PART ONE

IS UTAH READY TO TAKE ACTION TO REDUCE ITS EARTHQUAKE RISK?

YES....focused efforts during the last five years have achieved several successes including an adequate scientific and engineering base upon which to take action; a general willingness of public and private leaders to act responsibly relative to the earthquake risk; a general willingness of the public to accept actions to reduce the risk; and a willingness of a few key leaders—but not many elected officials—to provide leadership to bring about actions.

Key ingredients that now exist for future success in implementing earthquake hazard reduction include:

1. A High Level of Concern—Technically-trained public officials have an understanding of the earthquake hazards in Utah and realize that actions taken now can mitigate the hazard and reduce losses. The Wasatch Front news media is remarkably well-informed and has played a major role in enlightening the public to earthquake risks. Opinion polls show that the general public recognizes the potential for earthquake disasters and will support the adoption of a number of earthquake mitigation measures.

2. Reliable Information—Scientists, engineers, planners, and emergency response officials have amassed a substantial body of technical information about the Wasatch Fault and other active faults in Utah; their location and geometry, the hazards associated with them, the recurrence of large earthquakes, and what actions will be effective in reducing the risk. New hazard maps and recent loss studies show the nature and extent of the earthquake threat along the Wasatch Front. This information clearly demonstrates the vulnerability of the region's economy to earthquake damage.

3. User-Friendly Products—A wide range of data, reports, maps, guidelines, and digitized information has been translated into plain wording to answer the basic questions asked by planners, emergency managers, and public officials; i.e., Where? How often? What effects? "Translated" hazard maps have been developed specifically for technical users and disseminated through the cooperative effort of federal, state, and local governments working together with the academic and private sectors. The county geologist program has been exceptionally effective in bridging the gap between information producers and information users in local government.

4. Professional and Institutional Support—A core group of individuals believes the earthquake threat is real and these individuals are trained and committed to devising effective and appropriate hazard reduction techniques for the Wasatch Front. This group includes social scientists, architects, planners, civil engineers, structural engineers, earth scientists, public decisionmakers, public-safety professionals, and business people. These individuals provide leadership within their own groups and exert influence beyond their organizations.

5. Policy Champions—Dedicated proponents of earthquake safety both within and outside Utah have promoted specific earthquake safety policies in Utah. Past experience has taught many lessons in how to succeed with decisionmakers, business people, and the public. Although Utah lacks sufficient public concern to force action and elected officials at all levels of government to make a crusade of the issue, decisionmakers do recognize earthquake hazard reduction as part of their responsibility for public health and safety, and prosperity of their communities.

6. Information Exchange—A network of information exchange links seismologists, structural engineers, and landuse planners. New findings in seismology, geology, and engineering can be readily transferred for incorporation into local hazard mitigation policies. Conversely, spe-

cial needs in local policy can be readily addressed by experts drawing on an existing knowledge base. The network of information exchange enhances the credibility of mitigation policy even when implemented in a context of changing needs and expanding knowledge. New information can be incorporated into existing siting design, construction, tetrofitting, and landuse practices by redefining map boundaries and refining existing concepts about the hazard without jeopardizing the fundamental credibility of the program.

7. Window of Opportunity—Will it take a major destructive earthquake before Utah will take significant actions to reduce earthquake risk? Not now! Significant steps already have been taken (e.g., hospital construction standards; enactment of zoning ordinances) and other steps are ready to be taken. The damage caused by the 1982-86 wet cycle significantly increased 1) the level of awareness and 2) public officials' commitment to make the state less vulnerable to geologic hazards.

The "window of opportunity" during which the community can accelerate the adoption of seismic safety measures is wide open in Utah. The most recent, comprehensive 5-year effort consisting of several hundred worker -years and more than 15 million dollars of federal, state, and local resources built upon the legacy of Utah's Seismic Safety Advisory Council and earlier regional seismic research. Now that most of the technical and societal information is integrated, Utah is ready to take political and policy actions to reduce earthquake risk.

PART TWO

BASIC STRATEGIES FOR LOSS REDUCTION

To reduce its vulnerability to earthquakes, a community must adopt four basic strategies to keep expected losses within acceptable limits. These strategies necessarily involve an understanding of the earthquake threat, a knowledge of what actions will be effective in reducing risk, and an appreciation of the willingness and ability of the people involved to take action. The four basic strategies, which can be adopted and tailored to local needs, are: 1) improved development and construction practices; 2) public education concerning earthquake hazards and how to respond during a hazard event; 3) disaster-response plans; and 4) post-earthquake recovery plans.

Improvement of development and construction practices is primarily the responsibility of state, county, and municipal government agencies through adoption and enforcement of building codes and subdivision, zoning, and retrofit ordinances. When faced with earthquake hazards, communities have five possible alternative actions: 1) ignore the hazard; 2) avoid the hazard; 3) modify the hazard (reduce the likelihood or severity of the hazard); 4) modify what is at risk (strengthen structure to withstand the hazard event); and 5) understand the hazard and accept the risk (usually involves disclosure of the hazard to potential owners and occupants) (Anderson, 1987). Ignoring the hazard is not an acceptable action as it does not fulfill government's mandate to protect the health, safety, and welfare of its citizens and may lead to governmental liability for damages and/or loss of life accompanying earthquakes. In determining which of the other alternative actions is most appropriate, the risk, in terms of both economic and life loss, should be considered along with the cost of avoiding or mitigating the hazard and the type of facility which is being considered. Table 1 lists typical hazard-reduction techniques for some of the more widespread types of earthquake hazards. Which techniques are most appropriate for a particular development must generally be determined by a site-specific study.

One of the more serious problems in promoting earthquake-hazard reduction is convincing the public that there is indeed a hazard. Urban areas in Utah have not experienced a moderate or large earthquake (Richter magnitude 5.5 or larger) in historical time. In order to show the need for taking steps to reduce earthquake hazards, technical information must be translated so that it may be understood by the layman. This translated information must identify the likelihood of occurrence, location, severity in terms of what will happen when the event occurs, and what steps may be taken to reduce the risk. This consensus document is one attempt to provide translated information about earthquake hazards to the layman.

The purpose of disaster-response plans is to identify: 1) the types of decisions that are likely to be needed when the expected earthquake event occurs, 2) who will make the decisions, and 3) how the decisions will be transmitted to the public and emergency-response personnel so that they may be implemented. Disaster-response exercises are conducted to that implementation of disaster-response plans will occur in the fastest, most efficient manner possible.

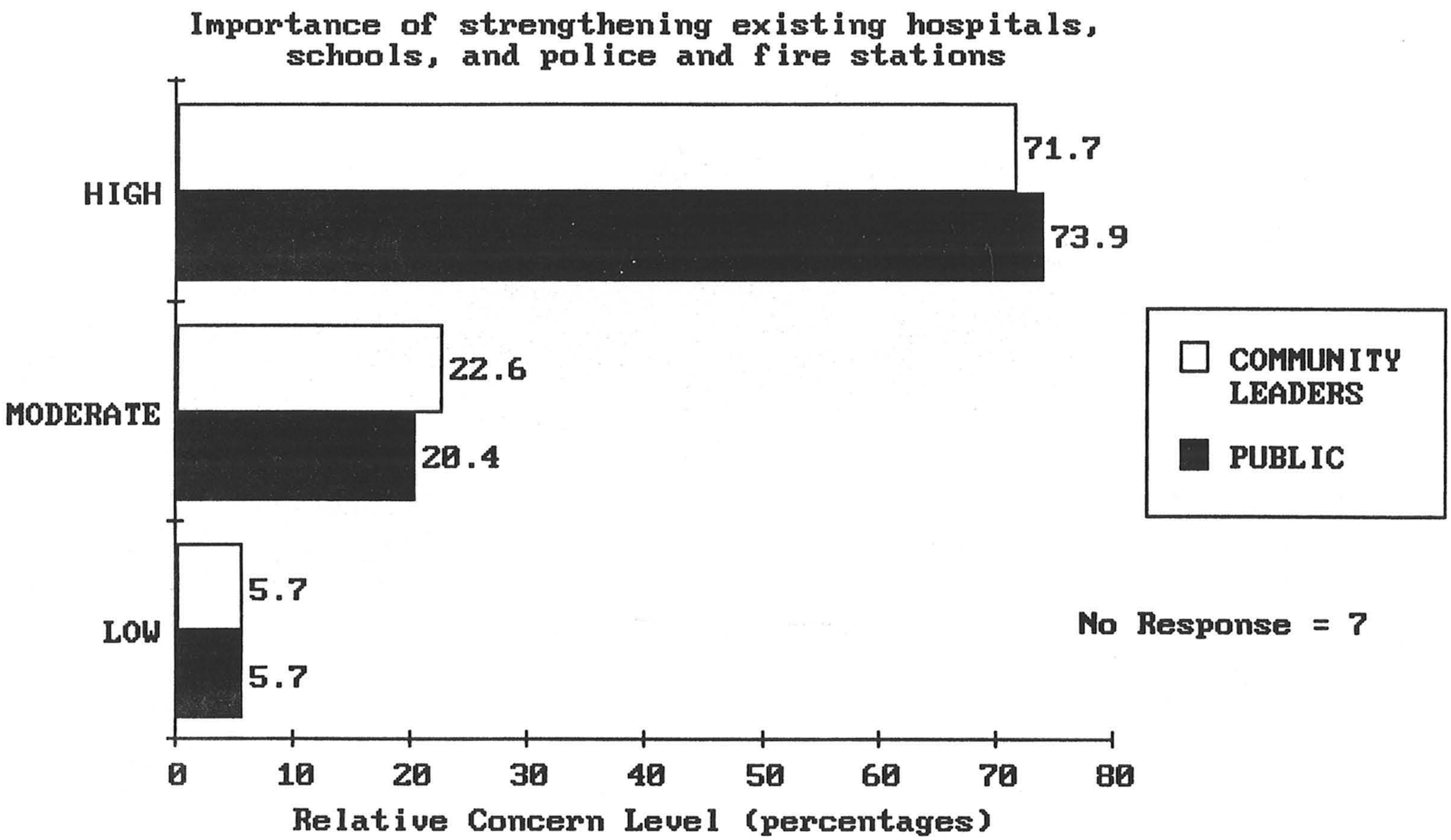
Recovery plans are designed to anticipate and meet the time-varying needs of the community as the post-earthquake recovery period unfolds over a period of 5 to 10 years. These plans will help ensure that the community quickly returns to cultural and economic viability following an earthquake.

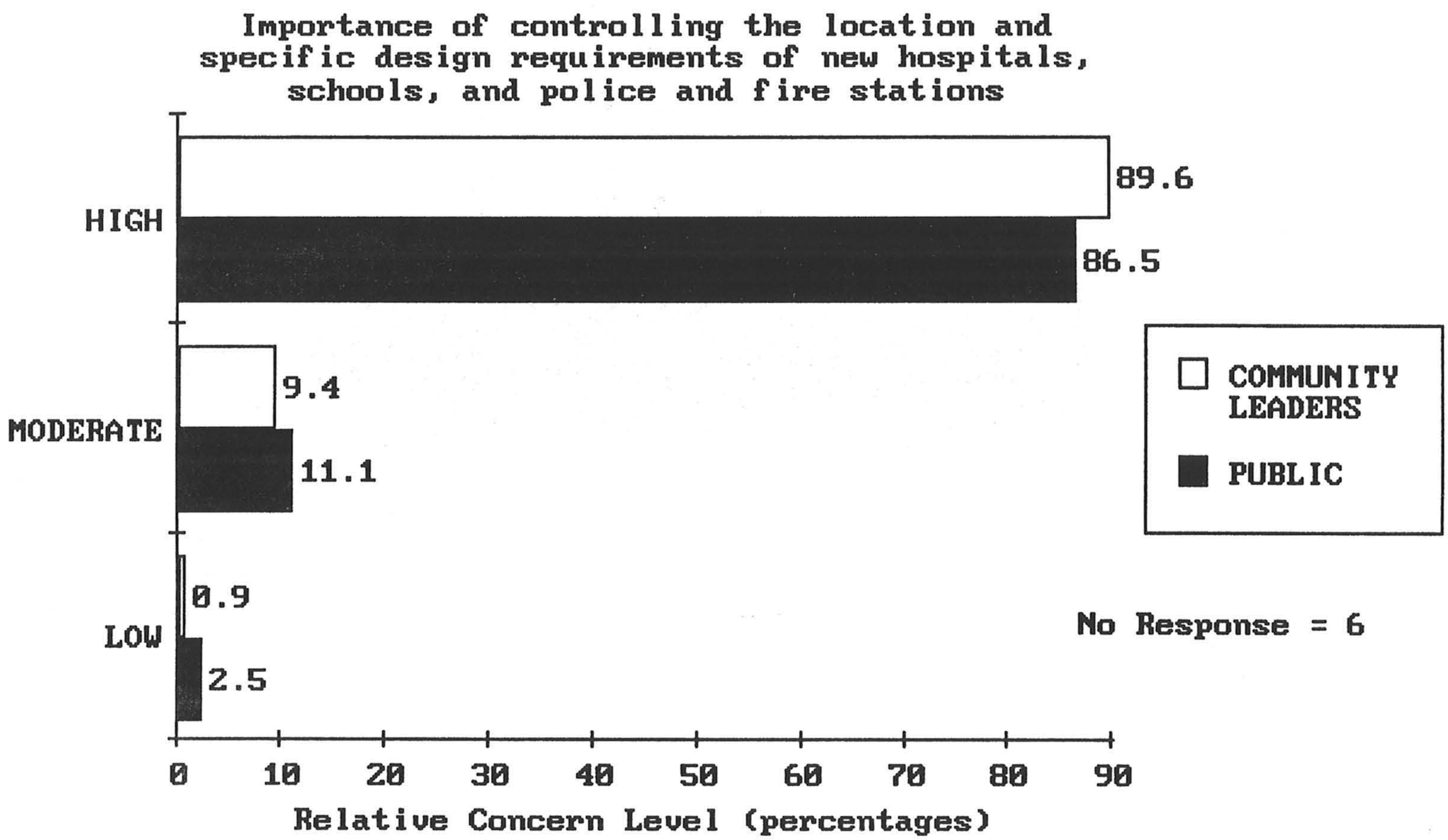
Basic products are now, or soon will be, available to develop and carry out these strategies for earthquake-loss reduction in Utah. They include: 1) maps showing susceptibility to earthquake hazards such as ground shaking, surface rupture, slope failure, and liquefaction, and depicting either explicitly or implicitly the affected area, severity of impact, frequency of occurrence, impact time, duration, and the potential for triggering secondary effects; 2) loss studies identifying the distribution and nature of the damage and losses expected in the realistic scenario of one or more earthquakes; and 3) risk-reduction studies based on experience in Utah communities and elsewhere describing which risk-reduction actions are likely to be most effective.

Table 1. PRINCIPAL EARTHQUAKE HAZARDS, EXPECTED EFFECTS, AND COMMONLY-APPLIED HAZARD TECHNIQUES

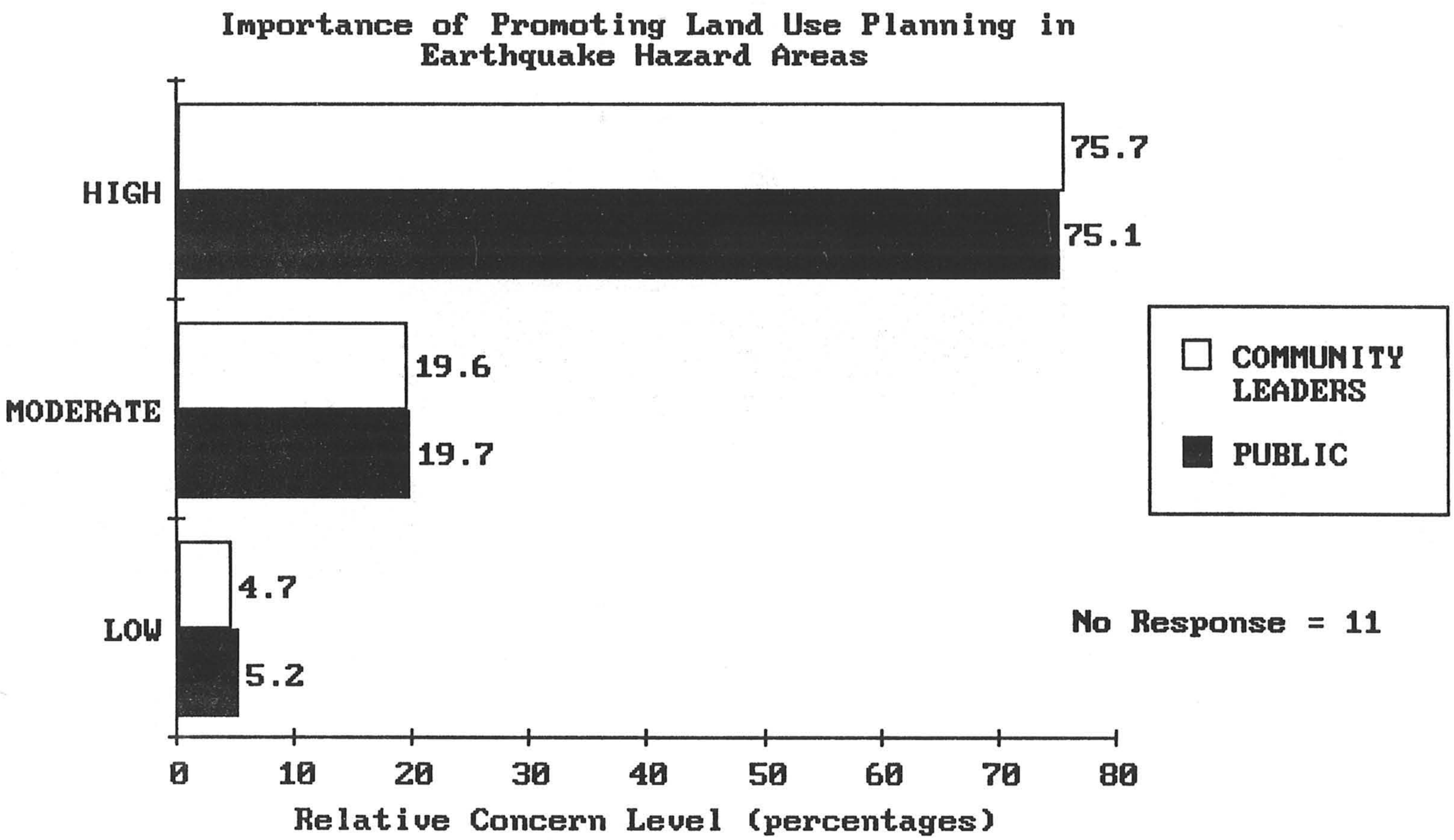
Hazard	Expected Effects	Commonly Used Hazard-Reduction Techniques. Other Mitigation Techniques May Be Used Which are Not Listed Here.
Surface-Fault Rupture	Rupture of ground with relative displacement of surface up to 15 feet along main trace of fault. Tilting and ground displacements may occur in a zone of deformation up to several hundred feet wide, chiefly on the downthrown side of the main fault trace.	Avoid active fault traces by setting structure back a safe distance from fault.
Tectonic Subsidence	Regional tilting of valley floor toward fault causing flooding near lakes and in areas of shallow ground water. May cause loss of head in gravity-flow structures.	Increase tolerance for tilting in gravity-flow structures; design structures for releveling. Buffer zones or dikes around lakes or impounded water to limit flood hazard; prohibit basements in shallow ground-water areas.
Ground Shaking	Vertical and lateral movement of the ground as seismic waves pass. Amplitude and frequency of seismic waves variable, as are peak ground displacements, velocities, and accelerations depending on source, path, and site conditions.	All new buildings designed to meet or exceed Uniform Building Code Seismic Zone requirements (currently zones 3, 2b, and 1). Retrofit older buildings to strengthen structures so they meet current UBC requirements. Site characterization studies for multi-story buildings to determine site response and design building to prevent destructive resonance. Tie down water heater and secure heavy objects inside the home.
Lique-faction	Saturated sandy soils may liquefy (become like quicksand) causing differential settlement, ground cracking, subsidence, lateral downslope movement of upper soil layers on gentle slopes, and flow failures (landslides) on steep slopes.	Improve soil-foundation conditions by removing susceptible soils, densification of soils through vibration or compaction, grouting, dewatering with drains or wells, and loading or buttressing to increase confining pressures. Structural solutions include use of end-bearing piles, caissons, or fully compensated mat foundations.
Earth-quake Induced Rock Fall	Downslope movement of bedrock fragments and boulders causing damage due to impact.	Avoidance. Removal of potential rock-fall boulders, stabilization of sources of rock fall by bolting, cable lashing, burying, or grouting. Protecting structures with deflection berms, slope benches, or catch fences.

Earth-quake-Induced Landslides	Downslope movement of earth material causing damage due to impact and/or burial below the landslide, differential displacement on minor scarps and movement in both vertical and horizontal directions within the central mass of the landslide, and loss of foundation support for structures straddling the main scarp at the top of the landslide.	Avoidance. Remove landslide-prone material. Stabilize slopes by dewatering, retaining structures at toe, piles driven through landslide into stable material, weighting, or buttressing slopes. Bridging.
Earth-quake Induced Seiches	Earthquake-generated water waves causing inundation around shores of lakes and reservoirs. Loss of life due to drowning. Damage due to flooding, erosion, and pressures exerted by waves.	Avoidance. Flood-proofing and streng-thening to withstand wave surge. Diking Elevate buildings.


Importance of strengthening existing hospitals,
schools, and police and fire stations
HIGH
71.7
73.9
MODERATE
22.6
20.4
LOW
5.7
5.7
COMMUNITY LEADERS
PUBLIC
No Response = 7
0
10
20
30
40
50
60
70
80
Relative Concern Level (percentages)



Importance of controlling the location and specific design requirements of new hospitals, schools, and police and fire stations
HIGH
MODERATE
LOW
89.6
86.5
9.4
11.1
0.9
2.5
COMMUNITY LEADERS
PUBLIC
No Response = 6
0
10
20
30
40
50
60
70
80
90
Relative Concern Level (percentages)


Importance of Promoting Land Use Planning in
Earthquake Hazard Areas
HIGH
MODERATE
LOW
75.7
75.1
19.6
19.7
4.7
5.2
COMMUNITY LEADERS
PUBLIC
No Response = 11
0
10
20
30
40
50
60
70
80
Relative Concern Level (percentages)