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EARTHQUAKE HAZARDS PROGRAM

THE BALANCED ROCK HILLS LANDSLIDE AN EFFECT OF THE SEPTEMBER 2, 1992, ST. GEORGE EARTHQUAKE

by Bill D. Black
Utah Geological Survey

House in the Balanced Rock Hills subdivision destroyed by landsliding. Photo by B.D. Black.

The major effect of the Richter magnitude (M_L) 5.8 earthquake on September 2, 1992 east of St. George, was a destructive landslide in the town of Springdale, referred to as the Balanced Rock Hills landslide (figures 1 and 2). The landslide damaged two water tanks (one of which was abandoned) and destroyed several storage buildings and three homes in the Balanced Rock Hills subdivision (cover photo). The landslide also ruptured buried and above-ground utilities in the subdivision and along State Route (SR) 9, and temporarily blocked SR 9 leading to Zion National Park (figure 3). A smaller slope failure west of the Balanced Rock Hills landslide, termed the Paradise Road landslide (figure 1), was also triggered by the earthquake but caused no damage.

GEOLOGY

Three geologic units are mapped by Cook (1960) in the area of the Balanced Rock Hills subdivision: (1) the Jurassic-age Kayenta Formation, (2) the Triassic-age Moenave Formation, and (3) the Triassic-age Chinle Formation (Petrified Forest Member). The Springdale Sandstone Member of the Moenave Formation (Harshbarger and others, 1957) forms a prominent cliff ledge north of the subdivision, above the main scarp of the landslide (figure 2). The landslide involved lower units of the Moenave Formation and the Petrified Forest Member of the Chinle Formation, and included colluvium containing rock-fall debris derived from the Kayenta and Moenave Formations.

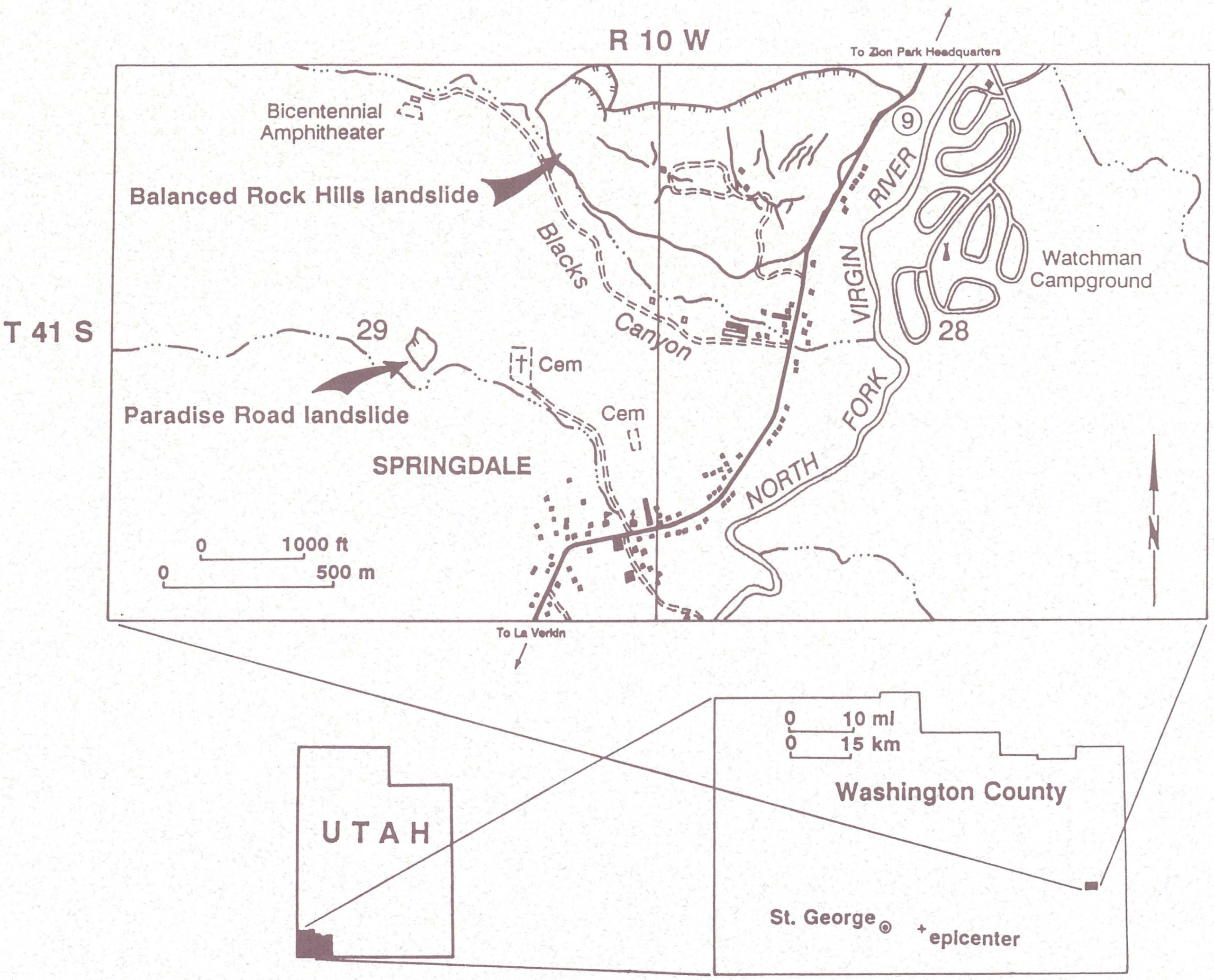

Figure 1. Location map.

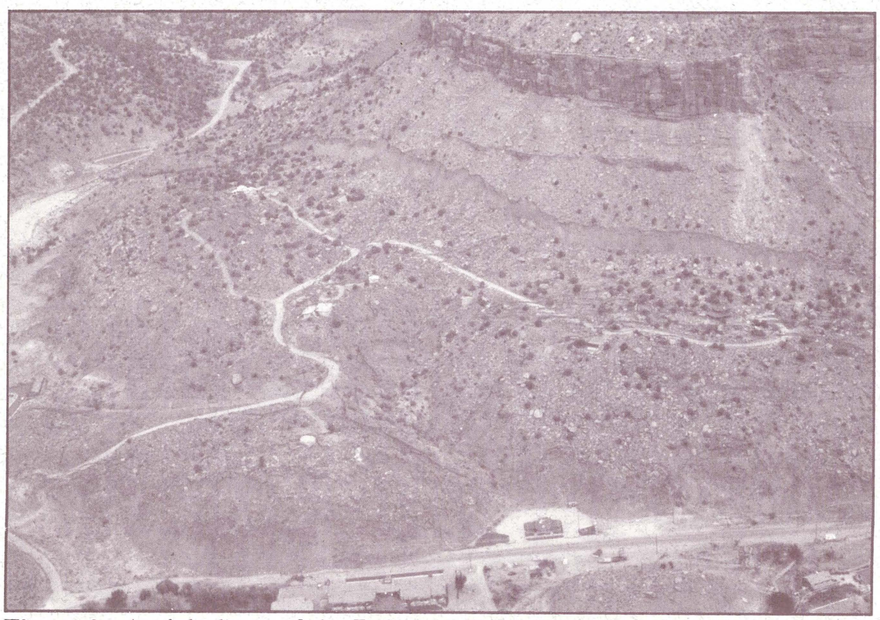

Figure 2. Aerial photo of the Balanced Rock Hills landslide. Photo by B.J. Solomon.

Although the Moenave Formation is not known to be susceptible to landsliding, the underlying Petrified Forest Member of the Chinle Formation contains abundant clay and is susceptible; a significant number of deep-seated landslides occur in the Petrified Forest Member in southern Utah (Harty, 1991). The basal slide plane is likely within the Petrified Forest Member, and older landslides in this unit are present in the Springdale area (Harty, 1990). A geologic reconnaissance for the Southern Utah Bicentennial Amphitheater (Kaliser, 1975), in Black's Canyon west of the Balanced Rock Hills landslide (figure 1), also noted potential slope instability in this unit.

LANDSLIDE DESCRIPTION

The Balanced Rock Hills landslide is a complex block slide likely involving both rotational and translational elements of movement. Although movement was initiated by ground shaking, the landslide moved slowly and continued moving for several hours following the earthquake. The slide has a clearly defined main scarp averaging 40 feet (12 m) high (figure 4), as well as numerous fissures and minor scarps that form a broken, irregular topography within the slide mass. The orientation of these scarps and fissures indicates that the landslide likely moved in several coherent blocks. Smaller slope failures have also formed on the oversteepened toe.

Figure 3. Toe of the Balanced Rock Hills landslide near State Route 9. Note ruptured utility lines in the toe of the slide. Photo by B.D. Black.

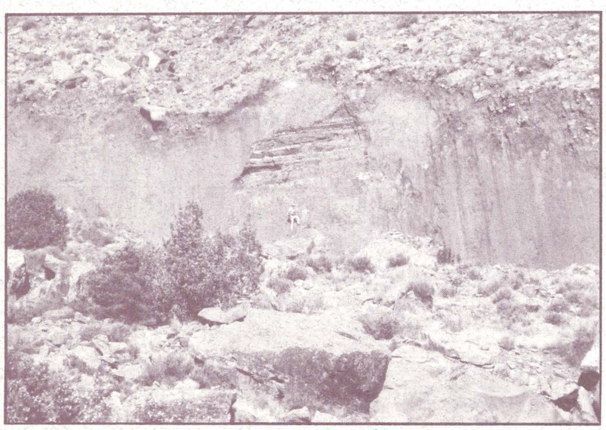

Figure 4. Main scarp of the Balanced Rock Hills landslide. Photo by Susan Olig.

The landslide measures roughly 1,625 feet (495 m) from the main scarp to the toe, with a width of about 3,595 feet (1,096 m). The slide plane is not visible in drainages which dissect the landslide. With a calculated surface area of 4.4 million square feet (400,000 m^2) and an estimated average depth to the projected slide plane of 110 feet (34 m), the total volume of the landslide is about 18 million cubic yards (14 million m^3). By comparison, the 1983 Thistle landslide in Spanish Fork Canyon was about 29 million cubic yards (22 million m^3) (Kaliser and Fleming, 1986).

LANDSLIDE CAUSES

Landslide studies in the Springdale area have noted a correlation between precipitation and slope failures. Kaliser (1975) cites a verbal communication with Wayne Hamilton, a geologist with Zion National Park, who indicated that the hill on which the (now abandoned) Springdale water tank rests in the Balanced Rock Hills subdivision (figure 2) was differentially moving on the order of two to three inches (5-8 cm) per year. Hamilton (1992) noted ten inches (25 cm) of precipitation and 1.3 inches (3.3 cm) of movement between August 1974 to June 1975. Another landslide in Springdale in May, 1988, was also attributed in part to increased precipitation; this landslide occurred following a total of 4.33 inches (11 cm) of precipitation in a 10-day period in April of that year (Harty, 1990).

A combination of long-term marginal stability and earthquake ground shaking is the most likely cause of the landslide. The slide is roughly 28 miles (45 km) from the epicenter of the St. George earthquake (figure 1); Keefer (1984) predicts a maximum distance of approximately 20 miles (32 km) for coherent landslides of this type to occur from the epicenter of a M_L 5.8 earthquake. However, if failure of a slope is imminent before an earthquake, a landslide could be initiated even by weak ground shaking (Keefer, 1984). Increased precipitation, which was about 120 percent of normal for the current water year in the Dixie region (Utah Climate Center, 1992), may have contributed to slope instability. Weather records from Zion National Park, the closest weather station to Springdale, showed only 0.67 inches (1.7 cm) of precipitation between August 15th, 1992, and September 1st, 1992. However, Al Warneke (local resident, verbal communication to Gary E. Christenson, September, 1992) reported 0.9 inches (2.3 cm) of precipitation in Springdale in 20 minutes on August 25, 1992, which caused local flooding along SR 9 near the landslide.

Other possible sources of water include effluent from septic systems or leaking water lines or tanks in the Balanced Rock Hills subdivision. However, no water was observed issuing from the slide, and the role of water from these sources is unclear, particularly in light of the Paradise Road landslide (figure 1) in an undeveloped area lacking any of these potential sources.

LANDSLIDE MONITORING AND HAZARD POTENTIAL

Following the landslide, the Utah Geological Survey (UGS) helped the town of Springdale establish Electronic Distance Measuring (EDM) reflector stations on each landslide block based on our mapping of prominent minor scarps and fissures (figure 5). These will be resurveyed periodically by Alpha Engineering, Springdale town engineers, to evaluate movement and response of the landslide to rainfall and future earthquakes. Surveys conducted since the earthquake show no evidence of any renewed movement (Doug Schneider, Alpha Engineering, written communication, October, 1992).

A potential hazard exists for further movement of the landslide or portions of the slide, and for smaller slope failures on the oversteepened toe. The potential also exists for another large earthquake in the region to reactivate the landslide. Precipitation or water from other sources entering the numerous cracks and fissures on the landslide and infiltrating the slide plane could cause further movement or slope failures. In addition to the potential for further movement, other hazards now exist on and around the periphery of the landslide, including: (1) debris flows or floods off the now-disrupted landslide surface during cloudburst storms, (2) continuing settlement, (3) erosion in disrupted drainages, (4) piping, and (5) collapse and widening of open fissures.

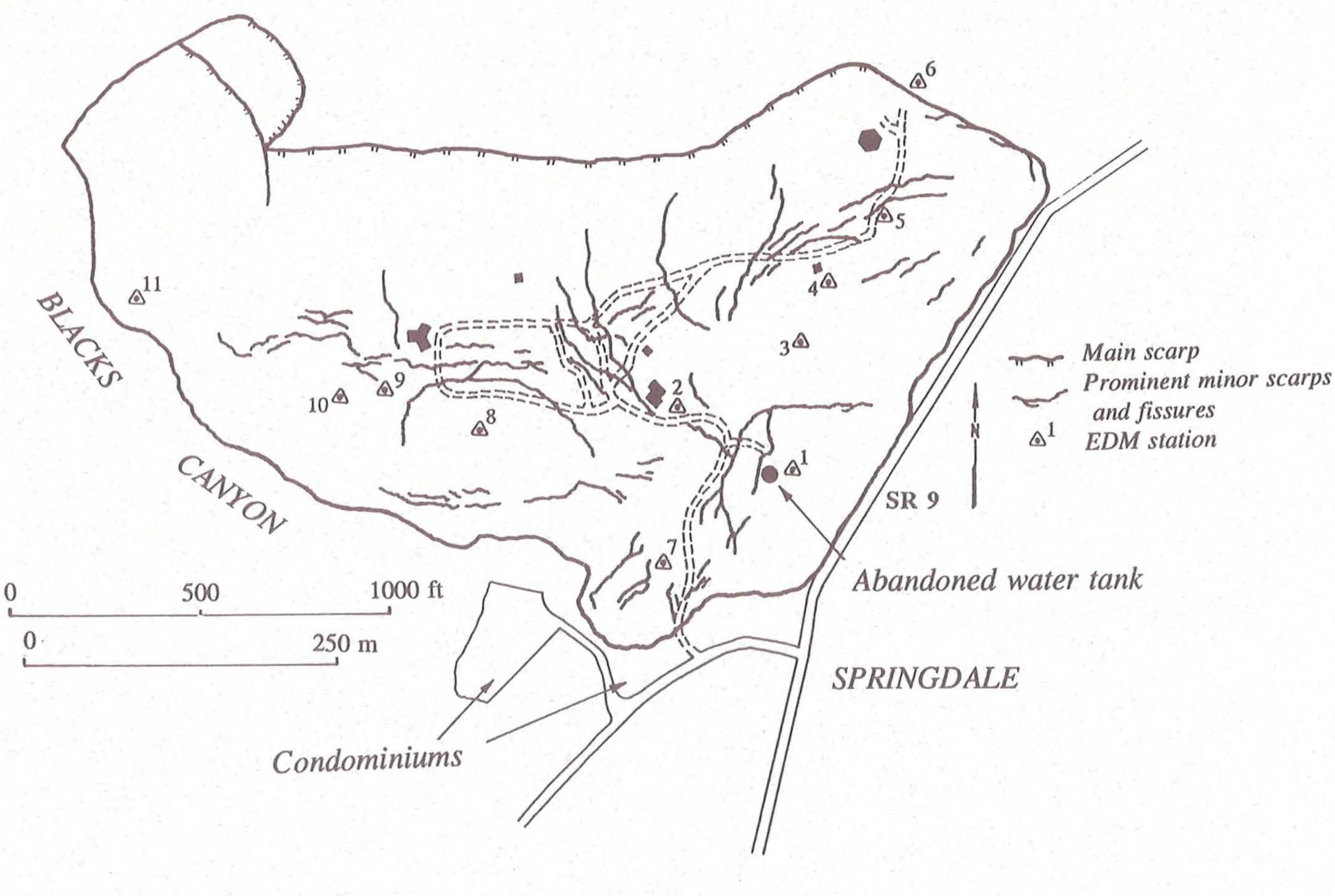

Figure 5. Main scarp, prominent minor scarps and fissures, and location of EDM stations on the Balanced Rock Hills landslide.

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USGS FUNDS UGS PROJECTS

Two Utah Geological Survey (UGS) proposals have been selected for funding through the 1993 National Earthquake Hazards Reduction Program administered through the U.S. Geological Survey (USGS). "We are very pleased that our proposals have been chosen from the 330 submitted to the USGS," says State Geologist M. Lee Allison. "These two projects will provide Utahns with important information about earthquake hazards."

The UGS will receive over $23,000 to map the southernmost, recently active segment of the Wasatch fault zone, from Payson to Nephi in Utah and Juab Counties. "The Wasatch fault zone is recognized as the most active fault zone in Utah, and the Nephi segment has had the most recent surface-rupturing earthquake on the Wasatch fault, about 300-500 years ago," explains Kimm Harty, UGS geologist who proposed the project. "Geologic maps depicting the Wasatch fault are the basis for statewide hazard maps, detailed site investigations for critical facilities, and local government geologic hazards ordinances." The USGS has completed and published geologic maps of the northern segments of the Wasatch fault but mapping has not been completed for the Nephi segment. "This project will enable us to finish the series," Harty said.

The USGS will also provide over $17,000 for the UGS to produce four publications for the general citizenry of Utah. "After more than five years of intensive earthquake research in Utah, we have a lot of new information that can be used in public policy making, reducing hazards and risk, and increasing public awareness," says Sandra Eldredge, UGS geologist who proposed this project. "The most effective way to get the appropriate information to specific user groups is to produce publications tailored to their needs," explains Eldredge. The four information brochures include 1) a Utah homebuyer's guide to earthquake hazards, 2) a full-color booklet describing the Wasatch fault, 3) a pamphlet on the ground-shaking hazard throughout Utah, and 4) a series of page-size, liquefaction-potential maps for Wasatch Front counties. These new products will be part of the UGS's Public Information Series and will be free to the public.

EARTHQUAKE ACTIVITY IN THE UTAH REGION
APRIL 1 - JUNE 30, 1992

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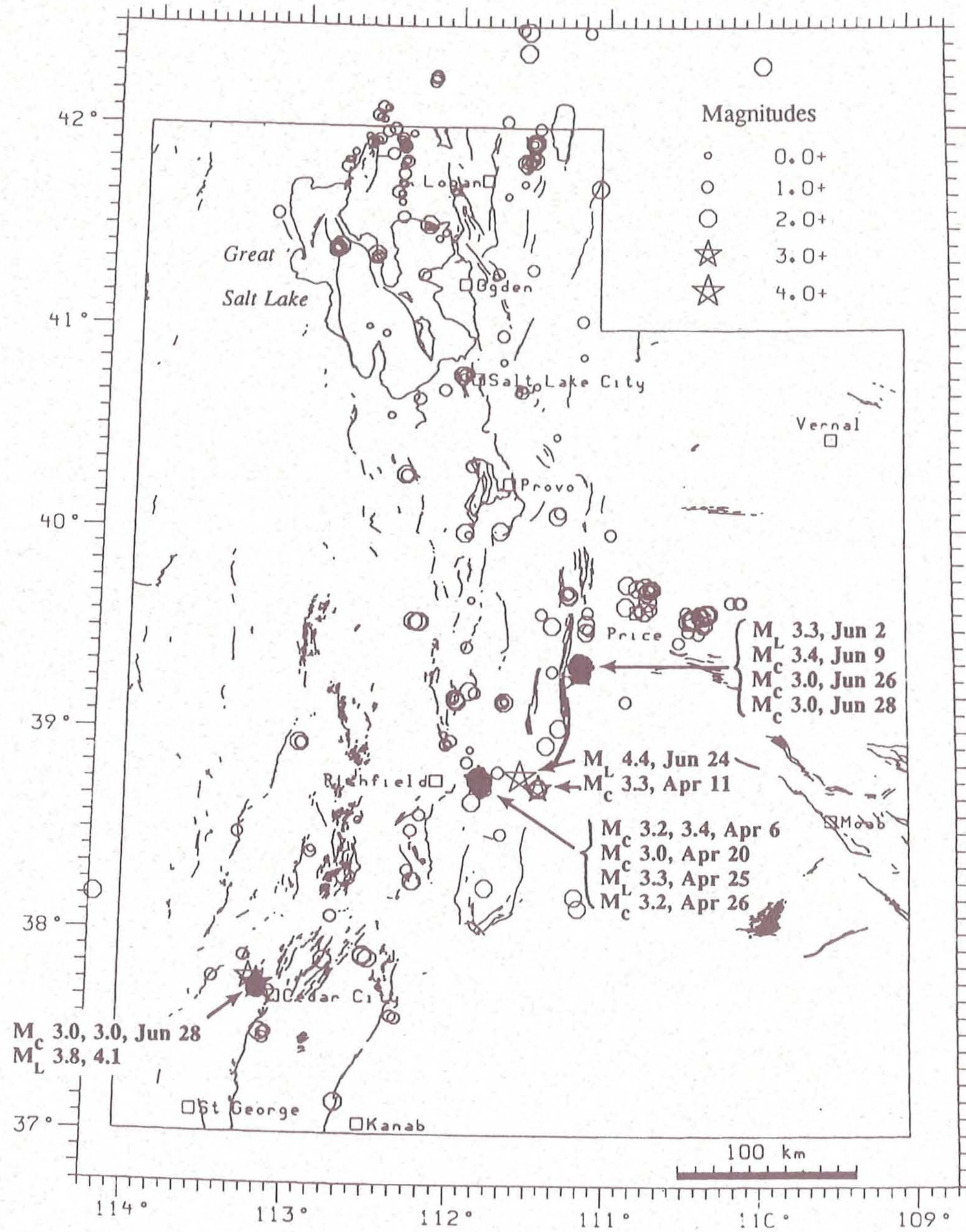
During the three-month period April 1 through June 30, 1992, the University of Utah Seismograph Stations located 515 earthquakes within the Utah region. The total includes two earthquakes in the magnitude 4 range, 13 earthquakes in the magnitude 3 range, and 206 in the magnitude 2 range. Earthquakes which have magnitudes of 3.0 or larger are plotted as stars and specifically labeled on the epicenter map. There were 11 earthquakes reported felt during the report period. (Note: Magnitude indicated here is either local magnitude, M_L, or coda magnitude, M_C. All times indicated are local time, which was Mountain Daylight Time).



Southern Wasatch Plateau (20-50 km east of Richfield: Several earthquake clusters occurred near the epicenter of the 1989 M_L 5.4 southern Wasatch Plateau earthquake. A swarm of 162 earthquakes occurred 16-18 km to the southwest of the 1989 main shock, primarily on April 5-6 and on April 24-26, with shocks ranging in size from magnitude 0.7 to 3.4, including five earthquakes in the magnitude 3 range. Twenty kilometers to the southeast of the 1989 main shock, a cluster of four earthquakes occurred on April 11 and 12, including a shock of magnitude 3.3. The largest earthquake (M_L4.4) of the report period occurred on June 24 about 8 km southeast of the 1989 main shock.

Book Cliffs/Price: Three clusters of coal-mining related earthquakes (magnitude 1.5 to 3.4) occurred during the report period.

Cedar City: A sequence of 34 locatable earthquakes, and 26 too small to be located, occurred northwest of Cedar City on June 28th. The swarm occurred in two distinct flurries. The first lasted about two hours, beginning 40 minutes after a magnitude 7.5 earthquake in southern California. The second primarily occurred 12-14 hours later, continued intermittently into the next day (June 29th), and included shocks of magnitude 3.0, 3.8, and 4.1.

Bear River Range (northeast of Logan): A cluster of 19 earthquakes, ranging in magnitude from 0.7 to 2.9, occurred in the report period.

Great Salt Lake: A cluster of 16 earthquakes occurred beneath the northwestern arm of the lake, occurring primarily on April 2nd with magnitudes from 1.0 to 2.8.

Salt Lake Valley: A series of 6 earthquakes occurred beneath the north-central portion of the Salt Lake Valley, primarily on June 3rd.

REMOTE SEISMICITY TRIGGERED BY THE M 7.5 LANDERS, CALIFORNIA EARTHQUAKE OF JUNE 28, 1992

by
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Smith, R.B., Nava, S.J., Arabasz, W.J., and Pechmann, J.C.,
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Gomberg, J., U.S. Geological Survey, Denver;
Brune, J.N., and DePolo, D., University of Nevada, Reno;
Beroza, G., Stanford University;
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[The following abstract was presented at the 1992 Fall Meeting of the American Geophysical Union in San Francisco and is reprinted with the permission of P.A. Reasenberg. Ed.]

An intense, widespread and sudden increase in seismicity, which began within minutes after the Landers earthquake at numerous remote sites in the western United States (figure 1), plainly establishes seismic triggering at distances up to 1250 km (17 rupture lengths) from the Landers earthquake. The most intense triggering occurred along the southern margins of the Great Basin. The largest triggered earthquake (M 5.6) was located near Yucca Mountain, Nevada. All of these sites have a history of persistent seismicity and most are characterized by recent volcanism and geothermal activity. At some sites triggered earthquakes began within 40 seconds after the local arrival of the Landers S wave. Postseismiccompressional strain recorded by the dilatometer at Devils Postpile closely resembles the seismicity rate at nearby Long Valley. Historically, the 1906 (M 8 1/4) earthquake on the San Andreas fault may have remotely triggered several earthquakes at regional distances, including a M 6.2 event in the Imperial Valley (700 km distance) 11 hours after the main shock. Because predicted static stress changes

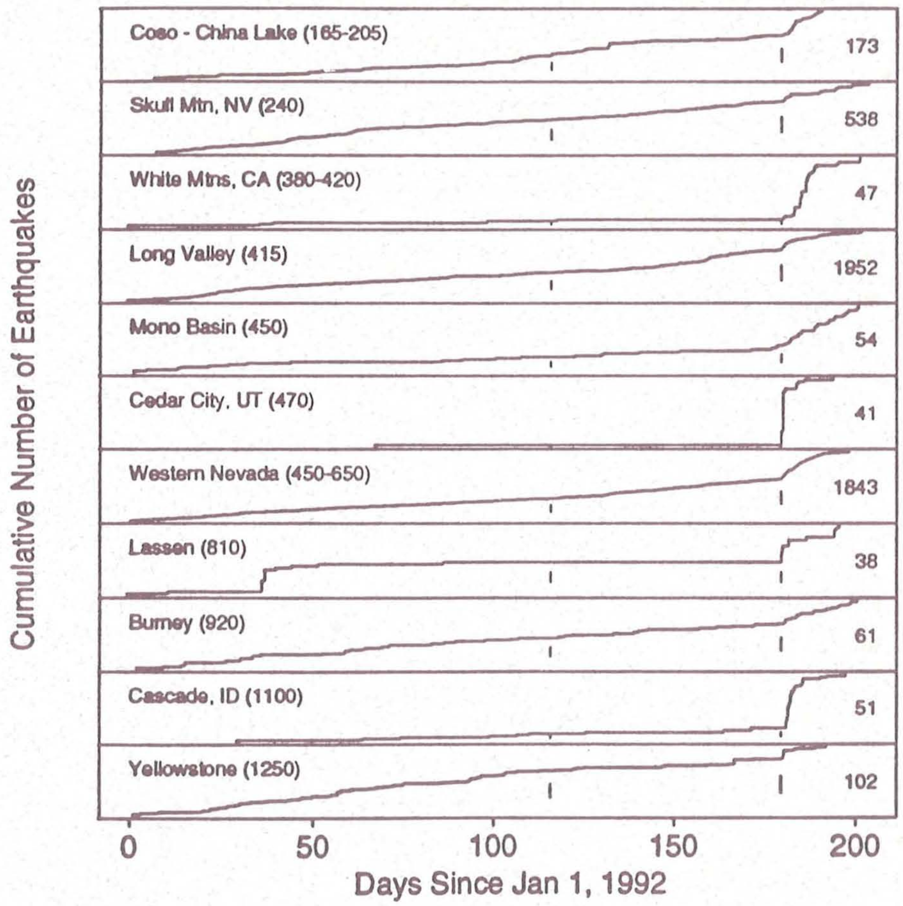

Figure 1. Cumulative number of earthquakes in selected zones, beginning January 1, 1992. Numbers in parentheses are distances (km) from Landers earthquake. Total number of earthquakes in each zone is shown at right. Vertical lines mark times of the April 23, 1992, Petrolia (Cape Mendocino) (M=7.0) and Landers (M=7.4) earthquakes.

for the Landers earthquake at distances greater than about 300 km are smaller than daily tidal stress fluctuations, they seem an unlikely explanation for all of the triggering. Other mechanisms under consideration involve the dynamic stresses associated with the passage of seismic waves, either acting directly (and nonlinearly) on faults, or nonlinearly interacting with pore fluids (pump action) or magma (liberating gas bubbles).

FUTURE SEISMIC HAZARDS IN SOUTHERN CALIFORNIA

Phase I: Implications of the 1992 Landers Earthquake Sequence

Summary and excerpts from a report by the Ad Hoc Working Group on the Probabilities of Future Large Earthquakes in Southern California

Following the most intensive review yet conducted of the seismic effects of the June 28, 1992 Landers, California earthquake, a report entitled "Future Seismic Hazards in Southern California, Phase I -- Implications of the 1992 Landers Earthquake Sequence," was released by the U.S. Geological Survey, the California Office of Emergency Services, and the California Department of Conservation. These federal and state agencies convened the panel of 12 scientists and public safety administrators known as the "Working Group on the Probabilities of Future Large Earthquakes in Southern California" which prepared the report. The panel evaluated the probability for a magnitude 7 or larger earthquake in southern California during the next year. They concluded that the probability stands at 4-12 percent. This figure is based on a higher than normal rate of large earthquakes in southern California since 1985.

"Although our revised estimates indicate the probabilities for a large earthquake are as high as 12 percent during the next year, it also means there's an 88 to 96 percent chance that it won't happen," said Keiiti Aki, Science Director of the Southern California Earthquake Center, and chairman of the working group that produced "Future Seismic Hazards in Southern California."

In this "Phase I" report the group made no assessment of how much the overall probabilities for a large earthquake in southern California may have increased during the next 30 years, but will do so in a later, more comprehensive document that will be completed in 1993. In 1988 a similar working group estimated there was a 60 percent probability of a magnitude 7.5 or larger earthquake occurring along the San Andreas in southern California by the year 2018 (see WFF, 1989, v. 5, no. 3, p. 8-10). The report confirms what many Californians have suspected-- there has been a significant increase in the rate of earthquake activity in southern California in the last decade. In the decade starting in 1985, earthquakes of magnitude 5 and larger have occurred in southern California at nearly twice the rate as in the previous four decades. In that same period of time, earthquakes of magnitude 6 and larger occurred at three and one-half times the rate of occurrence between 1945 and 1985.

At magnitude 7.5, the Landers earthquake is the third largest earthquake in California in this century, with only the 1906 San Francisco earthquake (8.3) and the 1952 Arvin-Tehachapi earthquake (7.7) being larger. The 1989 Loma Prieta earthquake (7.1), while far more destructive than the Landers earthquake, released only about one-fourth the amount of energy of the Landers quake. The 6.6 Big Bear earthquake that occurred three and one-half hours after the Landers earthquake is described in the report as an aftershock of the Landers quake, and the April 22 Joshua Tree earthquake (6.1) is regarded as a preshock to the Landers quake. The three earthquakes and their aftershocks are regarded as the "Landers sequence." There have been more than 30,000 aftershocks since June 28, and in the three-year period beginning September 1, 1992, the chances of aftershocks capable of damage (magnitude 5 and larger) are about 95 percent.

In addition to the short-term estimates for large earthquakes in southern California, the report reviews various scenarios for earthquakes on the San Andreas and other southern California earthquake faults. The intensity, or amount of ground shaking that would occur in any of the earthquake scenarios, was of special concern to the scientists, and maps that depict the intensity of shaking in these earthquakes are included in the report. "There was a high degree of shaking associated with the Landers earthquake," Aki said, "but the strongest shaking occurred in sparsely populated areas, so did not cause major loss of lives or property. Most of the future earthquakes we simulate would occur closer to urbanized areas, and therefore would cause much greater damage."

The effects of the Landers sequence on other, lesser known, faults are also discussed in the report and the possibility of a moderate to large earthquake occurring on even unknown faults is not ruled out. The increased stress over a broad region might be large enough to push some unrecognized fault toward the failure point.

In addition to discussing the probabilities for future earthquakes on various southern California faults, the report also touches on some of the more interesting facets of the Landers sequence, such as the large number of smaller earthquakes that occurred at various places in the western United States in the wake of the Landers quake. While admitting that they do not yet understand the mechanics of this "triggering," they confirm its reality (see also previous article, this issue).

U.S. Geological Survey Director Dallas Peck said, "This relatively rapid, coordinated evaluation by state, university, and federal investigators has advanced our understanding of the probabilities of large earthquakes in southern California, and has helped focus our attention on issues of preparedness and mitigation that must now be addressed." The report was reviewed and approved by the National Earthquake Prediction Evaluation Council and the California Earthquake Prediction Evaluation Council. Copies can be purchased from the California Department of Conservation, Division of Mines and Geology, Geologic Information Publications, 801 K Street, Mail Stop 14-33, Sacramento, CA 95814-3532, for $13.00 per copy, postpaid.

UTAH EARTHQUAKE ADVISORY BOARD NEWS

by Janine L. Jarva
Utah Geological Survey

The January 7, 1993 meeting of the Utah Earthquake Advisory Board (UEAB) centered on the consideration of proposed Federal Earthquake Insurance legislation. Presentations were made by Harold Yancey, former Utah Commissioner of Insurance and Del Ward, a Salt Lake City architect who serves on the Mitigation Committee of the Earthquake Project. The goals of the Earthquake Project are to increase building code requirements and code compliance to protect life and property, make earthquake insurance readily available and affordable, and foster a private - federal insurance partnership.

Commissioner Yancey described the still-mounting insurance costs of Hurricane Andrew, the largest hit by a single event that the U.S. insurance industry has ever taken. He said that as a result of this disaster, the current pending Federal Earthquake Insurance legislation may be changed in concept to take all hazards into account rather than just earthquakes. Earthquakes are different from other hazards because of the uncertainty of the risk predictions. The questions "where" and "when" greatly affect the losses. For example, a major earthquake in Los Angeles, California at 4 p.m. could result in $50 billion in insurance losses. The total surplus of all companies writing property casualty business in the U.S. is only $160 billion. Such a major event could put an entire state economy in jeopardy. Protecting against catastrophic vulnerability becomes a national responsibility when the consequences of the event will have national economic repercussions.

As it now stands, H.R. 2806 would mandate the purchase of an earthquake endorsement on all homeowners insurance policies, as well as requiring certified state mitigation programs in those states determined to have an earthquake exposure (39 out of the 50 states). This would spread the risk broadly enough that the cost to an individual homeowner would be approximately $30 per year. The current rates in Utah for earthquake insurance as an endorsement on a homeowners policy range from $1.60 per $1,000 value on wood-frame homes to $7.75 per $1,000 value on brick homes, with a 5 percent deductible. Former Commissioner Yancey is endorsing H.R. 2806.

The Mitigation Committee of the Earthquake Project develops technical input for Federal Earthquake Insurance legislation and acts in an advisory capacity to the National Committee on

Property Insurance and the industry in general. Del Ward pointed out that earthquake insurance is currently provided by insurance companies as a service. It is not pushed very hard by the industry because the actuarial tables used to predict losses and thereby determine earthquake insurance premiums are not very accurate. The insurance industry sees a catastrophic loss potential for themselves in the event of a major earthquake and are very anxious to see federal legislation passed that would place a cap on their risk exposure. The Mitigation Committee of the Earthquake Project believes that H.R. 2806 should remain focused on earthquake insurance. Its technical aspects were developed specifically to deal with the infrequent and unpredictable nature of earthquakes and its viability may be compromised by attempts to turn the legislation into Federal Catastrophic Insurance.

The UEAB voted unanimously to draft a resolution stating their support in concept of H.R. 2806 and offering their advice to the Utah congressional delegation on any federal legislation involving earthquake hazards.

SEISMIC DESIGN OF EMBANKMENT DAMS SHORT COURSE ANNOUNCEMENT

A short course on the Seismic Design of Embankment Dams will be held by the American Society of Civil Engineers Wasatch Front Branch Geotechnical Section on **May 14, 1993, 8:30 a.m. - 5:30 p.m. in Salt Lake City, Utah.** Topics include:

- History and performance of embankment dams
- Earthquake geology
- Liquefaction
- Pseudo-static and deformation analysis
- Seismic design provisions

Featured speakers will include Walt Jones, Jeff Keaton, Les Youd, Dave Marble, Kyle Rollins, and Loren Anderson. The majority of the content of this short course will be applicable to all structures. Therefore, engineers outside the dam design profession are strongly encouraged to attend. Additional information on the location and registration for this important short course will be provided in future announcements. Or you may contact Steve Brown at CH2M HILL, 4001 South 700 East, Suite 850, Salt Lake City, UT 84107, (801) 269-0110, fax 801-269-1115.

NEW PUBLICATIONS AVAILABLE FROM EPICENTER

In its mission to educate citizens about Utah's seismic risk and to help them prepare themselves and their communities, the Utah Earthquake Preparedness Information Center (EPICenter) of the Utah Division of Comprehensive Emergency Management (CEM) has announced the release of three important new publications.

"Earthquakes: What You Should Know When Living in Utah" is a completely revised version of CEM's awareness and preparedness document. In full color and well-illustrated, it makes the case for why every citizen should prepare for an earthquake. Preventive actions that can be taken before an earthquake to mitigate both structural and non-structural hazards are clearly explained. Preparation of a 72-hour kit and actions that should be taken during and after an earthquake are outlined. The publication discusses earthquakes in Utah and explains the associated hazards of ground shaking, fault rupture, ground deformation, subsidence, liquefaction, flooding, fires, and hazardous materials spills. Why and where earthquakes have occurred in Utah and the likelihood of future earthquakes are also discussed. Straightforward diagrams should make this publication especially useful to every Utah citizen.

"Utah Earthquake Insurance Guide for Homeowners" provides homeowners with information about the history, availability, and particulars of earthquake and catastrophe insurance. Most of the injuries, deaths, and economic losses that occur during and after an earthquake can be related to damage to structures. Careful long-term planning which includes the upgrade of structures and the purchase of earthquake insurance can substantially reduce earthquake risk. The differences are explained between earthquake insurance, a "nameperil" policy offered as an endorsement to standard comprehensive homeowner policies, and catastrophe insurance, an "all-risk" or "excluded-peril" policy purchased independently of the usual homeowner policies. Earthquake insurance rates are based on earthquake insurance zones. These zones are in turn based on an assessment of earthquake risk factors that include the frequency and severity of expected earthquakes, the population at risk, the type of construction, and the value of the structure being insured. A map showing the earthquake insurance zone for each county in Utah is included. The guide also informs the reader about the status of current federal legislative proposals to deal with the complex issues surrounding earthquake insurance (see also "Utah Earthquake Advisory Board News," this issue). Armed with this information, Utah citizens can make more informed choices about purchasing earthquake or catastrophe insurance.

"The Effects of Changing the Uniform Building Code Seismic Zone from Zone 3 to Zone 4 on the Wasatch Front of Utah (Brigham City to Nephi)" is also now available. In March of 1992, VSP Associates of Sacramento, California contracted with the EPICenter to investigate the potential socio-economic impacts if the Uniform Building Code seismic zone were changed from zone 3 to zone 4 along the Wasatch Front (see WFF, 1992, v. 8, no. 2, p. 11-12). This report was prepared for interested and concerned citizens as an objective assessment of the consequences of such a zone change. The authors specifically state that the scope of their study did not include evaluating "whether or not the technical basis for seismic risk along the Wasatch Front of Utah meets the established ICBO criteria for seismic zone 4." They begin with an introduction to seismic zone changes in general and with background information that makes the subsequent technical discussions about the impacts of a building code seismic zone change understandable to the general reader. They include a brief review of the purpose and intent of building codes, a review of the seismic risk along the Wasatch Front, and a summary of the expected impacts of a major earthquake there. They continue with assessments of the socio-economic consequences of Utah's prospective seismic zone change, answering such frequently asked questions as:

- What are the differences in the Uniform Building Code between seismic zone 3 and seismic zone 4?
- Will the knowledge and capabilities of architects, engineers, contractors, and building officials have to be increased?
- Will the potential liability of building owners be increased?
- What will be the impact on the cost of new buildings?
- What will be the impact on the change of use, renovation, or rehabilitation of existing buildings?
- What will be the impact on the value of existing buildings?
- What will be the impact on the value of new buildings?
- What will be the impact on residential earthquake insurance?
- What will be the impact on commercial earthquake insurance?

The authors conclude with a summary and overview of the subjective and objective attitudes of people who may be impacted by the zone change and the overall economic impact on development and the housing and construction trades, including architects, engineers, developers, and realtors.

Single copies of all three publications are free from the Utah Division of Comprehensive Emergency Management, 1110 State Office Building, Salt Lake City, UT 84114, (801) 538-3400.

DISASTER SCENARIO

On Monday, June 7, 1993, at approximately 6:00 a.m., mountain daylight time, a Richter magnitude 7.5 earthquake occurs on the Wasatch fault in northern Utah. The epicenter of the earthquake is determined to be in the Salt Lake City/County area. It causes significant damage to this area, as well as to Davis and Weber Counties to the north, and Utah and Tooele Counties to the south and west. Initial estimates of ground shaking intensities are MMI X to XI in Salt Lake and Davis Counties and MMI up to VII in adjacent areas within a 50-mile radius.

Initial casualty estimates in the Salt Lake County area are approximately 2,300 dead and over 9,000 injured requiring medical treatment. Total casualties throughout the entire affected area could exceed 3,495 dead and 13,980 injured. Damage to medical facilities, equipment, and supplies, and casualties among medical professionals severely restricts the ability to quickly rescue, evacuate, and care for the injured. Salt Lake County will experience a 70 percent bed loss in hospitals and other health care facilities due to structural and non-structural damage. Damage to highways and roads also affects the ability of ambulance and emergency medical team personnel to respond in a timely fashion.

City, county, state, and federal structures and facilities will all be damaged in the scenario event. The most significant

RESPONSE 93

by Janine L. Jarva
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In June 1993, the Wasatch Front will be the site of the largest full-scale, federal earthquake exercise ever undertaken in the U.S. Dubbed "RESPONSE 93," it is designed to test the policies and procedures of the Federal Response Plan, the Federal Emergency Management Agency's (FEMA) Region VIII supplement to the Federal Response Plan, and the federal and state coordination mechanisms for responding to a catastrophic earthquake on the Wasatch fault in northern Utah. FEMA Region VIII, headquartered in Denver, includes the states of Utah, Colorado, Wyoming, Montana, North Dakota, and South Dakota. The Wasatch Front area of Utah, having the highest seismic risk within Region VIII, was chosen as a test of the worst-case scenario. RESPONSE 93 represents the culmination of more than six years of concerted effort by federal regional and state planners.

The authority for the Federal Response Plan derives from two public laws passed by Congress. The Earthquake Hazards Reduction Act of 1977, as amended by Public Law 99-105, establishes the National Earthquake Hazards Reduction Program (NEHRP) to reduce the risk to life and property from earthquakes in the United States. FEMA is designated as the agency with primary responsibilities to plan and coordinate the NEHRP, which has five major elements: hazard delineation and assessment (see also "USGS Funds UGS Projects," this issue); earthquake prediction research; seismic design and engineering research; preparedness planning and hazard awareness; and fundamental seismological studies. Planning for the federal response to a catastrophic earthquake is a major aspect of the preparedness planning and hazard awareness element under the NEHRP.

In 1988, Public Law 93-288, the Disaster Relief Act of 1970, was amended by Public Law 100-707 and retitled the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Public Law 93-288, as amended). The Stafford Act provides the authority for the federal government to respond to disasters and emergencies in order to provide assistance to save lives and protect public health, safety, and property. It provides an orderly and continuing means of assistance by the federal government to state and local governments in carrying out their responsibilities to alleviate the suffering and damage which result from such disasters.

The Federal Response Plan (for Public Law 93-288, as amended) which RESPONSE 93 will be exercising is designed to address the consequences of any disaster or emergency situation in which there is a need for federal response assistance under the provisions of the Stafford Act and the NEHRP. It is based on the fundamental assumption that a significant disaster or emergency may quickly overwhelm the capabilities of an affected state and its local governments to carry out the extensive emergency operations necessary to save lives and protect property. For example, along the Wasatch Front in northern Utah (identified as a high-risk, high-population area), the

EXERCISE

occurrence of a large earthquake will cause casualties, property loss, and disruption of normal life-support systems, and will significantly affect the regional economic, physical, and social infrastructures. It has the potential to cause substantial health and medical problems, with hundreds or thousands of deaths and injuries, depending on factors such as time of occurrence, severity of impact, existing weather conditions, area demographics, and the nature of building construction. An earthquake may trigger fires, floods, or other events that will multiply property losses and hinder the immediate emergency response effort. The Federal Response Plan assumes that the disaster or emergency occurs with little or no warning at a time of day that produces maximum casualties.

The Federal Response Plan establishes an architecture for a systematic, coordinated, and effective federal response. To facilitate the provision and delivery of federal assistance, the types of resources which the affected state is most likely to need have been functionally grouped into twelve Emergency Support Functions (ESFs). These functions are transportation, communications, public works and engineering, firefighting, information and planning, mass care, resource support, health and medical services, urban search and rescue, hazardous materials, food, and energy. Twenty-seven federal departments and agencies have been assigned primary and support responsibilities for each of these functions. The twelve ESFs serve as the primary mechanism through which federal resources will be mobilized to augment state and local response efforts. ESFs will coordinate directly with their counterpart state agencies to provide support.

Federal assistance will be provided to the affected state under the overall coordination of a Federal Coordinating Officer (FCO) who is appointed by the Director of FEMA on behalf of the President. The FCO will work with the State Coordinating Officer (SCO) to identify and coordinate requirements with the ESFs. The FCO will head a regional interagency Emergency Response Team (ERT) composed of ESF representatives and other support staff. The ERT provides initial response coordination with the affected state at the State Emergency Operations Center (EOC).

Once formulated, the Federal Response Plan will serve as the foundation for the further development of detailed regional plans and procedures to implement federal response activities in a timely and efficient manner. FEMA has worked with national, regional, and state agencies and departments with identified responsibilities in the Federal Response Plan to provide a forum for participation in planning and exercise activities that develop, maintain, and enhance the federal response capability. The development of the Federal Response Plan and the Region VIII supplement have been covered by the Forum in the past (see WFF, 1987, v. 3, no. 3-4, p. 13-14, and WFF, 1988, v. 5, no. 1, p. 9-10). In 1990, a mock earthquake disaster exercise, called "Response 90," was held in Utah to test the initial planning efforts of the Region VIII supplement to the Federal Response Plan (see WFF, 1990, v. 6, no. 3-4, p. 7). It followed two years of mini-exercises centering on individual ESFs. Based on the problems and issues

DISASTER SCENARIO (cont.)

damage will be to structures in Salt Lake and Davis Counties, with city and county fire facilities sustaining the largest impact. Over 50 percent of these facilities will be damaged enough to render them nonfunctional. Other facilities will lose about 50 percent of their function due to structural, non-structural, or electrical power problems. Facility damage in Weber and Utah Counties will be around 20 to 30 percent. The County EOCs are located in hardened sites and will remain functional.

A large portion of the affected area immediately loses electric power as ground shaking causes transmission and distribution systems failure due to equipment damage and excessive power fluctuations. All public utility systems suffer damage, disrupting up to 100 percent of their operations in the Salt Lake and Davis County areas, and causing up to 50 percent losses of service in adjacent areas. The loss of power halts water, sewage, and other services essential to the maintenance of health and welfare. Damage to substations and control centers in Salt Lake County will prevent restoration of power to county residents for 30 days. Power to critical county facilities should be restored by emergency means within 72 hours. Contiguous counties will have power restored within 3 days through rerouted circuits. Other services critical to the normal functioning of the Wasatch Front and other Intermountain areas also experience serious losses,

DISASTER SCENARIO (cont.)

including petroleum transport and refining, industrial operations, financial institutions, and governmental agencies including military operations.

Telecommunications systems are immediately disrupted or totally overloaded by customer demands. Telephone and telegraph service, and local radio and television broadcasting are all affected. At least 50 percent of all phone service to the five-county area will be out for one week. Radio transmission may be interrupted for two to three days due to primary facility and repeater station damage. Emergency Broadcast Station capability from the state EOC will facilitate emergency communications within 6 hours. Television broadcast capability will be reduced but mobile units will be able to broadcast until power is restored to major facilities. Reception of broadcast signals will be greatly reduced due to electrical power loss.

The earthquake's effect on air, rail, and highway traffic is immediate. The Salt Lake International Airport will be out of operation due to damaged control towers at both the hub and air traffic control facilities. Evaluation of the structural integrity of runways and other airport facilities and the loss of primary and backup power can be expected to extend downtime to two to three days. Railways will be damaged by tectonic subsidence and ground shaking, especially near the terminals in north Salt Lake

RESPONSE 93

identified during Response 90, a state exercise was held in 1991 (see WFF, 1990, v. 7, no. 1, p. 4, and WFF, 1991, v. 7, no. 3, p. 8) to review and test the response capabilities of the 22 state agencies that have emergency response assignments under the Utah Natural Disaster Response Plan. In 1992, specific planning for RESPONSE 93 began. It is the next step in the joint federal/state catastrophic disaster response planning effort. It will be a "full-scale" exercise as compared to earlier exercises which were more "table-top" in nature.

Throughout 1992, Regional Interagency Steering Committee meetings held quarterly in Utah have focused on exercise planning for individual functional areas. A comprehensive exercise plan has developed during these ongoing meetings. It has required a well-coordinated and interactive effort by national, regional, and state planners. FEMA Region VIII and the Utah Division of Comprehensive Emergency Management (CEM) have led the effort supported by FEMA headquarters in Washington, D.C. RESPONSE 93 will provide an excellent opportunity for members of federal regional, state, and local response organizations to exercise their roles and responsibilities in responding to a major earthquake in the Wasatch Front region in one cooperative exercise.

RESPONSE 93 will include the active participation of FEMA headquarters, FEMA Region VIII, and the Utah Department of Public Safety's CEM. Utah state and local officials will form response elements to provide real-life interaction with the federal community. All state agencies having responsibilities under the Utah Natural Disaster Response Plan have been encouraged to participate in RESPONSE 93. Their involvement will facilitate a more realistic exercise environment as well as prepare them for an actual disaster response. In addition, CEM is involving as many local jurisdictions as is feasible. All 29 counties and many city governments in Weber, Davis, Salt Lake, Utah, and Tooele Counties have been invited to participate. CEM is also encouraging specific businesses and industries to get involved. Representatives of the 26 federal departments and agencies with responsibilities under the Federal Response Plan and the American Red Cross will also provide assistance to the state of Utah under the 12 ESFs.

Orientation and training for all exercise participants, including players, controllers, evaluators, and observers, will occur prior to the start of the exercise. On Monday, June 7, 1993 (exercise day one), at approximately 6:00 a.m. mountain daylight time (m.d.t.), a Richter magnitude 7.5 earthquake occurs on the Wasatch fault in northern Utah. By 8:00 a.m. m.d.t., FEMA's Regional Operations Center (ROC) in Denver and the Utah State EOC in Salt Lake City will be activated. The ROC is established in response to an event that may require federal assistance under the Federal Response Plan. The EOC is the site from which state officials will exercise direction and control during the disaster. The SCO will coordinate, prioritize, and communicate requests for assistance to the ROC through the FCO.

Exercise day one will begin with a status briefing on the simulated earthquake. The ROC in Denver will deploy the Advance Element of

EXERCISE (cont.)

FEMA's Emergency Response Team (ERT-A), which will arrive at the Utah State EOC to enter play about 12 noon m.d.t. The ERT-A will assess the impact of the disaster, collect damage information, and determine response requirements in cooperation with the EOC. At FEMA headquarters in Washington, D.C., the Catastrophic Disaster Response Group (CDRG) will activate the Emergency Support Team (EST) and the Emergency Information Coordinating Center (EICC).

Exercise days two, three, and four will begin with a transition briefing including information on the simulated events that occurred during the night. The full ERT will arrive on Tuesday, June 8 (exercise day 2), and set up the federal Disaster Field Office (DFO) at Camp Williams, Utah. The DFO is the primary field location for the support of response and recovery operations. It houses the FCO, the ERT, and, where possible, the SCO and support staff. It is estimated that about 1,500 players will be housed at the DFO during this exercise. The DFO's initial focus will be on response operations. A Joint Information Center (JIC) will be set up as required at the DFO to ensure coordinated, accurate, and timely release of information to the news media and the public.

By exercise days three and four, the DFO will be fully operational and activities will shift to recovery operations. The exercise will conclude on Thursday, June 10 (exercise day 4). An exercise debriefing will be held on Friday, June 11.

Exercise play will be occurring simultaneously at FEMA's EICC in Washington, D.C., the Region VIII ROC in Denver, the Utah State EOC in Salt Lake City, the DFO at Camp Williams, county and local EOCs to include Weber, Davis, Salt Lake, Tooele, and Utah Counties, and ESF primary and supporting federal field offices. During the conduct of RESPONSE 93, an exercise control group will be established to control, observe, and record player operations at all the federal and state play locations.

The major objectives of this exercise for FEMA are as follows:

- Exercise the federal/state interface and coordination process;
- Provide training for senior officials who play a key role in managing and coordinating operations under the Federal Response Plan;
- Test activation and deployment of the ERT-A;
- Test the deployment functions of the ERT-A to:
  1. Set up DFO functions;
  2. Establish communication links with the FEMA Region VIII ROC;
  3. Establish mobilization centers;
  4. Establish liaison with the state EOC;
- Test the ability of the ROC to:

DISASTER SCENARIO (cont.)

County. Terminal buildings will sustain heavy damage with the possibility of collapse. Damage to highways will effectively stop continuous travel on the three major Interstates 15, 80, and 215. Some bridges and overpasses have fallen, are damaged, or are otherwise unusable. All such structures will need to be inspected to ensure their inte-grity for safe use. The move-ment of goods and services in many areas is severely limited by direct damage to the trans-portation infrastructure or debris from damaged structures.

Another repercussion of the earthquake will be large hazardous-materials problems which will be concentrated in the refinery areas and indust-rial locations of Salt Lake and Weber Counties. Evacuation may be necessary in Davis, Weber, and Tooele Counties.

CEM wants to encourage any individuals or organi-zations with an interest in participating in the event itself or in seeing how the Utah State EOC functions to contact their County Emergency Serv-ices office for more informa-tion on becoming involved. In Salt Lake County, contact Kathy Cuff-Case at 535-5467. CEM can supply the names and phone numbers of all other county emergency management directors. More information will appear in upcoming issues of the Forum. Copies of "The Federal Res-ponse Plan," FEMA Public-ation 229, can be obtained by writing FEMA Publications Department, P.O. Box 70274, Washington, D.C. 20024.

RESPONSE 93 EXERCISE (cont.)

1. Implement information and planning activities;
2. Serve as an initial coordination office for federal activity until the ERT is established in the field;

- Exercise the CDRG and EST in Washington, D.C.;

- Exercise the JIC at Camp Williams and in Washington, D.C.

The major objectives of this exercise for the state and CEM are as follows:

- Provide training for senior officials who play a key role in managing and coordinating operations under the Utah Natural Disaster Response Plan;

- Provide an open exercise environment for local city and county jurisdictions to participate;

- Test initial activation and liaison with the ERT-A;

- Test the radio communications capabilities of the state as a result of limited telephone usage due to utility damage;

- Evaluate EOC activation and the specific function of information gathering and dissemination;

- Implement transition of the EOC to an alternate EOC at the DFO site, as a result of earthquake damage to the EOC;

- Evaluate methodologies used to transfer information under the EOC functions to ESF functions;

- Test integration of the basic Utah Natural Disaster Response Plan with the Federal Response Plan.

RESPONSE 93 will be conducted as a "no-fault" exercise. It will focus on the adequacy and feasibility of policies, plans, procedures, organizational structures, and supporting systems involved in implementing the Region VIII supplement to the Federal Response Plan, not on individual or group performance. The primary aim of the evaluation process is to substantiate the adequacy of existing procedures and systems in responding to a major earthquake. It will also provide a training and familiarization opportunity for participants whose normal duties do not involve response operations. An exercise evaluation methodology has been developed to document accomplishment of the exercise objectives and verify exercise findings. A final After-Action Report will be prepared from the analysis of observations and supporting information.

MEETINGS AND CONFERENCES

May 2-5, 1993, 1993 National Earthquake Conference entitled "Earthquake Hazard Reduction in the Central and Eastern United States: A Time for Examination and Action", will be held at the Peabody Hotel in Memphis, Tennessee. Hosted by the Central United States Earthquake Consortium and the Center for Natural Phenomena Engineering, this conference is designed especially for individuals interested in better understanding hazards in the central and eastern United States and knowing how to reduce the corresponding vulnerability and the consequences of a damaging earthquake occurring in this region. Conference participants will represent all aspects of earthquake hazard reduction. Themes to be emphasized include hazard assessment; mitigation of damage to the built environment; preparedness, awareness, and public information; emergency response and recovery; and socioeconomic and public policy impacts. For further conference information and registration, contact Dr. James E. Beavers, Conference Chair, Director, Center for Phenomena Engineering, Martin Marietta Energy Systems, Inc., P.O. Box 2009, Oak Ridge, TN 37831-8083, (615) 574-0569, fax 615-574-3118.

May 19-21, 1993, Geological Society of America Cordilleran/Rocky Mountain Sections Joint Meeting, held at the Reno Hilton in Reno, Nevada. Special symposia will include, "Basin and Range Seismic Hazard" and "Latest Pleistocene and Holocene Surface Faulting, Basin and Range Province." Two theme poster sessions of special interest are "Block Tectonics and the Relation between Normal and Strike-slip Faulting in the Western United States" and "Engineering Geology: Case Histories". For more information, contact meeting co-chairmen, Richard A. Schweickert, Department of Geological Sciences, University of Nevada, Reno, NV 89557,

(702) 784-6901, fax 702-784-1766 or Walter S. Snyder, Department of Geosciences, Boise State University, Boise, ID 83725, (208) 385-3645, fax 208-385-4061.

June 1-6, 1993, Third International Conference on Case Histories in Geotechnical Engineering, held in St. Louis, Missouri. One of the themes of this conference will be geotechnical earthquake engineering. For further information contact Shamsher Prakash, Conference Chairman, III CHGE, 308 Civil Engineering, University of Missouri-Rolla, Rolla, MO 65401-0249, (314) 341-4489, fax 314-341-4729.

August 29-September 3, 1993, Hazards-93, Fifth International Conference on Natural and Man-made Hazards, organized by the International Society for the Prevention and Mitigation of Natural Hazards and held in Quindao, China. The United Nations declared the 1990s as the International Decade for Natural Disaster Reduction. The objective is to prevent or mitigate natural disasters and the loss of life, property damage, and social and economic disruption they produce worldwide. The 1990s are also a time when, for many countries, coping with disasters is becoming virtually synonymous with development. The cost of rehabilitation and reconstruction in the wake of disasters is consuming available capital, significantly reducing the resources for new investment. Tackling this problem requires a sound evaluation of disaster mitigation policies and tools. The theme for Hazards-93 is disaster mitigation: scientific and socio-economic aspects. The organizing committee welcomes papers on all aspects of natural and man-made disasters, but priority will be given to those emphasizing the mitigation aspects and preventative measures. For more information, contact Professor Mohammed El-Sabh, Natural Hazards Society, Centre Oceanographique de Rimouski, 310 Allee des Ursulines, Rimouski, Quebec, G5L 3A1, Canada, (418) 724-1707, fax 418-723-7234.

October 9-15, 1993, Association of Engineering Geologists Annual Meeting, held in San Antonio, Texas. Abstracts are due May 1, 1993 and should be sent to Christopher C. Mathewson, Department of Geology, Texas A&M University, MS 3115, College Station, Texas 77843-3115. For meeting information, contact Edward G. Miller, Raba-Kistner Consultants, Inc., 12821 West Golden Lane, San Antonio, Texas 78249, (512) 699-9090.

October 25-28, 1993, Geological Society of America Annual Meeting, held in Boston, Massachusetts. Abstracts deadline is July 7, 1993. They should be sent to Abstracts Coordinator, GSA, 3300 Penrose Place, P.O. Box 9140, Boulder, Co 80301-9140. For further information about the conference, contact GSA Meetings Department, 3300 Penrose Place, Boulder, CO 80301, (303) 447-2020.

December 6-10, 1993, American Geophysical Union Fall Meeting, held in San Francisco, California. Abstract deadline is September 9, 1993. For information, contact AGU-Meetings Department, 2000 Florida Avenue, N.W., Washington, DC 20009, (202) 462-6900, fax 202-328-0566.

July 10-14, 1994, Fifth U.S. National Conference on Earthquake Engineering, organized by the Earthquake Engineering Research Institute and held at the Marriott Downtown Hotel in Chicago, Illinois, will have as its theme "Earthquake Awareness and Mitigation Across the Nation." A Call for Papers has been issued by EERI. Abstract deadline is May 1, 1993. The conference will provide an opportunity for both researchers and practitioners to share the latest knowledge and techniques for understanding and mitigating the effects of earthquakes. This quadrennial conference will bring together, and enhance dialogue among, professionals from the broad range of disciplines committed to reducing the impact of earthquakes on the built and natural environment: geology, seismology, geophysics, geotechnical engineering, soils and foundation engineering, structural engineering, architecture, social response, regional planning, emergency response planning, and regulation. For receive the Call for Papers announcement and future conference bulletins, contact the Earthquake Engineering Research Institute, 499 14th Street, Suite 320, Oakland, CA 94612-1902, (510) 451-0905, fax 510-451-5411.

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