PREPARING FOR THE "BIG ONE"

SAVING LIVES THROUGH EARTHQUAKE MITIGATION

IN LOS ANGELES, CALIFORNIA

January 17, 1995

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PREFACE

Although the deaths and injuries caused by the January 1994 Northridge earthquake were terrible, it is sobering to realize that much greater losses were averted only by an accident of timing--the quake hit in the pre-dawn hours of a holiday, when most people were in their beds. If it had struck in the middle of a weekday, thousands of children would have been injured or killed at school by falling debris, furniture, and light fixtures. Untold numbers of commuters would have fallen victim to collapsing roads and bridges. Critical health facilities could have been completely overwhelmed by the need for emergency and hospital care.

Recognizing that the timing of the next major seismic event may not be so fortunate, *Preparing for the "Big One": Saving Lives through Earthquake Mitigation in Los Angeles, California*, focuses attention on the earthquake mitigation needs of the Los Angeles area, discussing steps that can be taken to minimize injury and loss of life in future earthquakes. Most current mitigation efforts are actually a form of post-disaster response and recovery. This report looks at what can be done *before* the next emergency occurs.

Extensive interviews were conducted to draw on the experience and insights of persons directly involved in earthquake recovery and mitigation efforts, including Federal, State, and local government officials, as well as representatives from utility companies and other private and nonprofit institutions in the Los Angeles area. In addition, information for this report was compiled from news articles, published research on mitigation technology and the experience of other earthquakes, as well as from recently published assessments of the damage caused by the Northridge quake.

This study is intended to complement the Administration's first anniversary report on the Northridge quake, *The Northridge Earthquake: One Year Later*. While *Preparing for the "Big One"* focuses on earthquake mitigation needs, the Administration's report discusses Federal recovery and rebuilding activities in the wake of the disaster. Although vast Federal resources have been mobilized to assist in these efforts, alone they cannot defray the cost of improving the seismic safety of the Los Angeles area. The responsibility for creating a more resilient community will challenge the resources and creativity of State and local governments, public institutions, and community-based organizations. When, inevitably, the "big one" strikes, many lives will depend on the persistence and determination of efforts to prepare for it today.

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EXECUTIVE SUMMARY

At 4:31 a.m. on January 17, 1994, a 6.8-magnitude earthquake struck a densely populated area of Los Angeles near the community of Northridge. More than 30 people were killed in the tremor; a total of 61 deaths were attributed to direct and indirect causes. In the following 3 weeks, the region was rattled by more than 2,500 aftershocks. By the time the seismic activity subsided, at least 65,000 residential buildings had sustained damage; essential local facilities and services had been seriously disrupted as well. The State of California has estimated total damage at between $18 billion and $20 billion.

The Federal Government immediately mobilized to help the citizens of the Los Angeles area meet the emergency and begin to rebuild their lives and communities. Staff and resources from numerous Federal agencies—including the Federal Emergency Management Agency, the Small Business Administration, the armed forces, and the U.S. Departments of Transportation, Health and Human Services, and Housing and Urban Development—were quickly dispatched to the affected area. By June 30, an estimated $5.2 billion in Federal funds had been obligated to earthquake response and recovery activities and it was expected that an additional $6.7 billion would be committed in the near future.

Although the deaths, injuries, and damage caused by the Northridge earthquake were terrible, the toll probably would have been much worse if the quake had not occurred in the pre-dawn hours of a holiday, when most people were in their beds. This event was a harsh warning that can only be ignored at the risk of untold thousands of lives.

However, there is much that can—and should—be done to help at-risk communities minimize loss of life and property in the next major earthquake. This report is intended to support such efforts by placing actions already underway in the context of the Los Angeles area's most essential earthquake mitigation needs and describing mitigation strategies that would save lives when, inevitably, the "big one" strikes.

Focusing on Mitigation

Repair and rehabilitation activities in the aftermath of the Northridge disaster are only half the challenge. These are primarily intended to rebuild lives; the goal of mitigation is to *save* lives. Recovery efforts that merely recreated pre-earthquake conditions would be at best a temporary palliative—the risk to life and property in a future disaster would remain undiminished and, indeed, all the more tragic for being preventable. Mitigation is intended to achieve a higher level of safety. It encompasses policies and actions taken *before* an event to minimize the effects of damage and injury when an event does occur. It also includes strengthening buildings that may have escaped damage in a previous disaster.

Of course, mitigation and recovery are not entirely distinct from one another—rather, they are two parts of a single continuum. Mitigation is often presented as one of four phases in the cycle of disaster planning (Exhibit 1). In practice, it overlaps with the recovery period, which many assert is the best time to initiate mitigation strategies. Preparedness activities also can be considered as one aspect of mitigation. Thus, mitigation should be an ongoing, comprehensive process.

Los Angeles was spared much worse damage and loss of life in the Northridge earthquake through a combination of preparedness and luck. The area benefited from California's long experience with earthquakes and from the combination of laws, public programs, and private preparedness that limited damage and enabled critical systems and services to function effectively in the emergency. Nonetheless, additional injury and loss of life was averted by mere chance—the major shock occurred at a time when schools, businesses, and roads that sustained serious damage were largely deserted.

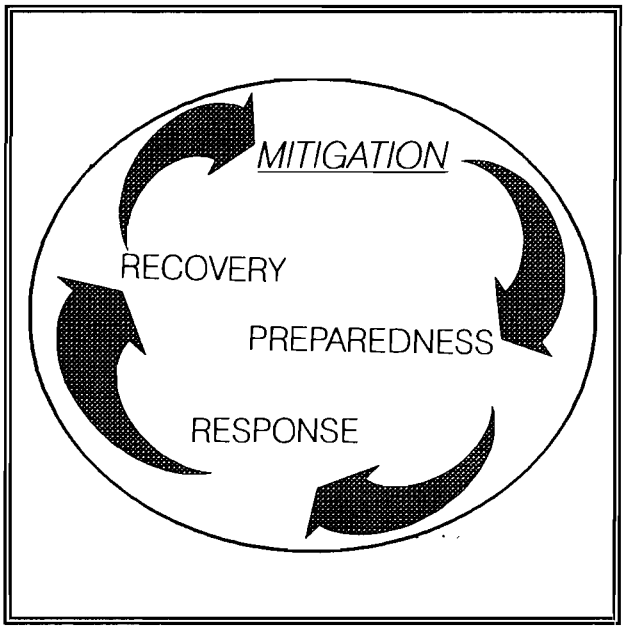

EXHIBIT 1 The Four Phases of Disaster Planning

This report is organized into six sections. The first describes the existing array of Federal, State, and local earthquake mitigation efforts available in the City and County of Los Angeles. The four succeeding sections review information on earthquake damage and mitigation needs for essential elements of the area's urban environment—housing, hospitals, schools, and lifelines. Each of these sections also discusses the current status and estimated cost of mitigation efforts. The report concludes with a discussion of gaps in the existing mitigation system and explores steps to support mitigation-related efforts in Los Angeles and other at-risk areas.

Extensive interviews were conducted to draw on the experience and insights of persons directly involved in earthquake recovery and mitigation efforts, including Federal, State, and local government officials, as well as representatives from utility companies and other private and nonprofit institutions in the Los Angeles area. In addition, information for this report was compiled from news articles, published research on mitigation technology and the experience of other earthquakes, as well as from recently published assessments of the damage caused by the Northridge quake.

Hospitals and Emergency Health Care

Sixty-one people were killed and over 8,700 were injured in the Northridge earthquake, including more than 1,600 people who required hospitalization. Hospitals and health care facilities experienced both structural and nonstructural damage that impaired their ability to protect occupants during the earthquake and to treat earthquake victims afterwards. Eleven hospitals were completely or partially closed, and their patients evacuated, due to earthquake damage.

The six acute hospitals and 44 health centers operated by the Los Angeles County Department of Health Services are the primary provider of basic health care services to the Los Angeles area—and often the only provider for the medically indigent population. Major earthquake mitigation needs at these facilities range from replacement and retrofitting activities intended to ensure seismic safety, to enhanced communication systems and expanded trauma facilities that will improve the capacity to respond to emergency medical needs in future disasters. The total cost of seismic upgrades to Los Angeles County's public hospitals and health centers is estimated at $2.3 billion. Cost estimates for additional improvements are not yet available; nor are estimates for the mitigation needs of hospitals and medical facilities outside the Los Angeles County system.

Schools

If the Northridge earthquake had struck during school hours, thousands of children would have been injured or killed by falling debris, furniture, and lighting. For 4 days after the earthquake, classes for the 640,000 students in the Los Angeles Unified School District were cancelled. Damage to school buildings left 250,000 children temporarily without classrooms. Nonetheless, all but 75 of the District's schools reopened within a week. Three weeks after the earthquake, only 21 schools remained closed. The total cost of damage to public schools is currently estimated at between $150 million and $200 million.

Overall, Los Angeles public schools withstood the Northridge earthquake remarkably well, due in large part to the stringent school construction code enacted by the California legislature in 1972. Structural damage to schools was minimal, although cracked foundations were severe enough in two cases to require demolition of the buildings. Approximately 10 percent of the Los Angeles Unified School District's school buildings require structural mitigation. Officials calculate that 35 lift-slab buildings, 572 masonry buildings, and 515 concrete buildings—all constructed before 1972—are in need of some structural retrofitting. The District estimates that this work would cost $786 million.

However, local and State officials have identified nonstructural retrofitting as the more pressing mitigation need. The Northridge earthquake made clear that nonstructural hazards—notably the collapse of suspended ceilings and lighting systems—pose a greater

safety threat than structural weaknesses at this time. School officials estimate that retrofitting lights and ceilings alone will cost approximately $297 million.

Residential Structures

To minimize loss of life in residential structures, particular attention should be given to retrofitting unreinforced masonry buildings (URMs), wood-frame homes, and hillside homes, as well as to anchoring manufactured homes and strapping gas water heaters. As of April 4, 1994, approximately 65,300 residential buildings in the City of Los Angeles, containing 308,900 units, were known to have sustained damage in the Northridge earthquake. Multifamily units suffered the most damage: 258,937 of the damaged dwellings were multifamily units and 49,909 were single-family homes. The cost of the damage has been estimated at over $1.3 billion; however, private insurance claims may be as high as $8–$11 billion.

Wood-frame buildings made up the vast majority of structures damaged in the earthquake. In particular, multi-story buildings with a "soft" first story—usually consisting of wood-framed parking facilities—performed poorly, in some cases putting occupants at serious risk. These facts have troubling implications for the urban areas of Los Angeles, where the majority of the multifamily housing stock is three- and four-story wood-frame construction. The collapse of the three-story Northridge Meadows apartment building, which killed 16 people, is a tragic example of wood-frame failure. Single family wood-frame homes with cripple-walls are also vulnerable. Mitigation costs for the estimated 100,000 single family homes within the City of Los Angeles requiring cripple-wall retrofit would range from $200 million to $400 million, compared with $3 billion for repairing the same number of damaged buildings.

Unreinforced masonry buildings are considered the building type most vulnerable to earthquake damage. However, retrofitting has proven to be very effective in mitigating damage—properly retrofitted unreinforced masonry buildings experienced far less structural damage than those buildings not retrofitted. Although many have already been retrofitted under a local seismic safety program begun in 1981, about 500 unreinforced masonry buildings, most of which are commercial and mixed use properties, still require work at an estimated total cost of between $75 million and $225 million.

Homes built on steep grades of more than 20 percent are also vulnerable in a seismic event. The Northridge earthquake damaged 400 hillside homes—in two instances, residents died in the collapse. Although the total number of homes constructed on hillsides is unknown, one informed guess puts the number at around 10,000 single-family dwellings, with the total retrofit cost in the range of $60 million to $250 million.

A lack of bracing was often responsible for seismic damage to manufactured homes. When the earthquake knocked manufactured homes off their foundations, gas supply

pipes often ruptured, causing fires that could easily spread to nearby homes. The cost of anchoring Los Angeles' 9,000 manufactured homes would be approximately $45 million.

Gas water heaters also pose a fire hazard in both manufactured and site-built housing under seismic conditions. According to the Southern California Gas Company, 40 percent of all structure fires during the earthquake was caused by water heaters breaking away from their gas supply even though any new water heater installed since 1984 is required by law to be strapped. The cost of properly securing a water heater to prevent failure and fire during an earthquake is approximately $100. Based on an upper bound estimate, providing all of the approximately 512,000 single-family detached units in the City of Los Angeles with proper water heater bracing would cost $51.2 million.

Lifelines

Broken lifelines posed serious threats to human life and public health safety in the aftermath of the Northridge earthquake. Ruptured gas mains fed over 100 fires and disrupted service. Approximately 100,000 customers lacked potable running water immediately after the earthquake. The tremor also damaged electric power stations and power lines, leaving more than 2.5 million southern California customers without electricity. Although the quake caused significant damage, the utility industry has concluded that power, water, and gas systems recovered exceptionally well after the Northridge earthquake. Within 10 days, fewer than 100 scattered customers remained without water service. Most customers had electricity again within a few hours, though a few were without service for more than 2 days.

A prime culprit in many of these utility system failures was older pipelines and substations, built before World War II to outmoded standards. The Los Angeles Department of Water and Power reports that it must replace 20 older substations in downtown Los Angeles at a total cost of $220–$320 million. It estimates that replacing 300,000 feet of pre-1940 trunklines in the water piping system will cost another $300 million.

Collapsed roads and bridges also threatened lives and recovery efforts. Infrastructure failure directly caused at least one death and several injuries to motorists when the Northridge earthquake struck. Damaged highways also created tremendous problems in the delivery of essential services. Although most of the 600-mile Los Angeles freeway system survived the Northridge earthquake, extensive damage or collapse closed 10 freeway structures and caused widespread disruptions in the following weeks. Current estimates by the California Department of Transportation set total highway damage at $334 million. Retrofitting all damaged and undamaged bridges in Los Angeles and Ventura Counties that fail to meet current seismic safety standards would require an estimated $500 million.

Addressing Gaps in the Earthquake Mitigation System

Despite the new resources identified and the new partnerships formed in the aftermath of the Northridge earthquake, serious gaps and deficiencies in the array of existing programs and resources limit the scope and effectiveness of earthquake mitigation efforts in the Los Angeles area.

The most fundamental problem is the short duration of our efforts to reduce earthquake hazards. Ongoing mitigation efforts are needed. Current Federal mitigation efforts are actually a form of post-disaster response and recovery. The primary source of long-term mitigation funding—the Federal Emergency Management Agency's (FEMA's) Hazard Mitigation Grants Program—can only be tapped after the President has made a major disaster declaration. Limiting assistance for long-term efforts to the recovery period, when attention is most focused on short-term needs and solutions, may work against effective mitigation.

State and local efforts to mount needed mitigation efforts may have been slowed by Federal program rules that make it difficult to apply some forms of assistance to mitigation or to coordinate their use with other public and private funds. Relevant Federal assistance programs should be reviewed to identify and reduce barriers to their use in disaster recovery and mitigation. Even before the Northridge earthquake, HUD launched a review intended to assess and remove obstacles to the use of CDBG and HOME for mitigation-related activities. More recently, FEMA convened an interagency Mitigation Task Force in November 1994 to develop a coordinated Federal Mitigation Plan.

Attempts at the State and local level to address the need for ongoing mitigation are too often frustrated by an inability to obtain the necessary funds. Although Hazard Mitigation Grants and other FEMA programs offer significant funding for repairs and mitigation, these grants are conditioned upon the eligible State or local entity matching at least some percentage of the amount. In California's climate of strict fiscal austerity, raising revenues to leverage Federal funds and operate State and local mitigation programs has been extremely difficult. In the months following the Northridge earthquake, one bond issue was rejected by voters and another died in the State legislature. As of early August 1994, State and local agencies lacked the funds to fully match available FEMA funds.

Without adequate public and private funding, it is also very difficult to enlist property owners in mitigation efforts. Although mitigation reduces the likelihood and cost of future damage, incentives can be essential to making mitigation attractive to property owners. Financial incentives should be considered to encourage continuing private sector participation in mitigation activities. Inducements such as discounted insurance premiums, tax credits, low- or no-interest loans, mortgages, and grants would make mandatory mitigation measures more palatable, as well as easier to enforce.

Mitigation efforts in Los Angeles also suffer from deficiencies in other types of essential resources. Further research on the seismic performance of various types of construction and on new building materials and methods is needed in order to strengthen building codes and encourage improved design and construction. Effective mitigation planning also demands reliable knowledge of the local building stock. However, the City of Los Angeles does not possess an accurate assessment of the number or construction type of the buildings within its boundaries. A complete, automated inventory of the Los Angeles building stock is needed. While city records contain a wealth of valuable information on residential structures, for example, data covering over 840,000 individual parcels can only be managed and analyzed efficiently with an automated system.

Chronic fiscal distress has also compromised State and local governments' inspection ability to ensure the seismic safety of buildings, public facilities, and infrastructure. Staff reductions at agencies responsible for hazard monitoring, as well as a lack of resources for professional development of local building and infrastructure inspectors, have contributed to a troubling degradation in inspection capacity. An adequate staff of qualified and properly trained inspectors, equipped with the resources to carry out their responsibilities, is needed at key State and local agencies to ensure vigorous enforcement of construction and seismic safety standards. To carry out their responsibilities, building inspectors must be trained in the most recent codes and principles of seismic design.

Expanding and Sustaining Mitigation Efforts

An aggressive, ongoing campaign of mitigation activities is needed to place the safety of Los Angeles area residents on a firmer footing. It is estimated that the cost of earthquake mitigation to residential buildings and essential facilities and systems will exceed $5 billion. However, even this figure almost certainly understates the total cost because estimates are still needed for some key mitigation activities.

Although Federal agencies mobilize vast resources to assist in response and recovery efforts after disasters such as the Northridge earthquake, the findings of this report strongly suggest the need for even more vigorous support for mitigation strategies that can save lives. Certainly, the Federal Government has an important role to play in creating a safer and more resilient Los Angeles. The Administration is in the process of developing a set of natural disaster reform initiatives, including pre-disaster mitigation reforms. These reforms will be submitted to the Congress.

Inevitably, though, the greatest responsibilities—and the greatest resources—are to be found at the local level. As this report will show, the creativity and determination of local residents, State and local governments, public and private institutions, and community-based organizations in the Los Angeles area has already stimulated many important mitigation efforts. However, the most critical challenge still lies ahead.

Leadership from many quarters will be needed to sustain earthquake mitigation initiatives in the coming months and years, as more tangible needs compete for attention and resources. It is easy to feel powerless before the threat of a force so unpredictable, physically overwhelming, and emotionally incomprehensible. But while people cannot begin to control the timing or the cataclysmic power of the next earthquake, mitigation can give them some measure of control over its impact on their lives, safety, and property. Therefore, preparing for the "big one" must continue to be an urgent public and private priority—for every action taken to upgrade a home or business, and every dollar spent to build a safer school or road, may mean lives saved. But just as surely, every action deferred and opportunity squandered may one day be reckoned in lives lost.

SECTION ONE

OVERVIEW OF EXISTING MITIGATION PROGRAMS

I. Introduction

All levels of government are involved in earthquake mitigation efforts. The Federal Government's strategy is two-pronged: the Federal Emergency Management Agency and other agencies fund and implement mitigation measures as one element of the Federal emergency response to an earthquake disaster, while the National Earthquake Hazards Reduction Program (NEHRP) focuses on federally sponsored research on earthquake hazard issues. On the State level, California is an active leader in earthquake preparedness. Local jurisdictions, including the City and County of Los Angeles, are also working aggressively to recover from the Northridge earthquake, but their mitigation activities have been slowed by funding problems and competing recovery needs.

II. National Earthquake Hazards Reduction Program (NEHRP)

NEHRP, established under the 1977 Earthquake Hazard Reduction Act, provides the foundation of research and code standards for Federal earthquake risk reduction efforts. It is a consortium of four agencies:

- The Federal Emergency Management Agency (FEMA), the agency with primary responsibility for Federal disaster assistance, coordinates the NEHRP research agenda, and supports activities leading to the implementation of prudent earthquake risk reduction measures.

- The U.S. Geological Survey (USGS) conducts the research necessary to characterize and identify earthquake hazards, assess risk, monitor seismic activity, and improve earthquake prediction.

- The National Science Foundation (NSF) funds research on the causes and behavior of earthquakes, as well as on topics related to earthquake engineering and human responses to earthquakes.

- The National Institute of Standards and Technology (NIST) undertakes a wide range of research and development activities designed to translate the wealth of theoretical knowledge, experimentation, and observation on earthquakes and their effects into building codes, engineering standards, and construction practices that will improve the seismic safety of structures and essential infrastructure systems.

Collectively, the four agencies received $93 million to fund NEHRP earthquake research activities in FY 1993.[1]

In response to a request made to President Bill Clinton by nine members of the House of Representatives, the White House Office of Science and Technology Policy (OSTP) is currently conducting a comprehensive review of NEHRP that will explore the concerns voiced at the 1993 NEHRP reauthorization hearings. These topics include:

- Lack of an overall strategic plan for NEHRP.
- Insufficient coordination among the agencies to shape a unified, coherent program.
- Too little emphasis on research designed to determine how to mitigate earthquake damage.
- Inadequate application of NEHRP research findings to policies, programs, and practices that will actually save lives and limit losses from earthquakes.

OSTP expects to complete and transmit to Congress a report that will review current Federal earthquake risk reduction efforts and recommend future activities.

III. Federal Earthquake Mitigation Efforts

Although a large number of Federal agencies participate in disaster relief and recovery efforts, FEMA provides most of the funds specifically intended to support mitigation. HUD, the Small Business Administration, and a handful of other Federal agencies have programs that include some mitigation activities as eligible uses; others play specialized supporting roles in the Federal effort through their regulatory and research functions.

Federal Emergency Management Agency (FEMA)

Working closely with Federal, State, local, and volunteer organizations, FEMA coordinates assistance programs designed to start disaster victims and their communities on the road to recovery. Mitigation assistance became a central element of this effort with the passage of the 1988 Robert T. Stafford Disaster Relief and Emergency Assistance Act. But while the Stafford Act expanded FEMA's hazard mitigation programs and activities, it explicitly linked their use in a particular locality to a presidential declaration of a major disaster. Thus FEMA's role in funding earthquake mitigation measures is primarily limited to post-disaster assistance.

FEMA administers three disaster assistance programs that can be used to support mitigation activities:

- FEMA's major mitigation initiative is the Hazard Mitigation Grants Program (HMGP), which funds improved seismic safety for undamaged buildings through activities identified by the locality in its required post-disaster hazard mitigation plan. FEMA will fund up to 75 percent of the eligible costs of each project—the remainder must be raised from State or local sources. This matching requirement does not need to be met in cash; the value of in-kind services and donated materials may be applied as well. The level of HMGP grants made available in the disaster area cannot exceed 15 percent of the FEMA funds allocated through its Public Assistance and Individual Assistance programs (described below). FEMA also provides some support for pre-disaster efforts to state and local governments, but it only funds mitigation planning, rather than actual seismic upgrade and retrofit activities.

- The Public Assistance Program authorizes funding for the repair, restoration, or replacement of damaged facilities belonging to public entities and eligible private nonprofit organizations, as well as for other associated expenses, including emergency protective measures and debris removal.[2] These funds may also be used for appropriate, cost-effective hazard mitigation measures related to damaged public facilities.

- The Individual Assistance Program provides two mechanisms for assistance to individuals adversely affected by a major disaster. The first is the Individual and Family Grant Program, which provides funding to States for the purpose of making grants to individuals or families with serious, unmet disaster-related needs. Eligible uses include measures necessary to protect damaged homes against the immediate threat of weather-related damage. The Minimal Repair Program makes direct grants to individuals for repairs needed to make their homes safe, sanitary, and secure.

As of July 1994, FEMA had approved applications for over $1 billion in disaster assistance related to the Northridge earthquake—and the amount continues to grow.[3] The Hazard Mitigation Grants Program is currently funding around $800 million in mitigation projects.

Small Business Administration (SBA)

Disaster assistance is part of the mission of the Small Business Administration (SBA), which provides individuals with loans for privately owned properties, including businesses and residences. Low-interest SBA disaster assistance loans can be used to rebuild a damaged structure, including the cost of bringing it up to the applicable building code

standards. Loans also can pay for some smaller projects that are not required by code. At the applicant's request, loans may be increased by up to 20 percent for necessary or appropriate hazard mitigation measures. SBA has approved over 87,000 loans for $2.7 billion in the aftermath of the Northridge earthquake.[4]

Department of Housing and Urban Development (HUD)

HUD's involvement in earthquake hazard mitigation issues can be traced to the 1971 San Fernando earthquake. Today, additional allocations made under HUD's Section 8 rental assistance and Community Development Block Grant (CDBG) programs provide crucial assistance in major disaster areas. CDBG, which provides aid to communities to carry out a wide range of community development activities, can be used for disaster recovery projects that have mitigation implications. These include repairing multifamily residential structures, rehabilitating commercial and industrial facilities, and making infrastructure improvements. Jurisdictions can also use CDBG grants as matching funds for FEMA disaster assistance and mitigation programs.[5]

All CDBG activities must benefit low- and moderate-income persons, aid in the prevention or elimination of slums and blight, or address other community development needs that present a serious and immediate threat to the health or welfare of the community. Los Angeles has received $400 million in supplemental CDBG funds for Northridge earthquake relief and housing rehabilitation, in addition to annual grants of approximately $80 million to the City of Los Angeles and $35 million to Los Angeles County. Through the HUD Earthquake Loan Program (HELP), the Department has also made available $100 million in flexible subsidy loans for repairing HUD-assisted multifamily properties in the Los Angeles area. And, an additional $100 million in HOME funds were allocated for multifamily rehabilitation and other earthquake recovery activities.

HUD regulations promote the safety and soundness of all public and HUD-insured housing by requiring that these structures meet the Minimum Property Standards (MPS) established by the Department, which are more stringent than many local code standards. Under newly revised Minimum Property Standards for single-family and multifamily housing, seismic safety is a mandatory standard for applicable housing.[6] Earthquake safety issues will also be addressed in revised design and construction standards currently being drafted for manufactured homes.

Other Federal Agencies

A number of other Federal agencies also have a fundamental interest in earthquake risk reduction. For example, agencies such as the Departments of Defense and Energy and

the Nuclear Regulatory Commission engage in independent hazard identification and risk reduction programs for their mission-oriented facilities. Other active agencies include:

- The Department of Transportation (DOT), which requires that all projects receiving DOT grants meet NEHRP standards. It sponsors research on reducing the vulnerability of DOT-funded buildings and structures, including bridges and tunnels. It has also developed instructional products, such as seismic retrofit design manuals, design criteria, and a primer on how to manage transportation systems.

- The Environmental Protection Agency (EPA) incorporates seismic safety standards into its regulation of activities and facilities for chemical processing, waste water treatment, and toxic waste disposal.

- The Department of Veterans Affairs (VA) has spent over $1.1 billion to retrofit and upgrade its hospitals and facilities. The VA Seismic Strengthening Program has made significant progress since it began in 1971. The screening of 1,064 VA buildings revealed that of the 497 structures at major risk of seismic damage, 301 required seismic strengthening as soon as possible. To date, 117 buildings have been retrofitted, and corrections to 13 other structures are in the planning or design stage. The VA Seismic Strengthening Program faces two major challenges in the future: it must compete with direct medical care needs for scarce funds, and it requires large capital investments for seismic safety improvements that do not address deficiencies in functional space and systems.

IV. Statewide Earthquake Mitigation Efforts

The State of California is a leader in earthquake preparedness. Under a program authorized by Proposition 122, the Earthquake Safety and Public Buildings Rehabilitation Fund of 1990, the State legislature has offered $250 million for the financing of seismic retrofitting, reconstruction, repair, replacement, or relocation of state buildings or facilities and another $50 million in matching funds to help localities retrofit public buildings. Two statewide institutions—the Governor's Office of Emergency Services and the independent Seismic Safety Commission—are principally responsible for coordinating the State's earthquake preparations.

Office of Emergency Services (OES)

The Governor's Office of Emergency Services (OES) coordinates most State disaster preparedness programs. It maintains California's Emergency Plan, which outlines the responsibilities of State and local officials during emergencies. Through its three regional

offices, OES provides technical assistance to local officials in the development of emergency plans, aids in the coordination of emergency services during a crisis, and distributes Federal and State relief funds. OES also administers the California Specialized Training Institute (CSTI), which trains officials at all levels of government in emergency management, earthquake preparedness, and the use of relief programs.

Seismic Safety Commission (SSC)

The nonpartisan Seismic Safety Commission (SSC) was established by the California legislature in 1975 to improve earthquake safety in California. To accomplish this, the Commission works with federal, state and local agencies, as well as the private sector, on a variety of activities including issuing policy studies, sponsoring legislation, and coordinating seismic safety activities through oversight and leadership. The Commission is also responsible for: (1) annually revising the California Earthquake Hazard Reduction Program;[7] (2) implementing Chapter 250, Statutes of 1986, which requires local governments to inventory hazardous buildings, develop a mitigation plan, and report to the Commission; (3) reviewing the state's progress in preparing for the inevitable earthquakes; (4) pursuing programs to strengthen state-owned buildings that lack seismic resistance; (5) studying the effects of the 1989 Loma Prieta (Bay Area) earthquake to assist in the preparation for earthquakes of an equal or greater magnitude; (6) advising the Legislature and the Administration on seismic safety policies and issues; and (7) conducting research and development studies on earthquake safety in public buildings.

V. Los Angeles Area Mitigation Efforts

Because of the tremendous pressure on local governments to meet the most immediate needs of their constituents, post-disaster efforts revolve around short-term recovery instead of long-term mitigation. However, even within this more limited sphere, local governments are finding that they can address less than half of the repair and rebuilding needs.

After the Northridge earthquake, the City and County of Los Angeles immediately set up new offices and ad hoc groups to plan for post-earthquake recovery. However, only a few of these task forces are considering mitigation needs in their damage assessments and recommendations.

City of Los Angeles

The Mayor's Blue Ribbon Panel on Seismic Hazard Reduction was established in 1993 to identify seismic risks and promote voluntary and mandatory retrofitting. The Panel is comprised of five subcommittees: Buildings, Structures, and Lifelines; Seismic Risk; Land

Use and Construction; Insurance, Banking, and Real Estate; and Educational Programs and Outreach.

The City's Task Force on Evaluating Damage from the Northridge Earthquake consists of 15 subcommittees, which are charged with investigating earthquake damage in buildings with selected design or site characteristics, such as cripple walls, sloping hillside lots, and slab-on-grade construction. The subcommittees are expected to report their findings and recommendations in August 1994.

The City Council of Los Angeles also has an active Ad Hoc Committee on Earthquake Recovery which has drafted and approved numerous ordinances related to hazard mitigation issues. The Committee continues to meet on an ongoing basis. The City Council recently approved an ordinance which requires all new construction projects to include gas shut-off valves.[8]

County of Los Angeles

As a first step to recovery, the County Office of Recovery (COR) was created to develop a strategic plan for restoring government services impacted by the Northridge disaster. COR consists of representatives from various County offices, including the Community Development Commission and Office of Emergency Management, as well as other personnel experienced in facilities and social recovery. The task of developing an action plan for recovery has been placed in the hands of a Recovery Coordinators Task Force made up of local officials involved in directing recovery efforts and filing FEMA claims.

Funding Sources

In June 1994 voters rejected Measure 1A, a proposed $2 billion bond issue earmarked for earthquake relief.[9] The resulting lack of funds caused Governor Pete Wilson to cancel a $575 million California Natural Disaster Assistance Program, which was to have provided loans for housing reconstruction. The loss of the State loans cast doubt on the future of 2,750 apartment buildings, primarily in the San Fernando Valley and Hollywood, that had been vacated because of earthquake damage. An additional 28,000 houses and apartment units could be abandoned as owners and tenants lose faith that repair funds can be obtained. These losses would diminish the affordable housing stock and increase blight.

However, in August 1994, President Clinton responded to an appeal from Los Angeles Mayor Richard Riordan by asking Congress to redistribute $225 million from highway and school retrofitting projects. With these funds, the cities of Los Angeles and Santa Monica would be able to make 30-year, no-interest deferred loans to owners of damaged buildings.[10] It is estimated that the new money will help rebuild 17,000 units, or about

half the number that Mayor Riordan has said are at risk for lack of the necessary funds.[11] Loans will be targeted to "ghost towns," crime-infested enclaves of vacant, damaged buildings.[12]

1. National Earthquake Strategy Working Group for White House Office of Science and Technology Policy, *National Earthquake Strategy*, revised draft, Washington, DC, June 28, 1994, p.7.

2. Federal Emergency Management Agency, *Hazard Mitigation Grant Program: Interim Guidance*, Washington, DC, June 1992, p. 2-4.

3. Office of Management and Budget, *Six Months after the Northridge Earthquake: A Look Back at the Federal Response*, Washington, DC, July 27, 1994, p. 2.

4. Ibid.

5. Ibid., p. A-2.

6. 59 *Federal Register* 36692, July 19, 1994.

7. Program and its findings are described in Seismic Safety Commission, *California at Risk: Reducing Earthquake Hazards, 1987 to 1992*, Sacramento, CA, December 31, 1991.

8. Dawley, Gregory, Assistant Chief of Staff. Office of the Mayor. City of Los Angeles. Letter. January 11, 1995.

9. Doug Smith, "Quake Recovery Program Canceled," *Los Angeles Times*, June 10, 1994.

10. Doug Smith, "Cisneros, Riordan Tour Quake 'Ghost Towns'," *Los Angeles Times*, August 5, 1994.

11. Ibid.

12. Hugo Martin, "More Funds for Quake 'Ghost Towns' Sought," *Los Angeles Times*, August 3, 1994.

SECTION TWO

HOSPITALS

I. Introduction

The seismic performance of health care facilities is crucial—their availability and safety can be regarded as a measure of the community's ability to protect its members. Not only do hospitals serve those who are already physically vulnerable, they also must be able, even in the aftermath of an earthquake, to respond to the basic and emergency medical needs of their community. The Northridge earthquake left 8,700 people injured, including more than 1,600 who required hospitalization. There were 82 buildings located on the 23 medical sites (hospitals and skilled nursing facilities) where one or more buildings were forced to evacuate many or all of their patients and personnel, compromising their ability to save lives and provide basic services.[1]

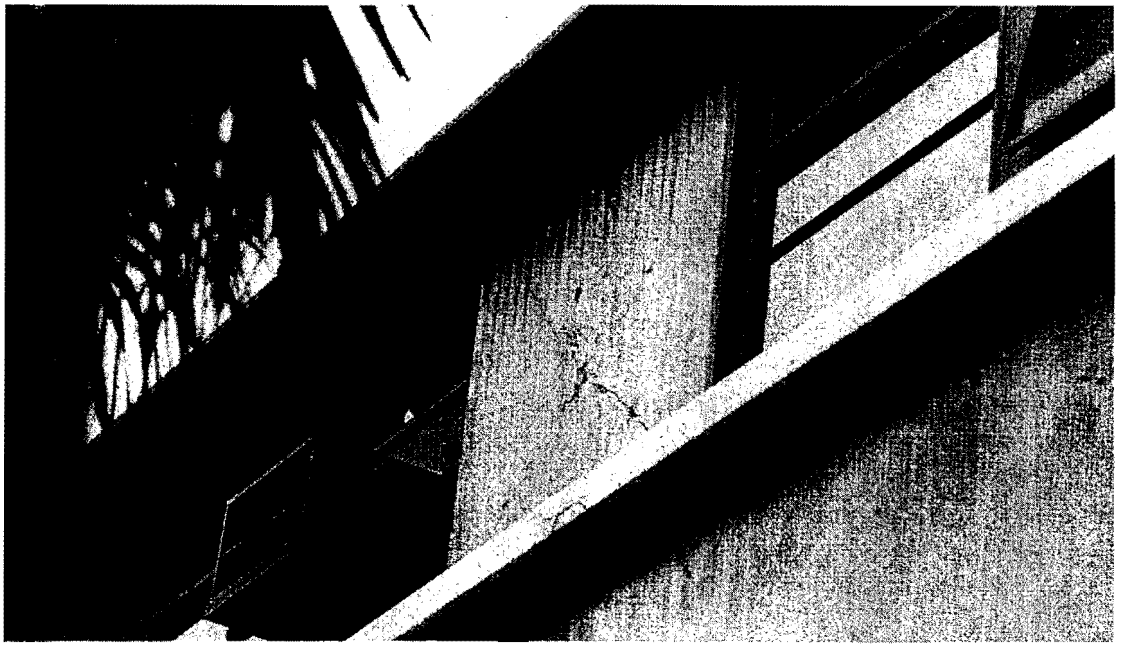

EXHIBIT 2 Structural damage to wall at Los Angeles County/University of Southern California Medical Clinic.

A number of hospitals suffered significant structural damage in the Northridge earthquake. One hospital was evacuated due to severe diagonal cracking, which extended through the entire thickness of its concrete shear walls. Another was evacuated because of a potential loss of vertical support resulting from column damage. However, from a structural standpoint, recently constructed hospitals in the Los Angeles area withstood the Northridge earthquake relatively well. Comparisons of facilities constructed before and after the 1972 Hospital Seismic Safety Act suggest that the

standards established in this law were very important in limiting structural damage; to a lesser extent, the Act was also effective in controlling nonstructural damage.[2]

The real lesson of the Northridge earthquake for health care providers and emergency services planners was that nonstructural damage is a serious threat to patients' safety and hospitals' capacity to function. In two cases, nonstructural damage was so severe that hospitals were forced to close.[3] In other facilities, damage to heating and ventilation systems and sprinklers forced major evacuations, even though there was no significant structural damage to the buildings. One State official later referred to the Northridge earthquake as the "nonstructural earthquake."

The significant nonstructural damage caused by this earthquake raises questions about whether current building code requirements for hospitals, which focus on structural elements, are sufficient to ensure that facilities will continue to function after an earthquake.[4] At the State level, the Governor's Office of State Health Planning and Development is already reviewing the adequacy of the Hospital Seismic Safety Act, which it administers.

EXHIBIT 3 Nonstructural damage to a ceiling at the Pediatric Pavilion, Los Angeles County/University of Southern California Medical Center.

This chapter will focus on the mitigation needs of the public health care facilities operated by Los Angeles County's Department of Health Services (DHS), which provides basic public health care services to Los Angeles area residents, including the medically indigent. It operates 6 acute care hospitals with a capacity of 2,862 beds, as well as 44

health centers that offer basic outpatient services in a community setting. The County's health care facilities also perform a wide range of essential supporting functions. Health centers are local headquarters for environmental specialists concerned with sanitary food and water, while the hospitals also serve as countywide resources for specialized functions such as trauma, burn and psychiatric care, and poison control. Critical information on mitigation plans and estimated costs for medical facilities outside the Los Angeles County system is not available.

II. What Needs to Be Done?

The mitigation needs of health care facilities in the Los Angeles areas—whether they are hospitals or clinics, public or private—are necessarily determined by two overriding objectives. The seismic safety of these facilities must be adequate to protect patients, as well as essential equipment and supplies, during and after an earthquake. At the same time, essential systems, ranging from ventilation to communication, must continue to function, so that hospitals and clinics can respond to their community's post-earthquake medical needs.

Los Angeles County Health Facilities

Prior to the Northridge earthquake, the Los Angeles County Department of Health Services had estimated that replacement and modernization of its older facilities would cost approximately $2.3 billion. Now the Department has begun to ask what additional improvements would be necessary to "harden" its critical facilities and communications systems in order to safeguard the integrity of essential services and supplies under severe seismic disaster conditions.

Modernizing and expanding hospital trauma facilities is also critical to adequately providing emergency health care needs after a disaster. The Trauma Facility of the Los Angeles County/University of Southern California Medical Center handles 28 percent of all trauma cases within the County. As the main point of entry to the Medical Center, the Trauma Facility has a patient load of 200,000 visits per year and treats patients from approximately 2,000 paramedic calls each month. Currently, it can only utilize four patient care areas at one time. This severely limits its capacity to provide the highest possible level of care, even under routine operating conditions. To meet the challenge of its growing patient load, as well as future emergencies, the Trauma Facility's capacity needs to double to accommodate eight patient care areas. Other needed improvements include additional radiological and oxygen equipment and storage cupboards and integration of infection control measures into the architectural design. The $2.7 million estimated cost of this expansion/renovation is included in the hospital's overall replacement plan.

Adequate communication also remains a major problem for local disaster response efforts. Disruptions can severely hamper vital coordination activities, such as determining bed availability at various facilities or ascertaining service levels in widely scattered areas. Highly effective radio systems for both the hospital emergency (ReddiNet) and civil emergency (CWIRS) sectors have been developed to meet these communication needs. The Department seeks to enhance the County's CWIRS communication network with the purchase of 110 additional radios at the approximate cost of $300,000. No firm cost for the ReddiNet has been established yet.

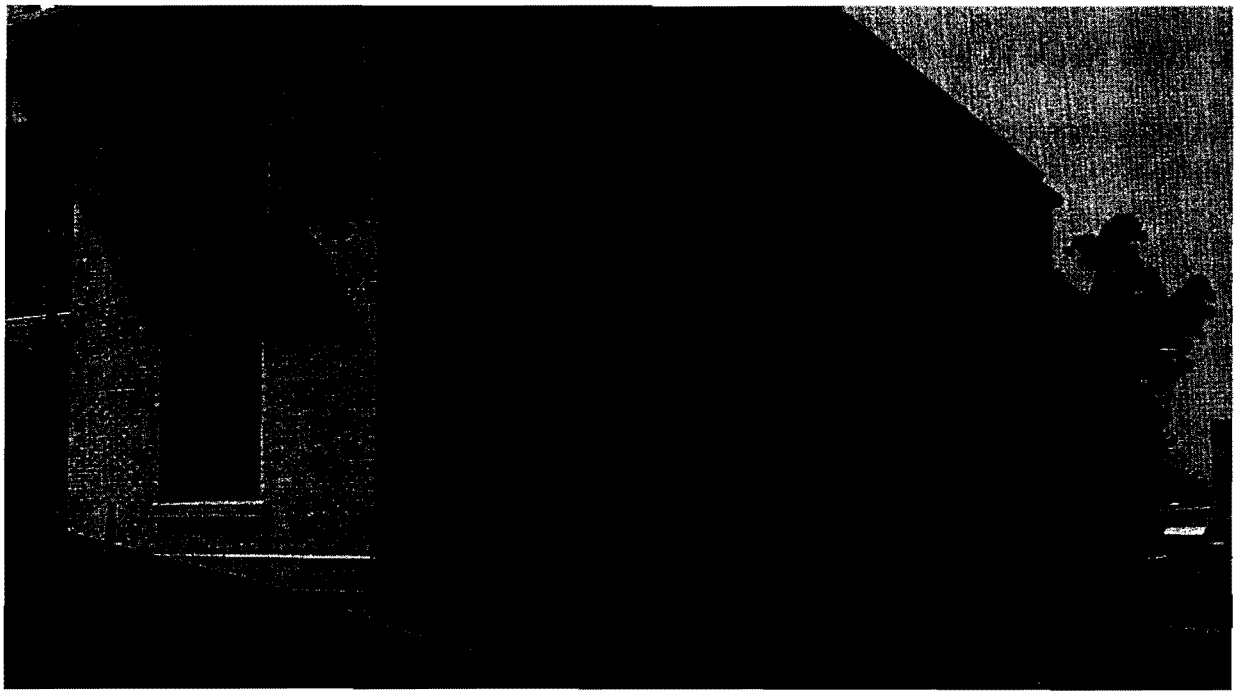

EXHIBIT 4 The Los Angeles County/University of Southern California Medical Clinic, housed in one of the Center's older buildings, sustained such considerable damage that it had to be demolished.

Two potential sources of funds have been identified to pay for these and other improvements. Approximately $23 million from FEMA's Public Assistance program has been earmarked for county facilities, primarily to make emergency repairs and conduct architectural/engineering surveys of damage. On the basis of these surveys, more Public Assistance funds can be authorized for replacement, repair, related code upgrade, and hazard mitigation in damaged facilities. The Department of Health Services also expects to request $400 million from FEMA's Hazard Mitigation Grants Program for seismic upgrade and code compliance-related hazard mitigation projects not covered by Public Assistance. In addition, it is developing cost estimates for projects that would harden essential facilities beyond code requirements— eventually, Hazard Mitigation funds may be requested for these projects as well.[5]

However, these Federal resources fall far short of the $2.3 billion needed for planned upgrade and replacement, to say nothing of the unspecified, but surely significant, amount required for hardening projects. Unmet needs also include the matching funds that the County must obtain to leverage Hazard Mitigation Grants. The County anticipates using long-term financing vehicles, such as bond issuances, to cover a portion of the total unmet costs, although recent ballot measures to authorize such bonds have failed.[6]

Community Health Clinics

Together with the County's community-based health centers, community health clinic corporations are the principal source of primary medical care for the indigent. In addition, many community clinics provide a variety of essential social services at relatively low cost. Consequently, they often operate on very small budgets and occupy buildings with low rents. A number of these buildings experienced earthquake damage and were rendered unusable.

Because of their central role as health care and social service providers to low-income households in Los Angeles County, community health clinics must remain operational after an earthquake. These clinics should be encouraged, through incentives such as rent subsidies or space in public buildings, to occupy seismically retrofitted buildings. No reliable estimate of subsidies or suitable publicly owned space for these clinics is available.[7]

III. What Is Being Done?

The Federal Government is contributing to efforts to ensure that Los Angeles hospitals are prepared for the next earthquake both through FEMA grant funds and through direct improvements to hospital facilities of the Department of Veterans Affairs. While the State of California has had difficulty raising funds for mitigation, it is actively pursuing education, training, and coordination activities. In addition, its statutes governing hospital construction have played a crucial role in promoting seismic safety in area health care facilities.

Federal Efforts

As providers of disaster medical relief, the U.S. Departments of Health and Human Services (HHS) and Veterans Affairs (VA) responded immediately to the Northridge earthquake. HHS activated seven Disaster Medical Assistance Teams and the VA activated four mobile health clinics—two to support the damaged Sepulveda Medical

Center and two to meet community medical needs. A total of 1,165 patients were treated by the two community-based mobile VA clinics. VA health care professionals treated three out of every four of the 27,539 persons who received medical services from a Federal health care provider.

The VA's effective disaster response recently prompted the Los Angeles County Department of Health Services to recommend that the Veterans Affairs Medical Center in West Los Angeles serve as a potential Casualty Collection Point site for the County's medical disaster response.[8] As one of these sites, the VA Center would be used for collection, triage, austere medical treatment, longer term holding, and evacuation of casualties in future disasters. The VA Medical Center was also selected because of its geographic location, available response staff, and physical facilities such as a helipad.[9]

The VA has been actively engaged in earthquake mitigation activities since 1971. Through its Seismic Strengthening Program, the VA has spent over $1.1 billion, or approximately $47 million per year, to retrofit its hospitals and ensure that VA facilities are structurally safe. The extent of nonstructural mitigation activities implemented through this initiative has depended on the hospital's location. For instance, VA hospitals in Los Angeles are in the most vulnerable seismic zone and thus warrant major nonstructural mitigation.

Currently, the Veterans Affairs Medical Center in West Los Angeles is reviewing and revising its 5-year retrofitting plan. Needed retrofit and replacement activities affecting 33 of the Center's 140 buildings and structures would cost approximately $41.8 million.[10]

State Efforts

The State of California has enacted important seismic safety laws and continues to coordinate disaster preparedness and ensure that hospital buildings are able to withstand earthquakes. In response, many hospitals have been implementing systematic, long-term mitigation and emergency planning programs. These actions have yielded impressive progress in enhancing the safety and sustainability of the Los Angeles area's health care delivery system.

The Hospital Seismic Safety Act (HSSA)

The Hospital Seismic Safety Act (HSSA) was enacted in the wake of the 1971 San Fernando earthquake, in which several hospitals sustained heavy damage or collapsed. The 1972 law requires that hospitals have special structural features. However, the Act only applies to the construction of new hospital buildings and to the alteration or remodeling of existing structures—the Office of Statewide Health Planning and Development has no authority to require that existing structures be upgraded to current

standards. Nonetheless, the State and many local jurisdictions are involved in programs to identify and retrofit certain types of older pre-Act buildings to the more stringent seismic standards.[11]

Within 4 months of the Northridge earthquake, amendments to the HSSA were being considered by the California legislature that would make significant changes to the Act. SB1953 recently passed in the Fall, 1994, requiring hospital owners of all buildings determined to be a "potential risk of collapse" to submit plans to replace, retrofit or change use or demolish them by January 1, 2008. Owners of all general acute care hospitals shall either demolish, replace or change use or retrofit buildings that do not meet the requirements of HSSA by January 1, 2030.[12] Hospitals must comply with either of the deadlines or receive an extension in time in order to retain their license. The Department of Health Services, as part of its periodic licensing inspections, would determine the capacity of a hospital to function during and after an earthquake.[13]

The Office of Statewide Health Planning and Development (OSHPD)

The mission of the Office of Statewide Health Planning and Development is to plan for and support development of a health care delivery system that meets the current and future health care needs of the people of California. Among its many functions, the Office conducts plan reviews and field inspections to monitor the structural soundness and functional safety of California's licensed health facilities. It also coordinates with the State Fire Marshal, the Office of Emergency Services, and other affected agencies to maintain the necessary seismic, fire, engineering and construction standards.

Starting in 1979, the Office of Statewide Health Planning and Development began the "General Acute Care Hospital Earthquake Survivability Inventory," which was completed in 1991. State agencies such as the Seismic Safety Commission have used the inventory as a means of assessing the survivability of hospitals in the event of high-intensity ground motions, geotechnical failures, or the failure of utility services.[14]

Governor's Office of Emergency Services (OES)

Since 1991 the Governor's Office of Emergency Services (OES) has been training hospitals in earthquake preparedness and—to the benefit of all Californians—hospitals have implemented much of what they have learned.[15] This initiative, called the Earthquake Program in California, will accelerate training in the Hospital Emergency Incident Command System, as well as update and continue presentations of a course on "Nonstructural Hazard Mitigation and Emergency Planning." Additional planning and preparedness issues emphasized include training evening and night shift personnel, acquiring better backups for water and power systems, using the Hospital Emergency Incident Command System structure, and developing mitigation strategies to protect

essential or hazardous building contents and systems.

Just prior to the Northridge quake, the Office of Emergency Services had started an earthquake preparedness training program for community clinics. This effort is now in high gear. In addition, the clinics are being assisted in the mitigation of selected building contents by teams of California Conservation Corps workers.

Moreover, the Office of Emergency Services is working with the Hospital Council of Southern California and Los Angeles County's Department of Health Services to convene representatives of key health care provider groups and agencies from Los Angeles and surrounding counties in an effort to identify unmet needs and prepare for future scenarios. Formal gathering of data and information on hazard mitigation needs of hospitals, clinics, and long-term care providers has just begun.[16]

Local Efforts

The Los Angeles County Department of Health Services is currently engaged in a comprehensive campaign of disaster recovery/hazard mitigation activities ranging from replacement of its oldest hospital facility to ensuring the continued operational capacity of the newer structures. In some cases, the Department is still in the process of identifying the extent of the physical damage to structures. As late as March 1994, as new aftershocks occurred, some of the structures initially considered safe were evacuated after reevaluation. Structures that pose hazards to human life are being demolished. Temporary, interim facilities are being used to provide medical care, particularly in the San Fernando Valley area.

State agencies are reviewing the County's replacement plans for the Los Angeles County/University of Southern California (LAC+USC) Medical Center, the County's largest and most critical facility, which suffered significant damage in the earthquake. The County is also requesting FEMA Hazard Mitigation Grant funding for its undamaged facilities.

IV. Conclusion

Efforts to ensure the seismic safety of the Los Angeles area's public hospital system proceed from a solid foundation. The State of California has provided strategic leadership through vigorous regulation, research, education, and other initiatives. The Hospital Seismic Safety Act offers apparently sound standards for hospital structures, although its provisions for nonstructural elements need attention. Important information on the needs of hospitals in Los Angeles and throughout California is available, and mechanisms for updating and elaborating on this knowledge is in place.

Mitigation plans for Los Angeles County hospitals demonstrate a clear understanding of the mission of the public health care system in a seismic emergency. In the light of this understanding and a careful analysis of damage sustained by its facilities in the Northridge earthquake, the County's Department of Health Services has defined priorities for mitigation. The "nonstructural earthquake" clearly pointed to the need for extensive nonstructural retrofitting. In addition, hardening of essential facilities, structural mitigation or replacement of older structures, and improved communications technology are also required.

Although a reasonable plan for mitigation of health care facilities has been established, the resources needed to implement this plan have not been identified. FEMA Public Assistance funds will be made available to help pay for structural repair of damaged facilities, but are of limited applicability to the system's acute need for nonstructural mitigation and hardening. Hazard Mitigation Grant funds could contribute to addressing these unmet needs; however, the County's ability to raise the necessary matching funds—as well as the much larger amounts needed to carry out mitigation not covered by Federal funding—rests on the uncertain prospect of securing public approval for bond issues.

1. Seismic Safety Commission, Draft Response to the Governor's Executive Order Report, January, 1995.

2. Ibid., p. 6.

3. Jo Weber Kimmel, *The Northridge Earthquake; Lessons Learned Concerning Health Care Facilities*, California Office of Emergency Services, talking points, Summer 1994.

4. Seismic Safety Commission, *Performance of Hospitals*, Interim Background Report B7, June 1994, p. 12.

5. Frank Binch, Network Development Administrator, Personal Health Services, Los Angeles County Department of Health Services, phone interview, September 8, 1994.

6. Ibid.

7. Neither the State Department of Health nor the Los Angeles County Department of Health Services had this information available, September 1994.

8. Letter from the Emergency Medical Services Agency, Los Angeles County Department of Health Services, to Veterans Affairs Medical Center in West Los Angeles, June 2, 1994.

9. Hank Maar, Emergency Preparedness Program Manager, Department of Veterans Affairs, VA Medical Center, Los Angeles, CA, memo, September 29, 1994.

10. Meeting with VA officials, Veterans Affairs Medical Center in West Los Angeles, July 1994.

11. Building Safety Board, *California at Risk Milestone 4 Report, A Recommended Program to Seismically Strengthen Pre-Hospital Act Facilities*, December 1990, Sacramento, CA, p. 2.

12. Seismic Safety Commission. Faxed information on SB1953. January 10, 1995.

13. Seismic Safety Commission, *Performance of Hospitals*, p. 4.

14. Applied Technology Council, *ATC-23, Part A. General Acute Care Hospital Earthquake Survivability Inventory for California: Survey Description, Summary of Results, Data Analysis and Interpretation*, Redwood City, CA, 1991. p.1

15. Jo Weber Kimmel, *The Northridge Earthquake.*

16. Harriet Glass Ulmer, Los Angeles Regional Director, Center for Health Resources, Hospital Council of Southern California, letter, August 4, 1994.

SECTION THREE

SCHOOLS

I. Introduction

The seismic safety of schools is essential to protecting both individuals and the community at large. If an earthquake were to strike during school hours, thousands of children would be at risk from falling debris or even structural collapse. In addition, most communities use their school buildings as shelters and relief stations after a natural disaster. The soundness of these buildings thus ensures refuge in familiar surroundings for all neighborhood residents. Finally, serious damage to school buildings and classrooms can force school closures and disrupt the academic schedule. Such interruptions can break the learning process, creating lasting delays in a child's educational development. In short, the value of seismically safe schools extends far beyond protecting people from full-scale structural collapse during an earthquake.

Overall, the schools of Los Angeles withstood the Northridge earthquake remarkably well. Although officials from the Los Angeles Unified School District (LAUSD) initially closed its 640 schools, all but 75 reopened the following week.[1] Officials currently estimate damage to schools within the Los Angeles District at between $150 million and $200 million.[2]

Although schools suffered a variety of structural damage from the Northridge earthquake, none collapsed and only one school and one major building were so badly damaged that they will have to be demolished and replaced.[3] Several schools experienced cracked foundations that will require extensive rehabilitation. There was also damage to auxiliary elements such as pole-supported walkways, lunch shelters, and portable buildings.[4] No buildings or rooms collapsed.[5]

However, as with hospitals, nonstructural damage within schools was considerable. About 1,500 buildings incurred some degree of damage to suspended lighting and ceiling systems.[6] Although current regulations require more secure lighting, many schools retain systems installed before these regulations were modified. There was also substantial damage due to falling equipment, file cabinets, and other furniture. In addition, sprinklers and other utility pipes in ceilings broke, causing widespread water damage.

If the earthquake had struck during school hours, these nonstructural hazards would have made safe exit impossible for hundreds of children and teachers. The Northridge earthquake thus illuminated the critical importance of mitigating nonstructural weaknesses in schools. All levels of government have a responsibility—and now, a clear opportunity—to promote such mitigation.

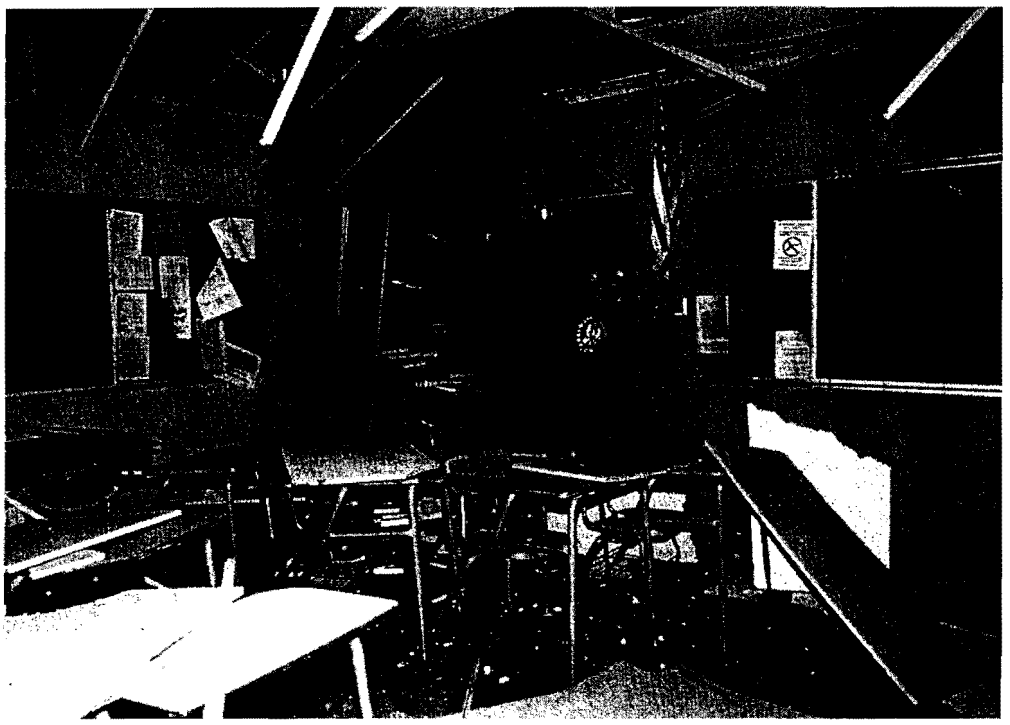

EXHIBIT 5 Nonstructural damage to ceiling fixtures in school classroom.

II. What Needs to Be Done?

Hazard mitigation in California schools must proceed on several fronts. For example, most schools need considerable nonstructural mitigation work to install safer lighting, ceilings, and piping, as well as to secure furniture and hanging items. There is a need to survey all schools to identify these needs systematically. School districts also must establish emergency communications systems and train staff to maintain seismic safety and respond effectively during earthquakes. This section outlines the scope and estimated cost of this work for California—and for the Los Angeles Unified School District in particular.

Despite considerable regulation of school construction since 1933, structural retrofit of California school buildings remains a substantial part of necessary mitigation activity. Over half of the approximately 53,000 public school buildings in the State were built more than 30 years ago. State officials estimate that at least 25,000 schools need structural retrofitting. Between 1,000 and 4,000 schools, built before State regulation of school construction became considerably stricter, require priority attention.[7] The California Seismic Safety Commission (SSC) estimates that this work will cost between $2 billion and $5 billion statewide.[8]

Despite the generally adequate performance of Los Angeles' school facilities in the Northridge earthquake, approximately 10 percent of the District's school buildings require structural mitigation. School officials calculate that 33 lift-slab buildings, 572 masonry buildings, and 515 concrete buildings—all constructed before the State made school construction standards more stringent in 1972—require some structural retrofitting. Lift-slab buildings, tilt-up buildings, and nonductile concrete frame buildings have been given the highest priority for retrofitting. The District estimates the cost of this work at approximately $786 million.[9]

EXHIBIT 6 Structural wall damage to school building.

However, local and State officials have recently determined that the more pressing need is for nonstructural retrofitting. In 1992 the Seismic Safety Commission had identified this mitigation work as a major priority for schools.[10] The Northridge earthquake affirmed this decision, making it clear that nonstructural hazards currently pose a greater threat to human safety than structural weaknesses. At a special hearing before the Commission in February 1994, local officials unanimously cited these hazards as the most critical targets for mitigation efforts in the Los Angeles schools.[11] Los Angeles school officials estimate that the cost of nonstructural retrofitting for suspended lights and ceilings alone will reach approximately $297 million.[12]

The total cost of retrofitting Los Angeles schools comes to an estimated $1.306 billion, including $851 million for structural mitigation and $455 million for nonstructural work.

FEMA's Public Assistance and Hazard Mitigation Grant Programs can pay a portion of this cost, but not without considerable matching funds from State and local treasuries. Under the most optimistic scenario, FEMA's programs could pay up to $359 million, or 27.5 percent of the total cost. Even assuming that local and State agencies meet the matching requirements and FEMA provides the maximum possible funding, total unmet need would still exceed $947 million.[13]

Finally, local officials have identified several important mitigation activities beyond retrofitting. Specifically, the Los Angeles Unified School District hopes to put in place an emergency communications system, provide training for school personnel in emergency procedures and maintenance of seismic safety within classrooms, and sponsor programs to integrate nonstructural retrofit measures into routine maintenance by school workers and contractors.

III. What Is Being Done?

Strategies for completing structural and nonstructural mitigation of Los Angeles schools are already in place. Implementation of these strategies has been facilitated by regulatory actions taken by the Federal Government (broadening eligible uses of FEMA programs) and the State of California (setting statewide standards for school buildings). However, the feasibility and impact of much of the planned mitigation activity depends on the ability of State and local government to raise the monies needed to fund State programs and leverage Federal grants.

Federal Efforts

The Federal Emergency Management Agency provides the bulk of Federal aid to States and localities for both repair and mitigation activities.[14] FEMA's Public Assistance program addresses recovery and repair work for buildings damaged in the disaster.[15] In severely damaged buildings, this program will fund restoration, including structural retrofit to make the site safer. As few school buildings in Los Angeles suffered structural damage during Northridge, the Public Assistance program can cover only a tiny portion of the work necessary to bring schools up to the safest current standards.[16] By the beginning of August, FEMA had awarded the Los Angeles Unified School District approximately $80 million to repair damaged school structures.[17]

FEMA has recently ruled that Public Assistance funds may be used to repair and retrofit pendant lighting and suspended ceilings in buildings where these systems were significantly damaged. However, the nature of the nonstructural retrofitting to be

permitted has not yet been settled. This ruling could affect about 300 school buildings in the Los Angeles district.[18]

Under a new, broader policy on funding hazard mitigation through the Public Assistance Program, FEMA will now consider mitigation proposals for any building that was damaged in the earthquake. The items proposed for mitigation—such as pendant lighting or the anchoring of equipment—do not need to have been damaged to qualify. Depending on how this policy is implemented, it is possible that as many as one-third of the Los Angeles Unified School District's buildings could be retrofitted with Public Assistance funding. However, even this best-case scenario would still leave millions of dollars in retrofitting projects that would not qualify for Public Assistance funding. For example, the cost of retrofitting pendant lighting and suspended ceilings in the two-thirds of Los Angeles' school buildings that were not damaged by the Northridge earthquake would be about $210 million.

FEMA's Hazard Mitigation Grant Program targets undamaged buildings for retrofitting and other efforts to improve their seismic safety. Hazard Mitigation Grants are likely to provide considerable, but still insufficient, funding for both structural and nonstructural mitigation of undamaged schools. Officials from FEMA and the Governor's Office of Emergency Services have indicated that Hazard Mitigation funds will flow primarily to nonstructural retrofitting, particularly suspended ceilings and lights.[19] The distribution of Hazard Mitigation funds, however, will not begin until FEMA has distributed Public Assistance funding and State and Federal officials have agreed upon a state funding strategy.[20]

At this point, it is impossible to know how OES will allocate the estimated $800 million in Hazard Mitigation Grants among the various public agencies that are seeking assistance. Given the natural concern for school safety, schools could qualify for as much as two-thirds of these funds. The amount of these funds allocated to Los Angeles schools will depend on factors such as the location of faults and hazardous soil conditions in different parts of Southern California, the kinds and distribution of conditions that need retrofitting, and historical patterns of earthquake damage.

Despite a relatively modest focus upon ceilings and lights, Los Angeles school officials lack adequate funding to complete this work.[21] To get $100 million in Hazard Mitigation funds, the schools would need to raise $25 million in matching funds. The availability of State matching funds remains in doubt, particularly in light of the voters' rejection of a recent State bond referendum. California Governor Pete Wilson had planned another referendum for November 1994, but this too failed when the State legislature did not vote to place a bond issue on the ballot.[22] In August, the Los Angeles Unified School District convinced the State Allocation Board to transfer $30 million from a new high school academies program to earthquake recovery. Nonetheless, District officials indicate that they will need most of these funds to fulfill Public

Assistance matching requirements and thus will be unable to meet the Hazard Mitigation match.[23]

In addition to FEMA, the U.S. Department of Education has provided considerable funding directly to the Los Angeles Unified School District for recovery activities. In June 1994 the Department approved $85.4 million to make up school hours lost during the earthquake. In addition, this grant funded onsite counseling and tutoring for children who missed considerable class hours, restored lost food services revenues, and purchased cellular phones for better emergency communications during future disasters. The Department does not fund any physical retrofitting or other long-term mitigation activities.[24]

The Department of Education also may be able to target funds to Los Angeles from the Elementary and Secondary Education Act passed by Congress in the fall of 1994. Titles XI, XII, and XV of the bill offers funding for modernization of dilapidated buildings in urban school districts across the country.[25] However, the funds do not cover nonstructural or extensive structural retrofitting.

State Efforts

Los Angeles schools were able to withstand the Northridge earthquake so well largely because of over 60 years of State regulation of school construction and operation. After the Long Beach earthquake of 1933, the California legislature passed the Field Act to ensure that all new public school buildings would remain structurally sound during an earthquake. The Division of State Architect enforces the Act by reviewing architectural plans and supervising construction of all new schools in the State.[26]

As engineering technology has advanced, the legislature has amended the Field Act several times to make its seismic building standards more stringent.[27] Currently, legislators are reviewing additional proposed revisions. Specifically, the poor performance of "T-frame" ceilings and steel-frame construction during that earthquake has suggested to some legislators a need to ban these architectural systems from school construction.[28]

In 1984 the California legislature passed the Katz Bill to address earthquake preparedness in public and private schools. This law requires all schools with more than 50 students to put in place an earthquake emergency system. Such systems generally include emergency drills, a staff assignment plan, and some nonstructural retrofitting. Despite the law's strong language, many school districts have not developed emergency systems because the legislature did not appropriate additional funding or establish enforcement mechanisms.[29] Nevertheless, local officials claim that Los Angeles schools are in substantial compliance with this statute.

In addition to these regulatory measures, the State has several programs to fund earthquake repairs and mitigation. The Leroy Greene Lease-Purchase program, commonly known as the State School Building program, gives grants to school districts for the modernization of older buildings. The Hughes Earthquake Relief program provides school districts with grants earmarked for repairing damaged buildings.[30] The State Allocation Board administers both programs, which school districts often use to match FEMA's Public Assistance and Hazard Mitigation funds after a disaster. These programs are funded through bond proceeds and thus have very little to offer at this time—the next major bond issue will not be on the ballot until 1995. Until such a referendum succeeds, these programs will remain dormant.

Finally, the Division of State Architect (DSA) started a complete review of the mitigation needs of the State's public and private schools in 1989. Unfortunately, the Division did not have the funding to finish this survey—officials estimate that approximately $300,000 would be needed to complete the work.[31] This survey would ensure that State and Federal decisionmakers have the information required to allocate resources to the neediest sites.

IV. Conclusion

The seismic safety of public schools is key to protecting the most precious members of any community—its children. Although Los Angeles area public school buildings withstood the Northridge earthquake extremely well and resumed operations quickly, only the fortuitous timing of the quake saved untold numbers of schoolchildren from injury or death.

The Northridge earthquake provided a warning that State and local officials had begun to heed long ago. A strong regulatory framework is already in place to govern the construction and operation of school buildings, and further strengthening of State laws is being considered. The effect of these measures is being reinforced through mitigation and preparedness education programs developed at the State level.

Additional research on building types susceptible to damage, as well as a statewide survey of school mitigation needs, would advance important planning efforts. However, nonstructural mitigation has already been identified as the most urgent mitigation need for schools in Los Angeles and elsewhere. Officials of the Los Angeles Unified School District have focused on two of the principal components of nonstructural mitigation—retrofitting suspended ceilings and pendant lighting—as an immediate priority.

However, as with hospitals, paying for this essential mitigation work has proven to be the most serious stumbling block. Despite recent rulings that should make it easier to use FEMA Public Assistance funds for nonstructural repair and mitigation, hopes for

retrofitting lighting and ceilings have been pinned on the school district's ability to successfully compete with other public institutions for a larger share of the limited pool of FEMA Hazard Mitigation Grants. However, local efforts—as well as existing State programs—designed to fund mitigation and match available FEMA monies are predicated on the passage of bond issues.

1. Robert Donald, Deputy Director for Architecture and Engineering, Los Angeles Unified School District, Los Angeles, CA, phone interview, summer 1994.
2. Douglas Powdrell, Disaster Assistance Branch, California Office of Emergency Services, telephone interview, summer 1994.
3. Roger Rasmussen, Director, Independent Analysis Unit, Los Angeles Unified School District, correspondence, September 29, 1994.
4. Division of State Architect, *Northridge Earthquake: Public School Buildings*, Sacramento, CA, May 1994, p. 1.
5. Ibid.
6. Roger Rasmussen, correspondence, September 29, 1994.
7. California Office of Emergency Services, *Unacceptable Risk: Earthquake Hazard Mitigation in One California School District*, 1993, p. 8.
8. Seismic Safety Commission, *California At Risk: Reducing Earthquake Hazards 1992-1996*, Sacramento, CA, December 31, 1991, p. 18.
9. Roger Rasmussen, telephone interview, summer 1994.
10. Seismic Safety Commission, *California At Risk*, pp. 18-19, 26.
11. Federal Emergency Management Agency, *Nonstructural Retrofit for Schools: Statement of Work*, 1994, p. 2.
12. Roger Rasmussen, telephone interview, October 10, 1994.
13. Roger Rasmussen, telephone interview, October 10, 1994.
14. For an expanded summary of FEMA's Public Assistance and Hazard Mitigation Grant Programs, see the first Section of this report.
15. Sarah Nathe, California Office of Emergency Services, telephone interview, summer 1994.
16. Roger Rasmussen, correspondence, September 29, 1994.

17. Ibid.

18. Ibid.

19. Marilyn MacCabe, Earthquake Program Manager, Mitigation Directorate, Implementation Division, FEMA; and Sarah Nathe, Office of Emergency Services, telephone interviews, summer 1994.

20. Roger Rasmussen and Marilyn MacCabe, telephone interviews, summer 1994.

21. Roger Rasmussen, telephone interview, summer 1994.

22. Roger Rasmussen, telephone interview, September 1994.

23. Ibid.

24. Letter from Charles E. Hansen, Director of Impact Aid Programs, U.S. Department of Education, to Sidney A. Thompson, Superintendent, Los Angeles Unified School District, June 10, 1994.

25. Roger Rasmussen, telephone interview, summer 1994.

26. Division of State Architect, *Northridge Earthquake: Public School Buildings*, p. 1.

27. Seismic Safety Commission, *Interim Background Report: Performance of Schools*, Draft, 1994, p. 1-2.

28. Jack Bruce, Principal Structural Engineer, Division of State Architect, telephone interview, summer 1994.

29. Office of Emergency Services, *Unacceptable Risk*, p. 4.

30. Office of Emergency Services, *Unacceptable Risk*, pp. 7, 12.
Cruz Maranjo, California State Allocation Board, telephone interview, summer 1994.

31. Seismic Safety Commission, *California At Risk*, p. 18.
Dennis Bellet, California Division of State Architect, telephone interview, summer 1994.

SECTION FOUR

HOUSING

I. Introduction

There are approximately 1.3 million dwelling units in the City of Los Angeles—about 791,000 multifamily units and 512,000 single-family homes.[1] As of April 4, 1994, the damage tally from the Northridge earthquake included 65,300 residential buildings containing 308,846 units. Multifamily housing suffered disproportionately, comprising 84 percent of the damaged units.

Although the incidence of residential damage was greatest in the City of San Fernando, the City of Los Angeles incurred the most total damage.[2] According to an April 1994 report from the Los Angeles Department of Building and Safety, estimated citywide damage to residential buildings totaled $1.15 billion—$599 million in multifamily buildings and $550 million in single-family buildings.[3] By October 1994, an updated estimate put the total damage to residential properties at over $1.3 billion. However, even this higher figure does not reflect the billions more that private insurance companies may have paid in claims.[4]

Three common types of residential construction pose the greatest risk to life and safety in a seismic event. The vast majority of structures damaged in the earthquake were wood-frame buildings—those with a "soft" first story were especially vulnerable. Unreinforced masonry buildings and hillside homes were also particularly susceptible to damage. Unexpected structural failure occurred in some steel-frame buildings. In addition to construction failure, gas-fed fires caused by unbraced water heaters and unanchored manufactured homes were a significant danger to life, safety, and property.

II. What Needs to Be Done?

Some measures of the nature and cost of mitigating the effects of future earthquakes on residential structures in Los Angeles are known. The City's Housing Department and Department of Building and Safety have identified mitigation priorities and estimated their costs. In addition, retrofitting measures and costs can be estimated for each construction type. However, other information critical to mitigation planning is not available. For example, the number of housing structures and units of each construction type is not known—Los Angeles lacks an automated building inventory system that could provide such fundamental data.

Another impediment to retrofitting residential structures is the lack of State and municipal statutes that would require appropriate earthquake damage mitigation measures—the associated cost to property owners would make such legislation extremely difficult to pass. Nor is the technical basis for mandatory mitigation necessarily in place. For example, no accepted standard for steel-frame buildings currently exists. A standard for cripple-wall retrofit has been developed, but is not officially accepted.

A great deal of information is available on retrofitting and repairing single-family homes, which make up the bulk of Los Angeles' residential structures. In contrast, research on multifamily housing—particularly wood-frame structures—is quite limited, although more studies are currently underway. Unreinforced masonry residential buildings are an exception—extensive research on this structural type has already been completed.[5]

The failure of steel-frame buildings in the Northridge earthquake was unexpected and requires further research. Although the majority of steel-frame buildings are used for commercial purposes, there are 140 steel-frame multifamily buildings in the City of Los Angeles.[6]

Wood-Frame Homes

The vast majority of buildings affected by the Northridge earthquake are wood-frame structures. In the urban areas of Los Angeles, three- or four-story buildings of this type make up most of the multifamily stock.[7] Under seismic stress, multi-story structures with a soft first story—usually in the form of wood-framed parking facilities—performed poorly. The three-story Northridge Meadows apartment building, which collapsed and killed 16 people, was one such wood-frame building.[8]

The most common structural weaknesses of light, wood-frame residential structures are:

- Discontinuous or non-existent foundations below the exterior walls.
- The absence of proper connections between the exterior walls and the foundation.
- Inadequate bracing of cripple walls, which extend from the top of the foundation to the underside of the lowest floor framing (see Exhibit 8).[9]

Incentives are needed to encourage property owners to retrofit their wood-frame buildings. The cost of retrofitting an undamaged wood-frame, single-family home ranges from $2,000 to $4,000, including the installation of sill bolts and cripple-wall bracing. However, the cost of repairing a damaged unit of this type is about $30,000.[10] The total cost of retrofitting 100,000 undamaged wood-frame, cripple-wall homes would range from $200 million to $400 million,[11] although the actual number of such buildings may be higher.[12]

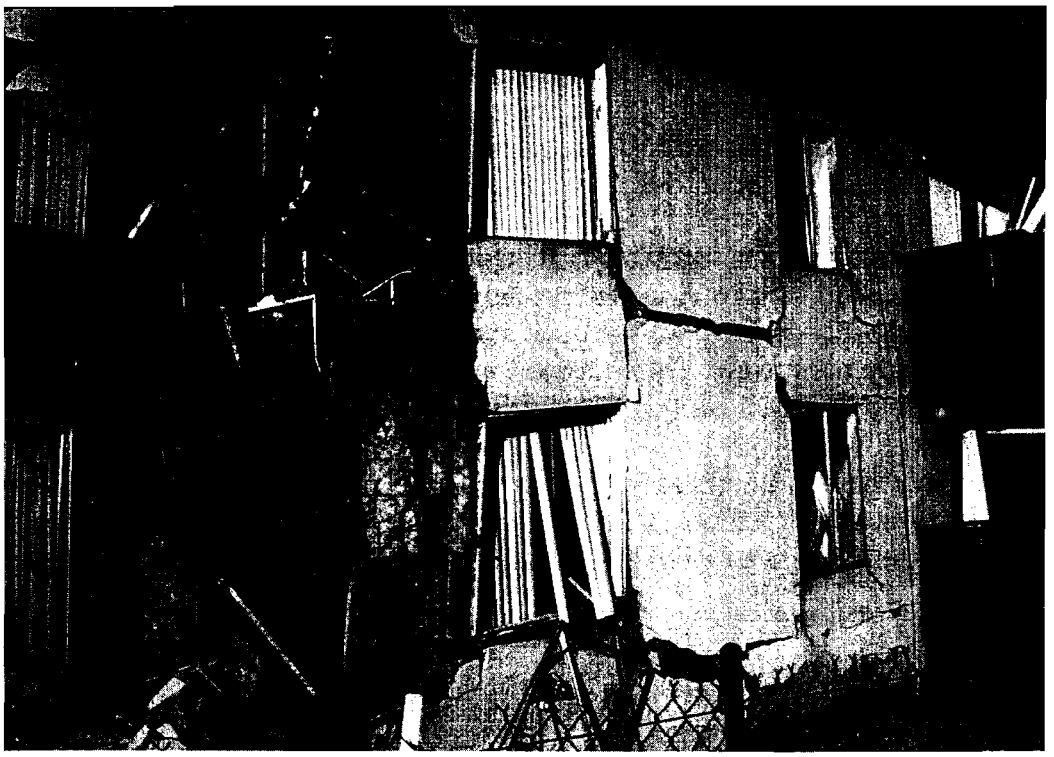

EXHIBIT 7 Structural damage at Northridge Meadows Apartments, where the top two floors collapsed, killing 16 people.

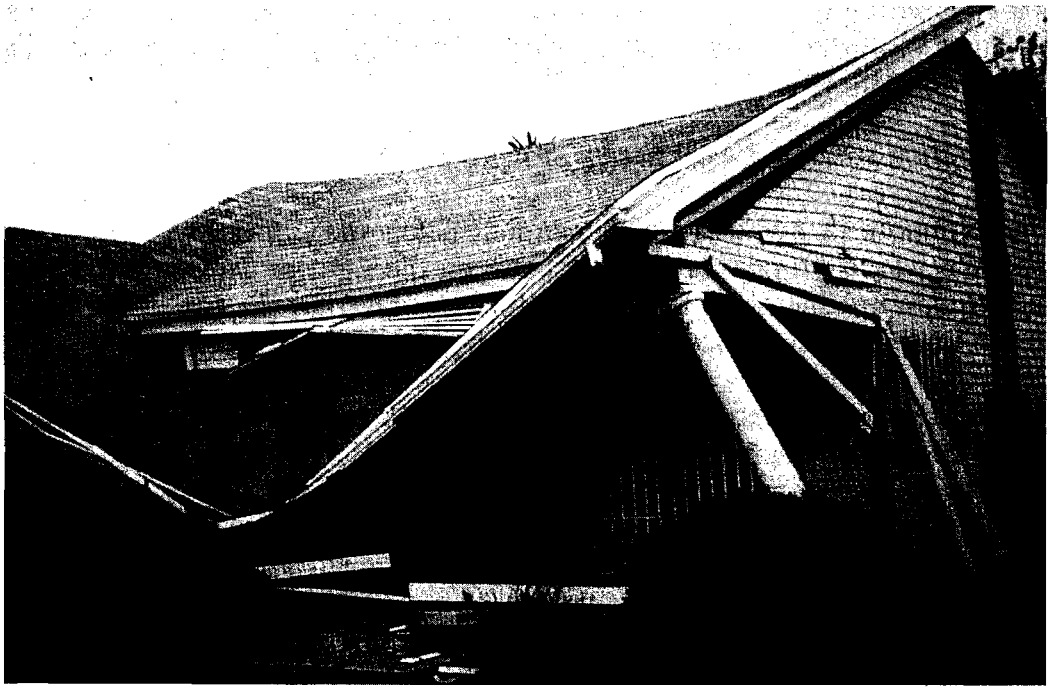

EXHIBIT 8 The result of cripple-wall failure in a wood-frame house.

Unreinforced Masonry Buildings

Unreinforced masonry buildings are the construction type considered most vulnerable to earthquake damage. Los Angeles' estimated 46,000 multifamily unreinforced masonry buildings are concentrated in four downtown neighborhoods: Hollywood, Boyle Heights, Wilshire/Westlake, and South Central.[13]

Observations after the earthquake confirmed that retrofitted unreinforced masonry buildings performed better than unretrofitted ones.[14] No properly retrofitted unreinforced masonry building sustained significant structural damage. Retrofitted buildings that were damaged were found, upon inspection, to have improperly designed or constructed systems. Correctly retrofitted masonry buildings were not immune to quake damage, but unretrofitted structures generally had more extensive damage, and a significant number of partial or complete collapses were observed. Typical damage included falling walls and parapets, shear cracks in walls, and partial collapse because of the loss of corner piers.[15] Masonry fireplaces, common in single-family structures, also performed poorly: many complete and partial failures of fireplaces and chimneys occurred in areas of seismic damage.

Unreinforced masonry buildings no longer pose as great a threat as in earlier years because many have been retrofitted through a local seismic safety program, which began in 1981. According to city officials, the program has successfully retrofitted 5,800 unreinforced masonry buildings in Los Angeles, but 500 are still in need of retrofit and another 300 should be demolished.[16] Included in this inventory are mostly commercial and mixed use buildings with some residential.

The average per-unit cost of retrofitting an unreinforced masonry building is between $5,000 and $15,000.[17] The lower boundary of this estimate applies to the addition of plywood to the walls, while the more extensive and expensive retrofit includes installing grade beams and steel columns. Other retrofit measures include bracing the parapet and tying the floor and walls together.[18] An upper bound cost estimate of completing retrofit of the 15,000 units in unimproved masonry buildings in the City of Los Angeles would range from $75 million to $225 million.[19]

Hillside Homes

Homes built on steep slopes of 20 degrees or greater are quite vulnerable to damage in a seismic event. The Northridge earthquake damaged 400 hillside homes—in two instances, collapsing homes killed the occupants.[20]

Because the City of Los Angeles does not have a building inventory system, the total number of homes constructed on hillsides is unknown—one guess places the figure at 10,000 units.[21] Retrofitting an undamaged hillside home costs an estimated

$6,000–$25,000, which includes adding plywood walls and anchor bolts. Thus the total cost of retrofitting the estimated 10,000 undamaged hillside homes in the City of Los Angeles would be between $60 million and $250 million. Repairs to damaged homes can exceed $70,000.

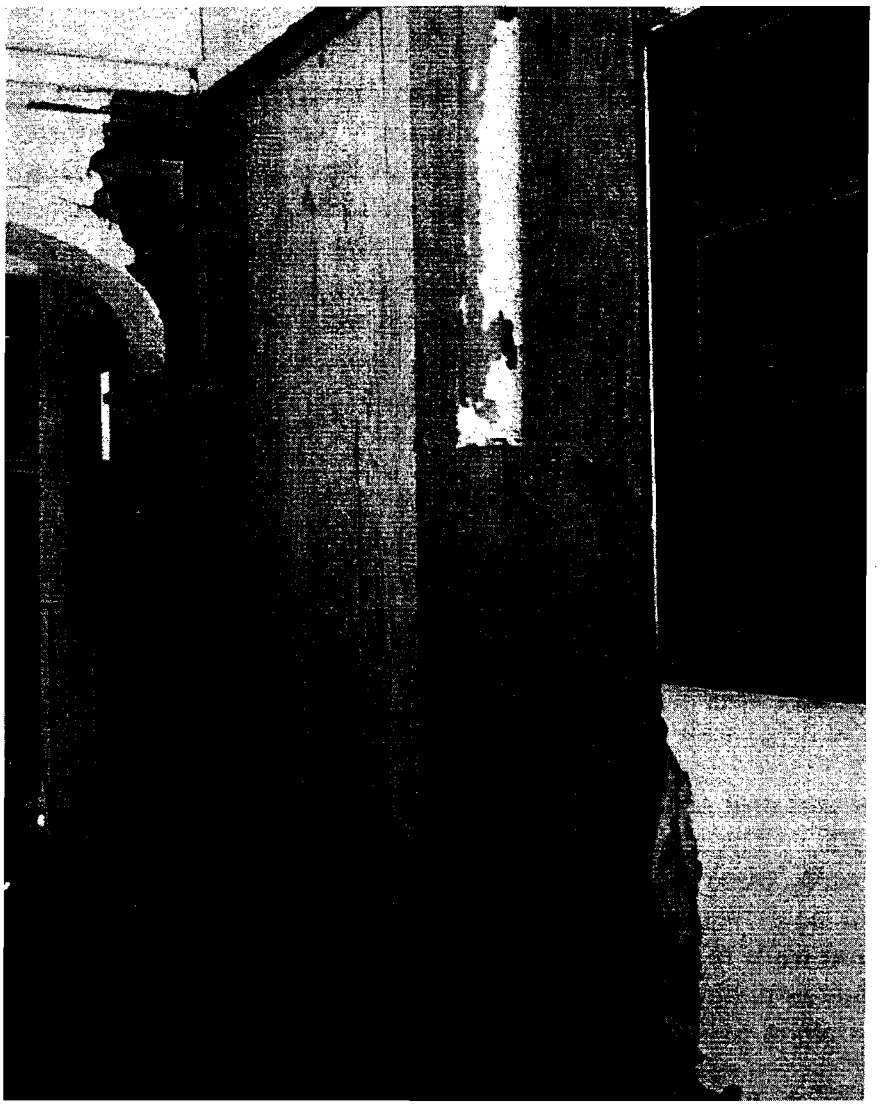

EXHIBIT 9 A damaged shear wall in an unreinforced masonry building undergoes repair and retrofit.

Due to the risk of seismic damage and high cost, owners of hillside homes should be offered incentives to retrofit their homes.

Gas-Fed Residential Fires: Water Heaters

Both the Los Angeles Department of Housing and the Southern California Gas Company (SoCal Gas) reported that gas-fed fires were a major concern during the Northridge earthquake. According to SoCal Gas, 40 percent of all structure fires were caused by water heaters whose gas lines had ruptured. Even braced water heaters were found to be inadequate—plumbing tape and staples, while commonly used, are not sufficient to safely secure a water heater and its gas pipes during a seismic shock. Another factor contributing to the potential for gas-fed fires was the buckling of the legs and/or plywood shelves used to support water heaters. Manufacturers should strengthen or eliminate water heater legs.

The cost of bracing and strapping a water heater is approximately $100.[22] Since 1984, any new water heater installed required strapping. Based on an upper bound estimate, providing all of the approximately 512,000 single-family detached units in the City of Los Angeles with proper water heater bracing would cost $51.2 million.[23]

Additional mitigation activities need to be undertaken as well. For example, local building codes should adopt the Division of State Architect bracing standard for new homes, replacement homes, and replacement water heaters. There is no requirement addressing the need for adequate bracing. To ease the expense of mitigation, cash incentives, similar to those offered for buying energy-efficient appliances or lighting fixtures, should be provided for homeowners who implement a seismic mitigation measure, such as properly bracing their water heater.

Gas-Fed Residential Fires: Manufactured Housing

Inadequate bracing also leaves manufactured homes extremely vulnerable to seismic damage. Eight separate fires started in one mobile home park during the Northridge earthquake. The earthquake shook manufactured homes off their 30-inch-high bases, damaging gas pipes and sparking fires that would then spread to several other homes. Water shortages caused by broken water mains and pipes exacerbated the crisis and complicated firefighting efforts. Manufactured housing developments, often located in hilly areas, were also sometimes difficult for firefighters to reach.

To prevent manufactured homes from slipping off their foundations in the next earthquake, units should be braced and anchored. In the Northridge area, there are currently about 9,000 mobile homes.[24] The cost of anchoring a manufactured home ranges from $2,500 to $5,000. However, this cost may be out of reach to many owners of manufactured homes, who are disproportionately elderly and often have lower (or fixed) incomes.[25]

Other mitigation measures that need to be implemented include developing construction standards that require manufactured homes to have seismic bracing and adequate anchorage; requiring that gas meters in new construction be located at least 4 feet from the home; and creating financial incentives for manufacturers and owners to anchor their mobile homes.

III. What Is Being Done?

Multifamily buildings are a vital housing resource, particularly for low-income families and elderly households. In Los Angeles, 54 percent of all housing units are in multifamily buildings.[26] Multifamily housing—especially low-rent property—is concentrated in the neighborhoods of downtown Los Angeles.

Such neighborhoods of largely multifamily properties were among those most devastated in the Northridge earthquake. More than a dozen "ghost towns" have sprung up in areas where property owners and residents have abandoned damaged buildings and homes because the cost of repair seems to outweigh the benefits of rebuilding. These ghost towns are single blocks or entire neighborhoods awaiting demolition or repair, populated primarily by squatters, drug addicts, and gangs.

However, apartment owners are perhaps least well-served by the existing response and recovery programs. Rebuilding and mitigation activities for multifamily housing are highly dependent upon Federal funds from FEMA, SBA, and HUD. Privately owned multifamily developments do not qualify for most FEMA funding—the small amount of funding available under its Minimum Home Repair program is unlikely to be sufficient. Many landlords face serious obstacles to obtaining adequate, timely SBA loans. And direct HUD assistance for multifamily housing is available only to owners of HUD-insured properties, although in recent months additional funds were allocated to address the multifamily rebuilding crisis. Most recovery resources are targeted at middle-class owners of single-family homes.

Small Business Administration

Although the Small Business Administration (SBA) offers low-interest loans for rebuilding damaged residential properties, vulnerable groups, such as owners of affordable multifamily housing, have had difficulty in using this resource. Restrictive, narrowly defined loan criteria can sometimes exclude even qualified borrowers with damaged homes. For example, a home that has twisted may not qualify for an SBA loan if it has no cripple-wall damage.[27] SBA's loan cap of $1.5 million is not sufficient to repair large apartment buildings. Loan approvals can take months, and loan proceeds often arrive up to 7 months after the earthquake. Moreover, because SBA loans are

based on the project's creditworthiness instead of the level of financial need or damage, financially marginal housing is less likely to qualify for sufficient loan amounts.[28] Nonetheless, SBA has approved over 87,000 loans for $2.7 billion in repairs related to the Northridge earthquake.[29]

At the applicant's request, loans may be increased by up to 20 percent of the amount of the loan for necessary or appropriate hazard mitigation measures. Although encouraging applicants for SBA loans to apply for mitigation funding would promote measures that improve safety and help structures better withstand future earthquakes, SBA does not publicize this component because it increases the debt load for the borrower.

U.S. Department of Housing and Urban Development

HUD's Earthquake Loan Program (HELP) authorized up to $100 million in loans to owners of HUD-insured multifamily properties for appropriate mitigation activities. HUD-insured single-family properties, including condominiums, are not eligible under the HELP program. The Northridge earthquake damaged approximately 3,500 condo units and fewer than 1,000 FHA-insured homes in the City of Los Angeles. In the early fall of 1994, an additional $255 million from the President's Discretionary Fund were allocated to rebuild "ghost towns" and repair multifamily buildings, including condominiums and non-HUD insured residential multifamily properties.

Los Angeles Task Force

To enhance the seismic safety of Los Angeles' building stock, committees of engineers and contractors from the City's Task Force on Evaluating Damage from the Northridge Earthquake are assessing building failures and plan to recommend the expansion and revision of local residential building codes and standards. Committee reports are expected to be available beginning in August 1994.

Low-Income Housing Mitigation

For the past 14 years, Southern California Gas Company has provided weatherization training through community-based organizations, Job Training Partnership Act (JTPA) programs, and others. Through ratepayer funds established by the Public Utilities Commission, the gas company contracts with community-based organizations to do one of three things: perform outreach to identify low-income candidates for job training and homes in need of weatherization, perform the weatherization, or inspect work performed by another organization.

More than 14,000 workers have been trained and well over 300,000 low-income homes have been weatherized through this program. FEMA has been so impressed with the program that it is considering modeling a mitigation program on it.[30] One possibility would be to combine mitigation with weatherization measures. A related option has been suggested by North Valley Occupational Center, a regional vocational school located close to the Northridge epicenter, which has expressed interest in adding retrofitting techniques to its curriculum of carpentry courses.

Limitations on Repair and Mitigation

Governments at all levels are encountering a number of challenges in their efforts to facilitate earthquake repair and mitigation activities, particularly among owners of multifamily properties. Many apartment owners, operating with minimal repair reserves and without earthquake or disaster insurance, cannot afford mitigation—or even basic repairs—without financial assistance.[31] Ironically, however, buildings owned by these uninsured—and often undercapitalized—landlords tend to be the most vulnerable to earthquake and fire damage. For those unable to qualify for loans, the only way to pay for repairs to damaged units is to raise rents—an option that is not always feasible.

This combination of problems can seriously reduce the local stock of affordable multifamily housing and result in the displacement of lower income renters. In addition, owners of damaged single-room occupancy (SRO) properties may be tempted to demolish them and rebuild as condominiums, commercial or industrial buildings. The market value of an SRO is typically less than the highest use of the land. Preserving this vital part of the affordable multifamily housing stock may require incentives to persuade owners to keep SRO properties from demolition, as well as to repair and mitigate damage.

For relief and recovery programs to be truly equitable across the spectrum of needs, resources and programs must be targeted not only to homeowners, but also to residents of affordable multifamily housing. Before the next earthquake, State and Federal agencies need to formally revise their policies on temporary shelter in a disaster, so that all victims have some access to assistance.

Simply recognizing that disaster victims are not primarily homeowners would be an important first step in reconceptualizing the recovery process. One way to encourage a more equitable distribution of recovery funds would be to channel Federal and State housing assistance through local governments, rather than aiding building owners directly. This would allow funding providers to allocate resources in a way that was sensitive to patterns of actual damage, such as the number and type of units affected. It would also give local governments the flexibility to target areas of need and/or to combine various funding sources to meet specific problems.[32]

IV. Conclusion

Numerous challenges confront efforts to save lives by making Los Angeles area housing more resistant to earthquakes. The first is a problem of information. The City of Los Angeles lacks fundamental data on the size, composition, location, and condition of its housing stock that is indispensable to effective mitigation planning. In addition, although Los Angeles building codes have been significantly strengthened in the past to encourage seismically safe construction, the Northridge experience indicates several types of construction—such as wood-frame homes, hillside homes, and steel-frame structures—on which more technical research and evaluation is needed as a basis for further code reforms.

However, building codes primarily affect new construction. In the absence of laws that would require property owners to upgrade their units to a seismically safe standard, it is vitally important to find mechanisms that will encourage retrofitting of existing housing. Currently, few such incentives exist that can overcome property owners' reluctance to voluntarily take on the expense of preventive measures to protect homes that may or may not have been damaged in previous quakes.

Perhaps most urgent is the fundamental disparity between housing mitigation needs and available assistance. Most forms of disaster assistance, to the extent that they support residential repair and mitigation activities, are best suited to the needs and circumstances of middle-class owners of single-family homes. However, the vast majority of housing units damaged in the Northridge earthquake were in multifamily structures, and in many cases were—by housing type, age of structure, or location—particularly likely to be occupied by low- and moderate-income households. Owners of such housing are usually less able to afford needed repair and mitigation. Moreover, Federal assistance for owners of private, affordable multifamily housing is quite limited and remains difficult to obtain and use. The consequences of this imbalance in assistance may be seen in the deterioration, abandonment, and disinvestment of the "ghost towns" that have sprung up in some of the neighborhoods most affected by the Northridge earthquake.

1. City of Los Angeles Housing Department, *Current Status of Damage to the Housing Stock of the City of Los Angeles from the Northridge Earthquake*, Los Angeles, CA, April 4, 1994, p. 5.

2. Joseph Carreras, *Impact of the Northridge Earthquake on the Regional Housing Market*, Southern California Association of Governments, Los Angeles, California, January 28, 1994, p. 2.

3. City of Los Angeles Housing Department, *Current Status of Damage to the Housing Stock.*

4. Nicolino Delli Quadri, Senior Structural Engineer, City of Los Angeles Department of Building and Safety, phone conversation, October 11, 1994.

5. Mary Comerio, phone interview, October 3, 1994.

6. Barbara Zeidman, Deputy Manager, City of Los Angeles Housing Department, phone interview, July 1994.

7. Mary Comerio, "Design Lessons in Residential Rehabilitation." *Earthquake Spectra* 10/1, 1994, p. 47.

8. Seismic Safety Commission, *Performance of Wood Frame Buildings*, Interim Background Report B13, Draft Report, June 1994, p. 6.

9. *Findings and Recommendations of the Residential Buildings-Cripple Wall Subcommittee of the City of Los Angeles Department of Building and Safety and Structural Engineers Association of Southern California*, Task Force on Evaluating Damage from the Northridge Earthquake, Final Report, Attachment C, June 16, 1994, p. 1.

10. *Findings and Recommendations of the Residential Buildings-Cripple Wall Subcommittee*, Final Report, p. 12.

11. However, for more complex retrofits, such as providing an independent new concrete foundation instead of strengthening an existing foundation, the cost could range from $8,000 to $12,000.

12. Ibid., p. 10.

13. Mary Comerio, "Design Lessons . . . " p. 47.

14. Earthquake Engineering Research Institute, *Northridge Earthquake January 17, 1994. Preliminary Reconnaissance Report*, Oakland, CA, March 1994, p. 43.

15. Ibid.

16. Nicolino Delli Quadri, October 11, 1994

17. Nicolino Delli Quadri, August 1994.

18. Mary Comerio, "Design Lessons . . .", p. 47.

19. Nicolino Delli Quadri, August 1994.

20. Ibid.

21. Nicolino Delli Quadri, October 11, 1994.

22. Nicolino Delli Quadri, August 1994.

23. 1980 and 1990 census tabulations, in Chamun Koo, *Selected Demographic and Housing Data for the City of Los Angeles*, prepared for the Los Angeles Housing Department, July 11, 1994.

24. National Conference of States on Building Codes and Standards, *Northridge Earthquake Effect on Manufactured Housing in California,* U.S. Department of Housing and Urban Development, Washington, DC, June 17, 1994, p. 2.

25. Barbara Zeidman, July 1994.

26. Mary Comerio, "Design Lessons in Residential Rehabilitation," p. 47.

27. Barbara Zeidman, July 1994.

28. Ibid., p.37.

29. Office of Management and Budget, *Six Months after the Northridge Earthquake: A Look Back at the Federal Response*, Washington, DC, July 27, 1994, p. 2.

30. FEMA office memo. Los Angeles, CA. July 11, 1994.

31. Similar problems were encountered in rebuilding after the Loma Prieta earthquake. See Mary Comerio, John Landis, and Yodan Rofe, *Post-Disaster Residential Rebuilding*, Institute of Urban and Regional Development, University of California at Berkeley, January 1994, p. 37.

32. Ibid., p. 69.

SECTION FIVE

LIFELINES

I. Introduction

Lifelines are utility services and transportation networks vital to the health and safety of the community and the functioning of an urban, industrialized society. Effective mitigation programs that help minimize interruptions of electrical power, natural gas, and water and the delivery of essential services and foodstuffs will improve the community's ability to respond to and recover from an earthquake. The Los Angeles area's aging infrastructure is an important factor in its need for improved mitigation arrangements.[1]

Electrical Power

The Northridge earthquake caused significant damage to the utility systems serving Los Angeles. For a brief period, the Los Angeles Department of Water and Power (LADWP) lost *all* power to its service area, which covers the City of Los Angeles and includes the San Fernando Valley, where the epicenter was located.[2] In addition, the earthquake disrupted service to over 1 million of the 4.2 million customers of the Southern California Edison Company (SCE). However, the company reports that service was restored to one-fourth of these customers within a minute, service had been restored to all but 2,500 customers within 24 hours, and all service was restored to Southern California Edison customers within 56 hours of the earthquake.[3] Overall, the utility industry concluded that electrical systems recovered exceptionally well after the Northridge earthquake.

Water Supply

The Los Angeles Department of Water and Power's water system facilities incurred extensive damage throughout the San Fernando Valley and in the Sherman Oaks area. There was also localized damage to water supply systems in the West Los Angeles area and throughout the eastern San Fernando Valley. Immediately following the earthquake, approximately 100,000 customers were without water, and a citywide "boil water" advisory was issued. Within 5 days, water service was restored to all but a few thousand customers; after 10 days, less than 100 scattered customers were without water. All "boil water" orders were lifted after 12 days. The Department of Water and Power estimates that repairs of earthquake damage to the city's water system will cost approximately $40 million.[4]

Gas Supply

Following the Northridge earthquake, the Southern California Gas Company (SoCal Gas) reported 151,000 gas outages. The large majority of these outages were due to customer-initiated shutoff. Within three weeks, roughly 120,000 services were restored; the remaining customers were inaccessible because of earthquake damage to structures or for other reasons. In total, SoCal Gas responded to over 400,000 customer requests after the earthquake.[5]

During the earthquake emergency, there were no gas utility incidents involving fatalities. However, gas-fed fires destroyed 23 structures and 172 mobile homes and partially damaged 28 others. SoCal Gas' main earthquake mitigation concerns pertain to manufactured home safety and water heater bracing (discussed in the previous section of this report), as well as to the vulnerability of vintage transmission pipelines. Most of the problems in these lines appear to have been related to the performance of pre-1932 oxyacetylene-welded steel pipe, which failed primarily because of poor welding associated with the joints.[6]

EXHIBIT 10 Conductor removed from a disabled tower at Pardee Substation, Santa Clarita, CA.

Transportation Structures

Failure of transportation infrastructure directly caused at least one death and several injuries to motorists when the Northridge earthquake struck. Portions of eight major roads leading to downtown Los Angeles were damaged; major highways and freeways collapsed. Ten freeway structures collapsed or were extensively damaged, causing widespread disruptions after the earthquake. Several interstate and State routes passing through the San Fernando Valley were closed for long-term repairs.

Structures designed to current standards appear to have performed well, suggesting that if the damaged structures had been similarly up-to-date, many of the observed failures would not have occurred. Major repairs to all damaged transportation arteries are either complete or currently underway. The total cost of demolition and repairs to state bridges and highways following the Northridge earthquake is estimated at $350 million.[7]

EXHIBIT 11 One example of the extensive freeway damage caused by the Northridge earthquake.

II. What Needs to Be Done?

Currently, the engineering community is exploring a variety of technical approaches to improving the seismic performance of key lifeline components. Utilities have identified system redundancy, brittle ceramic components, connections between electric components and between water tanks and piping, and the effects of soil conditions as areas requiring

improvement. Damage assessments of transportation structures further confirmed that inadequate transverse reinforcement can lead to catastrophic shear failure of bridge columns. Damage to connectors and abutments also demonstrated the need for improved earthquake-resistant designs. Beyond the technical problems, the implications of aging utility and transportation infrastructure, on earthquake mitigation must also be faced.

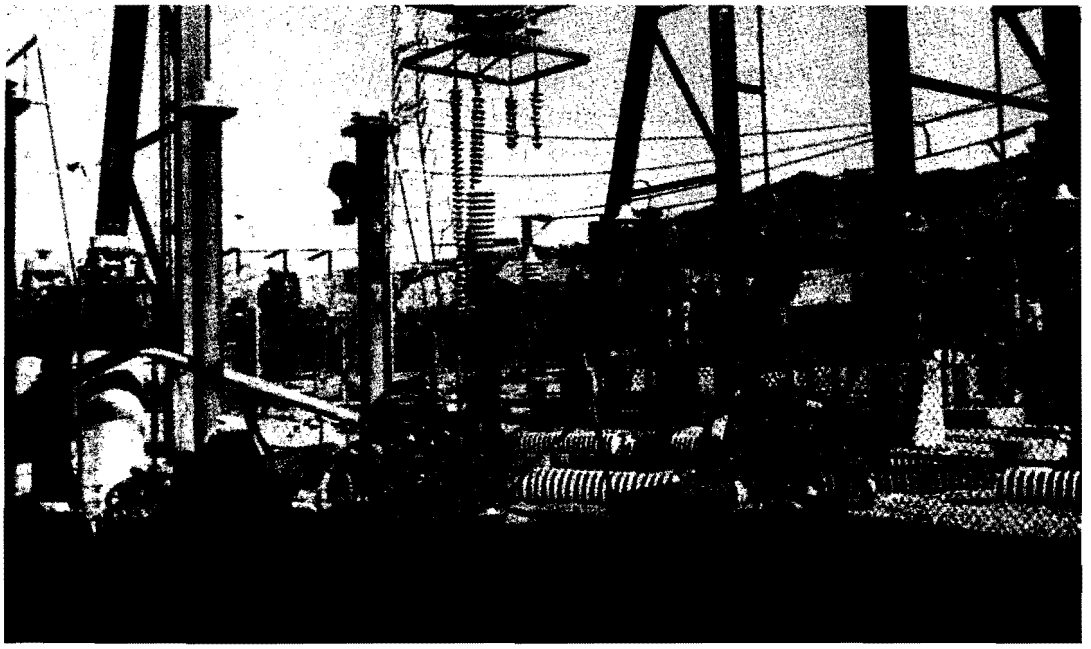

EXHIBIT 12 Less than 15 miles from the epicenter of the Northridge earthquake, the Sylmar converter station suffered major damage.

Aging Utility Lifelines

Older portions of power, gas, and water systems were built to seismic safety standards that are regarded today as outmoded. Some of these pre-World War II systems are sited near the governmental and financial centers of downtown Los Angeles, where outages could result in substantial economic losses. Although this earthquake did not severely affect the Los Angeles downtown area, some of its infrastructure was damaged. The Los Angeles Department of Water and Power estimates the cost to its electrical power system at $300 million for earthquake-related damage and restoration costs. Southern California Edison estimates that the total cost of damage to its plant and related losses will be approximately $50 million. As a municipal utility, the Department of Water and Power may receive $100 million from FEMA's Public Assistance program to repair damages.[8] Southern California Edison, as a private utility company, must recover its losses from its customers.

Failures in the gas distribution network tended to occur most frequently in pre-1930s pipe. The Los Angeles Department of Water and Power (LADWP) also perceives considerable risk in their vintage substations, which range in age from 39 to 113 years. The Department has stated that 20 substations in downtown Los Angeles need to be replaced, at a cost of between $11 million and $16 million each. This estimated cost includes purchasing new property, constructing a new substation, and demolishing the old facility. The estimated cost of replacing all 20 substations is $220 million to $320 million.

Most damage to the water distribution system occurred in cast iron mains with rigid joints, as well as in old steel pipe that is subject to corrosion. The Los Angeles Department of Water and Power has over 300,000 feet (about 57 miles) of pre-1940, large-diameter steel trunklines that need to be replaced at a total cost of $300 million. In addition, many older steel water tanks need to be replaced. Not designed or constructed to withstand stresses associated with earthquakes, many of these tanks buckled at the bottom during the Northridge quake.[9] LADWP expects to receive $75 million in FEMA Hazard Mitigation grants to help pay for station replacement, while bond issues and special rate increases will be needed to cover the cost of water system work.

Aging Transportation Lifelines

The Los Angeles metropolitan area is highly dependent on its transportation systems. The most vulnerable link in this system appears to be bridges. More than half the bridges in Los Angeles were built before 1980 and thus are presumed to be in need of seismic retrofit. However, this rough measure of susceptibility is itself an indication of the need for additional information on the seismic performance of bridge designs. A total of 701 bridges in Los Angeles and Ventura Counties are in need of an estimated $500 million in retrofitting. For the entire State, $920 million is needed for seismic retrofit of single- and multiple-column bridges, which are most susceptible to damage in the event of an earthquake.[10] Currently, no information is available on how much funding is to be authorized for this work—the largest share of any resources will come from the State legislature, with only a small contribution from the Federal Government.[11]

Education and Training

The development and introduction of entirely new design criteria in the past few years has left the average practicing highway engineer somewhat behind. A large number of experienced engineers have never been exposed to either dynamic or seismic design principles. Therefore, education and training programs are needed to update highway engineers on the latest seismic techniques. Correspondence courses and workshops are available, as are online computer tutorials and classroom instruction. The cost of offering these opportunities is estimated to be $350,000.

III. What Is Being Done?

Apart from some needs for mitigation activities targeted at well-defined components of Los Angeles' lifelines, a number of challenges face Los Angeles in continuing to improve coordination and planning on seismic safety issues and completing the repairing and retrofitting of structures in order to minimize loss of life in the next earthquake. A number of Federal and statewide initiatives now underway are intended to enhance existing standards and research on utility and transportation systems.

Federal Efforts

An Emergency Relief fund created by Congress in January 1994 has enabled the Los Angeles' highway system to make a rapid recovery. Federal agencies are also funding utility and infrastructure mitigation and upgrade activities at the local level and cooperating in State and local preparedness planning and infrastructure-related engineering research.

Utility Lifelines

The Federal Emergency Management Agency (FEMA), in consultation with the National Institute of Standards and Technology (NIST), is preparing to submit to Congress a Lifelines Plan for developing and adopting seismic design and construction standards for utility systems.[12] The draft plan concludes that standards to reduce the vulnerability of utilities to earthquakes need to be defined, and that adequate knowledge exists—or can be developed within this decade—to provide a sound basis for such standards. The new standards will:

- Establish acceptable physical and performance parameters for utility systems, equipment, and materials.
- Provide a basis for communication between buyers and sellers of utility system products and services.
- Establish foundation for regulations to protect the public health, safety, and welfare.[13]

Transportation Lifelines

The Federal Highway Administration (FHWA) responded quickly to repair area freeways after the Northridge earthquake. Innovative contracting techniques helped make it

possible to reopen important arteries in record time. In several instances, the Federal Highway Administration and the California Department of Transportation (Caltrans) agreed to an expedited contracting process that permitted State highway officials to advertise and award construction contracts in 3–5 days, in contrast to the 26–40 weeks needed under normal procedures.

Immediately following the earthquake, Federico Pena, Secretary of the U.S. Department of Transportation, approved nine contracts totalling $4.1 million for demolition, debris removal, and shoring up of damaged structures. An initial $15 million in funds made available by FHWA was allocated to meet the State's needs for debris clearance and demolition on federally funded highways. Only 2 days after the earthquake, an additional $30 million was approved for a transportation recovery plan to get Los Angeles moving again.

Federal engineers are monitoring the progress of repair projects and assuring adequate State inspection, compliance with specifications and regulations, and project quality. An estimated $244 million has been obligated by the Federal Highway Administration for the repair and restoration of approximately 43 miles of roadway and 119 damaged bridges.

The U.S. Department of Commerce is also implementing an innovative program that will assist local governments in repairing and upgrading damaged public infrastructure ineligible for funding under the Federal Emergency Management Agency's Infrastructure Repair program. Local agencies may access the Department of Commerce's $50 million Infrastructure Development Fund to enlarge the scope of FEMA projects, or to develop other infrastructure repair projects designed to reposition earthquake-impacted communities for future economic growth.[14]

State Efforts

To improve the seismic performance of lifelines, a number of statewide mitigation coordination efforts are taking place. The California Seismic Safety Commission (SSC) is involved in recommending seismic mitigation improvements and has directed the California Public Utility Commission (CPUC) which regulates the utility industry, and the California Department of Transportation (Caltrans), which administers State highway and bridge programs, to oversee the implementation of these recommendations.

California Public Utility Commission

The California Public Utility Commission is working to establish appropriate and, if possible, uniform seismic safety standards for all power and gas systems by December 1995. To date, uniform seismic safety criteria have been established and a policy on

acceptable risk has been adopted. The Public Utility Commission is currently reviewing and monitoring utilities' seismic risk policies and establishing performance standards.[15] It is also requiring each California utility to submit annual seismic preparedness reports. For fiscal year 1991-1992, the Public Utility Commission devoted an estimated total of $30,000 to earthquake hazard reduction activities; the costs to utilities are not known.

Interutility Seismic Working Group

The Interutility Seismic Working Group, an ad hoc group of utility company staff formed in 1987, meet periodically to address earthquake preparedness issues that would benefit from interutility cooperation. The Working Group also develops consistent seismic criteria, as well as sharing information and cooperating on research and joint projects.

The Working Group consists of two subgroups. The members of the electric subgroup are Pacific Gas and Electric, the Los Angeles Department of Water and Power, Southern California Edison, San Diego Gas and Electric, the Bonneville Power Authority, and British Columbia Hydro. The members of the gas subgroup are Pacific Gas and Electric, San Diego Gas and Electric, SoCal Gas, and Southwest Gas.[16] The Working Group is developing cost-sharing arrangements and methods to ensure that needed research is relevant and carried out in a cost-effective manner.

Caltrans

Caltrans is engaged in a multi-phased seismic assessment and retrofit of all its bridges. It also administers a statewide Bridge Seismic Retrofit Program to develop revised seismic standards for the design and construction of new highway spans. This seismic research program, which targets bridges that do not meet seismic safety standards, has two components—a State highway program and a local streets and roads program. Funded activities incorporate general engineering research and seismic monitoring of transportation structures. Techniques currently being used to strengthen bridges include the placement of steel hinge restrainers to tie bridge decks to their supports.[17]

Local Efforts

Although the Northridge quake caused significant damage, the utility industry has concluded that power, water, and gas systems recovered exceptionally well. Within 10 days, fewer than 100 scattered customers remained without water service. Most customers had electricity again within a few hours, though a few were without service for more than 2 days. For most California utilities, the 1971 San Fernando earthquake provided the impetus for new seismic design and analysis approaches for lifelines.

Since then, the utility companies have been engaged in seismic upgrading and retrofitting activities. In the mid-1980's, SoCal Gas initiated a pipe replacement program that concentrates on pre-World War II steel pipes. In the past decade, SoCal Gas has spent $200 million on pipeline replacement and rehabilitation and anticipates spending another $65 million by 1997. The electric utilities have also made substantial progress in improving the seismic performance of substations. "Live tank" circuit breakers, a primary cause of power outages during earthquakes, are being phased out and replaced by improved apparatus. The water supply industry has also steadily modified the seismic design of water facilities and taken steps to reduce seismic vulnerability of new transmission lines in order to fortify the reliability of water delivery systems.

Transportation Secretary Pena and Los Angeles Mayor Richard Riordan were driving forces in bringing the State and local governments to agreement on a plan for repairing freeways, promoting mass transit and ridesharing, and cutting Federal red tape. They quickly established an Emergency Transportation Relief Task Force to ensure a coordinated response to all emergency transportation measures. It is anticipated that State agencies, particularly those with operations located in the area of enhanced risk, will support local governments in these efforts by providing personnel and equipment.[18]

IV. Conclusion

Lifeline systems survived and recovered from the Northridge earthquake well, and seem well positioned to meet their substantial remaining mitigation needs. Major public and private utilities in the Los Angeles area have made long-range plans for replacing aging infrastructure and undertaking other improvements. State regulators have encouraged these actions. While major utilities cooperate closely in their mitigation planning efforts, some more inclusive forum is also needed to allow participation by smaller utilities and independent power producers, who often lack the technical resources and expertise of their larger competitors.

The Emergency Relief fund made available by Congress met all highway recovery and repair needs. However, continuing research is needed on retrofit design and materials standards for highways and bridges. Particularly urgent is the need for expanded education and training opportunities to ensure that State and local highway engineers remain up-to-date on these evolving seismic safety principles and practices.

1. Much of the information presented in this section is based upon HUD meetings with staff from the Los Angeles Department of Water and Power, the Southern California Gas Company, and the Southern California Edison Company in July 1994.

2. Seismic Safety Commission, *Electric Utilities*, Interim Background Report DBL14, July 13, 1994, p. 1.

3. Southern California Edison Company, *Northridge Earthquake After Incident Report*, p.1, March 29, 1994.

4. Robert Giles, Senior District Operations Engineer, Water Operating Division, Los Angeles Department of Water and Power, correspondence, August 29, 1994.

5. Seismic Safety Commission, *Natural Gas Pipelines*, Interim Background Report DBL3, June 10, 1994, p. 4.

6. Ibid, p. 5.

7. Douglas E. Bennett, Senior Transportation Engineer, Federal Highway Administration, U.S. Department of Transportation, phone interview, August 30, 1994.

8. Ronald Tognazzini, Los Angeles Department of Water and Power, interview, July 1994.

9. Technical Council on Lifeline Earthquake Engineering, *Lifelines Conclusions/Lessons/Recommendations*, American Society of Civil Engineers, August 15, 1994, p. 2.

10. *California At Risk: Reducing Earthquake Hazards 1992-1996*, Seismic Safety Commission, p. 32.

11. Phone interview with Debbie Mah, Project Development, U.S. Department of Transportation. August 30, 1994.

12. *Building the Future*, Fiscal Year 1991-1992 Report to Congress, National Earthquake Hazard Reduction Program, p. 44.

13. Ibid.

14. *Six Months After the Northridge Earthquake: A Look Back at the Federal Response*, Office of Management and Budget, Washington, DC, July 1994, p. 8.

15. *California at Risk; Reducing Earthquake Hazards 1992-1996*, 1994 Status Report, Seismic Safety Commission, Sacramento, CA, p. 32.

16. Pacific Gas and Electric Company, memorandum, February 24, 1994.

17. Ibid., p. 8.

18. *California Earthquake Advisory Plan*, Governor's Office of Emergency Services, Sacramento, CA, October 1, 1990, p. 5.

SECTION SIX

THE REMAINING CHALLENGE

I. Introduction

Los Angeles is generally well-prepared for earthquakes, with numerous seismic safety measures already in place. This resilience was on full display after the Northridge earthquake. According to most sources, residential structures performed well in minimizing loss of life. Hospitals continued to function heroically under difficult conditions. Lifelines were rapidly repaired and services restored to area residents. Schools reopened quickly and damaged freeways were returned to service in record time.

Nonetheless, significant gaps remain in the region's earthquake mitigation capacity. The stakes could not be higher— it is acknowledged that, in the absence of aggressive mitigation effort, the number of deaths and injuries will be much higher in the next major earthquake. A clear challenge confronts those committed to improving the area's seismic safety—balancing limited knowledge, finite resources, and competing priorities with the urgent need for ongoing mitigation. This section presents possible strategies for addressing deficiencies in the current earthquake mitigation system.

II. Agenda for Future Action

Although Federal, State, and local agencies have mobilized vast resources for natural disaster response and recovery efforts, the findings of this report strongly suggest the need for a more proactive commitment to disaster mitigation strategies that would save lives. The analysis of mitigation needs presented here reveals a number of opportunities to facilitate earthquake mitigation. The sheer diversity of these potential actions reflect the breadth of Los Angeles' identified mitigation needs.

Some of the ideas offered below are specific responses to the situation in Los Angeles; others are applicable to any community at risk of earthquakes or other natural disasters. Some actions can be taken independently; others require partnership among Federal, State and/or local agencies. Some actions require Federal agencies to take a leadership role; others are supportive or supplementary in nature. Finally, some of these actions involve programmatic changes, while others are regulatory, and still others rely on research or outreach.

Ongoing mitigation efforts in at-risk communities could minimize the loss of life and property caused by future disasters. Inevitably, post-disaster efforts focus more on essential recovery and places less emphasis on mitigation measures. The long-term effectiveness of the current Federal "mitigation" effort is diminished by being limited to the immediate post-disaster period, when the more pressing needs of response and

recovery efforts often take precedence. An approach that provides mitigation assistance to at-risk areas *before* a disaster may be warranted.

Although FEMA makes available funding for repairs and mitigation, State and local entities have not fully utilized these funds, perhaps because they cannot meet the Federal requirement for matching funds. However, an innovative strategy has been proposed by OES to allow for existing and budgeted investments in mitigation projects at the state and local level be considered as allowable match for grant program funds. This concept is a departure from past practice in meeting cost share requirements on a project by project basis and recognizes the ongoing commitment to mitigation.

Relevant Federal assistance programs should be reviewed to identify and reduce barriers to their use in disaster recovery and mitigation. State and local efforts to mount needed mitigation efforts may have been slowed by Federal program rules that make it difficult to apply some forms of assistance to mitigation or to coordinate their use with other public and private funds. Even before the Northridge earthquake, HUD launched a review intended to assess and remove obstacles to the use of CDBG and HOME for mitigation-related activities. More recently, in November 1994 FEMA convened an interagency Mitigation Task Force to develop a coordinated Federal Mitigation Plan.

Financial incentives should be considered to encourage mitigation efforts. The absence of financial incentives impedes mitigation activities on several fronts, but most particularly among owners of single-family and multifamily residential properties. Financial inducements such as lowered insurance premiums, tax credits, low- or no-interest loans, mortgages, and grants, can make the implementation of mitigation measures more palatable to building owners and much easier for regional and local jurisdictions to enact and enforce.

Los Angeles needs a computerized inventory of buildings within its jurisdiction, complete with such information as location and type of construction, that would be useful to planners, seismic safety officials, and code enforcement inspectors. Because a reliable, automated inventory of the Los Angeles building stock does not exist, accurate assessments of the number and types of buildings requiring seismic retrofit cannot be made. This diminishes the ability of planners and decisionmakers to identify mitigation needs and priorities.

Further research on vulnerable building types and their seismic performance needs to be undertaken. Construction types for which research is urgently needed include steel moment-frame buildings, hillside homes, and split-level homes. In support of this effort, the creation of an automated building inventory would enhance the city's ability to locate and assess earthquake risks and mitigation needs.

A higher level of building inspection and construction code enforcement is needed. Local governments should insist upon adequate inspection and enforcement of

construction regulations and standards—thus, they have an obligation to provide qualified and properly trained building inspectors who have adequate resources to carry out their responsibilities. Currently, however, there is a lack of resources to conduct inspections and educate inspectors about current codes and principles of seismic design. Relevant professional education should be mandatory for building inspectors. Moreover, structural engineers should be required to observe construction in order to ensure seismic safety.

III. Conclusion

In the end, perhaps the most important insight that can be gleaned from this report is also the simplest: while the disaster recovery period may be the most propitious time to undertake mitigation activities, these efforts must not end when the brief spasm of emergency relief and recovery programs winds down.

Because mitigation is only one of many problems competing for funds and resources in Los Angeles and other large urban centers, leadership is needed to ensure that seismic safety remains an important priority for creating communities of opportunity. Regardless of which specific courses of action they choose, Federal, State, and local governments must be steadfast in their commitment to supporting mitigation activities that will minimize loss of life in future earthquakes and make Los Angeles a more resilient community. The lives of many of their citizens hang in the balance.