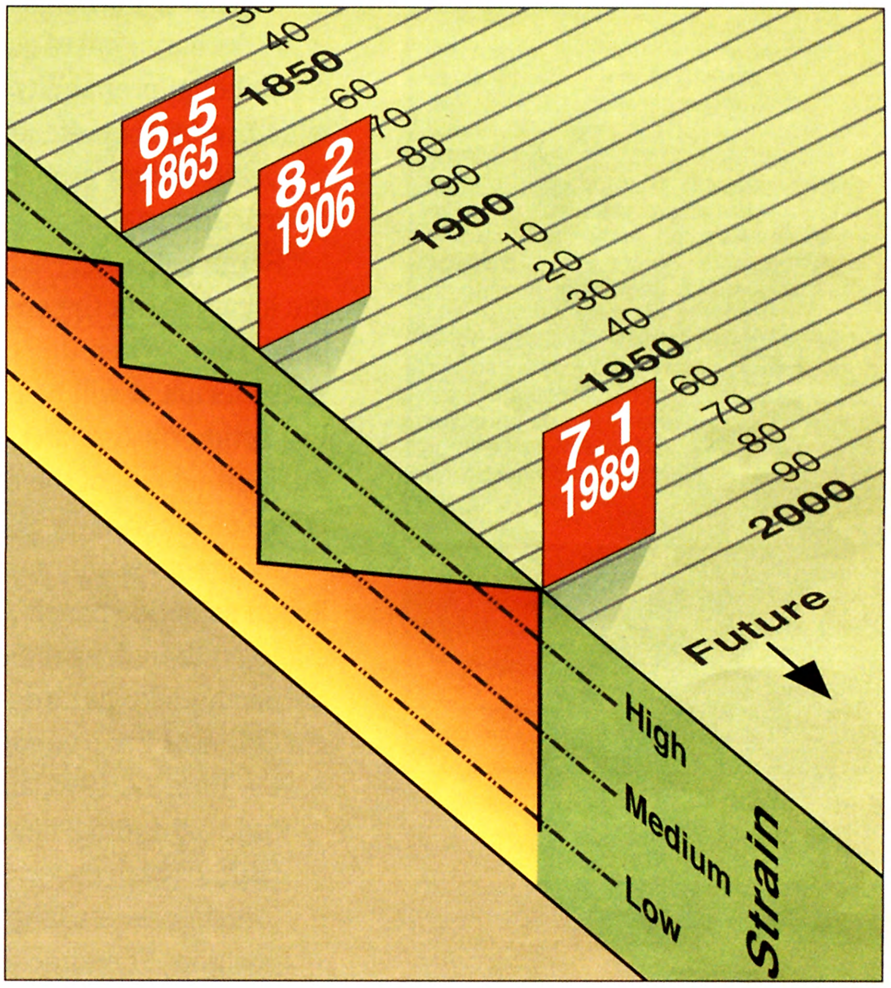
Scientists also use strain measurements to estimate the likelihood of future large earthquakes. When the strain in the rocks due to plate movement (see box on page 15) builds to a critical level, sudden slip results in an earthquake. Normally this slip takes place along one fault segment, but in very large earthquakes, about 7.5 or larger, more than one segment may move. The more slip that takes place during one earthquake, the more strain will be released. Thus, the longer, on average, it will be until the next large earthquake.

Using this method, the first step is to determine which fault segments have slipped in the past — these are the segments most likely to slip in the future. Once a fault segment is identified, the potential magnitude of an earthquake on this segment can be estimated by determining the length of the segment. For example, when there is sudden slip on a fault segment 25 to 50 miles long in California, there is a magnitude 7 earthquake. A magnitude 8 earthquake typically results from slip on adjoining segments whose total length is 200 or more miles.

Anticipating when the next earthquake will strike along a given fault segment involves determining how much time has gone by since the last earthquake along the segment, how much strain was released in the last earthquake, and how fast the strain is building up along the segment. With this information, scientists have calculated the time required for the strain to grow to dangerous levels, typically 70 to 280 years along faults in the San Francisco Bay Area. Written history in California covers less than 250 years, but detailed geologic studies of fault zones have allowed the dating of a few prehistoric earthquakes.

The graph at right shows how the strain may have increased at an average rate of about 0.75 inches per year along the Santa Cruz Mountains segment of the San Andreas fault — the segment that slipped on October 17, 1989, causing the Loma Prieta earthquake. Sudden slips reduced the level of strain along this segment during earthquakes in 1865 and 1906. The slip in 1906 was only about 5 feet, much less than the 15 feet of slip measured along parts of the San Andreas fault to the north. Based on this information, scientists suggested in 1981 that another damaging earthquake on the Santa Cruz Mountains segment was likely between then and 1996; the Loma Prieta earthquake proved their projections correct.

Although this strain model seems relatively simple, our information about strain is incomplete. Moreover, considerable judgment is required to determine the average time between large earthquakes on each segment, exactly where fault segments begin and end, the magnitude of anticipated earthquakes, the magnitude and amount of slip for some earthquakes in the 19th century that were not recorded by instruments, and the best statistical methods to use in calculating the probabilities.



Along the San Andreas fault in the Santa Cruz Mountains, strain appears to increase at an average rate of 0.75 inches per year. This strain was reduced by sudden fault slips during the magnitude 6.5 and 8.2 earthquakes in 1865 and 1906. In 1981, scientists estimated that the strain was at a high enough level to cause an earthquake and that this earthquake was likely to occur before 1996. The magnitude 7.1 Loma Prieta earthquake in 1989 proved their projections correct.

HOW TO RESPOND TO EARTHQUAKE ADVISORIES

Aftershocks

In the weeks and months after a strong earthquake, there will be many aftershocks, some strong enough to cause additional damage to structures already weakened in the main shock. A magnitude 7 earthquake in California is typically followed by about six aftershocks of magnitude 5 or larger. Most of these aftershocks strike during the first week, but some are possible as much as 3 to 6 months later.

Because strong aftershocks impose additional hazards and may seriously affect emergency response efforts, scientists at the U.S. Geological Survey in California monitor aftershocks closely and regularly issue forecasts about the probability of large aftershocks in the near future. Following the Loma Prieta earthquake, the USGS was able to transmit radio signals at the instant large aftershocks struck, providing warning to rescue crews tens of miles away several seconds in advance of the onset of strong shaking. Such a warning is possible because radio waves travel much faster than earthquake waves. Because of the potential for large aftershocks, removal of belongings from damaged buildings may have to be delayed.

You may hear a variety of advisories and predictions of future earthquakes. When deciding what action you should take:

- determine whether the statement was made by a scientist from a reputable organization.
- ask whether the statement has been reviewed and endorsed by the National and the California Earthquake Prediction Evaluation Councils.
- evaluate how much risk you and your family are likely to face during the anticipated earthquake.

A primary goal of continuing research on earthquakes is to increase the reliability of probability estimates, especially to narrow the time period during which an earthquake is anticipated. For example, scientists would like to be able to specify a high probability for a specific earthquake on a particular fault during a particular year.

Some data suggest that scientists may eventually be able to predict not only the location, but the specific time when an earthquake is likely, hours to weeks in advance. When this type of information becomes available for an earthquake in California, it will be reviewed by the California and National Earthquake Prediction Evaluation Councils. Such review involves a thorough examination of the method and of the data. If the prediction is found to be reliable, the California Office of Emergency Services will issue the prediction. In California, public safety agencies only respond to predictions reviewed and endorsed by established scientific panels.

Even though specific predictions of earthquakes are not yet possible, potential earthquake hazards have been described in advisories issued by the California Office of Emergency Services and will be issued in the future.

- On June 27, 1988, and August 8, 1989, there were two earthquakes of magnitude 5.0 and 5.2 near the Santa Cruz Mountains segment of the San Andreas fault. In both cases, scientists were concerned that these events could be foreshocks to a larger earthquake because of their magnitude and their position. Foreshocks do occur less than 5 days before about half of the large earthquakes in California. For these reasons, the California Office of Emergency Services issued an advisory of an increased likelihood of a major earthquake within the next 5 days following those quakes. The Loma Prieta earthquake of October 17, 1989, was a little late, but it was the quake anticipated by the advisories.
- On April 4, 1990, a magnitude 4.5 earthquake shook the region near Walnut Creek, California. Scientists were concerned that this earthquake could be a foreshock to a magnitude 6.5 quake on the Calaveras fault. They decided, however, that this event, and two others like it on April 27, were probably not foreshocks because of their location and the sequence of the many smaller earthquakes that accompanied them. No advisory was issued and no major earthquake has hit yet in this region.

We cannot now predict earthquakes, nor can we control them, but we have some control over how much damage will result. We still have a great deal to learn about earthquakes, the response of buildings and other structures to earthquakes, and ways to reduce earthquake damage; yet enough is known already that each of us can take action now to reduce earthquake hazards.

SOURCES OF MORE INFORMATION

- Your local library is a good place to start. Ask there for the material referenced below.
- Look at the "First Aid and Survival Guide" in the introductory pages of most telephone directories.
- Ask your city or county Office of Emergency Services or local chapter of the American Red Cross for pamphlets on preparedness and survival.

Other sources

Most organizations are willing to provide speakers for large groups of people when staff are available. None of these organizations will be able to answer questions about specific locations or structures.

BAREPP, Bay Area Regional Earthquake Preparedness Project. MetroCenter, 101 8th Street, Suite 152, Oakland, CA 94607, (415) 893-0818.

Publications, videotapes, and scripted slide shows on earthquake preparedness. Free catalog.

ABAG, Association of Bay Area Governments

P.O. Box 2050, Oakland, CA 94604-2050, located at MetroCenter, 101 8th Street, (415) 464-7900.

Maps that show ground-shaking probabilities, technical assistance in planning, publications on hazard mitigation, training courses for businesses. Free catalog.

USGS, U.S. Geological Survey, Earth Science Information Centers

Menlo Park, CA 94025, 345 Middlefield Road, (415) 329-4390.

San Francisco, CA 94111, 555 Battery Street, Room 504 Customs House, (415) 705-1010.

Publications and maps concerning earthquake hazards. Mail orders to USGS Books and Report Sales, P.O. Box 25425, Denver, CO 80225. For orders less than $10.00, include $1.00 for postage and handling.

FEMA, Federal Emergency Management Agency

Building 105, The Presidio, San Francisco, CA 94129, (415) 923-7100.

Documents should be ordered from FEMA, P.O. Box 70274, Washington, D.C. 20024.

CDMG, California Department of Conservation, Division of Mines and Geology

P.O. Box 2980, Sacramento, CA 95812-2980, (916) 445-5716.

Publications and maps concerning faults. Scenarios describing the likely effects of future earthquakes.

ATC, Applied Technology Council

3 Twin Dolphin Drive, Redwood City, CA 94065 (415) 595-1542.

Technical publications for engineers, architects, and other people interested in the details of design for reducing earthquake damage to buildings and their contents.

EERI, Earthquake Engineering Research Institute

6431 Fairmount Avenue, Suite 7, El Cerrito, CA 94530-3624, (415) 525-3668.

Technical information of most interest to engineers, researchers, and practicing professionals. Videotapes, annotated slide sets, and reconnaissance reports about earthquake hazard mitigation and the response of buildings, lifelines and bridges during major earthquakes around the world. Free catalog.

California Seismic Safety Commission

1900 K Street, Suite 100, Sacramento, CA 95814-4186.

Primarily concerned with encouraging hazard reduction and emergency planning. Information on legislation, state agency programs and unreinforced masonry building programs.

American Red Cross

Alameda	(415) 522-7711
Carmel	(408) 624-6921
Contra Costa	(415) 687-3030
Marin	(415) 454-1550
Mendocino	(707) 577-7600
Monterey	(408) 424-4824
Napa	(707) 257-2900
Palo Alto	(415) 322-2143
San Benito	(408) 637-2437
San Francisco	(415) 776-1500
San Mateo	(415) 692-7214
Santa Clara	(408) 292-6242
Santa Cruz	(408) 462-2881
Solano	(707) 643-5683
Sonoma	(707) 577-7600

Office of Emergency Services

Alameda	(415) 667-7740
Contra Costa	(415) 228-5000
Marin	(415) 499-6584
Monterey	(408) 755-5010
Napa	(707) 253-4080
San Benito	(408) 637-6017
San Francisco	(415) 441-6020
San Mateo	(415) 363-4790
Santa Clara	(408) 299-3751
Santa Cruz	(408) 425-2045
Solano	(707) 421-6330
Sonoma	(707) 527-2361

Additional Materials

How to Obtain Copies

To obtain copies of documents, please write to the sources given. Include a check for the price, postage and handling (P&H) where given, and 7.25 percent sales tax. Credit cards are not accepted by most of these institutions. ABAG sells BAREPP publications, accepts credit cards for orders of more than $10.00, and includes tax in P&H. Items can normally be purchased over the counter. Most of these organizations do not have large enough staffs to handle telephoned orders.

Generalized Books and Magazines About Earthquakes

Earthquakes and volcanoes. A bimonthly publication of the U.S. Geological Survey available yearly for $6.50 from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, or by credit card at (202) 783-3238.

California Geology. A monthly publication of the California Department of Conservation, Division of Mines and Geology available yearly for $10.00 from CDMG, 660 Bercut Drive, Sacramento, CA 95814.

Earthquakes. By Bruce Bolt, W.H. Freeman, New York, 1988, 282 pages ($13.95).

Earthquakes. By Bryce Walker, Time-Life Books, Alexandria, Virginia, 1982, 176 pages (out of print).

On shaky ground: America's earthquake alert. By John J. Nance, 1989, Avon Books, New York, 440 pages ($4.95).

Terra non firma. By J.M. Gere and H.C. Shah, 1984, W.H. Freeman, New York, 203 pages ($12.95).

About Emergency Preparedness

Surviving the Big One, How to prepare for a major earthquake. A very informative video developed for public television. KCET Video, 4401 Sunset Boulevard, Los Angeles, California 90027, 1990 (revised), 1 hour, (800) 228-5238 ($19.95 + $3.50 P&H).

General Preparedness Information Kit. Seven brochures covering personal preparedness in houses, apartments, mobile homes, high rises; preparedness for the elderly or disabled; non-structural checklist, BAREPP, 1988 (ABAG P87059BAR, $2.00 including P&H).

Safety and survival in an earthquake. American Red Cross, 1989, 52 pages ($3.00 from your local Red Cross Office, or by mail from American Red Cross, Los Angeles Chapter, 2700 Wilshire Boulevard, Los Angeles, CA 90057, $3.00 + $1.00 P&H).

The emergency survival handbook. American Red Cross, 1985, 63 pages ($3.00 from your local Red Cross Office, or by mail from American Red Cross, Los Angeles Chapter, 2700 Wilshire Boulevard, Los Angeles, CA 90057, $3.00 + $1.00 P&H).

Home earthquake preparedness. Many cities have booklets of similar title describing how to prepare home and family for a major earthquake disaster in your neighborhood. Check with your city Office of Public Safety or county Office of Emergency Services.

Getting ready for the big one. Health Plus, 694 Tennessee St., San Francisco, CA 94107, 1986, 45 pages ($7.50 + $2.50 P&H).

Earthquake preparedness — for office, home, family, and community. Lafferty and Associates, Inc., P.O. Box 1026, La Canada, CA 91012, 1989, 32 pages, (818) 952-5483 ($5.00).

Reducing losses from earthquakes through personal preparedness. By W.J. Kockelman, 1984, U.S. Geological Survey Open-File Report 84-765, 21 pages (USGS, $2.75).

Earthquake ready. By Virginia Kimball, Roundtable Publishing, Inc., Santa Monica, California, 225 pages, 1988 ($13.95).

NETWORKS, earthquake preparedness news. Periodic Publication of BAREPP (BAREPP, Free).

About Preparedness in Schools and Offices

Earthquake preparedness activities for child-care providers. BAREPP, 1989, 54 pages (ABAG P89002BAR, $7.00 + $2.00 P&H).

Earthquakes: A teacher's package for K-6 grades. By the National Science Teachers Association, 1988, 280 pages ($15.00 + $2.00 P&H from NSTA Publications, 1742 Connecticut Ave., N.W., Washington, D.C. 20009 (202) 328-5800. Schools may obtain a free, single copy from FEMA, Earthquake Programs, 500 C St., S.W., Washington, D.C. 20472).

Living safely in your school building. Lawrence Hall of Science, University of California, Berkeley, CA 94720, 1986, 9 pages, (415) 642-8718 ($2.00).

Earthquake ready; preparedness planning for schools. BAREPP, 1990, 76 pages (ABAG P9002BAR, $8.00 + $2.00 P&H).

Employee earthquake preparedness for the workplace and home. American Red Cross, 1988, 12 pages ($1.00 from your local Red Cross Office or by mail from Red Cross Disaster Services, 1550 Sutter Street, San Francisco, CA 94109.

Earthquake preparedness: a key to small business survival. BAREPP, 1985, 8 pages (ABAG P85055BAR, $2.00 + $.90 P&H).

Corporate comprehensive earthquake preparedness planning guidelines. BAREPP, 1985, 48 pages (ABAG P87054BAR, $8.00 + $1.50 P&H).

About Reducing Damage Within Buildings

Reducing the risks of nonstructural earthquake damage: A practical guide, 1988, 86 pages (ABAG P87056BAR, $7.00 + $1.60 P&H).

Hazardous materials problems in earthquakes: Background materials [preliminary version]. ABAG, 1990, 280 pages (P900001EQK, $12.50 + $2.50 P&H).

About Making Buildings Safer

Peace of mind in earthquake country. By Peter Yanev, Chronicle Books, San Francisco, California, 1990, 304 pages ($12.95).

Getting ready for a big quake, Special Report. Sunset Magazine, March 1982, p. 104-111 ($1.00 from Earthquake Reprint, Sunset Magazine, 80 Willow Road, Menlo Park, CA 94025).

Home buyer's guide to earthquake hazards. BAREPP, 1989, 13 pages (BAREPP, single copies free).

Strengthening woodframe houses for earthquake safety. BAREPP, 1990, 36 pages (ABAG P90004BAR, $2.00 + $1.00 P&H).

Earthquake safe. By David Helfant, 1989, 55 pages ($8.95 + 1.50 P&H from Builders Booksources, 1817 Fourth St., Berkeley, CA 94710, (415) 845-6874).

Rapid visual screening of buildings for potential seismic hazards: A handbook. Federal Emergency Management Agency, FEMA-154, 1988, 185 pages (FEMA, free).

Earthquake hazards and wood frame houses: what you should know and can do. By M. Comerio and H. Levin, 1982, 46 pages ($6.44 from Center for Environmental Design Research, 390 Wurster Hall, University of California, Berkeley, CA 94720 (415)642-2896. Make check payable to "U.C. Regents").

The home builder's guide for earthquake design. By the Applied Technology Council, 1980, 63 pages (ATC, $17.50).

Professional Societies for Architects

The local offices for the American Institute of Architects are:

Oakland, 499 14th Street, Suite 210, (415) 464-3600.
Monterey, P.O. Box 310, (408) 372-6527
Santa Rosa, P.O. Box 4178, (707) 576-7799.
San Francisco, 130 Sutter Street, Suite 600, (415) 362-7397.
San Mateo, P.O. Box 5386, (415) 348-5133.
Santa Clara, 36 South First Street, Suite 200, (408) 298-0611.

Professional Societies for Engineers

SEAONC, Structural Engineers Association of Northern California, 217 2nd Street, San Francisco, CA 94105, (415) 974-5147.
Consulting Engineers Association of California, 925 L St., Suite 870, Sacramento, CA 95814, (800) 442-2322.

Professional Societies for Geologists and Geotechnical Engineers

Association of Engineering Geologists, P.O. Box 132, Sudbury, MA 01776-0001, (508) 443-4639.
California Geotechnical Engineers Association, P.O. Box 431, Yorba Linda, CA 92686, (714) 777-3423.
ASFE, The Association of Engineering Firms Practicing in the Geosciences, 8811 Colesville Road, Suite G106, Silver Spring, MD 20910, (301) 565-2733.

San Mateo County Maps

The following five maps for San Mateo County are prototypes of the kind of detailed work that is now possible and could be carried out by state, county, or local workers or consultants.

Map showing slope stability during earthquakes in San Mateo County, California. By G.F. Wieczorek, R.C. Wilson, and E.L. Harp, Geological Survey Miscellaneous Investigations Series Map I-1257-E, 1985 (USGS, $3.10).

Map showing faults and earthquake epicenters in San Mateo County, California. By E.A. Brabb and J.A. Olsen, Geological Survey Miscellaneous Investigations Series Map I-1257-F, 1986 (USGS, $5.50).

Map showing liquefaction susceptibility of San Mateo County, California. By T.L. Youd and J.B. Perkins, Geological Survey Miscellaneous Investigations Series Map I-1257-G, 1987 (USGS, $3.10).

Map showing predicted seismic-shaking intensities of an earthquake in San Mateo County, California, comparable in magnitude to the 1906 San Francisco earthquake. By J.M. Thomson and J.F. Evernden, Geological Survey Miscellaneous Investigations Series Map I-1257-H, 1986 (USGS, $3.10).

Maps showing cumulative damage potential from earthquake ground shaking, San Mateo County, California. By J.B. Perkins, Geological Survey Miscellaneous Investigations Series Map I-1257-I, 1987 (USGS, $9.30).

About Faults

Fault-rupture hazard zones in California. Alquist-Priolo Special Studies Zones Act of 1972 with index to special studies zones maps, California Department of Conservation, Division of Mines and Geology Special Publication 42, 1988 (revised), 24 pages (CDMG, $1.00).

Living on the fault: A field guide to the visible evidence of the Hayward fault. BAREPP, 1988, 16 pages (ABAG P88004BAR, $2.00 + $1.00 P&H).

Living on the fault II: a field guide to the visible evidence of the San Andreas fault. BAREPP, 1990, 16 pages (ABAG P90003BAR, $2.00 + $1.00 P&H).

Geology and active faults in the San Francisco Bay Area, a map. Point Reyes National Seashore Association, Point Reyes, California 94956, (415) 663-1155 ($3.00 + $2.19 P&H and tax).

Visit the Earthquake Trails at Point Reyes National Seashore, Olema, California, and at Los Trancos Open Space Preserve, Page Mill Road and Skyline Boulevard, Palo Alto, California.

About Regions at Higher Risk

The San Francisco Bay Area - On shaky ground - San Francisco map set and text. ABAG, 1987, 32 pages, seven maps at scale of 1:125,000 (includes San Francisco and Berkeley to Hayward) (P87001EQK, $8.00 + $2.00 P&H).

The San Francisco Bay Area - On shaky ground - Alameda and Contra Costa Counties map set. ABAG, 1988, seven maps at scale of 1:125,000 (intended to be used with the San Francisco map set and text) (P88002EQK, $60.00 + $2.00 P&H).

The San Francisco Bay Area - On shaky ground - Santa Clara County Map Set. ABAG 1987, seven maps at scale of 1:125,000 (Intended to be used with the San Francisco map set and text) (P87002EQK, $60.00 + $2.00 P&H).

Map set, 20-map blue-line ozalid set for entire nine-county Bay Area. (Intended to be used with the San Francisco map set and text), 20 maps at scale of 1:250,000 (ABAG M80000EQK, $40.00 + $5.00 P&H). Map set includes maps of fault surface rupture, fault traces, geologic materials, anticipated ground shaking intensities for earthquakes from 10 different possible sections of fault, maximum ground shaking intensity, cumulative damage potential from ground shaking for 3 different types of buildings, dam-failure inundation areas, and liquefaction susceptibility and potential maps.

Eight-map mini-set, (part of the above set). (ABAG M80001EQK, $20.00 + $5.00 P&H). Set includes maps (scale 1:250,000) of fault surface rupture, geologic materials, anticipated ground shaking intensities for San Andreas and Hayward faults only, maximum ground shaking intensities, and cumulative damage potential from ground shaking for three different types of buildings (Intended to be used with the San Francisco map set and text).

Maps showing maximum earthquake intensity predicted in the southern San Francisco Bay region, California, for large earthquakes on the San Andreas and Hayward faults. By R.D. Borcherdt, J.F. Gibbs, and K.R. Lajoie, 1975, U.S. Geological Survey Miscellaneous Field Studies Map MF-709 (USGS, $4.50).

About Regional Planning to Reduce Earthquake Risk

The following documents are all technical in nature and are of most interest to regional planners and residents interested in regional planning.

California at risk — Steps to earthquake safety for local governments. California Seismic Safety Commission Report SSC 88-01, by G.G. Mader and M. Blair-Tyler, 1988, 56 pages (California Seismic Safety Commission, $10.00).

Seismic hazards and land-use planning. By D.R. Nichols and J.M. Buchanan-Banks, U.S. Geological Survey Circular 690, 1974, 33 pages (USGS, free).

Geology for decisionmakers - Protecting life, property, and resources. By R.D. Brown and W.J. Kockelman, 1985, 11 pages, Bulletin of the Institute of Governmental Studies, Regents of the University of California, Berkeley (Free from W.J. Kockelman, USGS, Mail Stop 977, 345 Middlefield Road, Menlo Park, CA 94025).

Seismic safety and land-use planning - Selected examples from California. By M.L. Blair and W.E. Spangle, U.S. Geological Survey Professional Paper 941-B, 1979, 82 pages (USGS, $6.50).

Examples of seismic zonation in the San Francisco Bay region. By W.J. Kockelman and E.A. Brabb, U.S. Geological Survey Circular 807, 1979, pages 73-84 (USGS, free).

Putting seismic safety policies to work. By M. Blair-Tyler and P.A. Gregory, 1988, 44 pages (ABAG P88006BAR, $8.00 + $1.75 P&H).

Evaluating earthquake hazards in the Los Angeles region. Edited by J.I. Ziony, U.S. Geological Survey Professional Paper 1360, 1985, 505 pages (USGS, $24.00).

Flatland deposits - their geology and engineering properties and their importance to comprehensive planning: Selected examples from the San Francisco Bay region, California. By E.J. Helley, K.R. Lajoie, W.E. Spangle, and M.L. Blair, U.S. Geological Survey Professional Paper 943, 1979, 88 pages (USGS, currently out of stock).

Relative slope stability and land-use planning: Selected examples from the San Francisco Bay region, California. By T.H. Nilsen, R.H. Wright, T.C. Vlasic, and W.E. Spangle, U.S. Geological Survey Professional Paper 944, 1979, 96 pages (USGS, currently out of stock).

Quantitative land-capability analysis: Selected examples from the San Francisco Bay region, California. By R.T. Laird, J.B. Perkins, D.A. Bainbridge, D.A. Baker, J.B. Boyd, R.T. Huntsman, P.E. Staub, and M.B. Zucker, U.S. Geological Survey Professional Paper 945, 1979, 115 pages (USGS, $6.50).

Geologic principles for prudent land-use: A decisionmaker's guide for the San Francisco Bay region. By R.D. Brown, Jr., and W.J. Kockelman, U.S. Geological Survey Professional Paper 946, 1983, 97 pages (USGS, currently out of stock).

About Anticipated Earthquakes

Earthquake planning scenario for a magnitude 7.5 earthquake on the Hayward fault in the San Francisco Bay Area. California Department of Conservation, Division of Mines and Geology, Special Publication 78, 1987, 260 pages (CDMG, $30.00).

Earthquake planning scenario for a magnitude 8.3 earthquake on the San Andreas fault in the San Francisco Bay Area. California Department of Conservation, Division of Mines and Geology, Special Publication 61, 1982, 160 pages (CDMG, $8.00).

Probabilities of large earthquakes occurring in California on the San Andreas fault. By The Working Group on California Earthquake Probabilities, U.S. Geological Survey Open-File Report 88-398, 1988, 51 pages (USGS, $9.75).

Probabilities of large earthquakes in the San Francisco Bay region. By The Working Group on California Earthquake Probabilities, U.S. Geological Survey Circular 1053, 1990, 84 pages (USGS, free). Very technical report for specialists only.

Predicting the next great earthquake in California. By R.L. Wesson and R.E. Wallace, Scientific American, v. 252, no. 2, 1985, pages 35-43.

Disclaimer

This publication is meant to be instructional and to provide information that will help you understand and reduce the risk from earthquakes. The information in this publication is believed to be accurate at the time of publication. The agencies and individuals involved in the preparation, printing, and distribution of this publication assume no responsibility for any damage that arises from any action that is based on information found in this publication.

Credits

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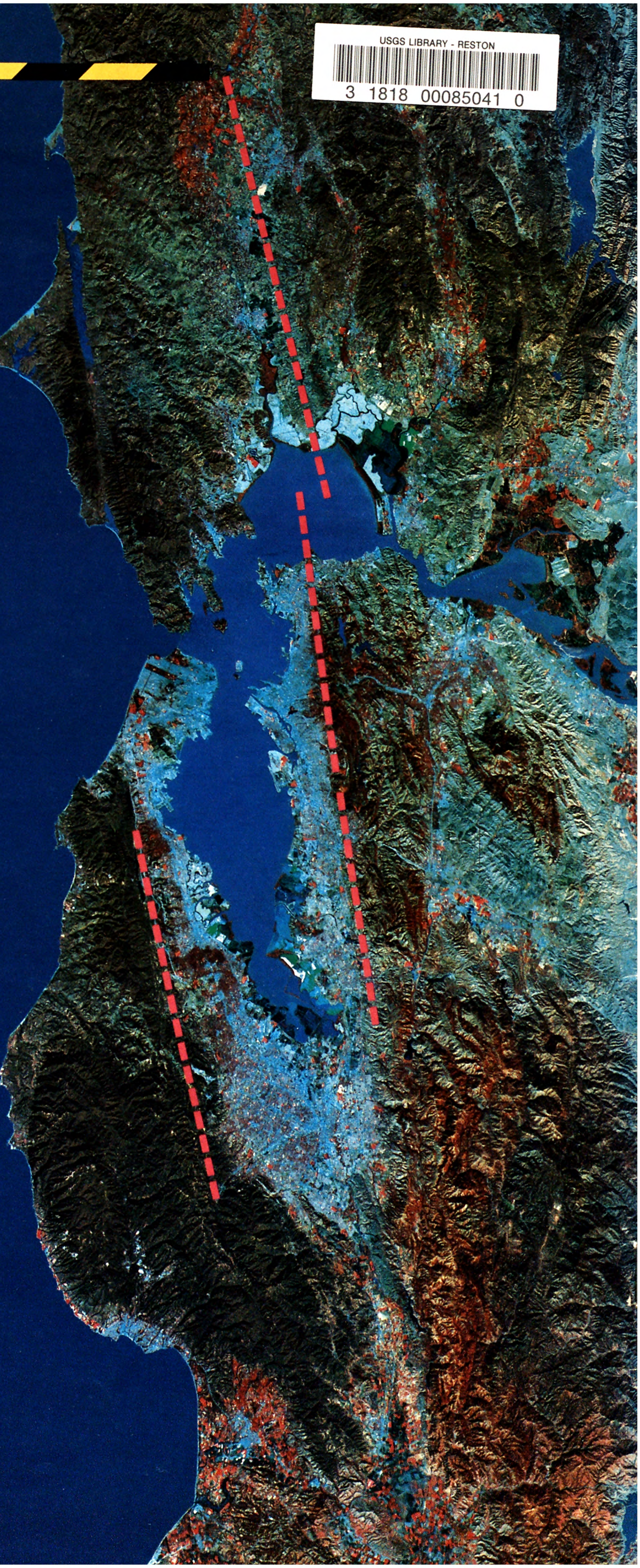
ARE YOU PREPARED FOR THE NEXT BIG EARTHQUAKE IN THE SAN FRANCISCO BAY AREA?

Major earthquakes in the near future are considered most likely on segments or parts of major faults shown in red. Earthquakes on any of these fault segments will be closer to major population centers than the Loma Prieta earthquake and will therefore cause more severe damage. By taking action now, we can drastically reduce earthquake losses.



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