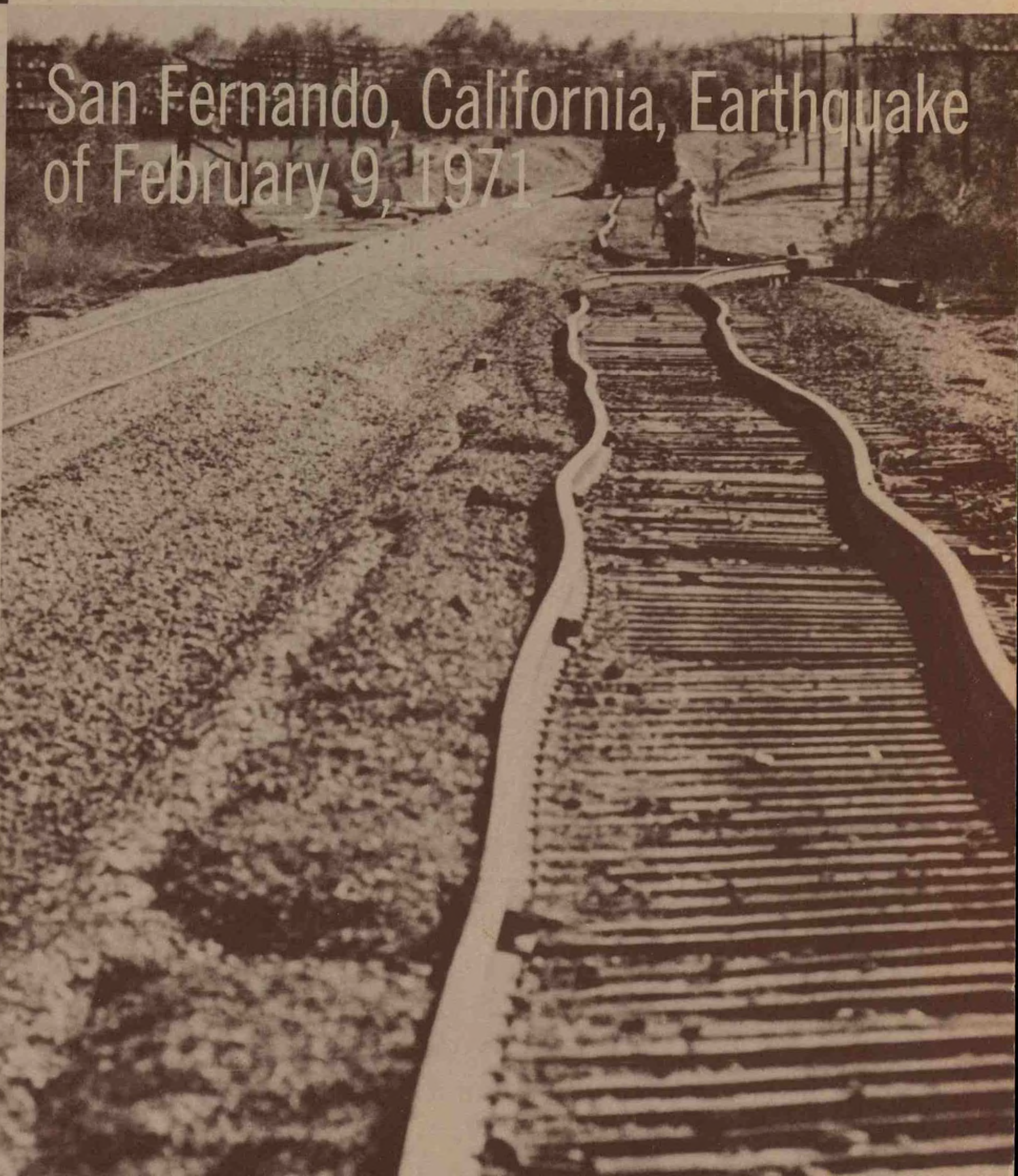
NOAA NDSR 71-1

NATURAL DISASTER SURVEY REPORT 71-1

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

San Fernando, California, Earthquake of February 9, 1971



ROCKVILLE, MD.
JUNE 1971

U. S. DEPARTMENT OF COMMERCE
Maurice H. Stans, Secretary

U.S.
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
Robert M. White, Administrator

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FOREWORD

This National Oceanic and Atmospheric Administration Natural Disaster Survey Report is another in the series describing the effects of major natural disasters in the United States, the performance of NOAA's hazards detection and warnings systems as they relate to such disasters, and the impact on present and future NOAA programs and services. Previous reports in this series dealt with the more frequent weather-related hazards — tornadoes, hurricanes, and floods. This is the first report in the series to analyze the effectiveness of NOAA's earthquake programs and services as they performed before, during, and after an earthquake — the devastating San Fernando, California, Earthquake of February 9, 1971.

The field survey was conducted by NOAA's National Ocean Survey as part of an intensive postearthquake field study involving many Federal and State organizations, and also academic institutions. The way in which all these groups interacted is described in the report.

The report clearly indicates that the catastrophic effects of the San Fernando earthquake, which was only moderately severe in terms of its 6.6 magnitude, are but a small indication of the much greater effects that could be expected from earthquakes that release greater amounts of energy. A major recommendation of this report is that an intensive detailed study of the San Fernando earthquake be undertaken in the national interest to more clearly understand the full implications of this event and to better prepare for future seismic events.

Robert M. White, Administrator
National Oceanic and Atmospheric Administration

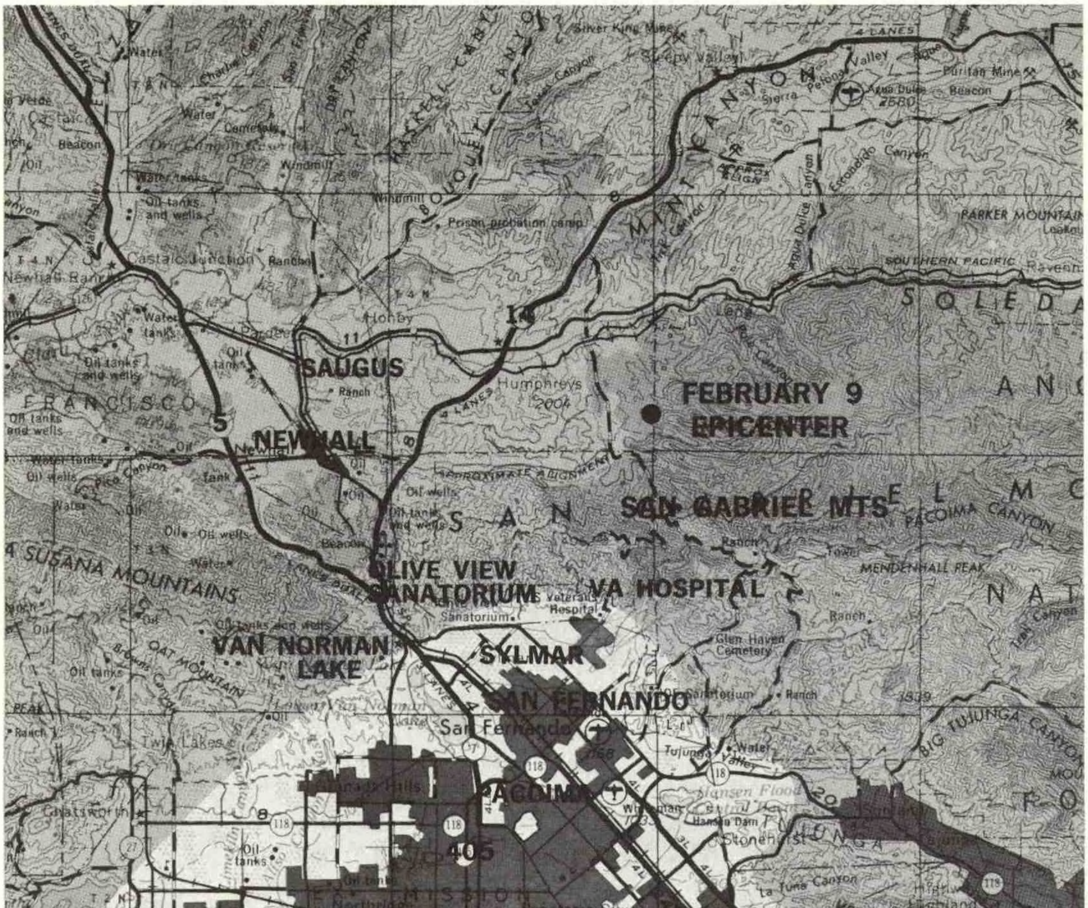


Figure 1. Area of heavy damage and location of epicenter, San Fernando, California, Earthquake of February 9, 1971.

CHAPTER 1

The San Fernando Earthquake

On February 9, 1971, 06:00:41.6 Pacific Standard Time, a major earthquake occurred at 34° 24.0′ N, 118°23.7′ W (the computed epicenter), approximately 20 miles north of the center of Los Angeles, Calif., and near the densely populated San Fernando Valley (fig. 1). The magnitude of the shock was calculated at 6.6 on the Richter scale. The earthquake was felt over an area of 80,000 square miles. The main shock was felt at Fresno, Calif., about 180 miles to the north, at the Mexican border about 130 miles to the south, and at Las Vegas and Tonopah, Nev., 225 and 285 miles distant, respectively (fig. 2). The earthquake caused 64 deaths and damage estimated at $500 million, with major damage to buildings, dams, highway overpasses, railroads, and power and water facilities, principally in the San Fernando area.

The area of damage—intensity of VI or greater on the Modified Mercalli Scale—extends from Ventura on the coast north of Los Angeles, inland beyond Lancaster in the north, thence southeast beyond San Bernardino and Redlands, and southwest to San Clemente on the coast south of Los Angeles (fig. 2). In this area are many urban centers with multistory buildings, hospitals, and other complex structures, including the more densely populated centers of Los Angeles, Burbank, Glendale, Oxnard, Santa Monica, Long Beach, Santa Ana, Riverside, and Pasadena, and the smaller towns (closer to the earthquake epicenter) of Newhall, Saigus, Castaic, Solemint, and Honby, all of which were subject to major damage. Major highways, and the Southern Pacific Railroad, cross and recross numerous faults in the area and in some places follow relatively steep-walled canyons that trend parallel to the faults from which the canyons developed. Several earthfill dams in the area—Van Norman, Stone Canyon, Hansen, and Encino—hold water reservoirs that pose a threat of inundation to large residential sections in the event of failure.

The population in the area of damage is estimated at 10 million. Most of these people were just awakening in single-family suburban homes. This undoubtedly reduced the number of casualties—which might have been much greater had the earthquake occurred during the school and work day at a time when commercial and public buildings (some of which sustained heavy damage) would have been occupied.

The greatest loss of life occurred at Sylmar, a few miles south of the earthquake epicenter, at the Veterans Administration Hospital and the Olive View Hospital. The center wing of the Veterans Administration Hospital, a 45-year old three-story structure, totally collapsed, burying many occupants under tons of debris and killing 44 people. The main building at the Olive View Hospital, a six-story structure dedicated in January 1971, although designed to be earthquake resistant, was severely damaged. Two older structures of this complex collapsed, and others received serious damage. Three persons died, and the damage sustained was estimated at $34 million.

The towns of Newhall and Saugus, located 7 to 10 miles west of the epicenter, suffered considerable damage. Four old buildings in downtown Newhall were condemned by the city engineer, who estimated that fireplaces and chimneys on 90 percent of the two-story houses in the area were damaged.

Many residential homes were totally destroyed in upper San Fernando City by movement along a previously unmapped fault zone. An additional 750 homes and 100 businesses sustained major damage in San Fernando.

Structures in downtown Los Angeles sustained some damage. One old building, the Midnight Mission, collapsed, killing one person, and some high rise structures sustained moderate damage. Several schools in Los Angeles County were damaged. At least four have been condemned, including Los Angeles High School, Morningside Elementary School,

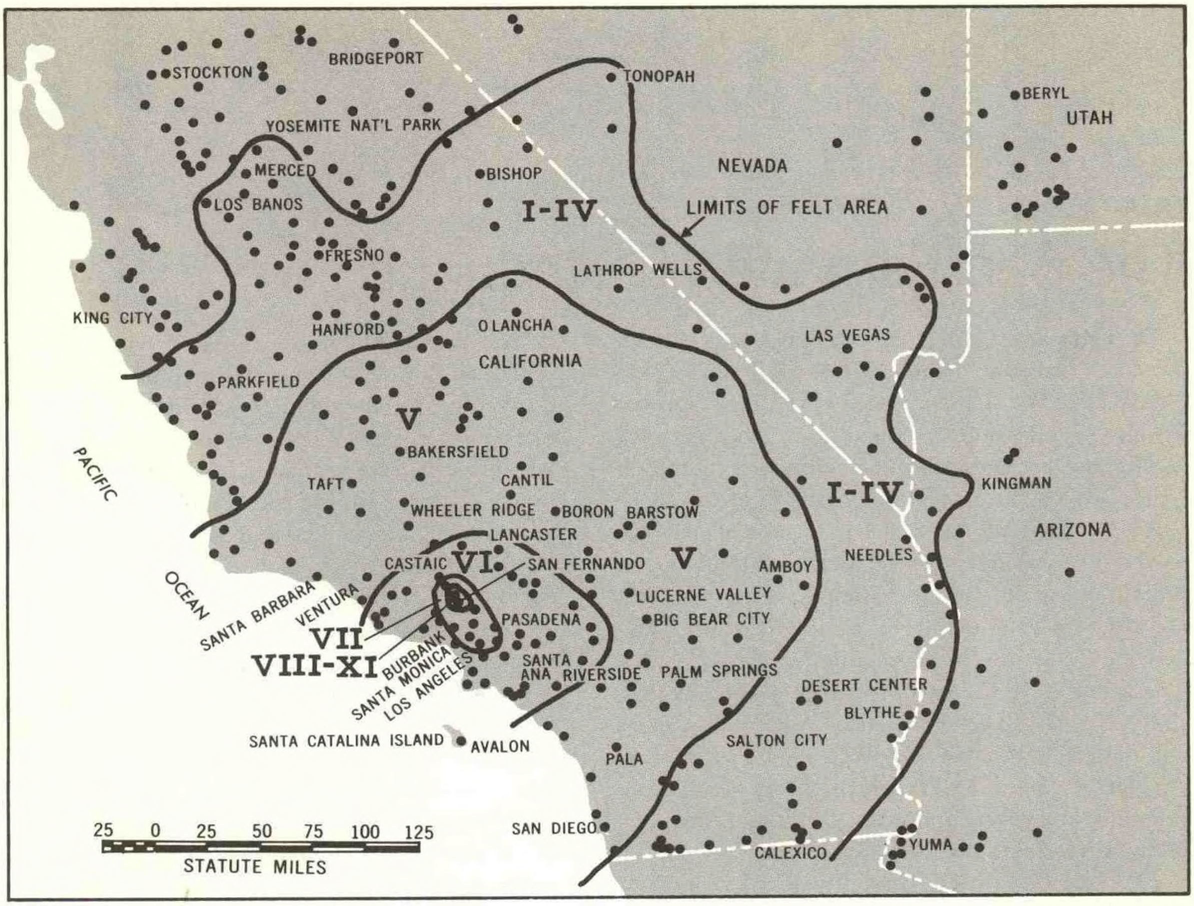


Figure 2. Preliminary map showing area affected by San Fernando, California, Earthquake of February 9, 1971. Isoseismals indicate zones of equal apparent intensity on Modified Mercalli Intensity Scale.

San Fernando Jr. High School, and Van Gogh Street Elementary School. Two Los Angeles Public Library branch buildings, Vernon and Echo Park, have been condemned and will be razed.

At the west end of San Fernando Valley there was much ground breakage around the 56-year old San Fernando Dam. The dam showed evidence of severe structural damage, and appeared about to collapse. As a precaution, about 80,000 residents were evacuated from that area and most of the water was drained from the reservoir. Water and Power Department officials estimate that repairs may cost up to $20 million.

All highways linking the Newhall-Saugus and Palmdale-Lancaster population centers of the Antelope Valley with metropolitan Los Angeles were closed to through traffic. Two men were killed on one of these routes when a bridge over the San Diego Freeway, between Rinaldi Street and the Golden State Freeway, collapsed on them. The Golden State Freeway was closed to traffic from its junction with the Hollywood Freeway (near the Tujunga Wash) and 20 miles northwest to California 126 at Castaic.

Electric, gas, water, and telephone services were disrupted for thousands of residents. A main feeder line of the Southern California Gas Company ruptured and erupted into flames near San Fernando. Electric service failed briefly in scores of areas, and power remained off until late afternoon in many parts of Los Angeles and in the Newhall-Saugus area. Two main water trunklines into the Mission Hills-Sylmar area of the San Fernando Valley broke, cutting off the water supply to hundreds of homes.

CHAPTER 2
General Seismicity of Southern California

All United States areas are vulnerable to earthquake damage; however, the possibility of damage in the conterminous United States is relatively remote except for a few well-defined areas. The most vulnerable include the St. Lawrence Valley, the Charleston (South Carolina) region, the New Madrid (Missouri) area, the western mountain region, the Puget Sound area, and the State of California. Of these, California is the most active earthquake region and is subject to many earthquakes each year (fig. 3). The shocks usually are associated with movements along the major fault systems of the State (fig. 4). Such earth movements can occur as sudden dramatic shifts, as much as 20 feet in a few seconds, or as slow creep ranging from a few hundredths of an inch to several inches per year.

Although there have been hundreds of earthquakes of sufficient magnitude to have been felt by residents of Los Angeles, the last shock of comparable magnitude and damage to the San Fernando earthquake of February 9, 1971, occurred in 1933 at Long Beach and had a magnitude of 6.3. This shock was not of major magnitude from the seismological point of view, but it ranks among the most destructive shocks in the history of the United States because of its location near a densely settled area that had many poorly constructed buildings. About 115 lives were lost, hundreds of persons were injured, and damage amounted to about $40 million. The epicenter was located just offshore near Newport Beach. Major destruction extended from Long Beach to the industrial section south of Los Angeles. Water-soaked alluvium, other unfavorable geological conditions, and the poor structural design of many buildings increased the damage.

Another earthquake of note occurred more recently in southern California on April 8, 1968, near Borrego Mountains, 33°12′ N, 116°7′ W. It was felt over approximately 60,000 square miles. Although it was of comparable magnitude to the San Fernando shock, its center was relatively remote from populated areas and damage was minor, consisting mainly of landslides, ground fissures, and the destruction of one 3,600-gallon water tank at Ocotillo Wells.

Geologically, the Los Angeles Basin has basement rocks that are comprised of intrusive rocks of late

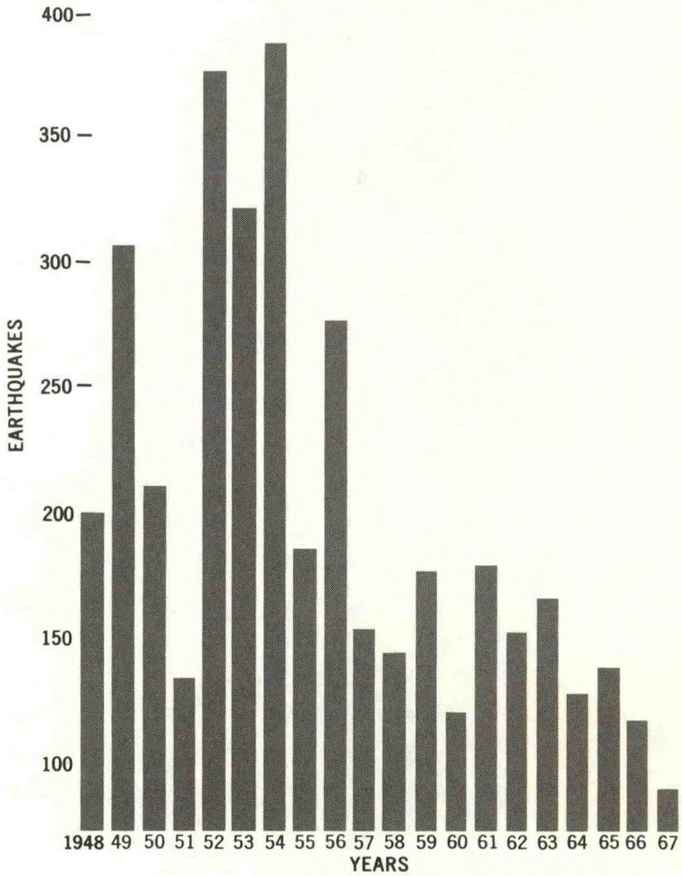


Figure 3. Recorded and located earthquakes of magnitude 3.0 or greater per year in Southern California.

Mesozoic age, earlier sedimentary and volcanic rocks that were subjected to severe metamorphism during the late Mesozoic orogeny, and Precambrian rocks that outcrop in some localities. The California sector of the circum-Pacific belt is not typical of the belt in general because it has neither the usual offshore deep and intermediate to deep earthquakes, nor the degree of volcanism that usually characterizes island arc structure. The controlling factor in California's surface evolution has been the San Andreas Fault system, which dates from the early Cenozoic. Earth movements within this system have produced local fault-controlled basins and fragmentation of the continental border.

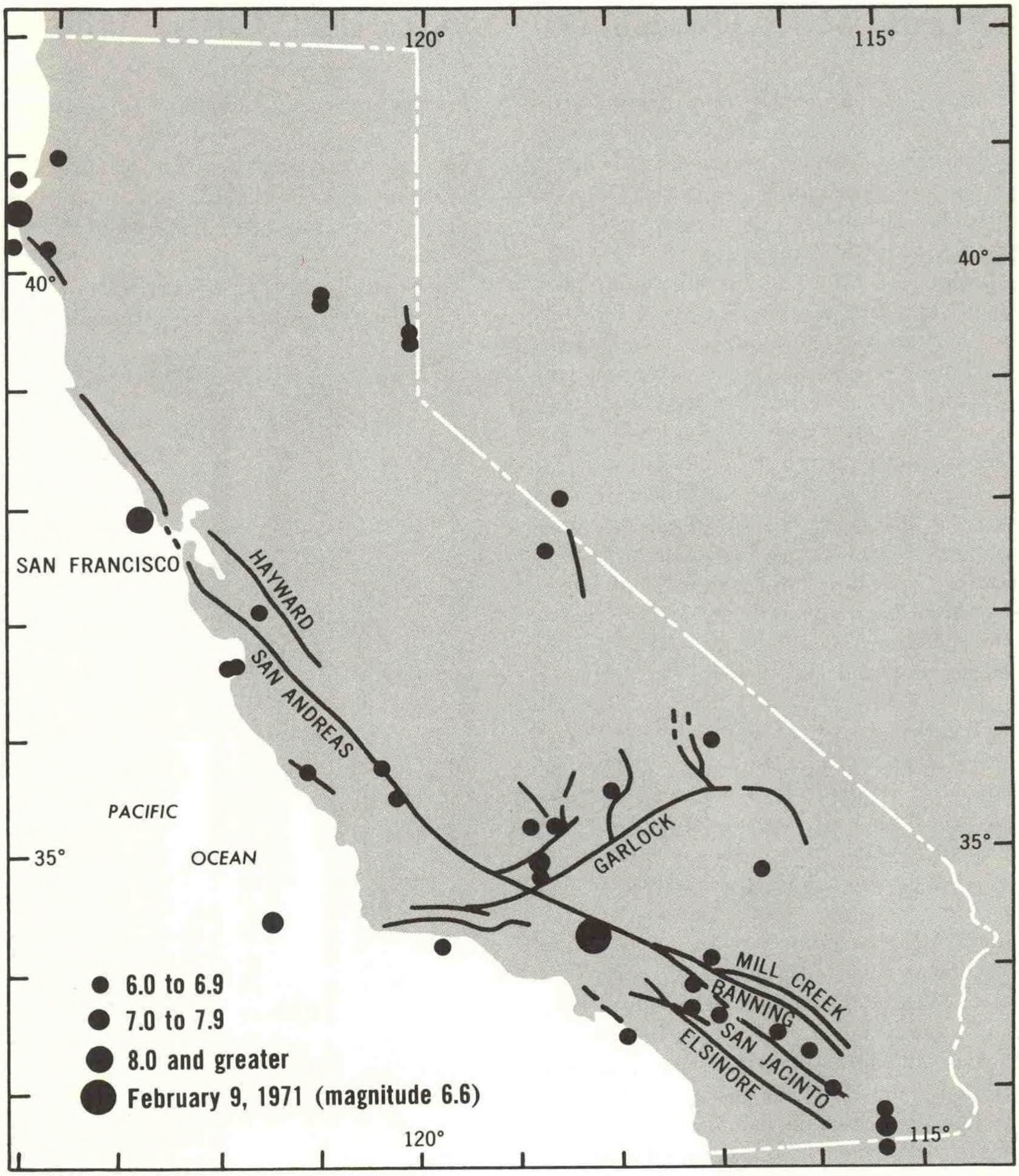


Figure 4. California earthquakes of magnitude 6.0 and greater, 1906–1967, and associated faults.

CHAPTER 3

NOAA's Role and Programs

The mission of the Department of Commerce is to promote the Nation's economic development and technological advancement—in part by assisting States, communities, and individuals toward economic progress and in part by assuring effective use and growth of the Nation's scientific and technical resources. To achieve these goals, the National Oceanic and Atmospheric Administration conducts programs to better understand the atmospheric, marine, and solid earth environment and to better provide for protection of life and property from the hazards of the physical environment—particularly severe atmospheric storms, floods, and earthquakes, which, because of their sudden occurrence, violent nature, and devastating effects, are the cause of major disasters. Accordingly, NOAA conducts scientific research and provides technical services relating to earthquake hazards and seeks to apply its scientific and technical resources in effective action to prevent casualties and reduce property losses from earthquakes.

The effects of severe earthquakes pose a threat to the rapid economic growth and development of large urban centers in earthquake-prone regions. Nevertheless, loss of life and damage to property from earthquakes, and the risks involved in areas most susceptible to damage, can be greatly reduced by studying probabilities of earthquake occurrences, learning more about the nature of damaging effects of earthquakes, and developing improved guidelines for safe construction and land use. To this end, NOAA is cooperating with the Geological Survey of the Department of the Interior, the Department of Housing and Urban Development, the Atomic Energy Commission, the National Science Foundation, other Federal agencies, State agencies, universities, and industry through NOAA's continuing research and technical services programs in the solid-earth environment, especially seismology, geodesy, and marine geophysics. In carrying out these programs, NOAA operates the National Earthquake Information Center, the Earthquake Mechanism Laboratory, the Seismological Data Center, the National Tsunami Warning Center, and the national networks for observing earthquakes and their damaging strong ground motions, and conducts several major projects on a continuing basis, including the following.

1. The National Earthquake Information Center maintains a 24-hour watch of the seismic activity of the world, reporting the origin time, location, and magnitude of all major earthquakes

View showing failure of Lower San Fernando Dam and floor of Lower Van Norman Lake after drainage of water.

Van Norman Lake drainage tower snapped at base.

(within one to two hours of their occurrence) to organizations responsible for emergency relief and scientific study and to other interested groups. These include Federal, State and local relief agencies, transportation and communication agencies, civil defense and Department of Defense installations, unversities, seismological and geophysical observatories, and public news media.

2. The San Francisco Seismological Field Survey maintains and services a network of 449 strong-motion seismographs and 380 seismoscopes in the western United States, Alaska, South America, and Central America. These instruments are specially designed to record the accelerations and displacement of ground motions and are activated only when a strong shock occurs nearby.

3. The Earthquake Mechanism Laboratory, which is located at San Francisco, makes intensive field studies of long-term movements across the San Andreas Fault and other active faults. This is done through the establishment of arrays of tilt meters, creep meters, and strain meters. These measurements are obtained to determine relationships between the accumulation and release of strain in the earth and to identify recognizable premonitory variations in measurable physical parameters of the earth.

4. NOAA's Geodetic Horizontal and Vertical Control Networks have monitored earth movements in areas of faults for many years. These highly accurate geodetic nets are remeasured at frequent intervals to determine the deformation caused by earthquake stresses.

CHAPTER 4

NOAA's San Fernando Earthquake Operations

The National Earthquake Information Center received notification of the earthquake within 10 minutes after its occurrence. The first report came from the Tucson, Ariz., Geophysical Observatory. Within a half-hour, several additional reports were received and processed, a preliminary epicenter and magnitude were determined, and press and disaster officials were notified. Subsequent contacts were made with NOAA's observatories at Newport, Wash., and Palmer, Alaska, and with the Earthquake Mechanism Laboratory at San Francisco. In accordance with operating procedures, the NOAA Public Information Office, Smithsonian Institution, U.S. Geological Survey, National Communication Service, Federal Aviation Agency, and others were informed and kept abreast of developments concerning the earthquake. Throughout Tuesday morning and afternoon (February 9), numerous inquiries were received from press, radio, television, government agencies, and Congressional offices.

Personnel were immediately dispatched from the Earthquake Mechanism Laboratory and the Seismological Field Survey, both at San Francisco, the Albuquerque Seismological Center, and the Special Projects Party at Las Vegas to begin field studies.

Four men with equipment from the Earthquake Mechanism Laboratory arrived in Los Angeles the afternoon of February 9, and, after conferring with other seismologists to coordinate NOAA's field survey efforts, installed four three-component seismic stations in the area, the first of which was operational by 8:00 p.m. Two other men, specialists in fault movement, surveyed the surface faulting and installed fault-movement instruments spanning fresh surface breakage at 5 localities. These instruments, and several small ground control networks installed at other locations, will provide the basic data for a study of seismic afterslip.

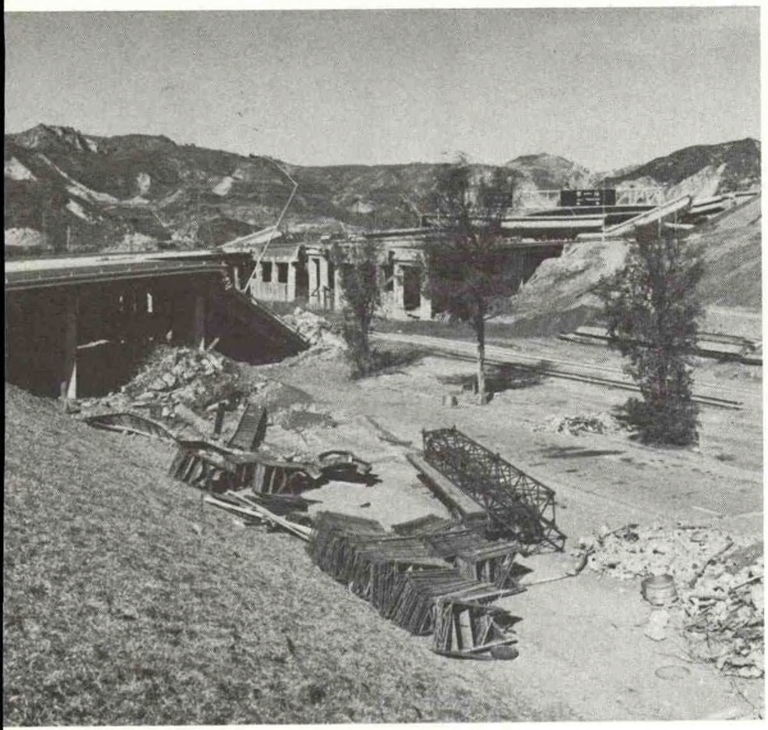
Five men from the Seismological Field Survey arrived in Los Angeles the afternoon of February 9 to assist the two men regularly assigned to that area. This team immediately proceeded to recover strong-motion records from the accelerographs in the area, to install additional instruments, and to survey the earthquake damage. This team also established and manned an operating field office in the Los Angeles area.

Three men and five sets of portable seismic instruments from the Albuquerque Seismological Center arrived at the Los Angeles airport by 7:00 p.m., February 9. By 6:00 a.m., February 10, the instruments were assembled, vehicles were obtained, and installation sites were selected to establish a network surrounding the epicenter at distances of 10 to 18 miles from the epicenter.

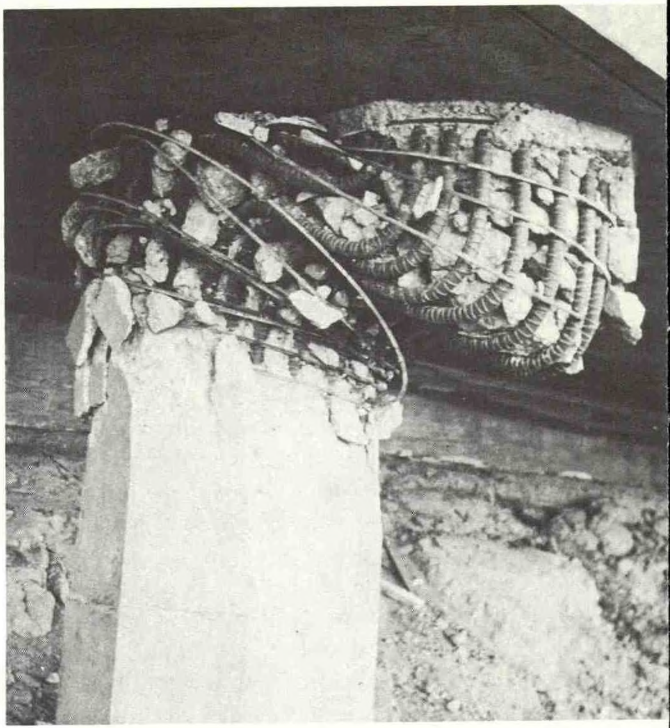
Five men and five sets of instruments from the Special Projects Party left Las Vegas by vehicle at noon, February 9. By approximately 2:30 a.m., February 10, these instrument systems were installed and operating at distances of 5 to 8 miles from the epicenter.

The Assistant Administrator for Plans and Programs, NOAA, contacted the Director, Geological Survey, in regard to the earthquake to insure that related Federal activities were properly coordinated and to establish on-site representatives for each agency. William K. Cloud, Chief of the San Francisco Field Survey, was designated coordinator of the NOAA field operations.

The NOAA-NOS office at Rockville, Md., sent two seismologists (specialists in field work and engineering) to the earthquake area to survey damage and to act in a liaison and consultant capacity, particularly with respect to surface faulting. In addition, a NOAA geophysicist on exchange to the Office of Emergency Preparedness (OEP) accompanied the OEP inspection team and assisted in coor-



Collapsed freeway bridge.



Distortion in supporting column of freeway overpass.

dinating the total emergency effort among U.S. Government, State, and local agencies and the universities.

Within the first week following the earthquake additional instruments were installed in the area to obtain pertinent data for NOAA's planned aftershock studies. Of the hundreds of aftershocks detected, most were in the 2.0 to 3.0 magnitude range (the main shock was 6.6 magnitude). Many were larger than 3.0 and some were as small as 1.0 magnitude. The zone of aftershock activity was around the Soledad Canyon Fault.

The collection of strong-motion seismograms and the servicing and resetting of instruments began immediately after the earthquake. Preliminary analyses were made and processing of representative acceleration and displacement data was begun. The records are being processed in digitized form and will be made available to research seismologists for special analysis. Also, immediately after the earthquake, persons at over 2,000 selected locations (from a computer-generated list) were canvassed for reports about the earthquake's effects. The listing included 784 postmasters and 1,284 other persons, including several hundred structural engineers.

Temporary seismographic sensors were installed for ground-motion studies in areas having anomalously high damage. In the upper San Fernando Valley, instruments were installed along a line from Sylmar Veterans Hospital to the San Fernando Jr. High School, and at Laemany School. A control station for relative motion was placed on a granodiorite outcrop 1 mile north of the Veterans Hospital. Additional ground motion data were obtained at the Pacoima Dam, a permanent strong-motion station, where very high accelerations were recorded during the earthquake. Observed ground motions in areas of intense damage can be correlated with the observed damage and used as a basis to improve building code requirements.

The NOAA geodetic party assigned to California to monitor crustal movement, repeat fault-crossing

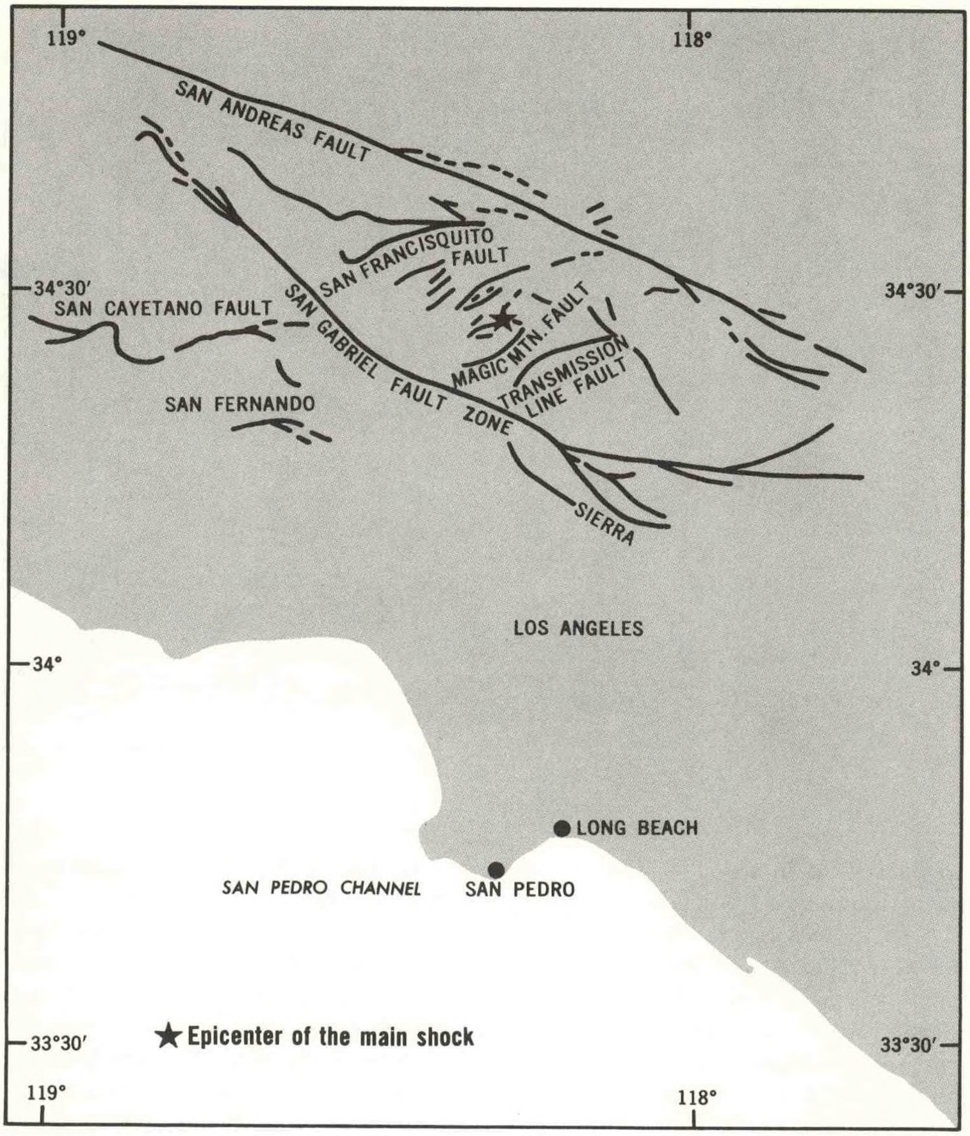
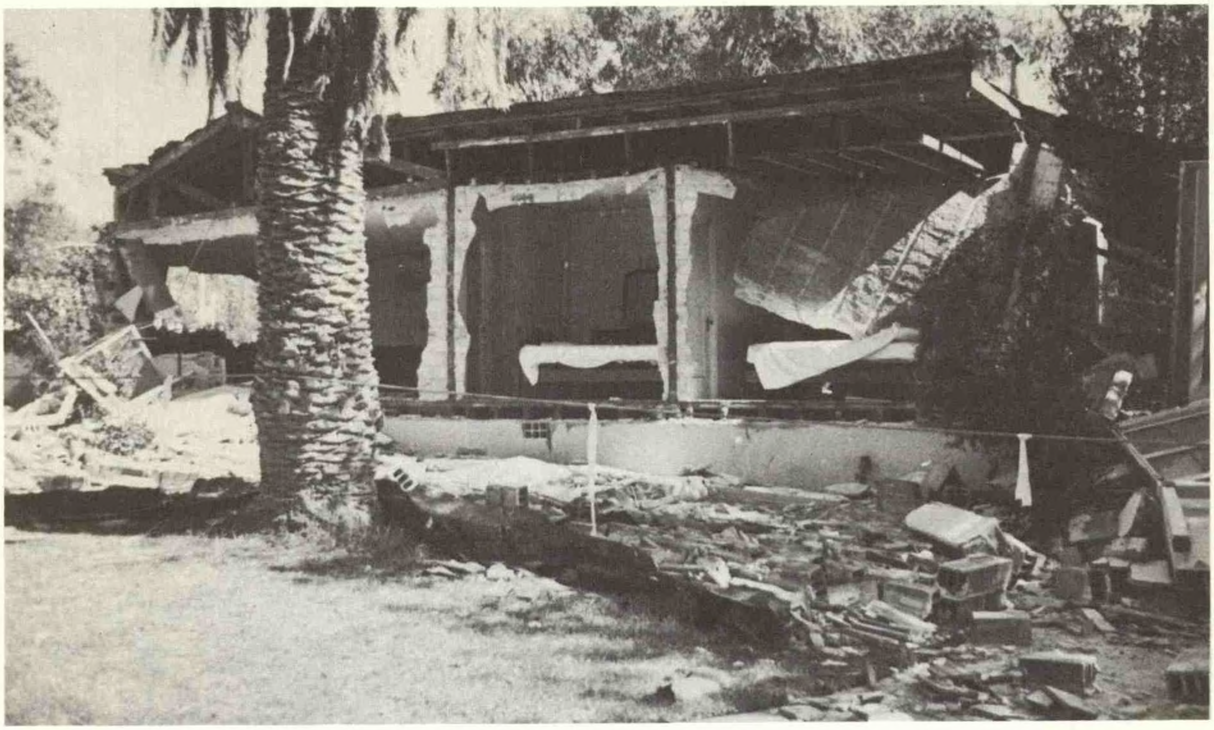


Figure 5. Major fault systems in San Fernando epicentral area.

surveys, and detect fault slippage had been working in the Los Angeles area for a few days immediately preceding the San Fernando earthquake. Preearthquake remeasurements at three of these fault crossings along the San Gabriel and San Andreas faults (fig. 5) indicated no slippage prior to the earthquake. This seven-man party, with a few additional geodetic technicians, was assigned the task of reobserving the networks of geodetic control in the San Fernando region and the San Gabriel Mountains. Some of this control, which consists of triangulation and leveling, had been established by the Los Angeles County Engineer's Office. Personnel from that office are also engaged in reobserving portions of these networks.

The epicenters of the earthquake and major aftershocks are very near the southern end of one of the older arcs of triangulation established in 1932 as part of a broad program for detecting crustal deformation in California. This arc extended from San



Exterior walls stripped from residence.

Fernando to Bakersfield in a dog-leg fashion such that the axis of the arc was perpendicular to the San Gabriel, San Andreas, and Garlock faults. This special survey was repeated in 1952 and again in 1962. The analyses of the resurveys in those years did not indicate any slippage along those major faults. Several weeks will be required to complete the postearthquake field surveys, reduce the measurements, and analyze the results.

Damage has been assessed by personnel from NOAA, and by the Earthquake Engineering Research Institute under NOAA contract. Reports are not yet complete, but studies already are planned to determine the causes of structural failures and the less obvious damages to structures that occurred in hundreds of instances.

The basic requirements of damage assessment and engineering studies are being complimented by ground amplification surveys. These surveys are conducted by a NOAA team from the Special Projects Party in Nevada. The first survey, using a 26 element array in the San Fernando Valley, is complete and the team is making a similar survey in the Glendale area.

In the Los Angeles area, approximately 40 buildings, where strong-motion records were obtained, are being subjected to induced vibrations to determine their resonant periods and to find out whether any changes have occurred in their response characteristics.

Between February 23 and March 4, a geomagnetic survey was made in the epicentral area to measure seismomagnetic effects. A second survey will be necessary to detect any change because there are no preearthquake surveys of the area. A similar geomagnetic field study was made by Japanese geophysicists after a recent Japanese earthquake and repeated a year later. The study revealed that a significant change (over 100 gamma) was caused by the seismic activity. The San Fernando survey consisted of measurements at 15 sites with a proton precession magnetometer. Several of the sites were occupied two or more times during the survey. A base station was maintained in the middle of the epicentral region and used a continuously recording magnetometer to measure the total magnetic field. The base station records will be used to correct the acquired data for diurnal and temporal variations.

CHAPTER 5

Other Related Field Studies

Other principal scientific investigations of the San Fernando earthquake are being conducted by the U.S. Geological Survey, California Institute of Technology, Columbia University, and various Los Angeles County activities.

U.S. Geological Survey

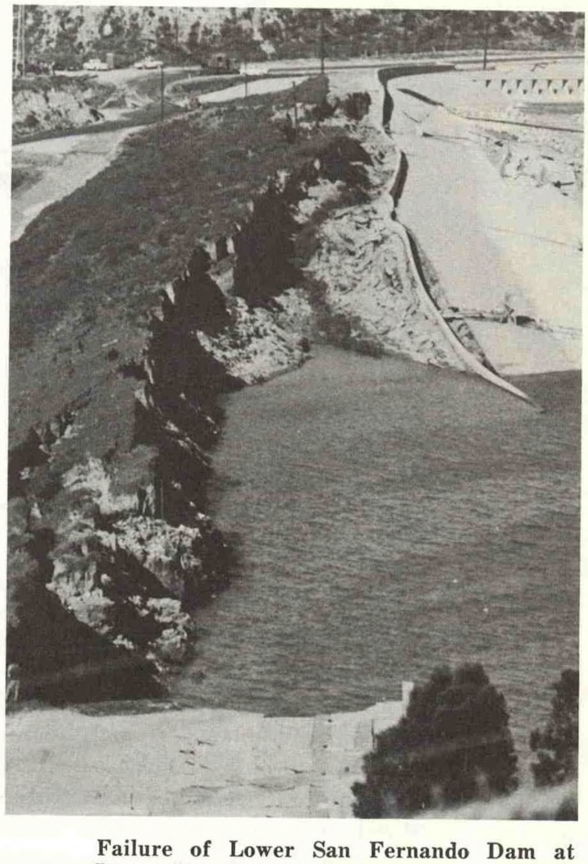
The U.S. Geological Survey (USGS) established 19 seismographs in the epicenter area, within a 4-day period after the earthquake, to augment those of other cooperating organizations. These seismographs were of the type used to record aftershock activity, which the USGS is studying in an effort to relate aftershock activity to the geologic structure of the area, such as the faults involved in the general readjustment to the earthquake series. These studies include determining the location and character of the fault interface, the movement of geologic blocks with respect to each other, and the amount of residual readjustment taking place subsequent to the main shock.

California Institute of Technology

The California Institute of Technology (CIT) has an extensive network of permanent seismic stations in southern California that made it possible to locate the main shock of the earthquake very quickly and very accurately. By February 11, CIT had installed six additional temporary stations to record and locate even very small aftershocks. CIT is particularly interested in the seismicity or historic distribution of earthquakes, but the recorded information can be used to determine fault movements, residual deformation, and geologic relationships in the epicentral area. By February 23, 199 aftershocks of magnitude 3.0 or greater had been located. These represent all of the shocks during the period except for the first hour after the main shock.

Columbia University

The Lamont-Doherty Geological Observatory of Columbia University placed five temporary high-frequency seismographs across the San Andreas fault, 20 miles or more from the epicenter, in a unique experiment to test whether there would be



Failure of Lower San Fernando Dam at Lower Van Norman Lake. Danger of imminent sudden release of waters threatened downstream residential area of 80,000 people. Immediate action consisted of reservoir drainage and reinforcement and evacuation of imperiled area.

Damage at Sylmar Converter Station.

adjustment along the major fault comparable to that of the faults directly affected by the earthquake and its aftershocks.

Los Angeles County

In addition to the NOAA geodetic net, Los Angeles County has established both horizontal and vertical control nets in the southern portion of the disturbed area. Eight temporary earthquake monitoring geodetic stations which are checked every day have been set up by the USGS and two have been installed by the California Institute of Technology. These plus the five "creep meters" installed by NOAA's Earthquake Mechanism Laboratory provide a day-to-day record of deformation, or readjustment of geologic structures affected by the earthquake.

Other Field Surveys

The National Bureau of Standards, at the request of OEP, sent a team of six men to the damage area for one week. Two reports of the findings are in preparation: one describing the damage in detail and the other analyzing the damage by types of facilities, such as hospitals, schools, post offices, General Services Administration buildings, and the like.

Other inspection teams in the area include: the Veterans Administration, in regard to hospitals; Bureau of Public Roads; California Institute of Technology, representing the National Science Foundation; American Iron and Steel Institute; and the Structural Engineering Society of Southern California on behalf of the Los Angeles County Engineers.

CHAPTER 6

San Fernando Earthquake Publicity

Initial publicity efforts in NOAA concentrated on press, radio, and TV releases. These were expedited within a few hours by telephone interviews and during the next few days by personal interviews at the National Earthquake Information Center (NEIC) headquarters. Two television news spots were made, one by WRC-TV, Washington, at the NEIC Office and another by WTOP-TV, Washington, at their studio. NBC News, New York, featured an interview with a NOAA seismologist on the nationally televised "Today Show" on the Wednesday morning (February 10) following the earthquake. *The Washington Post* sent a reporter to the NEIC Office for an interview Wednesday afternoon. CBS News, Washington, sent a correspondent (Bernard Kalb) and film crew to the NEIC Office for a news feature, televised nationally Thursday morning (February 11).

Considerable activity involving the news media centered about the Earthquake Mechanism Laboratory (EML) in San Francisco. On February 9, three TV film units visited EML; the footage that was taken was shown the evening of February 9 in San Francisco. EML staff members appeared on one TV show on February 9 and again on another TV show on February 10. EML answered numerous telephone calls from TV and radio stations in San Francisco. Many of the releases by NEIC and EML were disseminated through national news services such as AP, UPI, NBC, and CBS.

The Seismological Field Survey arranged a press conference at California Institute of Technology during which NOAA, CIT, and EERI representatives presented their findings from engineering seismology studies. Particular emphasis was placed on the value of the strong-motion seismograms obtained at stations near the earthquake epicenter and in the severely damaged areas. Most of the strong-motion instruments are privately owned, but are maintained by the Seismological Field Survey. NOAA and CIT provided a display of significant strong-motion records and pictures of damaged structures—bridges, hospitals, homes, and utilities—which were carried in the press announcements.

A major public information service was the early publication of results from the field and laboratory investigations in *The San Fernando, California, Earthquake of February 9, 1971: A preliminary report published jointly by the U.S. Geological Survey and the National Oceanic and Atmospheric Administration,* Geological Survey Professional Paper 733, for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 — Price $2.25 (paper cover). Though many of the papers are written for the specialist, the general reader and public officials will find most of the papers and 224 illustrations in this 254-page volume very useful in learning about the earthquake and its effects.

Overturned elevator and stair tower at Olive View Hospital.

CHAPTER 7

Findings and Recommendations

NOAA's response to the San Fernando earthquake was prompt, and its field activities were timely and coordinated despite the difficulties encountered within the damaged area by disruption of communications and transportation facilities. Liaison with other organizations operating in the disaster area was maintained at all times, including interagency coordination involving the U.S. Geological Survey, Office of Emergency Preparedness, and National Bureau of Standards, and cooperation with various State and local agencies and universities. Findings from the postearthquake investigations and recommendations follow.

1. **Finding:** More instrumental records of all types were obtained during and after the San Fernando earthquake—principally by NOAA, the USGS, and academic institutions—than from any previous earthquake in this country. Valuable lessons can be learned from thorough analyses of these records and the knowledge gained can be applied to other earthquake-prone areas of the Nation. The preliminary earthquake report by the USGS and NOAA has proven extremely valuable, but much work remains to be done.

   Recommendation: *NOAA recommends that an extensive postearthquake analysis be undertaken immediately.* NOAA's role in this analysis should include: (1) collection and analysis of vibratory ground motion data, available from the strong-motion seismograph network; (2) collection and analysis of "felt" earthquake effects and damage information; (3) studies of structural damage, in cooperation with the Earthquake Engineering Research Institute; (4) investigation of earthquake mechanisms; and (5) preparation of a comprehensive report on these findings.

2. **Finding:** Although the San Fernando earthquake produced more strong-motion records than any earthquake in history, most of the instruments were placed at sites designated by current building codes. As a consequence, instruments were concentrated in multistory buildings and other large structures. This type of coverage is extremely important because of the capital investment, and because each building is unique and thus provides the engineer with invaluable data. However, it is impossible to predict the locations of future earthquakes, and therefore it is imperative that instruments be located in accordance with more comprehensive network designs that also relate to geologic materials, fault systems, seismicity, and free-field measurements as well as manmade structures.

   Recommendation: *It is recommended that NOAA design a more comprehensive network for location of seismic instruments,* incorporating the instruments already installed as part of the building code regulations into the more comprehensive network system.

3. **Finding:** NOAA's contract with the Earthquake Engineering Research Institute brought together a coordinated group of leading scientists and engineers that responded immediately to the earthquake emergency. This response provided field teams, local utilities, and transportation and service groups with technical advice, and contributed to the organization and early publication of a comprehensive technical report.

   Recommendation: *NOAA recommends that this type of contractual service be expanded* to insure that the best possible resources are available for effective response to future destructive earthquakes.

4. **Finding:** The San Fernando earthquake brings into sharp focus the vital need for an expanded national program in earthquake hazard reduction. The extensive damage (1/2 to 3/4 billion dollars) from this earthquake of only moderately severe magnitude (energy release) clearly demonstrates the Nation's lack of fundamental knowledge needed to prevent such disasters and emphasizes the inadequate mechanisms that are used in applying what knowledge is available. The tragic events at the Veterans Administration Hospital and the Olive View Hospital and the near catastrophe at the San Fernando Dam, clearly indicate this need.

Recommendation: *NOAA recommends that an accelerated National Earthquake Hazards Reduction Program be undertaken immediately.* As part of the recommended accelerated national program, NOAA recommends that those Federal agencies with the capability to direct a national effort participate in a Joint Program Plans Committee to strengthen coordination of the related programs. This Committee also should serve as the focal point where academic institutions and other interested groups can coordinate field activities after future earthquakes. This function is needed to insure optimum utilization of the Nation's scientific capabilities in reducing earthquake hazards, preparing for effective emergency operations, and planning for rational growth and development in earthquake-prone regions.