UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Office of Earthquake Studies

PROCEEDINGS OF CONFERENCE V

COMMUNICATING EARTHQUAKE HAZARD REDUCTION INFORMATION

Convened Under Auspices of

NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM

22-24 May, 1978

OPEN-FILE REPORT 78-933

This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards and nomenclature

Menlo Park, California

1978

CONFERENCES TO DATE

Conference I	Abnormal Animal Behavior Prior to Earthquakes, I
Conference II	Experimental Studies of Rock Friction with Application to Earthquake Prediction
Conference III	Fault Mechanics and Its Relation to Earthquake Prediction
Conference IV	Use of Volunteers in the Earthquake Hazards Reduction Program
Conference V	Communicating Earthquake Hazard Reduction Information

VOLUMES IN PREPARATION

Conference VI	Methodology for Identifying Seismic Gaps and Soon-To-Break Gaps
Conference VII	Measurement of Ground Strain Phenomena Related to Earthquake Prediction

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Organizer and Editor

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Office of Earthquake Studies

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COMMUNICATING EARTHQUAKE HAZARD REDUCTION INFORMATION

by

Walter W. Hays
U.S. Geological Survey

INTRODUCTION

Under the Earthquake Hazard Reduction Act of 1977, the federal government is significantly increasing its effort "to reduce the risk of life and property from future earthquakes in the United States through the establishment and maintenance of an effective earthquake hazards reduction program". This program is sponsored primarily by the U.S. Geological Survey and the National Science Foundation and includes research by geologists, geophysicists, seismologists, engineers, sociologists, educators, and public policy experts.

In the USGS program, there is a strong emphasis on effective communication of the results of research to a wide community of decision makers and users. This action is the key to implementation at all levels in federal, state, and local government, in the private sector, and on an individual basis.

The U.S. Geological Survey convened a workshop involving approximately 65 people on May 22-24, 1978 in Denver, Colorado, to examine the communication problem. The purpose of the workshop was to evaluate critically the information-flow process for a number of past experiences, including:

(1) land use planning in Portola Valley, California,

(2) the seismic safety element, Santa Clara County, California,

(3) earthquake preparedness, Puget Sound, Washington area,

(4) mitigation of geologic hazards in Colorado,

(5) earthquake planning in the Mississippi-Arkansas-Tennessee area,

(6) water resource and land use planning in the northeast United States,

(7) acquiring and disseminating scientific and engineering information following an earthquake,

(8) development, use, and review of geologic and seismological data for siting of nuclear power plants,

(9) development and use of building codes that incorporate earthquake provisions,

(10) use of research products produced in the HUD/USGS San Francisco Bay region study, and

(11) achieving landslide hazard reduction.

The objective was to identify the most significant lessons learned during the course of each experience and to develop recommendations for improving communication that might be incorporated in the research program of the USGS.

To focus the discussion on each experience, a number of questions were posed. These questions were used as guides by the participants to prepare a written narrative about each experience. The questions are given below; the narratives are contained in later sections of the proceedings.

1. DEFINE THE INFORMATION PRODUCER/USER COMMUNITY

A. People, Activities and Strategies

1. What were the scientific-socio-economic-legal-political motivations for the activity?
2. When did the activity take place?
3. What were the objectives?
4. What were the strategies for accomplishing the objectives?
5. Who (federal-state-local-private sector groups and individuals)

was critically involved in the communication of information and what was their role or responsibility?

6. What were the critical scientific, socio-economic, legal-political issues and problems that had to be resolved?
7. What were the strategies for resolving critical issues?
8. What were the component parts of the information communication model used in the activity?

II. EVALUATION OF INFORMATION COMMUNICATION ACTIVITIES

A. Relationships of People and Activities

1. What were the specific requirements for information by each member of the information producer/user community?
2. Was 2-way communication achieved? How?
3. Was there a focal point or information center involved in the information communication?
4. How were the public media (TV, radio, newspaper) utilized?
5. Were standard or existing channels for communicating information sufficient or were new ones created?
6. Was there a need for intermediate (i.e., translators) individuals or groups in the communication process in order to bridge the gap between information producers and users?

B. Performance Evaluation

1. Did the proper information get to the concerned user in a timely manner? What percentage of the information had to be reworked or was useless?
2. How was information communication monitored?
3. What were the strengths and weaknesses of the information communication process? How were they determined?

4. Was the activity a pilot project? Could the activity now be used as a model for information communication with certain specific improvements or refinements?

5. What lessons were learned from this information communication experience?

6. How were decision makers helped by the activity?

7. Did legislation result as a consequence of the activity?

SUMMARY OF LESSONS LEARNED FROM EACH EXPERIENCE

The following statements give a concise summary of the facts, trends, and interpreted tendencies that characterized each experience. The papers give more detail.

Land use planning in Portola Valley, California - A number of factors helped to increase awareness and to contribute to effective communication in Portola Valley. The most important factors were:

- Strong, persistent individuals ("crusaders") served as catalysts in the communication process.
- A local landslide served as a "triggering" event and helped to mobilize community response to the hazard.
- Community residents who were already considering low-density land development were receptive to land use measures.
- Public officials were concerned about their legal liability.
- Individuals who could perform the role of "translator" of new and existing technical information for local decision makers and public officials with operational responsibilities were in demand and invaluable in the communication process.
- The mayor and volunteer citizen committees provided strong support for hazard mitigation.

Once the community acknowledged the need to enact hazard mitigation measures a band-wagon effect occurred. The focal point of activity tended to shift to different public officials as the hazard reduction programs were developed and implemented.

Seismic safety element, Santa Clara County - Several factors were similar to the Portola Valley experience:

- "Crusaders," two USGS geologists contributed significantly to effective communication.
- Receptivity, local environmentalists interested in conservation of the marshlands and mud areas were receptive to land use restrictions implicit in the seismic safety element.
- Liability, the increase in the number of lawsuits initiated by home owners convinced county officials to consider seismic safety seriously.
- Translation of data, performance of this function was very critical in the development of the county's seismic safety element.

In addition, the following lessons were learned:

- Once Santa Clara County had identified its needs for special maps and earth science information, data gathering began. The presence of a prestige agency (USGS) or university greatly aided the efforts by student data gatherers.
- Education required time, effort and patience. The local decision making process moved slowly and committees absorbed technical information slowly.
- It proved to be vitally important to give clear, simple, and factual information to the citizens on a continual basis.
- Recognition that government and people tend to operate by crisis instead of by predisaster planning helped to give a perspective when evaluating performance.

Seismic safety element in California - The seismic safety element became a part of the State Planning Law in 1971, soon after the 1971 San Fernando, California, earthquake. From the experience gained in implementing this program, the following lessons were learned:

- Of the 412 cities and 58 counties in California, 81 cities and 19 counties in January 1977 still did not have a seismic safety element as part of their general plan. At present, there is no state requirement that can force local jurisdictions to complete their general plans.
- The total cost per capita for preparing a seismic safety element report ranged from $0.06 to $0.26 with the average cost being $0.10. Cost, however, was not the controlling factor in noncompliance.

- The requirement for a seismic safety element seemed to increase planner's awareness of the importance of integrating knowledge of local geologic hazards in land-use planning. It is very difficult, however, to measure performance in terms of impact on decision making.

Earthquake preparedness, Puget Sound area - The Puget Sound study pointed out a communication problem at the federal-state-local government interface. The primary causes of the communication problem were:

- Definition of the needs of state and local users was inadequate.

- Motivation of state and local officials was insufficient. Local government needed to have a "stake" in the study.

- State and local officials could not use all the information that was provided to them.

Geologic hazard mitigation, Colorado - Since 1969, Colorado has been able to develop and implement legislation designed to reduce geologic hazards. The primary lessons learned from Colorado's experience were:

- A few 200-year floods occurring within a few years time served as "triggering" events and stimulated action.

- A continuous education process to inform the public about hazards and how they impact man and his works was essential. Geologic information must be developed in many formats ranging from reports to color slide presentations to show in lay terms the importance of using basic knowledge about geologic hazards to plan effective mitigation measures.

- Continuous contact, independent of politics, with state agencies and the state legislature to provide advice and counsel was very important in the eventual development of legislation to mitigate geologic hazards.

Regional earthquake planning, Mississippi-Arkansas-Tennessee area - Although Memphis is within 160 km of the epicenter of the 1811-1812 New Madrid earthquakes, there are at present no planning constraints, no seismic design requirements, and a generally low level of seismic awareness within the community. Official reaction was varied and nonproductive to the finding of the MATCOG study that there is a higher risk of earthquake damage than previously thought. Some of the lessons learned from this study were:

- It is apparently more difficult to motivate and educate decision-makers and the various publics in the central United States to be earthquake conscious because there have been no recent "triggering" events.

- People seem to respond best to the earthquake hazard if they are given earthquake loss information that can be compared easily to loss from another disaster (e.g., flood, tornado) that they are familiar with.

- People respond to pocketbook issues. Some financial institutions in the area have recently had an impact on seismic awareness by refusing to loan money for construction that did not incorporate seismic design provisions.

- One can hypothesize that community awareness in Memphis would be much greater if the New Madrid earthquakes had been named "the Memphis earthquakes."

<u>Land-use planning and water-resource management, northeast United States</u> - The primary lessons learned from this study were:

- Education is a long-term process in the northeast because of the low seismicity. Apathy is greater when you are dealing with non-dramatic events that occur over a long period of time.

- Communication to local policy makers is difficult because planning authority is usually at the city level where resources are typically inadequate to hire a staff geologist or planner.

- Information transfer must be planned, structured and refined continuously if effective 2-way communication between the information producer and the information user publics is to occur. Earth sciences information must be provided in a useful and understandable format and at the right scale that correlates with political (planning) boundaries.

- Availability of local staff to provide expert advice and counsel and to respond to possible dramatic events has a positive effect on the communication process.

- Early identification of the local institution (or institutions) that will carry on the activity after a federal agency has terminated or reduced their effort in an area is important and serves to give a local "stake".

Acquiring and disseminating scientific and engineering information following an earthquake - Damaging earthquakes have provided unique opportunities to improve understanding of the nature and distribution of earthquake related losses and the earthquake mechanism. During the past 15 years study of damaging earthquakes in the United States and in foreign countries has pointed out a number of important lessons. The primary lessons were:

- Unique geologic, seismological, engineering, economic, and sociological data are available after a damaging earthquake and can be used to transform scientific theory into fact, and myths into reality. We need to be ready to take advantage of these opportunities, not only for scientific reasons but also for "triggering" of actions leading to legislation.

- Transfer of factual information to the concerned publics in a timely and effective manner is extremely important in the period immediately following an earthquake.

- Post-earthquake conferences and publications are effective ways to communicate new knowledge gained from an earthquake.

- An interdisciplinary team of experts working cooperatively with local experts seems to be the most effective means of acquiring and disseminating scientific and engineering information gained from an earthquake.

- On the basis of the distribution of subjects of technical papers presented at recent earthquake conferences, more emphasis should be given to studying damage to residential structures. The potential primary and secondary losses to residential structures in the United States is larger than for any other structural category. Also, it appears that relatively minor engineering considerations might reduce this potential loss considerably.

Development, use, and review of geologic and seismological data for siting of nuclear power plants - A procedure for incorporating the best available geologic and seismological data in the siting of nuclear power plants has been in effect since 1971. The effect of this procedure is to "force" communication. The primary lessons learned from this experience were:

- The communication process has proven to be very complex, partly because of the adversary nature of the procedure.

- The factors that seemed "to guarantee" effective communication are: early definition and regular exercise of informal and formal communication mechanisms between all concerned parties, provision of many opportunities for all parties to enter their inputs, and elemination of "surprises".

Development and use of building codes that incorporate earthquake provisions - Legal building codes are one of the most important ways that results of earthquake hazard research are introduced into the design and construction of earthquake-resistant structures. There are four model building codes produced in the United States: 1) the National Building Code, 2) the Uniform Building Code, 3) the Standard Building Code, and 4) The Basic Building Code. The process of developing building codes having earthquake provisions has provided a number of important lessons:

- The development of building codes that incorporate seismic design provisions is a complex and slowly evolving communication process. It typically takes about a decade to incorporate today's state-of-the-art into a building code.

- The greatest progress in development of building codes with earthquake provisions seems to be in reaction to particular earthquakes. Most of the advances have occurred in California and have been based on experience with specific earthquakes.

- At present, most legal building codes are the law of cities and towns, not states, and exhibit tremendous diversity with regard to adoption of earthquake provisions. This diversity complicates the communication problem.

Use of research products produced in the HUD/USGS San Francisco Bay region study - USGS and HUD jointly supported a study during the period 1970-1976 to demonstrate how earth science information could be used in regional urban planning and development. The focus was in the nine-county San Francisco Bay region. ABAG, a regional comprehensive planning agency owned and operated since 1961 by the local governments of the San Francisco Bay area, had a prominent role in the HUD/USGS study. A number of important lessons about effective communication were noted:

- Assignment of planners to the USGS staff to serve as liaison to users in the nine counties and to evaluate applications of USGS research products seemed to be a key decision that significantly contributed to 2-way communication.

- A consultative panel composed of members from the planning and development community at all levels of government and from the private sector provided an effective means for local participation.

- Mutidisciplinary committees composed of local experts were useful in designing specific products that would meet user's needs.

- Outside motivation, such as the requirement in 1971 for each city and county in California to develop a seismic safety element for their general plan, undoubtedly increased the interest of the user community in the study and contributed to the overall effectiveness of the communication process.

- Readiness of users to use the earth-sciences data seemed to be a direct function of factors such as: 1) availability of someone at ABAG or USGS to "translate" the data, 2) cost of the information, 3) adequacy of the data for uniform coverage of the planning area, and 4) access to "experts" to provide advice and counsel, as needed.

- User feedback suggested that earth-science products should be of an interpretive type; for example, estimated recurrence interval for geologic and hydrologic hazards; location, extent, and quality of energy, mineral, and water resources; and geologic unit capabilities for selected land uses.

- From the point of view of the information producer, it appears that earth-science products should be designed for one common user group, for example; intelligent and interested citizens. Such a product meets almost all user-needs as to content, scale, and detail and has a common basis for discussion and agreement during public hearings. If the products are designed for this one common-user group, it is not necessary to select target users and user groups.

- Evaluation of the "pay off" of the study is difficult to measure and will require continuous monitoring over a fairly long period of time.

<u>Achieving landslide hazard reduction</u> - Landslides are widespread throughout the United States. Almost every state has significant problems related to landslides. At present, communities such as Los Angeles,

California, and Cincinnati, Ohio, are making a concentrated effort to reduce the risk of damage from landslides. The primary lessons learned from past experiences were:

- Development of an effective landslide hazard reduction program appears to be feasible. The essential factors seem to be: 1) an able and concerned local government, 2) close coordination among geologists and engineers and communication with city agencies and elected officials, 3) a comprehensive base of scientific data about the hazard, and 4) a "triggering" event that captures the headlines and motivates legislative action.

- It can take considerable time (e.g., a decade in the Los Angeles area) for the scientific-socioeconmomic-legal-political elements of the solution to be set into motion.

SUMMARY OF RECOMMENDATIONS FOR IMPROVING COMMUNICATION

The participants in the workshop developed a number of general recommendations for improving communication of earthquake-hazard reduction information. These recommendations were suggested following an in-depth review of the communication process defined in each of the experiences described above. The purpose was to suggest procedures that might be adopted immediately by the Office of Earthquake Studies, USGS, in communicating the results of their internal and external research to decision makers and users.

It is clear that the challenge of earthquake hazard reduction requires two actions: 1) development of a broad base of technical information and 2) effective communication of the research results via a two-way process based on far-reaching linkages that persist over time. Progress is being made in both areas, but much remains to be done.

The recommendations for improving communication are listed below:

1. Be prepared to take advantage of triggering events to maximize effectiveness and to learn more rapidly.
2. Key communication activities to enabling legislation (e.g., 1977 Cranston Earthquake Hazard Reduction Act, 1971 amendment to the California State Planning Law, and Colorado House Bill 1041 in 1974).
3. Develop staff capabilities for communication
   a. identify and involve "crusaders"
   b. train staff to communicate effectively
4. Develop the message to be communicated by the staff
   a. make the message credible and timely
   b. make the message useful
   c. tailor the message to needs of decision makers, user groups, and the publics.
   d. package the message effectively (e.g., use technical reports, executive summaries, etc.) and use visual aids.
   e. personalize the message.
5. Develop interfaces with decison makers, user groups, and the publics
   a. start developing a comprehensive set of personalized interfaces early in the life of an activity.
   b. be patient and consistent.
   c. establish and use informal and formal communication mechanisms.
   d. develop a two-way communication process.
   e. refine your communication process through continuous interactive and iterative actions.

f. develop mutual understanding so that there will be few, if any, surprises.

6. Define projects/programs that lead to optimal communication of the message.

   a. identify and involve local experts and decision makers in planning, in user advisory groups, and in project development.

   b. develop a "bottom up" communciation mechanism to correct "top down" practices.

   c. identify products that can be used for policy development, ordinance formulation, and state/local legislation.

   d. focus on the gaps in knowledge and the critical needs.

   e. be aware of and avoid the myths in communication.

      (1) There is a consistency between what people say and what they do.

      (2) There is a general relationship between the provision of scientific information and what is done with the information.

      (3) There is a general public or "the public".

      (4) Scientific assessment is the equivalent of a group assessment.

   f. develop projects/programs that lead to a range of transfer and application options for the decision makers and user groups.

   g. determine the cost effectiveness of planned activities.

   h. insist on periodic critical evaluations to assess the lessons that have been learned.

7. Develop an effective educational process to achieve both short and long term goals.

   a. utilize workshops, seminars, symposia, etc.

b. publish relevant information on a timely basis

c. hold post-hazard conferences to communicate new knowledge.

8. Use the legal liability stick to make the communication process more efficient.

9. Be innovative

   a. use computer technology as a communication tool,

   b. look for new ways to accomplish the goal,

   c. keep learning.

10. Develop effective ways for utilizing the public media.

Steps are already being taken to develop a communication process that incorporates these considerations.

EXAMPLE OF A SEISMIC RISK PROFILE MEASUREMENT "NGT"

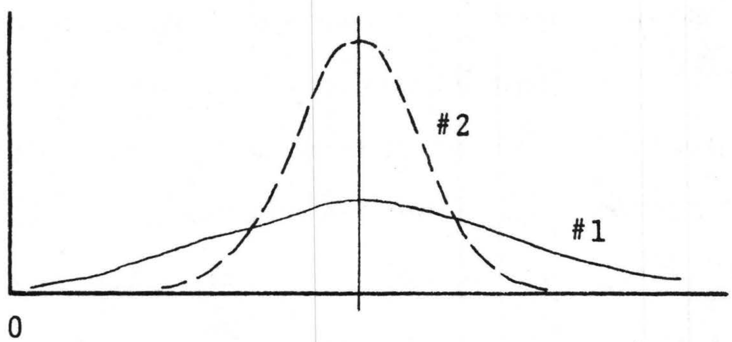
BY

O. CLARKE MANN*

During the Denver Workshop we demonstrated how the "Nominal Group Technique "NGT", as discussed in our paper, could be used as a communications tool. A five question sampling, Fig. 1, of opinions was taken on questions regarding the respondents' safety from seismic hazards. The answers required a knowledge of earthquake hazards and the making of free judgement. A summary of the answers and a brief analysis is given.

QUESTION 1 The group is in agreement that when choosing a living place, one should consider the seismicity of a region. This is especially true if the region is highly seismic.

QUESTIONS 2 & 3 The average of the group opinion reflects a correct appraisal of the relative risks of Zones 1, 2 and 3, but the range, high to low, indicates considerable opinion diversity. Such diversity is characteristic of first iterations and would reduce greatly during a second cycle, such as suggested by curve 2.



* CONSULTING ENGINEER

QUESTION 4 This question is controversial and draws to the surface opinions reflecting the established economic traditions of our country. The second part, related to existing buildings, is extremely important since it deeply affects the nation's seismic safety for at least 50 more years and here the group was almost equally divided. An exchange of views could possibly improve the unity of opinions on a second sampling. In any event, two or three iterations would indicate whether or not the public would support a "retro" program. The possibility that a partially financed "retro" program would be publically acceptable could be informatively investigated using "NGT".

QUESTION 5 The differences of opinion regarding relative importance of type-functions of structure is usually wide spread. This group, although seismically wise, exhibited the normal range of differences. The group's ordering by priorities is shown in Fig. 2. A second priority bar is shown which reflects the ranking given by a group of business executives on a first iteration. In Fig. 3 we have given a histogram of four individual functions. Histograms for hospitals and warehouses indicate substantial unity of opinion, in constrast to homes and water and sewers. The unity of opinion on hospitals and warehouses can be misleading. It is an "obvious" reaction and would probably change considerably after discussion and reiteration. For example, respondents come to realize after some discussion that hospitals are already full with day-to-day patients and could never carry the surge load of a major earthquake.

This discovery greatly alters their hospital priority. In a normal situation, the responses would be reiterated until opinions coalesced or indicated stability in their wide divergence. Either answer can be used by the planner-decision maker.

We have found that societal values can be modeled by using a microcosmic structure and that ordinary judgement in the choice of participants is adequate. The group should represent real decision making positions and the individuals should be knowledgeable in their own field. The "NGT" is a quick and economical method to distill the informational contributions of a group into a form useful to planners, researchers and other decision makers.

We express our appreciation to you who participated in the exercise and hope it proves useful to each of you in your planning.

A SEISMIC RISK PROFILE MEASUREMENT USING NGT OR DELPHI

(TO BE USED WITH PERSONS WHO ARE SEISMICALLY KNOWLEDGEABLE)

1. If you were choosing a place to live, would you give consideration to the seismicity of the area?

Zone	Yes	No
3	100%	0
2	64%	36%
1	37%	63%

2. If you were buying a residence in which to live or renting an office, how much increase would you be willing to pay for structures appropriately designed to resist earthquakes?

Zone	0%	2%	4%	6%	8%	10%	Observations (N)
3 Residence		Lo			Av.8.1	Hi	31
Office		Lo			Av.8.3	Hi	29
2 Residence	Lo		Av 4.6			Hi	31
Office		Lo	Av 5.2			Hi	29
1 Residence	Lo	Av. 2.0				Hi	30
Office	Lo	Av.1.8				Hi	29

3. If you lived in a seismically active area, how much would you be willing to pay for earthquake insurance relative to fire insurance?

Zone	0%	5%	10%	15%	20%	25%	50%	Observations (N)
3	Lo				Av 23.6		Hi	30
2	Lo		Av 11.5				Hi	32
1	Lo	Av.3.7			Hi			31

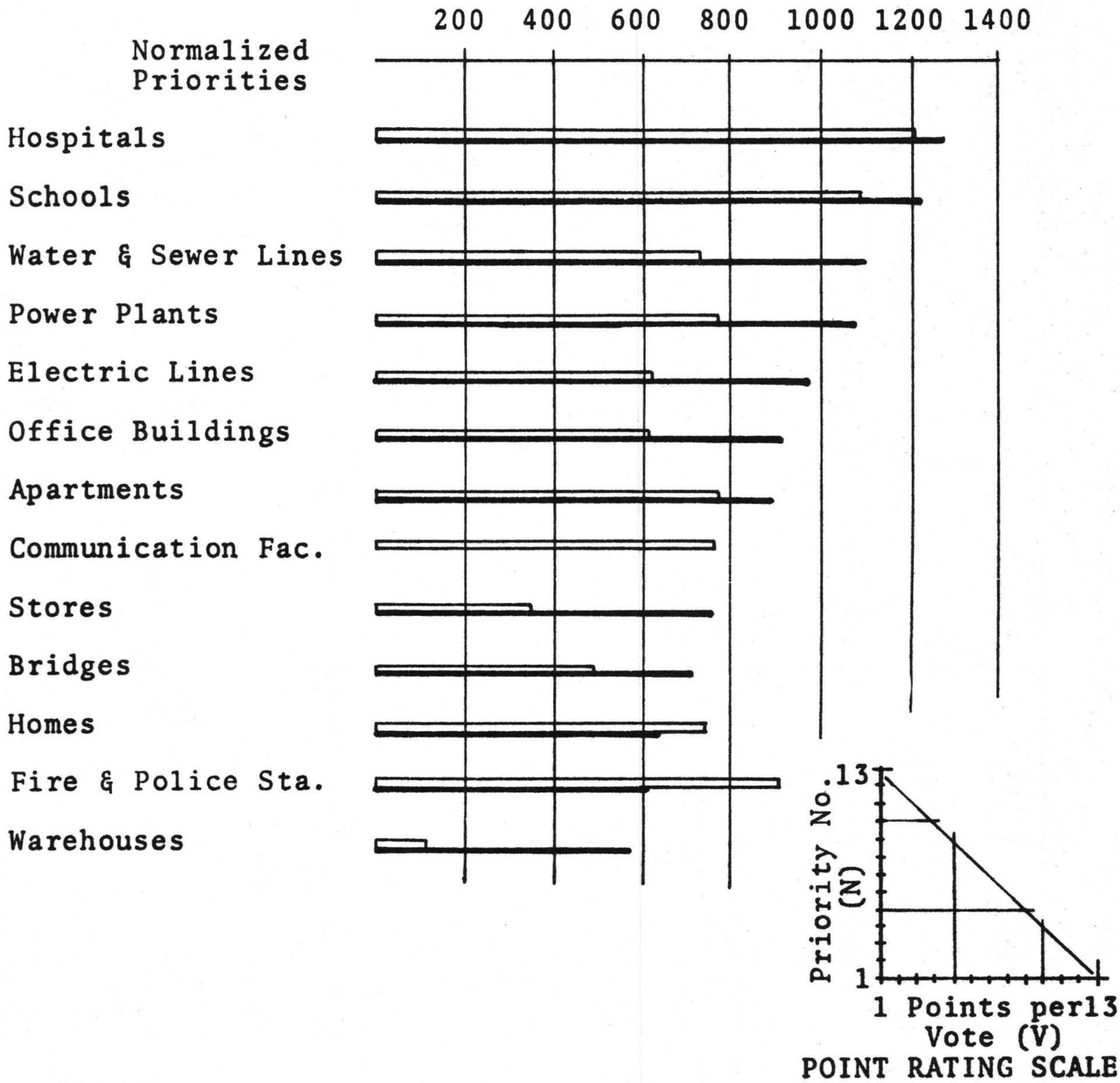
4. If a government should decree that earthquake resistance should be built into all structures, should that government pay for the added building cost to provide that resistance?

	Yes	No	Observations (N)
New Buildings	9%	91%	32
Existing Buildings	44%	56%	32 "retro"

5. If structures are to have built-in resistance to earthquakes, list the priority in which this should be done using the following scale? (Rank by numbers 1 through 13) Observations (N) 28±

Warehouses	13	Bridges	11	Electric Lines	9
Apartments	4	Schools	2	Fire & Police Stations	3
Office Bldgs	10	Stores	12	Power Plants	5
Communication Facilities	6	Hospitals	1	Water & Sewer Lines	8
		Homes	7		

FIG. 1

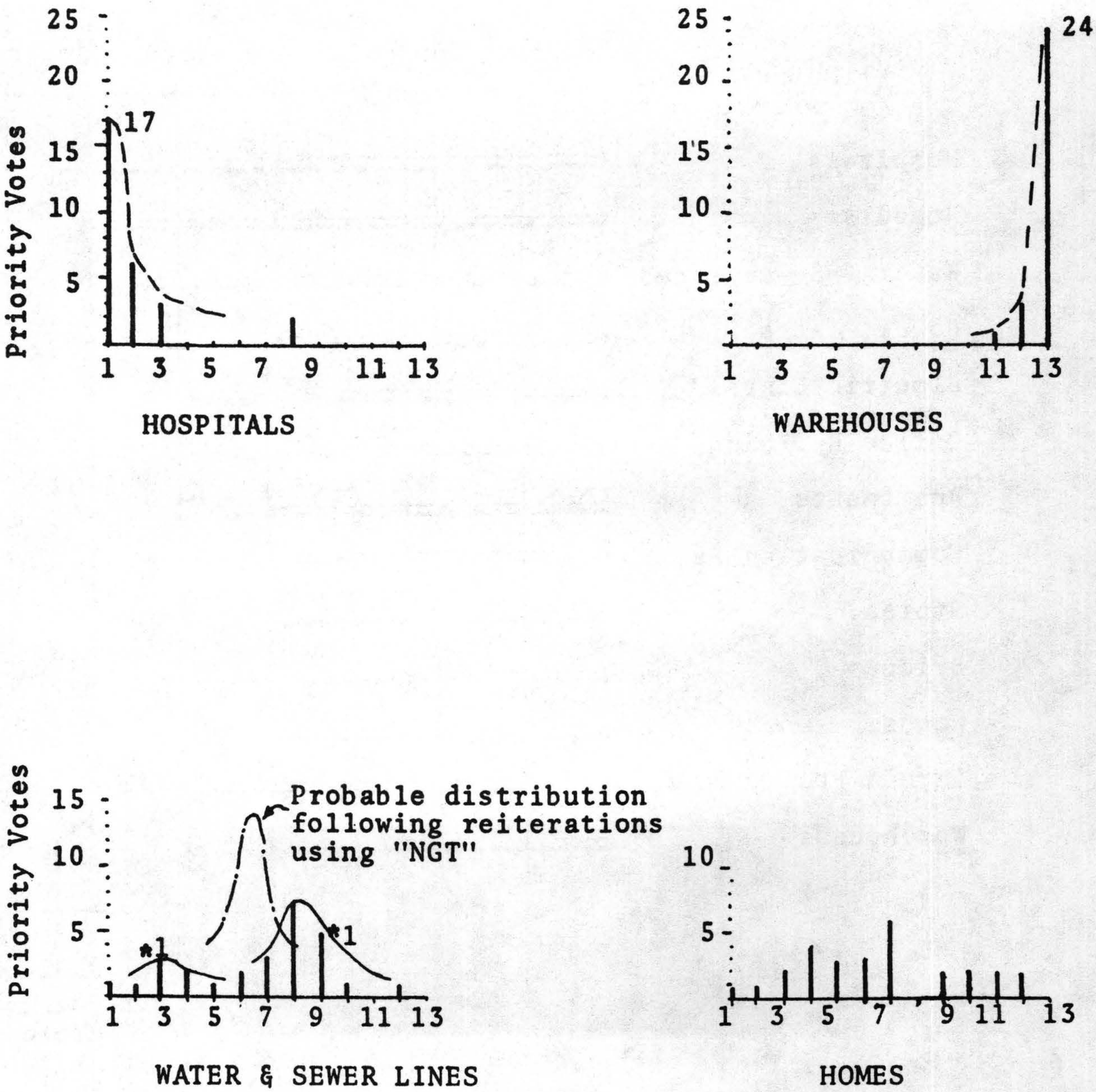


Black Bar - Group of 10 decision makers from industry and government

White Bar - Respondents from Workshop on Communicating Earthquake Hazard Reduction (28 ±)

BUILDINGS AND LIFE LINE ASEISMIC PRIORITIES

FIG. 2



*1 Two fundamental and different decision bases

FIRST ITERATION OF STRUCTURES PRIORITY RANKING

FIG. 3

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LAND USE PLANNING IN PORTOLA VALLEY, CALIFORNIA

by

George G. Mader

William Spangle and Associates

INTRODUCTION

The Town of Portola Valley has since the mid-1960's taken four major actions which have firmly entrenched geology as a significant part of the land use planning function in the town. These actions have been: inclusion of geologic considerations in basic planning regulations, hiring of a town geologist, adoption of fault setback regulations, and adoption of geologic maps and related policies as devices for guiding land use decisions. Each of these actions will be described and evaluated in this paper.

The Town of Portola Valley is not a typical town and therefore requires some description to provide a basis for evaluation of its programs. This residential community has a population of approximately 4,000 and is located some thirty miles south of San Francisco on the San Francisco Peninsula. The population is composed largely of upper income persons, many of whom come from professional fields, teaching and business. Most of the development has occurred since the 1940's. Residents share a concern for the natural environment and want to keep a low-density town in which people can keep horses and pursue "rural" type activities. The town council and planning commission have been composed of individuals who reflect the desires of the town.

Physically, the town is divided by the San Andreas Fault zone. The low hills to the east are made up of older and relatively stable formations. The higher mountains to the west are made up of younger formations, are youthful in appearance and have large areas of active or potentially active landslides. Most of the residential development has occurred in the eastern portion of the town.

ACTIONS TAKEN BY THE TOWN

Each of the four actions introduced above will be described and illustrated by a diagram indicating the information flow process.

Inclusion of Geologic Considerations in Basic Planning Regulations

The town was incorporated in 1964 and soon thereafter adopted a newly prepared general plan which called for the preservation of the natural qualities of the area. The next step was to prepare zoning, subdivision and site development (grading) regulations to carry out the provisions of the general plan. The sequence of events that took place are outlined on Figure 1.

In 1966, the town council retained William Spangle & Associates as consultants with George Mader of the firm named as town planner. The consultant was asked to prepare ordinances covering zoning, subdivision and site development. The consultant prepared drafts of ordinances addressing matters he thought were of importance to the town. Drafts of these ordinances were circulated to the numerous committees and commissions in the town. Being a small community, volunteer groups were important. Fortunately, there were many highly-qualified people in these groups and they provided much

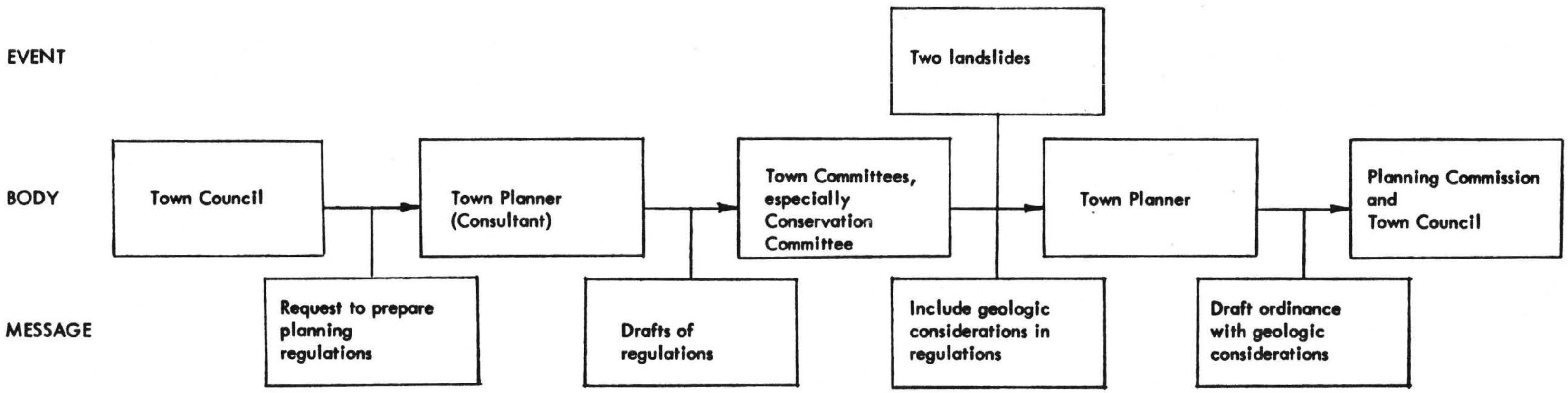

Figure 1

Inclusion of Geologic Considerations in Basic Planning Regulations needed advice. One of the committees to which the ordinances were referred was the conservation committee. This committee had a very strong member in the person of Dwight Crowder, a geologist with USGS in Menlo Park. Dwight, highly aware of the geologic problems in the town, had since his appointment tried to make the town officials aware of the local conditions. His early descriptions to town officials of problems in terms of the geologic timetable fell on basically deaf ears for a considerable period of time. When he received the proposed ordinances, he wrote short terse memos with considerable zeal on each one to the town and proceeded to convince the town planner of the necessity to include consideration of geology. Being a comparatively new subject to the town planner, the geologist was forced into a basic education job. The geologist took a firm stand that each of the three ordinances should include provisions that would require the preparation of geologic studies for development projects. These recommendations, included in the ordinance drafts, met with mild enthusiasm by elected officials as they questioned the need and were concerned about the cost to developers for preparing such reports.

Thus, in early 1967, the future of geologic requirements in the town regulations was somewhat in doubt. Two events, however, convinced the council of the wisdom of such requirements. These events consisted of two landslides which occurred early in the year. One landslide, just outside the town boundary, destroyed a road and a house and resulted in public and private losses in excess of $270,000 in San Mateo County. The other landslide occurred in a small subdivision recently approved by the town. The costs to the public in the first landslide and the potential liability to the town in the second landslide convinced the town council that there were serious geologic problems in the town and that it was imperative to include geologic considerations in town regulations.

As a result of the foregoing the town regulations were adopted with the following provisions:

1. The zoning ordinance (adopted July 18, 1967) requires engineering geology and soils reports and a demonstration of how development relates to such information for all planned community zoning districts. In addition, the zoning and subdivision ordinances each carry a broad objective, "To protect the community against excessive storm water runoff, soil erosion, earth movement, earthquakes, and other geologic hazards."

2. The subdivision ordinance (adopted March 22, 1967) requires reports by soils engineers and engineering geologists for all subdivisions. Further, the town can retain soils and geologic consultants to review the reports submitted by developers.

3. The site development ordinance (adopted March 22, 1967) requires reports by soils engineers and engineering geologists and provides for consultant review similar to the requirements of the subdivision ordinance. The site development ordinancecarries a statement of an objective similar to the one for the zoning and subdivision ordinances.

Hiring of a Town Geologist

In May of 1967 the town council appointed the Geologic Hazards Committee, a committee intended to advise the towns of Portola Valley and Woodside (see Figure 2). In this action the council indicated its desire to minimize the losses from geologic hazards to residents and to the town. The mayor, a research chemist, evidenced strong concern for liability questions and an interest in the proper use of scientific information. Another member of the council, a wife of a retired general and a concerned environmentalist, indicated her interest in respecting the geology in development. These and concerns of other council members, the recent landslides and the urgings of the geologist member of the conservation committee, led the council to seek additional advice from the newly formed committee.

The committee was composed of three research geologists (two from USGS and one from Stanford University), a local attorney with experience in landslide litigation, and the town building official with experience in administering regulations. The committee met eight times from May to July and rendered a report to the town council in August. The report contained three recommendations:

1. The town should retain an engineering geologist to advise the town on a continuing part-time basis.

2. The town should review all ordinances and regulations governing matters in which geologic hazards could be relevant and make revisions as necessary to ensure adequate consideration is given to geology.

3. A "geologic hazards map" should be prepared for the town and, in particular, the San Andreas Fault should be mapped as soon as possible.

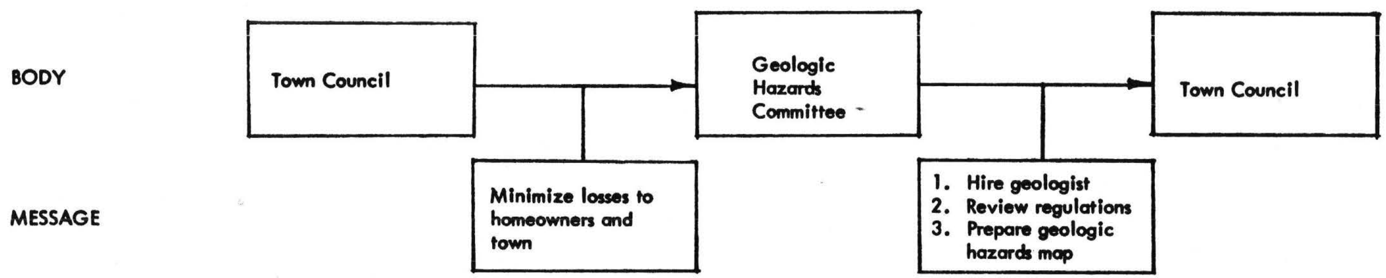

Figure 2

Hiring of a Town Geologist

In February 1968, the town council adopted the recommendations in general as proposed by the Geologic Hazards Committee. On September 25, 1968, the town retained a professor of geology from Stanford University as town geologist. His job was to advise the town on a day-to-day basis, participate in the revision of regulations, review development applications and related geologic and soils reports, and assist the town in preparing a geologic hazards map.

The mayor's continuing interest was demonstrated by his request in January 1970 for a progress report on implementation of the Geologic Hazards Committee's recommendations.

Fault Setback Regulations

The town geologist realized the need for good information regarding the location of the San Andreas Fault traces as he dealt with development applications. He therefore recommended to the town council that an expert in faulting be retained to map the San Andreas Fault (see Figure 3). The council accepted the recommendation and in mid-1969 a professor of geology from Stanford undertook the mapping based on surficial field observations, aerial photographs plus what other data was available. He submitted his report to the town in July 1970 and in the report he identified several active traces of the San Andreas Fault through the floor of the Portola Valley. The report was subsequently used by the town geologist in his on-going activities. The town geologist realized, however, policy guidance was needed with respect to guiding land use along the fault. He therefore recommended to the town council, in 1971, that a technical review committee be formed to review the report and maps and recommend policy to the town.

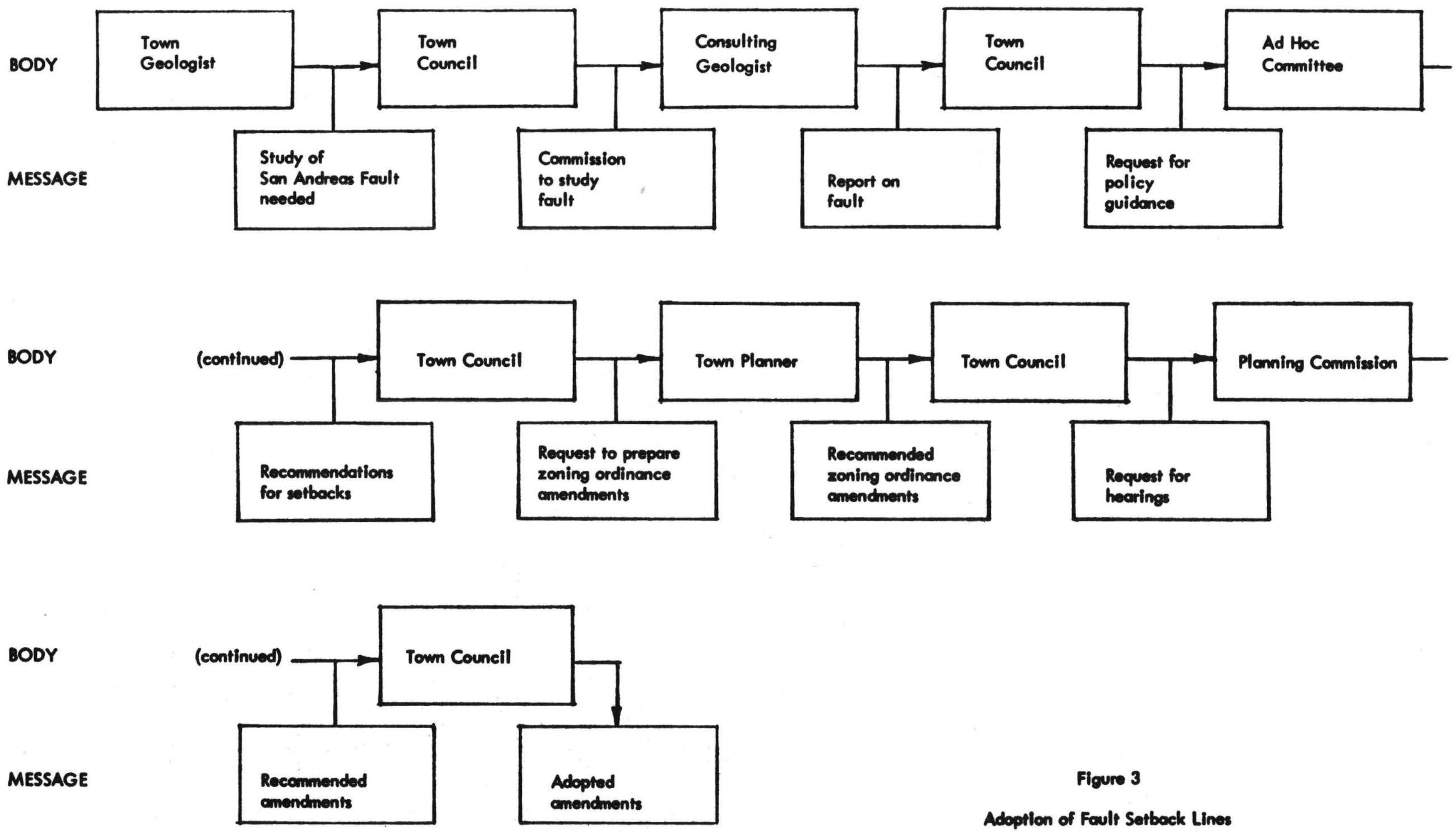

Figure 3

Adoption of Fault Setback Lines

The council then appointed the Ad Hoc San Andreas Fault Study Committee which included the following members: town planner (chairman), town geologist, town building inspector, the geologist who prepared the fault study, town engineer, two engineering geologists, and a civil engineer with extensive experience in geology and soils. The charge to the committee from the town council was as follows:

> "The Town Council wants reasonable, scientific and good judgment with respect to how close buildings can be built to the fault or whether, in fact, some can be built on the fault. The Council is concerned with this matter and needs good sound advice as they have sought in the past relative to geologic problems in the Town."

The committee first met in mid-1971 and finally delivered its report to the town council in March 1972. The committee recommended that buildings for human occupancy be kept back at least 50 ft. from mapped traces and that for an additional 75 ft. on each side of the trace uses be no more intensive than one-story wood frame residences. Beyond the 75 ft. bands, major uses would require special study relative to the fault hazard (see Figure 4). The council accepted these recommendations in March 1972, adopted interim zoning for the fault zone and directed the town planner to prepare appropriate amendments to the zoning ordinance. The town planner, as chairman of the committee, was well prepared to undertake this task.

In September 1972, the town planner presented proposed permanent zoning ordinance amendments which provided for setbacks along the fault traces. In the preparation of the setbacks, the town planner consulted with the members of the committee and their endorsements were carried forward to the town council. The recommendations were forwarded from the council to the planning commission where public hearings were held. Subsequently, the town council held public hearings and adopted the amendments to the zoning ordinance in February 1973.

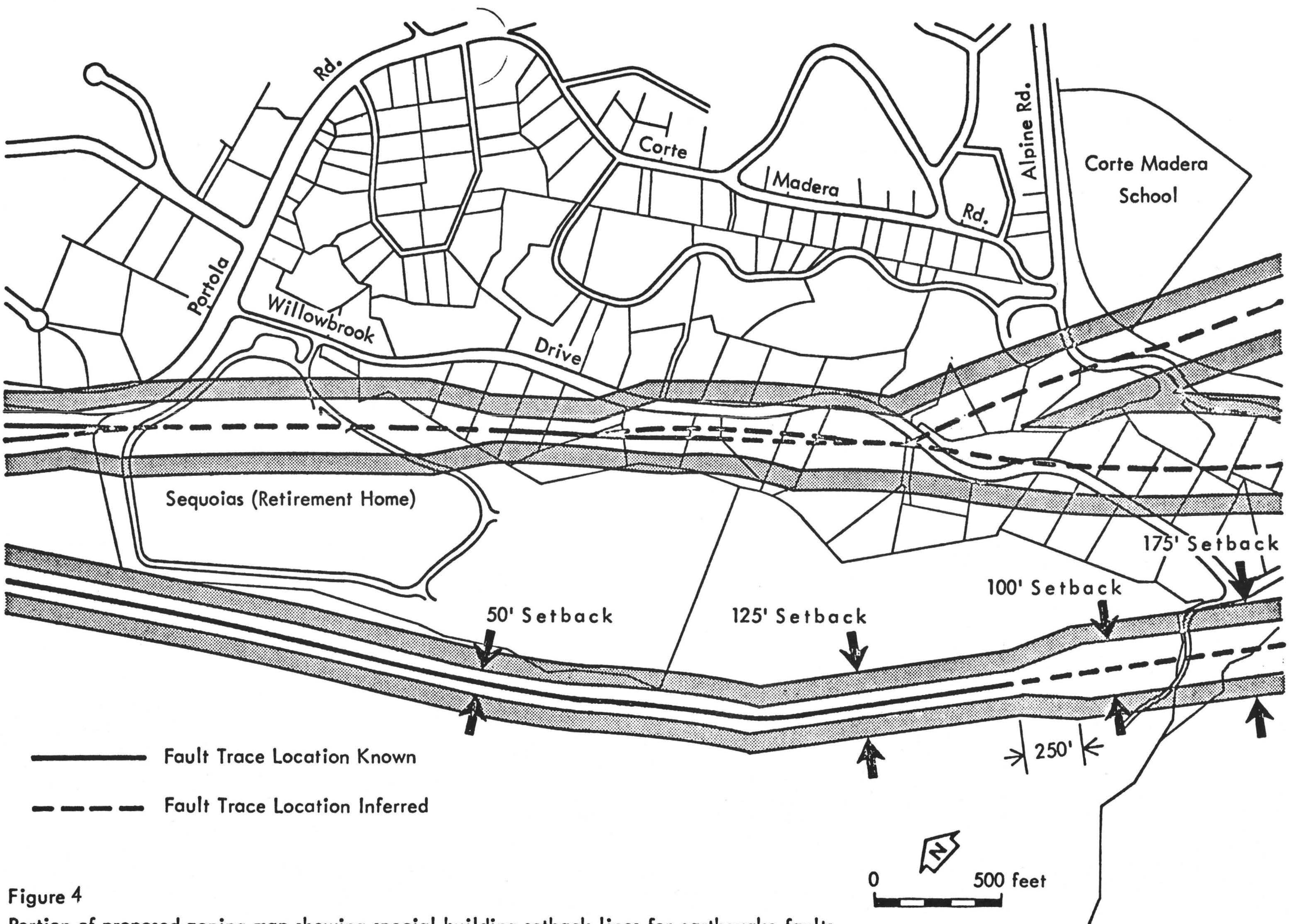

Figure 4

Portion of proposed zoning map showing special building setback lines for earthquake faults
Source: Reference 2.

Geologic Maps and Related Policies

After his appointment, the town geologist recommended to the town council that a geologic mapping program be undertaken as had been recommended by the geologic hazards committee (see Figure 5). The council provided funds which allowed the town geologist to retain graduate students to carry out mapping under his supervision. The mapping took place from 1969 to 1974. The products were two maps, each at a scale of 1" = 500'. One map showed the geology and the other translated the geology into stability categories and was termed "Movement Potential of Undisturbed Ground."

In August 1973, the partially completed map was presented to the town council. The council adopted an interim ordinance which prohibited the processing of most development applications in areas of significant instability while the town undertook a study to determine appropriate policies to impose on all categories of land stability.

In October 1973, the Ad Hoc Geologic Committee, appointed by the town council on the advice of the town geologist, had its first meeting. The committee membership was as follows: town geologist (chairman), town planner, a local attorney with experience in landslide litigation, a civil engineer with experience in soils and geology, an engineering geologist, two geologists from USGS and the graduate student who completed the mapping and wrote the descriptive report. The committee met four times and in March 1974 presented to the town council its final recommendations. The recommendations were set forth in a matrix that correlated land uses with land stability categories (see Figure 6). The recommendations included provisions for challenging the town maps based on new geologic information and amending them if the new information supported the change. The town council adopted the recommendations of the committee as a policy matter by resolution on May 1974.

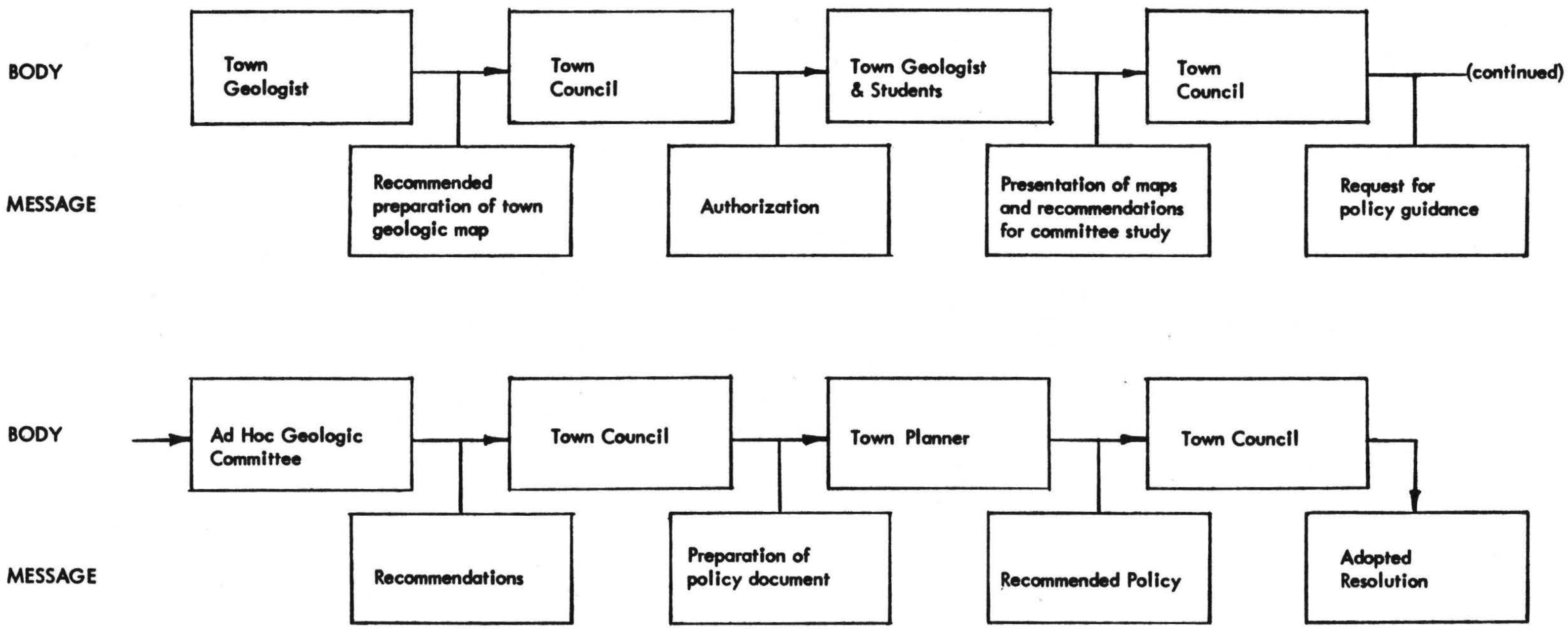

Figure 5

Geologic Maps and Related Policies

CRITERIA FOR PERMISSIBLE LAND USE IN PORTOLA VALLEY

	Land Stability Symbol	Roads: *Public*	Roads: *Private*	Houses (*parcel acreage*): *¼-Ac*	Houses (*parcel acreage*): *1-Ac*	Houses (*parcel acreage*): *3-Ac*	Utilities	Water Tanks
MOST STABLE	Sbr	Y	Y	Y	Y	Y	Y	Y
	Sun	Y	Y	Y	Y	Y	Y	Y
	Sex	[Y]	Y	[Y]	Y	Y	Y	[Y]
	Sls	[Y]	[Y]	[N]	[Y]	[Y]	[Y]	[N]
	Ps	[Y]	[Y]	[N]	[Y]	[Y]	[Y]	[N]
	Pmw	[N]	[N]	[N]	[N]	[N]	[N]	[N]
	Ms	[N]	[N]	N	N	N	N	N
	Pd	N	[N]	N	N	N	N	N
	Psc	N	N	N	N	N	N	N
	Md	N	N	N	N	N	N	N
LEAST STABLE	Pf	[Y]	[Y]	(*Covered by zoning ordinance*)			[N]	[N]

LEGEND:

- Y Yes (construction permitted)
- [Y] Normally permitted, given favorable geologic data and/or engineering solutions
- N No (construction *not* permitted)
- [N] Normally *not* permitted, unless geologic data and/or engineering solutions favorable

- S Stable
- P Potential movement
- M Moving

LAND STABILITY SYMBOLS: (as used on geologic hazards map)

- br bedrock within three feet of surface
- d deep landsliding
- ex expansive shale interbedded with sandstone
- f permanent ground displacement within 100 feet of active fault zone
- ls ancient landslide debris
- mw mass wasting on steep slopes, rockfalls and slumping
- s shallow landsliding or slumping
- sc movement along scarps of bedrock landslides
- un unconsolidated material on gentle slope

Source: Reference 3.

Figure 6

EVALUATION OF INFORMATION COMMUNICATION ACTIVITIES

Evaluation of the activities previously described can provide lessons for future efforts to communicate geologic concerns to decision-makers.

Relationships of People and Activities

Information Requirements. While the nature of the information varied, the constant concern was that the information be honestly presented and described. Thus, if information was general, it should be so stated and provisions made for refinement of information as better data became available. There was great concern that data not be misused.

Two-Way Communication. At the early stage of the development of the program, communication was essentially one-way as the geologists tried to convince the town of the need to consider geology. Two-way communication was achieved only after two devastating landslides which amply demonstrated the vulnerability of the town to landslides and related liabilities if care was not taken in the planning and development process. This communication was further enhanced when the town realized consideration of geology could aid in retaining the open space character of the town.

Focal Point of Information. The repository for information was at all times the town hall. The focal point for activities, however, varied with the project. Focal points included the crusading geologist at the outset, then the Geologic Hazards Committee, the town geologist, town planner and the other two special committees.

Public Media. The local weekly paper gave excellent coverage to the landslides and reports of committees as they were made. Some of this information was also picked up in the Palo Alto Times, a daily. It is not easy to evaluate the impact of the newspaper coverage. Since the local weekly is believed to have a very high readership and since the information was well presented and had considerable inherent interest, one would believe that the local citizens became rather well aware of the geologic problems. Concern at public hearings by local residents would seem to verify this conclusion.

Channels of Communication. It should be clear by now that standard channels of communication were not entirely sufficient for the several projects mentioned. The crusading geologist used his membership on the conservation committee of the town as a basis for his initial input in the town regulations. This was of course a legitimate use of this membership. For the other three projects described, however, the town appointed three separate committees to provide special channels of communication from the earth scientists to the decision-makers.

Intermediate Groups. Strong reliance was placed by the town council on the three committees discussed. The council named very competent and some very well-known experts in their fields to the committees. Since the council respected the members, they also respected their recommendations.

Performance Evaluation

Proper Conveyance of Information. Because the town is small and few individuals are involved in town government, there is little chance for information to be lost or mired in government. Information flowed in a timely manner. Any slowing of the process was due to the fact that volunteer committees were used extensively and hence schedules had to be arranged for their convenience. This was not, however, a significant problem. The communication process between the producers and users was so complete that there was no need to rework information. In each instance, the producer knew the eventual types of use to be made of his product. The need for translating the descriptive geologic maps into policy documents, however, became more clear as time went on. This later stage, however, did not require a reworking of the earlier data. It was simply a logical next step.

Monitoring of Communication. All committees and staff members involved prepared memos and minutes so that all involved were well aware of the status of each project. Also, heavy emphasis was placed on carefully prepared maps that conveyed information to all persons involved.

Strengths and Weaknesses of Communication Process. The strength was that the use of committees appointed by the town council provided a good mechanism for linking the earth scientists and the council. The potential weakness was that this vital link was a volunteer group of professionals. This did not present a particular problem, however, in this instance.

Could the Activity Be Used as a Model? The carefully chosen committees of qualified members could be a model for similar efforts. Also, the types of maps prepared could be models for information communication.

Lessons Learned. A number of lessons have already been described. A brief summary and some additional lessons should be mentioned.

1. Role of the Crusader -- In this instance, the unflagging energies of a professional with a strong desire to see the local government use geology was a major factor in success.

2. Triggering Disaster -- The two local landslides brought home the geologic problems and were the key events in mobilizing the town. Without these, even landslides in similar geologic and topographic conditions removed from the town would have been difficult to sell as arguments for local action.

3. Bias of Community -- The bias of the community toward low-density development and open space was an important factor in the willingness of the town to accept consideration of geology.

4. Liability -- The concern for public liability was a significant factor in convincing the town council to take action. This is of course closely tied to item 2 above.

5. Translator -- The role of translator has been important in all projects. This has varied from individuals (conservation committee member and staff) to committees.

6. Focal Point -- Once programs have been established, the focal point has shifted to staff. In this shift the close and continued contact of the town geologist and town planner has been very important.

Were Decision-Makers Helped? The projects have provided the decision-makers with products that are continually used with considerable confidence.

Did Legislation Result? Legislation resulted in amendments to the three basic planning regulations (zoning, subdivision and site development) and in administrative decisions and policy formulation.

REFERENCES

1. Mader, George G. and Dwight F. Crowder, "An Experiment in Using Geology for City Planning--The Experience of the Small Community of Portola Valley, California," in Environmental Planning and Geology, U.S. Department of the Interior and U.S. Department of Housing and Urban Development, 1971.

2. Mader, George G., Edward A. Danehy, Jon C. Cummings, and William R. Dickinson, "Land Use Restrictions Along the San Andreas Fault in Portola Valley," in Proceedings of the International Conference on Microzonation for Safer Construction Research and Application, Vol. II, Seattle, Washington, October 30-November 3, 1972.

3. Mader, George G., "Earthquakes, Landslides and Public Planning," Cry California, Summer 1974, San Francisco, California.

THE SEISMIC SAFETY ELEMENT, SANTA CLARA COUNTY, CALIFORNIA

by

Eleanor Young*

Repercussions following major earthquakes take many forms, one of which is new State legislation. The Long Beach earthquake of 1933 triggered the Field Act which now governs the construction of public schools in California. The San Fernando earthquake of 1971 was sufficient impetus for the State legislature to mandate that all California cities and counties prepare and adopt a Seismic Safety Element so that seismic hazards will be taken into account in their planning programs.

Preparation of the Seismic Safety Element in Santa Clara County was actually the culmination of many years of interest in geologic factors as well as other physical characteristics that could and should provide an important basis for land use planning. The specific Santa Clara County projects and programs will be dealt with below. Let's step back for the moment and look at the regional - San Francisco Bay Area - picture. Geologic factors as a part of a total package for regional decisionmaking emerged in the early 1960's with the "Save the Bay" movement which culminated in the San Francisco Bay Plan adopted in 1969 and now administered by the San Francisco Bay Conservation and Development Commission (BCDC). During the detailed study which was used as the basis for the Bay Plan, the problems associated with fill placed on top of the younger Bay mud received significant attention. This formation of mud intersticed with sandy lenses, having the potential for differential settlement, generally marked the location of the former marshlands that ringed the Bay prior to the urbanization and filling of much of the edge of the Bay.

The implication of construction on filled marshland areas received publicity when two USGS geologists, Marvin Lamphere and Brent Dalrymple, wrote a paper, " Potential Earthquake Hazards on Bayfill and Marshlands Adjacent to San Francisco Bay." This report

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was prepared for and presented to the Bay Conservation Study Commission in December, 1964. The two geologists had prepared the paper as private citizens, not as members of the Survey and since it did not relate directly to their work, they were not required to have it precleared with Survey Management. Nevertheless, the prestige of the Survey whether authorized or not was now thrown into the controversy. Many geologists have questioned the stability of construction on Bay marshland areas, but these were the first to have the courage to do it publicly.

The environmental movement which got underway in earnest in the late 1960's picked up on the geologic hazards issue of Bay mud, landslides and hillside and baylands development in general with all its associated environmental degradation. Environmental impact reports were unknown. Ian McHarg was an anonymity. Political candidates began to hear the environmental concerns of the electorate. There were some surprising election results as some long term politicians failed to be elected when they chose to ignore environmental issues. They were, of course, other factors involved in elections but the "growth is progress" syndrome was beginning to erode at the edges.

Lawsuits by property owners against local government in landslide areas were beginning to bring some attention to the direct cost of geologic hazards. As the citizenry demanded more and more services and the normal maintenance and service costs began to escalate with no new revenue available, local governments had to acknowledge that future urban growth into the Baylands, hillsides and other presently non-urbanized areas was financially unattractive.

The specific actions, projects and programs that provided earthquake hazard information in Santa Clara County are outlined in Figure 1. The major participants are listed on the vertical side: Santa Clara County Board of Supervisors and Planning Commission; Santa Clara County Planning Policy Committee (PPC), Ad Hoc Committees, City Councils and

FIGURE ONE

COMMUNICATING EARTHQUAKE HAZARD REDUCTION INFORMATION

Participants	1964	1966	1967	1969	1970
Santa Clara County Board of Supervisors & Planning Commission					
Santa Clara County Planning Policy Committee; Ad Hoc Committees; City Councils; Santa Clara Valley Water District			PPC Subcommittees study hillside & baylands generally 1967		PPC Baylands Study 1970-72
Santa Clara County Planning Department		Land use/transportation study using environmental constraints in analysis 1966 USDA/County Coop Soil Study 1966 Andre Sarna Bay Mud Study 1966 LaJoie/Curry Landslide Study 1966	PPC Subcommittee staffing 1967	Arvid Johnson report on need for hillside geologic analysis 1969	PPC Baylands Subcommittee staffing 1970-72
Santa Clara Valley Water District Staff					Flood Control Report to PPC Baylands Subcommittee
Lifeline Staff					
USGS	Lamphere/Dalrymple report of Bay fill December 1964				Nichols' Historic Marshlands Report 1970
CDMG & Consultants		USDA/County Coop Soil Study 1966 Andre Sarna Bay Mud Study 1966 LaJoie/Curry Landslide Study 1966		Arvid Johnson report on need for hillside geologic analysis 1969	Geology/Structural Engineering Report to Baylands Subcommittee 1970
General Public, Press, TV, & Conferences	Environmental Movement mid 1960's				

Participants	1971	1972	1973	1974		1976
Santa Clara County Board of Supervisors & Planning Commission		B/S adopts 2.5 acre zoning in Santa Cruz Mtns. 1972	B/S adopts 2.5 acre zoning in Santa Cruz Mtns. 1973 B/S adopts Baylands Plan 1973	B/S adopts Monte Bello Plan 1974 (Sept.) Planning Commission holds meeting on Alquist-Priolo zones	B/S adopts Geologic Ordinance 1974	B/S adopts Seismic Safety Element Jan. 1976
Santa Clara County Planning Policy Committee; Ad Hoc Committees; City Councils; Santa Clara Valley Water District	PPC Hillside Subcommittee 1971-73	PPC adopts Baylands Plan & Santa Cruz Mtn. Plan 1972		PPC adopts Monte Bello Plan 1974 (June)		
Santa Clara County Planning Department	PPC Hillside Subcommittee staffing 1971-73		Preparation of Geologic Ordinance 1973-74		Preparation of Seismic Safety Element 1973-74	
Santa Clara Valley Water District Staff			Tudor report on salt water flooding 1973			
Lifeline Staff				County request lifeline data from Cal Trans, PG&E, Water District & SP pipeline Jan. 1974	County receives replies from lifeline agencies June 1974	
USGS	USGS/HUD S.F. Bay Region Environment & Resource Planning Study 1970/76					
CDMG & Consultants	CDM/County Coop Santa Cruz Mtn. Geology & Planning Program 1971	CDM/County Coop Monte Bello Geology & Planning Program 1972	CDM/County Coop So. County Geology & Planning Program 1973/74	CDM/County Coop contract for Seismic Safety Element 1973/75	Alquist-Priolo Geologic Hazard Zones Act maps 1974	
General Public, Press, TV, & Conferences	San Fernando Earthquake 1971	NOAA report on earthquake losses in SF Bay Area 1972	Earth Science & Environmental Decisionmaking Conf. Sept. 1973 Community Planning for Seismic Safety Conf. Dec. 1973	Saber Conference Sept. 1974 Earthquakes & Lifelines Conference Dec. 1974		

The Santa Clara Valley Water District Board; County Planning Department and other County staff; Santa Clara Valley Water District staff; "lifeline" staffs (PG&E, CalTrans, S.P. Pipelines); USGS, California Division of Mines and Geology (CDMG), and other consultants; the general public, the official press, public media, and conferences. The timeline is shown on the horizontal side from 1964 to 1976.

Santa Clara County Planning Department staff has had a history of trying to save the prime agricultural land dating back to the mid 1950's. Since the soils had been mapped for a number of years as well as the area subject to historic flooding, it was an easy transition to begin the consideration of other physical characteristics.

The County Planning Department had received part of a large "701" planning grant in 1966 to do a land/use transportation study. It was to be a complex program with many facets, one of which was the formulation of a computer model which would simulate land development and population growth within small statistical areas. Several factors were examined to determine what did indeed influence growth. As an aside, it was found that local government had very little to do with influencing growth at that time.

Part of the background data base, which was assembled at that time, was a series of maps at a scale of 1" = 1 mile: percentage of slope, earthquake faults, areas subject to historic flooding, landslide potential and extent and depth of Bay mud. There were very few geologic maps available. The Department relied mostly on the mineral map of the county done by the California Division of Mining and Geology (CDM), a geologic report done by the California Department of Water Resources and other small area studies. No interpretive work had been done. As an example, there was no way for planners to discriminate between an active or inactive fault. So we plotted every fault we found on maps.

In order to get more information, two small contracts were let to graduate geology students of Dr. Clyde Wahrhoftig at U. C. Berkeley. Andre Sárna did about 200 hand auger borings as well as other research to map the extent and depth of young Bay mud in Santa Clara County. Ken La Joie and Robert Curry mapped active, inactive and potentially active landslides from aerial photographs. La Joie and Curry were to have done follow-up consulting but funds were not available. At a later date, the landslide maps were to be a source of political controversy in which a private consultant's interpretation was matched with the student work. The lesson learned was that regardless of the merit of the student's analysis, the weight and prestige of a public agency such as USGS or CDM are important factors when it comes down to decisionmaking.

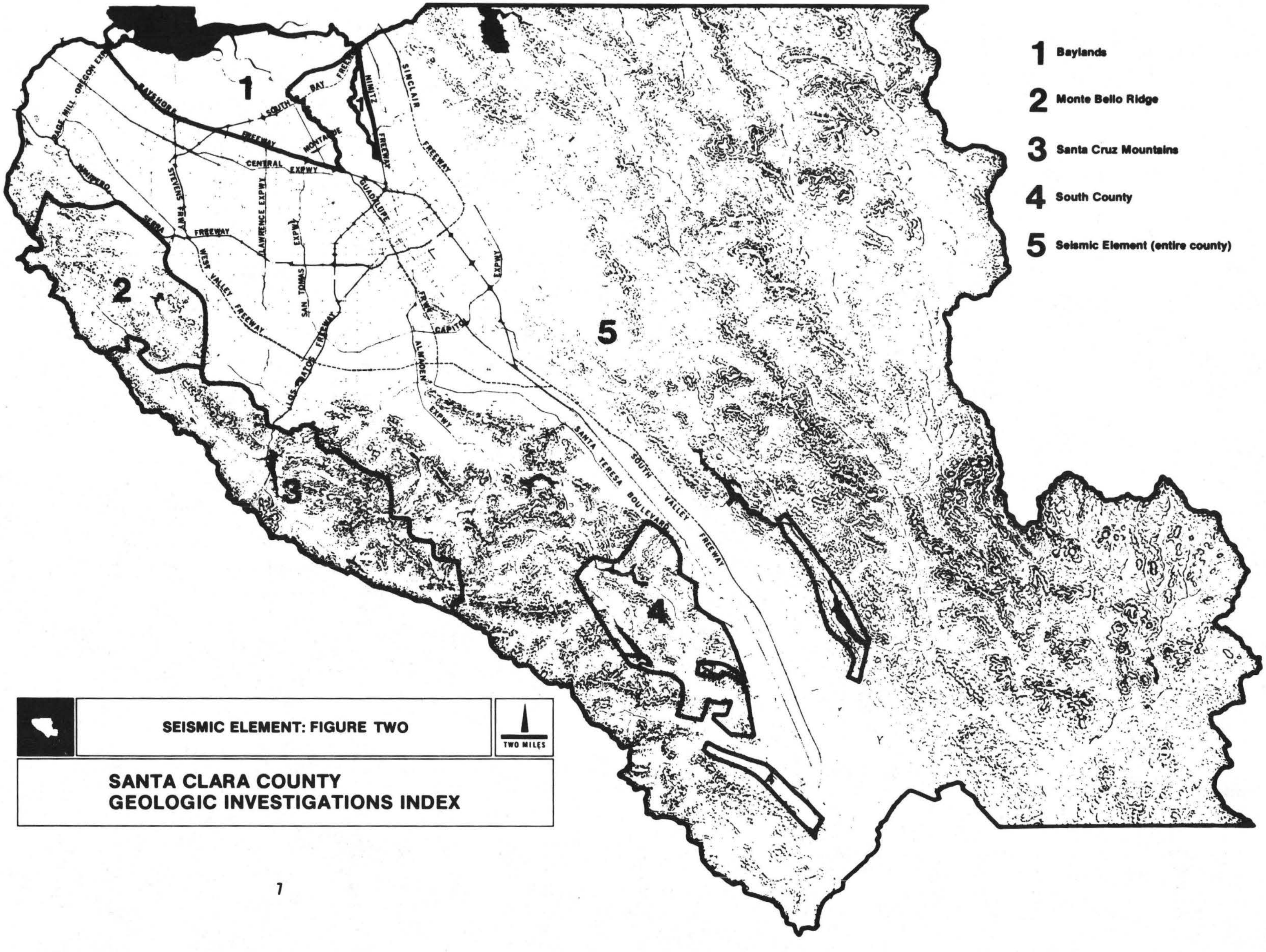
The information assembled during the land use transportation study was used in a general fashion as background data for citizen participation. The Santa Clara County Planning Policy Committee (PPC) was formed in 1967 to act as a forum for countywide decisionmaking. That body was composed of a council member and planning commissioner from each of the fifteen cities and one member of the Board of Supervisors and a County Planning Commissioner acting in a voluntary capacity. The PPC allocated the examination of various major issues and geographic areas to subcommittees - Industrial, Commercial, Residential, Hillside and Baylands. The subcommittees were composed of not only the members of PPC but also citizens at large and "resource people," that is persons having special knowledge of the matter of interest to the subcommittee.

It's probably fair to say that the geologic and other data that were presented to the hillside and baylands subcommittee in the early years did not have much if any direct impact on development. It was a long educational process. Any planner hoping for some concrete action affecting development was doomed to frustration for a number of years. PPC developed recommendations that at least for the first time codified countywide (city and county) policy on a number of topics. Neither the hillsides or the baylands were under any serious threat at that time.

In 1966, a cooperative contract between the County and the U.S. Department of Agriculture was signed. This time the soils report would not only report the usual agricultural data but would do analytical work for bearing capacity for foundations and roadways, percentage of slope, septic tank suitability and potentially appropriate land uses. Additionally, the soil types were mapped on aerial photographs of reproducible film positives at a scale of 1" = 1000'.

As the need for more definitive geologic interpretive work was felt by the Planning Department, a small contract was let in 1969 to Professor Arvid Johnson of the Stanford University Geology Department to state the case for such an analysis in the Santa Cruz Mountains. This led to the first cooperative contract with the California Division of Mines and Geology in 1971 to do the "Santa Cruz Mountain Study" which is shown as number three area on Figure 2. In 1972, the "Monte Bello Ridge" cooperative contract was signed to do that area also as shown in Figure 2 as number two area. The CDM choice of staff for these two study areas was particularly fortunate. Tom Rogers, Chuck Armstrong and John Williams were extremely patient, dedicated and thorough not only in their geologic work but more importantly with the citizen groups with which they worked in concert with the planning staff. The PPC Hillside Subcommittee was the major citizen group that developed the policy in the two study areas.

After review by the parent committee (PPC) and the cities within whose sphere of influence the Santa Cruz Mountain and Monte Bello Ridge studies were situated, the PPC adopted the plans in 1972 and 1974 respectively. The Board of Supervisors did not adopt the Santa Cruz Mountain Plan; it did, however, change the zoning in that and the Monte Bello area from a



SEISMIC ELEMENT: FIGURE TWO

TWO MILES

SANTA CLARA COUNTY
GEOLOGIC INVESTIGATIONS INDEX

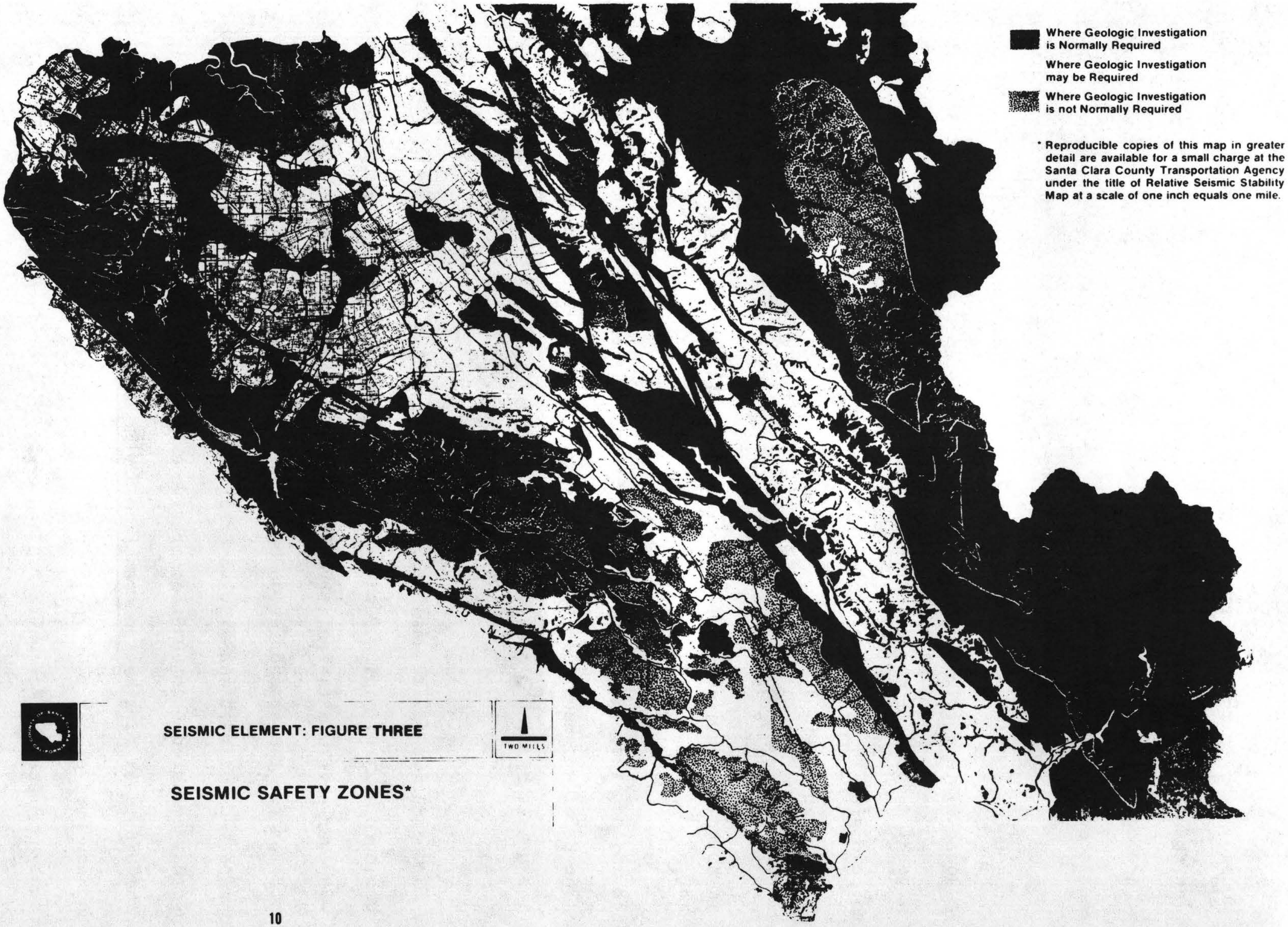
basic 1 acre lot size to 2.5 acre minimum lot size, which was a considerable achievement at that time. In 1973, the Board of Supervisors rezoned the area for slope density which meant that the density would be anywhere from 2.5 to 10 acre minimum lot size. The Monte Bello Plan was adopted by the Board of Supervisors in 1974. The pattern of the Board of Supervisors adopting implementing action prior to the adoption of a plan for the area was to occur again. The task of getting a plan adopted is often a long tedious one often involving the preparation of an attractive planning document and a series of long public hearings stretching out over many months. Since the educational process and citizen involvement occurred earlier, it is not unreasonable to find the impetus to rezone an area predating the plan adoption. The process has generally used a committee comprised of local landowners who generally want to further subdivide, conservationists who want to limit development, and bureaucrats who want to minimize public problems.

The major implementation device for earthquake hazard reduction to emerge from the Santa Cruz Mountain and Monte Bello studies was the geologic ordinances. The proposed ordinance evolved in draft form as a very long list of "every question you always wanted answered but were afraid to ask." After several months, a citizen committee - Green Mountain Study Committee - was pretty much at dead center with the staff of CDM and the County Planning Department staff. With the hiring of James Berkland as the County's first staff geologist and a change of planning staff representative (to ease a deadlock and not to demean the previous dedicated work), the geologic ordinance was greatly simplified to a few paragraphs to be inserted in selected sections of the County code that could be enforced at any stage of development from subdivision to building permit. The rationale was to investigate at the earliest possible stage of development to minimize the potential for anyone ending up with a totally underdevelopable parcel. The level of investigation would be appropriate for the stage of development. However, since many parcels had already been created that had potential problems, it was important to also require a geologic site analysis before a home was constructed.

The acceptance of such general language for geologic investigation in the County code was due in no small way to the rapport that Jim Berkland, the County Geologist, established with the "Green Mountain Study Committee." The citizen group trusted him. This was important. When the geologic ordinance went to public hearing, previously vocal opponents not only supported it but gave warm compliments to Jim for his positive and cooperative attitude.

Another communication technique used other than committee work was visual. Most geologic maps are an absolute puzzle to the layperson. There appears before the citizen committee member a great maze of lines, peculiar symbols, and a range of colors and hues ranging from cream to pale pink to aqua, etc. Planning staff felt that a clear visual communicative color scheme was needed to simplify the concept of geologic hazards. A traffic light color scheme of red, yellow, green was chosen with the legend reading: (for red) where geologic investigation is normally required; (for yellow) where geologic investigation may be required; and (for green) where geologic investigation is not normally required. By 1974 when the geologic ordinance was adopted, the CDM map for the Seismic Element was available as shown in Figure 3. A blue line print was hand colored in the red-yellow-green scheme and used as a major visual aid in the public hearing process.

A third communicative device was the use of a very explicit list of what constituted official county geologic hazards maps. Such a list was included within the geologic ordinance itself. Wherever possible the relative stability code keyed to the red-yellow-green scheme was identified for the categories on each map cited. As a sample of the above-mentioned hazards maps, we included the Alquist-Priolo Geologic Hazards Zones (all red zone) (see p.15), all maps that emanated from CDMG cooperative studies with the County, the PPC Baylands Risk Zones, the USGS maps for the San Francisco Bay Region Environment and Resource Planning Study (HUD) and any maps prepared by registered California geologists for any area within Santa Clara County. Precedent for which map had greater priority was based on the most recent and



SEISMIC ELEMENT: FIGURE THREE

SEISMIC SAFETY ZONES*

10

most detailed work having greatest priority.

We now have to back up in time to focus on a non-mountain study area that established a precedent based on the concept of risk zoning. In 1970, the City of San Jose was considering relocating the existing municipal airport. One of the potential sites was between Routes 101 and 17 in north San Jose with another one reaching possibly into the salt evaporation ponds which extend around southern San Francisco Bay and which are underlain by Bay mud. The proposed new airport was to be large enough to accommodate supersonic aircraft. The surrounding cities were very concerned about the noise impact. The county had been contemplating doing a plan for the entire baylands area for a few years as a follow-up to the PPC recommendations earlier. There were 29 different plans for the baylands by various jurisdictions most of which were conceived at various points in time. The San Francisco Bay Conservation and Development Commission had been formed by the State legislature and was encouraging local government to do a more articulate level of planning for the Bay fringes at the edge of its jurisdiction. It seemed reasonable to have one plan for the entire area. The PPC asked County Planning staff to do a study design and cost estimate. The design was patterned a great deal after the Bay Conservation and Development Plan study.

The estimated cost of the study, which was to be done partly by County Planning staff (at no cost to PPC) and by consultants, was allocated to each of the 15 cities and the county based on population. After a few months, all the jurisdictions agreed to pay their share. The City of San Jose agreed to pay only if the study area exempted most of the area under consideration for the new airport. There were several background papers developed: Water Quality and Circulation (consultant), Estuarian Ecology and Wildlife (consultant), Air Quality (consultant), Recreation (consultant), Residential Land Use (staff), Industrial Land Use (staff), Flood Control (staff), Dredging (staff), Solid Waste (staff), Transportation (consultants), Ownership and Government Powers (consultants), and, notable among them, Geology and Structural Engineering (consultant).

The funds available for consulting were modest. Several of the papers were done by individuals acting as consultants. The largest amount was allocated to geology and structural engineering which went to bid. Twelve top engineering and geology consultant teams vied for the job. We were very pleased to have such a choice and the contract was awarded to the consortium of Woodward, Clyde and Associates and McClure and Messenger.

One of the stipulations of the original study design was that the work be completed in six months. A new PPC Baylands Subcommittee was appointed. The members represented the cities bordering the Bay, Palo Alto, Mountain View, Sunnyvale, San Jose, Milpitas, the County, League of Women Voters, Leslie Salt (owner of the salt ponds), the California Department of Fish and Game, and others. The reports, normally about 30-40 pages were sent out to the committee members one week in advance of the meetings. Anyone who requested to be on the mailing list also received copies. There were approximately 200 people on the mailing list. The reports were sent out and reported to the PPC Baylands Subcommittee every two weeks. In retrospect, we know now that it was far too much data to be delivering to a committee in that period of time. The reports were completed in six months as promised. The committee took 18 additional months to digest the data, negotiate compromises and adopt a recommended plan which was subsequently adopted by the PPC and the Board of Supervisors in 1972 and 1973 respectively.

The earthquake hazards reduction information that emanated from the engineering and geology report did not result in any immediate changes but rather served as an important stage of education and an innovative approach to defining various foundation problems before permitting certain land uses and structural types to be approved. The USGS report and map of Former Marshland Areas by Don Nichols and Nancy Wright was a tremendous visual aid during the Baylands program. Don was also an extraordinary geologist in working with the public and planning staffs.

Through the process of plan development and adoption, we became aware that in order to build safely in former marshland areas, special expertise was required - structural engineers, engineering geologist, and a soils engineer familiar with special problems during earthquake conditions. At that time no local jurisdictions had this kind of staff. The consultants recommended the establishment of a highly competent Advisory Board to:

1. review the scope and extent of an applicant's engineering investigations and design and construction procedures; and
2. advise local building and public works department's on the adequacy of the proposed investigations and procedures to provide margins of safety appropriate for the intended use and location of the development.

The proposed Advisory Board was patterned after the one created by the Bay Conservation and Development Commission to advise it regarding critical projects under the Commission's jurisdiction. Since most of the jurisdictions were not interested in building in the salt ponds or sloughs which were judged to be the most troublesome areas, there was no impetus to establish such a board.

We also became aware that all the jurisdictions were not using the same building codes and much of the burden of the appropriateness of complex structural engineering practices fell on the developer's engineer since most jurisdictions were not staffed to evaluate problems of this magnitude.

The most obvious problem to development in the former marshland area was both salt and fresh water flooding. The areal subsidence in Santa Clara County due to groundwater withdrawal lowered the existing Bay levees 9 feet in some places. The levees were repaired from time to time with the available mud in the immediate area. These were not engineered levees nor were they constructed for flood control but rather simply to contain the brine in the salt ponds. The Baylands Plan was followed up by a report, "The Baylands Salt Water Flood Control Planning

Study," which was done in January 1973 by Tudor Engineering and paid for by the Santa Clara Valley Water District. It was concluded that to provide flood protection for the salt pond area was uneconomical to local government.

A tremendous acceleration of land development in the valley floor of South County in 1973 led to the next geologic investigation. A portion of the South County was to be the third cooperative contract with the CDM. While the CDM staff were conducting their investigation, County Planning staff, as well as other County department staffs, presented a series of reports over a period of several months. The emphasis in this study area was more on the problems of servicing existing development and the poorly designed land development occurring. When CDM staff made their report, they did not receive either the volatile reaction of some North County mountain developers or the warm reception a North County conservationist might give. Most of the audience were farmers or flat land developers. The reaction was simply polite disinterest. The CDM South County report did, however, become part of the growing library of geologic data available for planning.

Between 1970 and 1976, a joint program between USGS and HUD - the San Francisco Bay Region Environment and Resource Planning Study issued many maps and reports which were a tremendous help to local government. Most of the reports that covered Santa Clara County and constituted information on hazards were incorporated as official County Hazard Maps in the geologic ordinance. If the author of this paper were to select the most effective report of the series for purposes of communication on hazards it would be Tor Nilsen's report* on the San Jose Highlands. It was a well documented and illustrated statement of what happens when local government ignores geologic hazards and the subsequent costs involved to both the public and the individuals directly involved. This was a report a citizen could read and understand. It was one foldout sheet so the text wasn't overwhelming and the map covered an area that could be readily identified and visited.

* "Preliminary Photointerpretation and Damage Maps of Landslides and Other Surficial Deposits in Northeastern San Jose, Santa Clara County, California" by T.H. Nilsen and E.E. Brabb (1972).

Early in 1974 the first maps to implement the Alquist-Priolo Geologic Hazard Zones Act were released by the CDM.

> "The intent of the Alquist-Priolo Act is to provide for public safety from the hazard of fault rupture by avoiding, to the extent possible, the construction of structures for human occupancy astride hazardous faults."

There were some difficulties initially between local jurisdictions and CDM staff in the administration of the Alquist-Priolo maps. It was apparent the CDM staff was not prepared for the large task of dealing with all the jurisdictions involved in the mapped zones. Most cities used maps at a scale of 1" = 200' with parcel maps at 1" = 50'. Having the Alquist-Priolo maps at 1" = 2000' was difficult for the cities to work with in addition to the implementation of the Alquist-Priolo provisions themselves.

Since the County was required to notify all property owners within the Alquist-Priolo zones, and there were hundreds or rather thousands of parcels, we chose to notify by a press release. The public was invited to view the maps in the Planning Department and comment to the Planning Commission in a public meeting. The major information to emerge out of the public meeting was the unwillingness of geologic consultants to report on single family dwelling unit lots since the fee that could be reasonably charged was not sufficient to offset the costs associated with malpractice suits. Eventually, the Alquist-Priolo zones administrative problems of communication between CDM and local government were smoothed out. One newspaper article on the Alquist-Priolo zone meeting cited some local schools located with the zones. One of the local school superintendents sent a letter to one of the supervisors protesting such adverse publicity for a school in his district. Earlier, however, due to the availabilitv of geologic information, we were able to persuade a junior college district to abandon one site in favor of another for a multi-million dollar new campus.

The press release and staff commentary for the Alquist-Priolo zone meeting included within it information about the Seismic Safety Element which was being prepared. In the spring of 1974, there were three earthquake hazard reduction information activities occurring simultaneously:

the County's geologic ordinance was in the final stages of preparation, working with a citizens committee which had been an opponent previously; the Alquist-Priolo zone public meeting served to focus public attention on active earthquake faults; and all the city and county staffs were in some stage of preparation for the State mandated Seismic Safety Element.

County Planning staff worked with the Santa Clara County Association of Planning Officials (SCCAPO) to explain what products would be coming out of the County's Seismic Element and what kind of follow up the cities might consider i.e., more definitive geologic analysis for problem areas in their cities and more frequent inspection programs to enforce hazardous building codes. Some cities chose to use information coming out of the CDM's investigation for the County's Seismic Element, some chose to use whatever information was already available from the USGS/HUD San Francisco Bay Region Environment and Resource Planning Study while a few cities such as San Jose, Saratoga, and Milpitas hired geologic consultants to prepare part of their Seismic Element.

The information gathering process for the Seismic Element had begun in July of 1973 for the CDM staff and in the fall for the County Planning staff. The original responsibilities for the Seismic Element were to be distributed as follows: Geologic Setting (CDM staff), Soil and Geologic Effects on Building Damage During Earthquakes (H. Bolton Seed, Ph.D.), Seismicity and Structural Design (Frank McClure), Land Use and Its Relationship to Hazards, Balancing Risks, Relationship to Other Elements of the General Plan and Urban Development/Open Space (County Planning staff). The responsibilities as finally carried out were the same with the following exceptions: as Frank McClure did not participate, the Planning staff wrote Seismicity and Structural Design as well as an added section - Non-Seismic Conditions. The latter section seemed necessary, since there are other geologic phenomenon that influence urban planning and, while not "seismic" in nature, they fit in the Seismic Element better than any other element of the general plan.

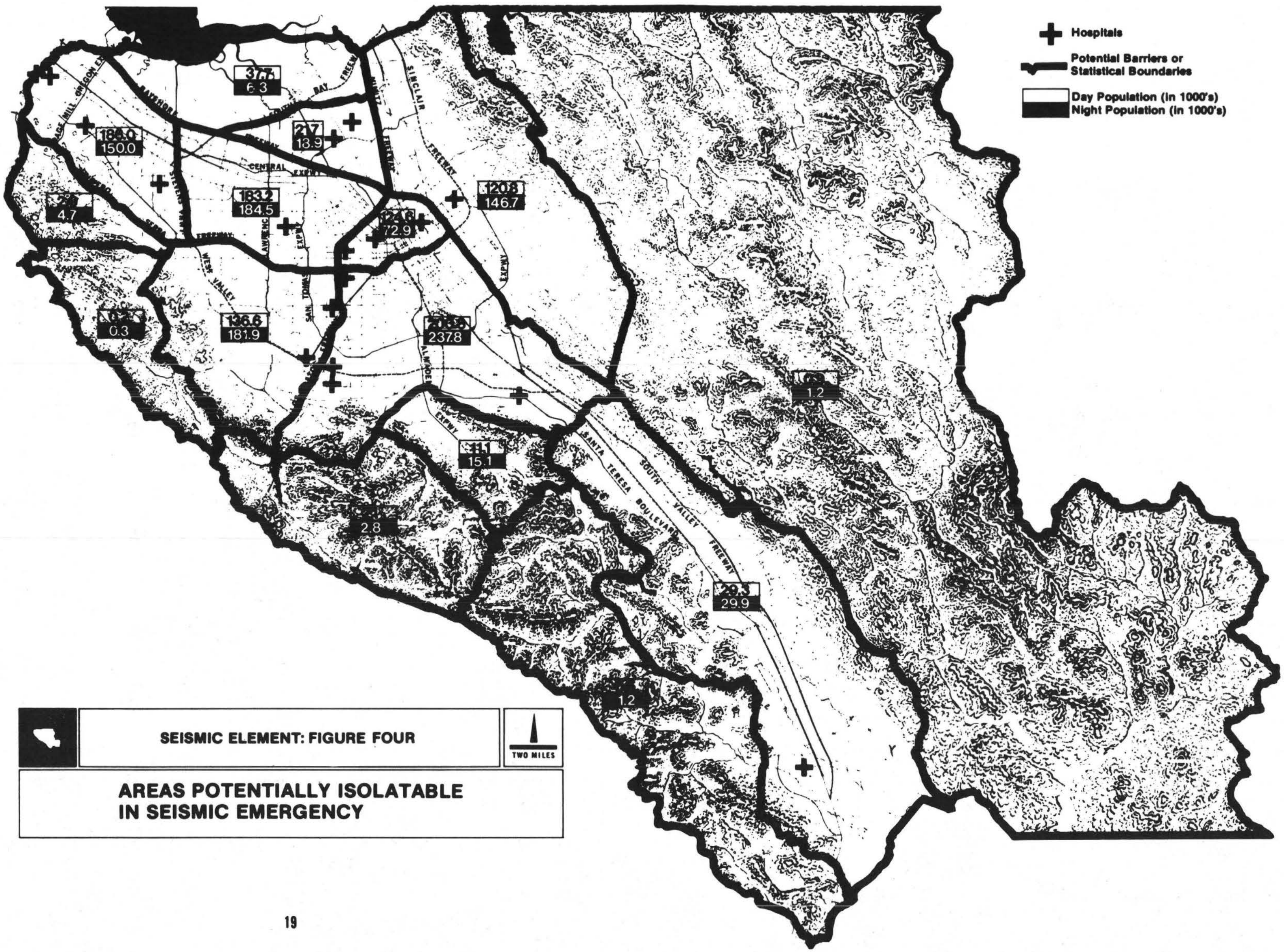
In the preparation of the Seismic Element, public involvement was not by way of a special committee but rather by progress reports to a committee of planning directors from the 15 cities, to the County Planning Commission, and by public speaking engagements. One of the largest and most interested audiences was the San Jose Board of Realtors, which included over 200 people. This was a combined presentation with Planning staff and the County Geologist Jim Berkland. The realtors asked many questions and were eager to get any written material available at that time. In public speaking engagements, planning staffs almost always used colored slides combining actual scenes, buildings, and graphics, such as maps and charts, as the communications medium. The visual impact was necessary. Today's audience is accustomed to the professional presentations of television and theatre. A lone speaker with maps has to be very talented to get and hold the public's attention. After several years of planning experience, this writer must also conclude that subtleties are lost on most audiences. The message must be simple, straightforward and as strong as possible. Additionally, the problem must be brought as close to home as possible. Make it very personal.

With those criteria in mind, Planning staff studied the impact of the San Fernando Earthquake and the similarities that might be shared by Santa Clara County if an earthquake of that magnitude were to strike there.

The most significant personal and community-wide impact of the San Fernando earthquake was the disruption of lifelines - freeways, sewer, water, electricity, gas and telephone. A temporary loss of power over a few hours normally turns family activities into a combination of an indoor picnic/camping lighthearted interlude with each member of the household playing a not-to-serious survival game. If the loss of power goes on for 8-12 hours, the game becomes an irritation and later becomes a definite hazard to the individual and community well-being.

The question posed to the appropriate agencies was "How vulnerable are the lifelines in Santa Clara County if a major earthquake were to occur?" The Santa Clara Valley Water District, owner of most of the major dams, was required by State law to identify the area subject to inundation if the dams were to break when the reservoirs were at full capacity. The maps depicting the area that might be inundated were not available from the State immediately. The State Offices of Planning and Research and Emergency Services sent a letter out stressing the need for "utmost caution" in using the maps. The manner in which the maps were prepared made them very difficult for the non-technical person to interpret. Initially, there was no time interval available on the maps, i.e., the time between when a dam would break and when the water would reach particular locations. Time intervals (floodway times) are available now. The maps covered such an enormous area that they were relatively useless for land use planning because it was almost impossible to keep the entire area in open space, the most reasonable land use considering the hazard. We requested that inundation maps be prepared that would depict the area based on a reservoirs normal operating levels rather than full. Additionally, we needed depth and velocity of flooding mapped. With that information the area of greatest hazard could be identified and the probability was greater of acquiring and maintaining the area in open space. Depth of flooding is now available.

The California Department of Transportation (CalTrans) was very cooperative by evaluating and giving Planning staff information on a large number of State Highway bridges (over and under passes) that could possibly fail during an earthquake, since this was a major effect in the San Fernando earthquake. This led us to the concept of potentially isolatable areas within the county as shown in Figure 4. If the freeways were not usable and bridges collapsed, the freeways themselves would create barriers. The County's emergency service plan provides for local owners and operators of bulldozers to clear away debris from streets, etc. With a major earthquake, it might take more than two days to clear major debris and several months to rebuild a number of bridges. Figure 3 shows potentially isolatable areas with day/night population and hospitals. Given the age of some hospitals in Santa Clara County (three prior to 1933, four between 1933 and 1960 and five between 1960 and 1970), major hospitals may become a burden rather than an aid after a major earthquake. Given the age and type of construction, local public schools may be the safest structures to house emergency aid stations. The lack of valley floor water storage, makes it important that families store 2 1/2 gallons of water per person as well



SEISMIC ELEMENT: FIGURE FOUR

AREAS POTENTIALLY ISOLATABLE
IN SEISMIC EMERGENCY

as emergency food and other supplies similar to camping gear.

We felt that having a vulnerability report from Pacific Gas and Electric was very important. In spite of a written request and several verbal requests, we never received a statement describing the vulnerability of local PG&E facilities and services. We did eventually receive a multi-page statement prepared for PG&E facilities all over the state which simply described their normal safety equipment and method for meeting emergencies. The Seismic Element contained a map which superimposed PG&E facilities over the three seismic safety zones with red, yellow, green coloring scheme.

One of the several hazards noted in the excellent National Oceanic Atmospheric Administration (NOAA) report A Study of Earthquake Losses in the San Francisco Bay Area (1972) was the possible rupture of petroleum pipelines. In Santa Clara County, oil storage tanks and pipelines were located near the Guadalupe Creek about 10 miles from San Francisco Bay. The general area is subject to ground failure. In their response, Southern Pacific Pipeline indicated that they had not done a geologic investigation for seismic problems prior to construction nor did they have automatic shutoff valves. They did, however, have 24 hour staffing to turn valves manually and were working to improve the seismic design of their storage tanks.

With all the data in and the analysis completed, the Seismic Safety Element sailed through the public hearing process with no problems and was adopted in January 1976. Very little activity has occurred since that date. It received excellent coverage in the July 1977 issue of Ekistics, a planning publication of worldwide distribution. Requests for copies of the Seismic Safety Element have come in from different parts of the United States and the world.

In conclusion, 1) nothing communicates earthquake hazards better than a serious earthquake; 2) effective communication is promoted by skillful orchestration of federal, state and local governmental resources, work, and mandated requirements; and 3) it is essential to have a feeling for human dynamics and the political process.

While the adoption of the Element was easy given the educational effort spanning many years, the implementations remain largely unfulfilled. Much of that task fell to agencies other than the County so it could not be mandated. Given the demands on the cities and special districts, the priority for addressing seismic hazards is very low. We live in a time of government by crisis. What is really the most important priority changes from week to week. As earthquake prediction methods improve, the public and government will be forced to acknowledge the "unfinished business" of earthquake preparedness as the probability of a major earthquake draws nearer each day.

AN EVALUATION OF THE SEISMIC SAFETY ELEMENT REQUIREMENT IN CALIFORNIA

by

Robert A. Olson*

INTRODUCTION

In 1971, soon after the San Fernando Earthquake, the State Planning Law was amended to require that each city and county in the State prepare and adopt a Seismic Safety Element (SSE) as part of its general plan. The requirement was brief and required:

> "A seismic safety element consisting of an identification and appraisal of seismic hazards such as susceptibility to surface ruptures from faulting, to ground shaking, to ground failures, or to the effects of seismically induced waves such as tsunamis and seiches."

This example of public policy was based on the belief that better land use decisions will be made if California's communities consider seismic hazards along with other important factors in their planning processes.

Subsequently, in 1973, the California Council on Intergovernmental Relations (CIR) adopted advisory guidelines for all required general plan elements, including the SSE (See Appendix A). The CIR guidelines emphasized, in addition to other matters, the relationship of the seismic safety element to other elements of general plans:

> "The seismic safety element contributes information on the comparative safety of using lands for various purposes, types of structures, and occupancies. It provides primary policy inputs to the land use, housing, open space, circulation and safety elements."

State law required all SSEs to be adopted by September 20, 1974. CIR was allowed to grant extensions upon individual application.

This paper briefly reviews this program for the purpose of learning about how the planning process has been affected

* Executive Director, California Seismic Safety Commission

by the SSE requirement and what steps are being taken to improve the program in light of the experience gained in the first few years of operation.

The paper focuses primarily on an evaluation of the program done recently by the Seismic Safety Commission. In essence, the results of the evaluation are a critique of the program and include assessments of the adequacy of the basic legislation, value of the State's guidelines, factors important to the work of local governments in preparing SSEs, and possible next steps for at least some communities - implementation of programs to carry out locally adopted policies contained in SSEs.

EVALUATION OF THE PROGRAM

The Seismic Safety Commission in 1975 determined that the role of SSEs in California was of great importance and that the Commission should undertake an evaluation of experience with the SSE requirement in California to date.

The purpose of the Commission's study was to assess the effectiveness of the seismic safety elements to determine the adequacy of the State legislation and suggest changes, if any were needed, to insure stronger consideration of seismic hazards in land use decision making.

The SSE Review Committee decided at the outset that in order to evaluate SSEs, it would be desirable to review a cross-section of elements and interview persons who were involved in the preparation and implementation of the elements. Eight jurisdictions were selected. The Committee believed that they were distributed widely enough throughout the State to provide a sampling of significantly different kinds of hazardous conditions, especially as they relate to land use. It was recognized that by no means were all types of jurisdictions or geologic settings reviewed.

It should be stressed that this study was designed to examine and assess SSEs for the purpose of evaluating the effectiveness of the State requirement. The Committee was not acting as a State reviewing agency of local compliance with State law. Jurisdictions contacted were informed of this and told that their anonymity would be preserved with respect to detailed findings or recommendations of the Committee.

The procedure followed by the Committee in reviewing the selected SSE's consisted of two steps: staff review and interviews. Before convening a meeting between the principals involved in working on an SSE and the Committee, staff completed and distributed a review of the SSE to Committee members. This review consisted of basic questions pertinent to the organization, format, and content of the SSE, along with a critique and observations. This review served as a foundation to familiarize Committee members with specific aspects of the SSEs; since the same questions were applied to all of the SSEs, the review also provided an opportunity for comparison. The review questions are attached as Appendix B.

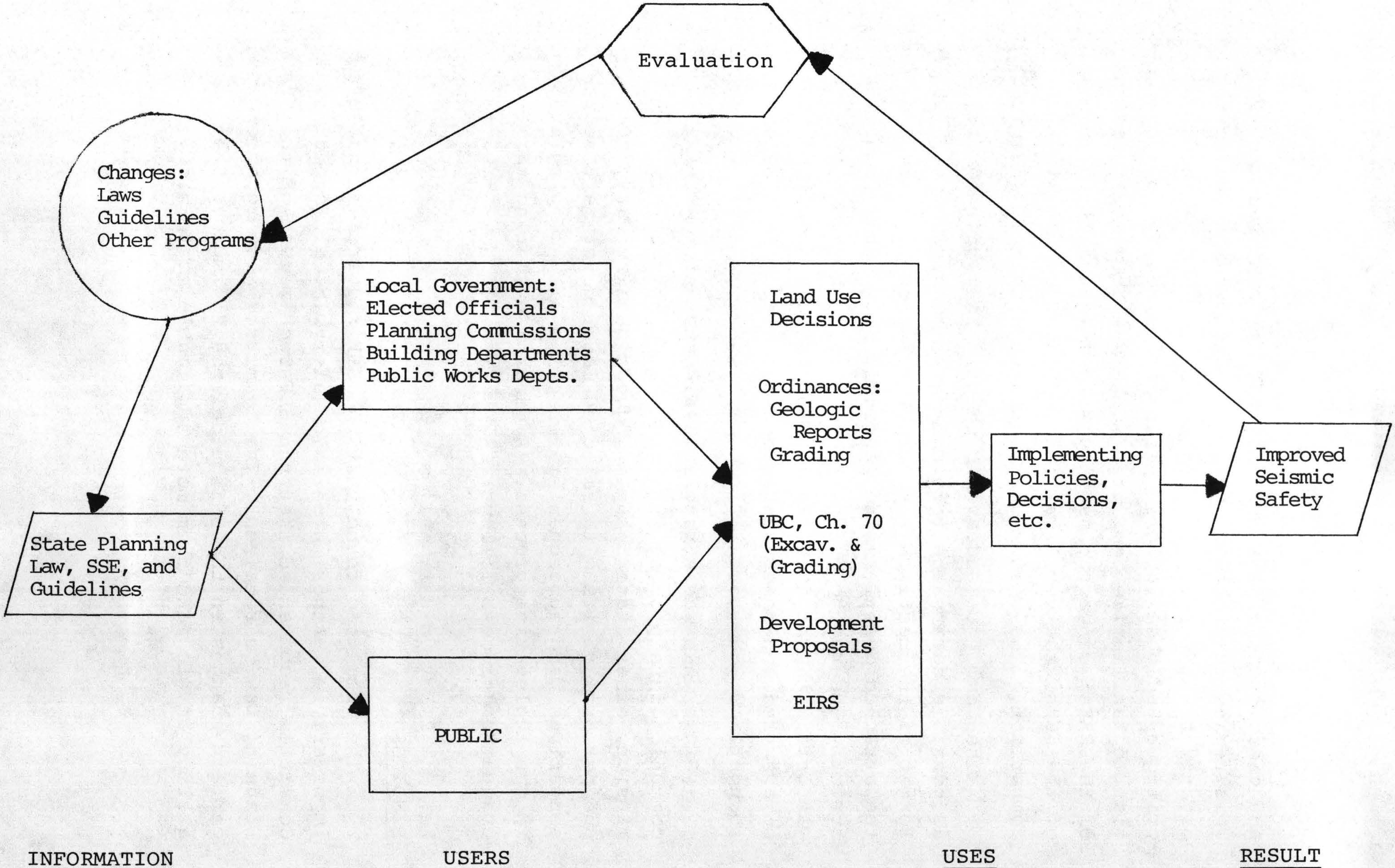
The Committee endeavored to gain as much information as possible during the informal three hour sessions. The format of the meetings was structured along the lines of the attached questionnaire (Appendix C). Although not strictly adhered to during the meeting, the questionnaire was left with the jurisdiction so that the questions could be answered and observations be made with more time and thought.

Since this was a program evaluation project, the communications process involved the Seismic Safety Commission, other State agencies, questionnaire data from and personal visits with selected local government representatives, and subsequent interaction with people involved in the legislative process. A diagram outlining this evaluation process follows.

FINDINGS

The Committee found that the SSE requirement has been important in furthering seismic safety in California. The Committee recommended that the SSE requirement of the State Planning Law be retained. The Committee also recommended certain changes in the SSE Guidelines to improve their quality and to make them more applicable state-wide.

INFORMATION FLOW FOR THE EVALUATION OF SEISMIC SAFETY ELEMENTS



Compliance with SSE requirement

Of the 412 cities and 58 counties in California, as of January 21, 1977, there were still 81 cities and 19 counties that did not have a seismic safety element as part of their general plan. At present, there is no State requirement that can force local jurisdictions to complete their general plans even though general plans are mandated by the State. Most of the incomplete general plans had more than one of the nine mandatory elements missing or in progress, so the problem is not peculiar to SSEs.

Review of SSEs by State

At present, no State agency has the responsibility for reviewing the adequacy of any general plan elements.

A few jurisdictions have voluntarily submitted their SSE's in draft form for review by staff members of the California Division of Mines and Geology (CDMG). CDMG's comments concentrate only on technical aspects of geological information and suggestions for further research and do not deal with planning applications of such data.

Variety of Approaches

The State requirement has generated a variety of approaches for dealing with seismic safety. The variations result from a variety of differing local conditions such as budget, sophistication, political concern, staff capabilities, and geologic conditions. Characteristically, however, the elements consist of a background report prepared by geographers, geologists and/or planners, plus a policy document intended to be included as a part of the adopted general plan. The quality of the elements has a wide range from those that brush the topic lightly to those that deal with the subject in great depth.

It is clear, however, that the effects of the legislation have been felt state-wide, have led to local identification of seismic problems and formulation of policy, and are leading toward significant impacts on land use decisions.

Quality of Background Reports

The quality of background reports has been especially scrutinized since the information contained in them is vital to the success of the SSE. In this regard, committee review disclosed inadequacies, ommissions, mis-information and inaccurate data. These lacks result in elements that are less than adequate. The problem of poor background information highlights the critical need for more extensive involvement by professionals knowledgeable in the fields of seismic and geologic hazards. This problem also hints at a need for reviewing and perhaps revising the guidelines for SSE preparation.

Cost of Preparing Elements

The Committee attempted to get an idea of the cost of preparing SSEs. Each jurisdiction interviewed was asked to submit total cost figures or barring this, an estimate of cost. These figures were to include all costs: staff, consultants, etc. The average cost is $.10 per capita. The range, however, is from $0.06 to $0.26 per capita.

The costs per capita are in general less for larger jurisdictions indicating some apparent economy of scale. The range of $0.06 to $0.26, however, is largely a reflection of different approaches, thoroughness and completeness of cost information.

The Committee wanted to know the state-wide cost of SSEs, which using the average data developed, would be $2,100,000

($.10 x 21 million people). There are 470 cities and counties in the State and therefore, based on the Committee's limited sample, the average cost would be approximately $4,500. This is a very rough approximation of average expenditures and is in no way an indication as to the adequacy of such levels of expenditure. Also, local situations vary so widely that average figures may have little local applicability.

Implementation

Some policies and programs suggested for implementation in the SSes are being carried out even though most SSEs were completed only one or two years ago. Implementation of SSE policies is especially apparent in areas where general plans are undergoing revision or new plans are underway.

The Committee observed that the type or size of an SSE has very little relationship to the effectiveness of its potential implementation; only local jurisdictions can implement, and it is the implementation of recommended policies that is the real measure of whether an SSE is effective.

RESPONSES TO QUESTIONNAIRES

The questionnaires were reviewed and answers to the more important questions are summarized below:

Question 1: Has the SSE had any impact on decision making or added new information for planners and decision makers?

Answer: All jurisdictions answered in the affirmative. Most stated that, had the SSE requirement not been mandatory, the information would not be available for planning purposes. The SSE has increased planners' awareness of geologic problems related to land use planning, and, in several cases, maps or atlases have been produced which illustrate seismic and geologic hazards. Most jurisdictions believe that information generated by the SSE requirement has provided important seismic and geologic data for decision makers at all levels of government. Some of the maps produced are used for determining where detailed geologic studies must be done before certain permits are issued, others are used as criteria for issuance of building permits. The Committee found that some jurisdictions were misusing the information in their SSEs by attempting to apply seismic information to site-specific situations. One county, located within an active earthquake area, stated that for the county and its cities, the SSE has been the most effective of all the newer mandated elements to the general plan, and has had the greatest factual effect on land-use planning.

Question 2: Has the SSE generated new attitudes toward seismic or geologic problems in the community?

Answer: Community attitudinal changes are difficult to assess. In areas where problems have been recognized by way of a recent or historical earthquake, or a clear threat of another (near an active fault), community interest in the SSE was generally higher than in other general plan elements.

Question 3: Has the SSE generated new attitudes within the planning staff or department of public works?

Answer: Most jurisdictions stated that the planning staffs, public works, and building departments had developed an appreciation of seismic problems. Some stated they were now more aware, and that seismic hazards are now considered as an integral part of the plan development process. Several jurisdictions stated the SSE process had provided a new realization that seismic and geologic problems exist. In part because of these realizations, three jurisdictions have hired geologists on their staffs. At the other end of the spectrum, two jurisdictions' public works personnel questioned the usefulness of the data provided to them through the SSE process.

Question 4: Has SSE generated new attitudes for elected officials?

Answer: Several jurisdictions stated that city councils and boards of supervisors generally accepted the need for considering geologic and seismologic hazards for general planning purposes, and that the SSE has resulted in a better understanding of the problems. Most jurisdictions stated that such information would not have been considered had the SSE requirement been optional. One jurisdiction said that the SSE had minimal impact on the elected officials because their planning process already considered natural hazards and the SSE studies did not reveal any new problems.

In general, some elected officials have somewhat begrudgingly accepted the SSE requirement; others have pushed for its implementation. Some interviewees said State requirements for implementation are needed to insure uniform and consistent local action.

Question 5: Have any general plan elements been changed as a direct result of the SSE?

Answer: Most agreed that because of the recency of the SSE requirement, not enough time had passed to fully answer the question. However, one jurisdiction was in the process of changing land-use policies based largely on its SSE. Other actions that have been prompted by the completion of SSEs are: the development of ordinances dealing with the preparation of geologic reports, the adoption of grading ordinances, and the adoption of Chapter 70 (Excavation and Grading) of the Uniform Building Code. Several stated that no ordinances were being contemplated. One jurisdiction stated that the SSE has not provided them with any new information because they are located in a seismically active area and had completed most of the essentials required by the planning law; however, the SSE did prompt some procedural changes in their existing ordinances pertaining to geologic reports.

Question 6: Has the SSE been used for environmental impact reports?

Answer: All jurisdictions stated that the SSE information has been used for EIR's. One said that over 75 percent of the EIR's in the county include reference to the SSE background data.

Question 7: Has the SSE been used in administering already adopted regulations?

Answer: The SSE is frequently referred to in analyzing development proposals. The SSE geological hazards map has identified areas where geological investigations are required before development is approved. The SSE is used to determine plan conformance of proposals.

Question 8: Should the CIR Guidelines be changed? How?

Answer: Most stated that guidelines were absolutely necessary and were a great help, especially since the law requiring SSEs is so general. Most felt that changes were unnecessary; one jurisdiction wanted changes dealing with the rehabilitation or phasing out of pre-1934 unreinforced masonry structures.

Question 9: Should the SSE requirements of the State Planning Law be revised? How?

Answer: Suggestions ranged as follows:

a. There is a definite need for State level review of SSEs.

b. State law should require the adoption of policies for reducing seismic and geologic hazards.

c. The State law as written and the CIR Guidelines need no revisions.

d. Land-use and circulation should be the only mandatory elements of the general plan; other physically oriented elements such as conservation, open space, noise, and seismic safety should be informational and used for the development of the General Plan.

CONCLUSIONS AND RECOMMENDATIONS

With this information the Seismic Safety Commission was able to reach certain conclusions and make several recommendations related to the seismic safety element program in California.

A major problem the Committee encountered during the study, however, was the newness of the SSE law. Since the final date for completion of SSEs for cities and counties was September, 1974 (counties of 100,000 population or less had until December 1976), implementation of policies developed for most of the SSEs is really just beginning. Certain local jurisdictions have developed or modified review processes to better take seismic factors into consideration. However, the newly adopted elements have not been in effect for sufficient time to judge their real long-range impact on land use.

The Commission is of the opinion that the State mandated seismic safety element requirement has produced very significant benefits in the interests of public safety. It is obvious that most cities and counties had little awareness of seismic problems prior to undertaking the preparation of an SSE and fewer had any related land use policies. Seismic safety is not a topic recognized in all cities and counties in the State and is imbedded in many general plans. Thus, the legislation has resulted in public education and has affected public policy.

The adoption of seismic safety elements must be considered only the first step in establishing local land use planning, regulations, and procedures needed to effectively deal with seismic problems. It is in the implementation of seismic safety elements that real safety is to be achieved. Many of these implementation measures are outside the realm of seismic safety elements, but recommendations for implementation should be included in the elements.

With respect to the variety in SSEs some comments are in order. Even with the advisory CIR guidelines, a fair variety in SSEs is evident. The Committee believes that experimentation is in order because by this method better approaches should emerge. It is recognized that this is a new field and no one has the perfect answer.

The quality of elements has also varied considerably. Variations in quality, however, are not as acceptable as variations in content and organization. The Commission is concerned that there is no check on quality. These variations relate to depth of investigation and interpretation as well as competency.

The recommendations of the Commission are under five headings: planning law, other laws, guidelines, State assistance, and additional review.

1. Planning Law

a. The planning law should require that copies of all SSEs be submitted to the State for review. They should be indexed, cataloged, and made available for use by State and local entities. While it is not suggested that the State review all elements submitted, this submission requirement would provide a better opportunity for the State to become aware of the types and quality of the elements prepared.

b. The planning law should be amended to stipulate that seismic safety and safety elements can be combined as single elements. The division between seismically induced and non-seismically induced geologic failures is too meaningless to warrant two separate elements, a Safety Element and a Seismic Safety Element. In practice many jurisdictions have combined the elements as suggested by the CIR guidelines. The law, however, should clearly make it permissive.

c. The planning law should indicate more clearly what aspects of seismic data and policy should be in background studies and what aspects should be in the adopted seismic safety element.

2. Other Laws

a. Laws relating to the control of land development should increasingly ensure the involvement of geologists, engineers, and planners for purposes of review and recommendations. In the end, it is the involvement of competent professionals in land use and design decisions that will vastly help increase seismic safety. Thus, basic laws controlling the subdivision of land, construction of public improvements and approval of building construction should be reviewed and appropriate revisions made to ensure involvement of the proper professionals.

3. General Plan Guidelines

a. The Seismic Safety Commission should have a responsibility in establishing the content of the SSE guidelines.

b. The guidelines should be reviewed and expanded.

c. The guidelines should provide for different approaches depending on the complexity of geologic environments.

d. Identify State level hazards which require treatment in all SSEs.

e. Include provisions for updating SSEs.

f. Include more recommendations for implementation.

4. State Assistance

a. The State should select several of the best SSEs in California and bring them to general attention. There are a number of SSEs that represent innovative approaches and models. The State might consider selecting some for distribution or preparing summaries which could be circulated.

b. The State should provide for education in the preparation and use of SSEs.

c. Review of SSEs on request. It would be desirable if the State would provide a mechanism whereby local jurisdictions could submit their SSEs for review and advice regarding geotechnical and planning aspects.

5. Additional Review

The effectiveness of the SSE requirements should be reviewed again in several years. The first round of preparation of SSEs has about been completed. The real question will be their long term impact. It would be worthwhile to review the SSEs in several years. Some questions which should be asked include:

1. Have the elements been used in planning decisions or have they been relegated to the "back shelf"?
2. Have land use plans been modified based on the SSEs?
3. Have implementing regulations and programs been adopted?
4. Have elements been amended to include new data and policies?

How are the recommendations resulting from this evaluation being implemented so that the desired changes will occur? First, the Commission sponsored Assembly Bill 2752. This legislation will allow local governments to combine general plan elements as long as they comply with the State Planning Law, and it will also allow cities to use county seismic and geologic hazards information where such information applies. Cities and counties also will be required to send a copy of their SSE and supporting technical information to the California Division of Mines and Geology. Second, staff members from the Commission, Division of Mines and Geology and the Office of Planning and Research are revising the guidelines for the preparation of

SSEs as part of a comprehensive effort to improve guidance for all the elements of general plans.

Perhaps not often enough are independent reviews made of various programs by knowledgeable professionals. The review of the seismic safety element program in California by the Seismic Safety Commission is just one of the earthquake hazard reduction programs the Commission has been reviewing during the last two years.

SEISMIC SAFETY ELEMENT

1. *AUTHORITY*

A. Authority

Government Code Section 65302(f) requires a seismic safety element of all city and county general plans, as follows:

> A seismic safety element consisting of an identification and appraisal of seismic hazards such as susceptibility to surface ruptures from faulting, to ground shaking, to ground failures, or to the effects of seismically induced waves such as tsunamis and seiches.
>
> The seismic safety element shall also include an appraisal of mudslides, landslides, and slope stability as necessary geologic hazards that must be considered simultaneously with other hazards such as possible surface ruptures from faulting, ground shaking, ground failure and seismically induced waves.

The effect of this section is to require cities and counties to take seismic hazards into account in their planning programs. All seismic hazards need to be considered, even though only ground and water effects are given as specific examples. The basic objective is to reduce loss of life, injuries, damage to property, and economic and social dislocations resulting from future earthquakes.

B. Background

Earthquake losses in California through the remainder of this century, assuming that additional significant counter-measures are not taken, have recently been estimated at approximately $20 billion (Urban Geology Master Plan, California Division of Mines and Geology). Estimates of potential loss of life for this period range well up into the thousands and most of this loss is preventable.

The most widespread effect of an earthquake is ground shaking. This is also usually (but not always) the greatest cause of damage. Structures of all types, including engineered structures and public utility facilities, if inadequately constructed or designed to withstand the shaking force, may suffer severe damage or collapse. The vast majority of deaths during earthquakes are the result of structural failure due to ground shaking. Most such deaths are preventable, even with present knowledge. New construction can and should be designed and built to withstand probable shaking without collapse. The greatest existing hazard in the State is the continued use of tens of thousands of older structures incapable of withstanding earthquake forces. Knowledge of earthquake-resistant design and construction has increased greatly in recent years, though much remains to be learned.

A second effect of earthquakes is ground failure in the form of landslides, rock falls, subsidence and other surface and near-surface ground movements. This is often the result of complete loss of strength of water-saturated sub-surface foundation soils ("liquefaction"), such as occurred near the Juvenile Hall in the 1971 San Fernando earthquake, and in the massive Turnagain Arm landslide in Anchorage, during the 1964 Alaska earthquake. Most such hazardous sites can be either avoided or stabilized if adequate geologic and soil investigations are utilized.

Another damaging effect of earthquakes is ground displacement (surface rupture) along faults. Such displacement of the earth's crust may be vertical, horizontal or both and may offset the ground by as much as 30 feet (as in 1857 in Southern California). It is not economically feasible to design and build foundations of structures (dams, buildings, bridges, etc.) to remain intact across such zones. Fault zones subject to displacement are best avoided in construction. In addition to regional investigations necessary to the basic understanding of faults and their histories, detailed site investigations are needed prior to the approval of construction in any suspected active fault zone. Utilities, roads, canals and other linear futures are particularly vulnerable to damage as the result of ground displacement.

Other damaging effects of earthquakes include tsunamis (seismic sea waves, often called "tidal waves"), such as the one which struck Crescent City and other coastal areas in 1964; and seiches (waves in lakes and reservoirs due to tilting or displacement of the bottom or margin). The failure of dams due to shaking, fault displacement or overtopping (from seiches or massive landsliding into the reservoir) can be particularly disastrous. Most modern dams are designed and constructed to be earthquake-resistant; some older dams were not. In addition to man-made dams, temporary dams may be created by earthquake-triggered landslides. Such inadvertently created dams are certain to fail within a relatively short time.

2. *THE SCOPE AND NATURE OF THE SEISMIC SAFETY ELEMENT*

A. A general policy statement that:

1. Recognizes seismic hazards and their possible effect on the community.
2. Identifies general goals for reducing seismic risk.
3. Specifies the level or nature of acceptable risk to life and property (see safety element guidelines for the concept of "acceptable risk").
4. Specifies seismic safety objectives for land use.
5. Specifies objectives for reducing seismic hazard as related to existing and new structures.

B. Identification, delineation and evaluation of natural seismic hazards.

C. Consideration of existing structural hazards.

Generally, existing substandard structures of all kinds (including substandard dams and public utility facilities) pose the greatest hazard to a community.

D. Evaluation of disaster planning program

For near-term earthquakes, the most immediately useful thing that a community can do is to plan and prepare to respond to and recover from an earthquake as quickly and effectively as possible, given the existing condition of the area. The seismic safety element can provide guidance in disaster planning.

E. Determination of specific land use standards related to level of hazard and risk.

3. *METHODOLOGY*

As an initial step, it may be helpful to determine what aspects of the element need greater emphasis. If a community is largely developed, emphasis on structural hazards and disaster planning would be most appropriate. This would also be the case for communities whose greatest hazard will be from ground shaking. On the other hand, communities with extensive open areas and areas subject to urbanization may wish to focus on natural seismic hazards and the formulation of land use policies and development regulations to insure that new development is not hazardous.

Additionally, local planning agencies may wish to consider the preparation of the element or portions of the element in joint action. This would be particularly practical for the study of natural seismic hazards.

A. Initial organization

(1) Focus on formulating and adopting interim policy based on very general evaluation of earth science information readily available.
(2) Evaluate adequacy of existing information in relation to the identified range and severity of problems.
(3) Define specific nature and magnitude of work program needed to complete the element in a second stage.

B. Identification of natural seismic hazards

(1) General structural geology and geologic history.
(2) Location of all active or potentially active faults, with evaluation regarding past displacement and probability of future movement.
(3) Evaluation of slope stability, soils subject to liquefaction and differential subsidence.
(4) Assessment of potential for the occurrence and severity of damaging ground shaking and amplifying effects of unconsolidated materials.
(5) Identification of areas subject to seiches and tsunamis.
(6) Maps identifying location of the above characteristics.

C. Identification and evaluation of present land use and circulation patterns should be recognized in the formulation of seismic safety-land use policies.

D. Identification and evaluation of structural hazards relating structural characteristics, type of occupancy and geologic characteristics in order to formulate policies and programs to reduce structural hazard.

E. Formulation of seismic safety policies and recommendations.

F. Formulation of an implementation program.

4. *DEFINITION OF TERMS*

A. Acceptable risk: The level of risk below which no specific action by local government is deemed necessary, other than making the risk known.

Unacceptable risk: Level of risk above which specific action by government is deemed necessary to protect life and property.

Avoidable risk: Risk not necessary to take because the individual or public goals can be achieved at the same or less total "cost" by other means without taking the risk.

B. Technical Terminology:

Tsunamis: Earthquake-induced ocean waves, commonly referred to as tidal waves.

Seiches: Earthquake-induced waves in lakes or ponds.

Seismic: Pertaining to or caused by earthquake.

Soil Liquefaction: Change of water saturated cohesionless soil to liquid, usually from intense ground shaking; soil loses all strength.

Tectonic, forms, forces, and movements resulting from deformation of the earth's crust: Movement may be rapid resulting in earthquake, or slow (tectonic creep).

Fault: A plane or surface in earth materials along which failure has occurred and materials on opposite sides have moved relative to one another in response to the accumulation of stress in the rocks.

Active Fault: A fault that has moved in recent geologic time and which is likely to move again in the relatively near future. (For geologic purposes, there are no precise limits to recency of movement or probable future movement that define an "active fault". Definitions for planning purposes extend on the order of 10,000 years or more back and 100 years or more forward. The exact time limits for planning purposes are usually defined in relation to contemplated uses and structures.)

Inactive Fault: A fault which shows no evidence of movement in recent geologic time and no evidence of potential movement in the relatively near future.

Seismic Hazards: Hazards related to seismic or earthquake activity.

Ground Failures: Include mudslide, landslide, liquefaction, subsidence.

Surface ruptures from faulting: Breaks in the ground surface resulting from fault movement.

5. *RELATIONSHIPS*

A. To Other Elements:

The seismic safety element contributes information on the comparative safety of using lands for various purposes, types of structures, and occupancies. It provides primary policy inputs to the land use, housing, open space, circulation and safety elements.

Because of the close relationship with the safety element the local planning agency may wish to prepare these two elements simultaneously or combine the two elements into a single document. If combined, the required content and policies of each element should be clearly identifiable. The local jurisdiction may wish to include the seismic safety element as a part of an environmental resources management element - ERME - as discussed previously.

B. To Environmental Factors:

(1) Physical: Geologic hazards can be a prime determinant of land use capability.

(2) Social: May provide basis of evaluating costs of social disruptions, including the possible loss of life due to earthquake and identifies means of mitigating social impact.

(3) Economic: Cost and benefits of using or not using various areas related to potential damage or cost of overcoming hazard.

(4) Environmental Impact Report: Provides basis for evaluating environmental impact of proposed projects in relation to slope stability, possible structure failure, etc.

C. To Other Agencies:

The State Geologist is required by Chapter 7.5, Division 2 of the Public Resources Code to delineate by December 31, 1973, special studies zones encompassing certain areas of earthquake hazard on maps and to submit such maps to affected cities, counties, and state agencies for review and comments.

By December 31, 1973, the Division of Mines and Geology will have delineated the special studies zones encompassing all potentially and recently active traces of the San Andreas, Calaveras, Hayward, and San Jacinto faults. The special studies zones will be delineated on U.S. Geological Survey quadrangle sheets. The quadrangles listed in Appendix F will be included in the initial distribution which will begin on or about October 1, 1973, and be completed by December 31, 1973. In addition to the faults named above, all active or potentially active faults within the quadrangles listed will be zoned. The zones are ordinarily about one-quarter mile in width.

The State Mining and Geology Board is required by Chapter 7.5, Division 2 of the Public Resources Code to develop policies and criteria by December 31, 1973, concerning real estate developments or structures to be built within the special studies zones.

6. *IMPLEMENTATION*

A. Concurrent or subsequent revision of other general plan elements to give specific recognition to seismic safety policies and criteria.

B. Inclusion of appropriate requirements and procedures in zoning, subdivision and site development regulations and building codes. Designation of special zones with special land development regulations such as "seismic hazards management zones".

C. Preparation of renewal plans for areas where a change in use and development pattern is necessary because of major seismic damage or extreme hazard.

D. Building inspection program to identify unsafe structures and instigate necessary corrective measures.

E. Inclusion of potential earthquake destruction in contingency plans for major disasters and emergencies. Review and liaison with Emergency Preparedness Organizations and Police Departments of overall plans and major public facilities proposals as to their adequacy in emergency situations.

F. Educational programs to develop community awareness of seismic hazards.

G. Updating the building code to reflect changes in technology.

NOTE: These guidelines drew extensively from:

Suggested Interim Guidelines for the Seismic Safety Element in General Plans, prepared by the Governor's Earthquake Council, July, 1972.

Draft Guidelines for the Seismic Safety Element, prepared by Advisory Group on Land Use Planning for Joint Committee on Seismic Safety, California State Legislature, September, 1972.

Seismic Safety Concerns in CIR/OIM Program prepared for CIR by William Spangle & Associates, March 1972, unpublished.

QUESTIONS FOR PRELIMINARY STAFF REVIEW

1. Is the SSE separate or combined with other elements.
2. Number of pages (text)
   a. Pages of basic geological principals (Geology)
   b. Pages devoted to specific areas, i.e., hazards, hazardous buildings, etc.
3. Number of maps
   a. Previously published, USGS, CDMG (reproduced)
   b. Original maps
4. Is the technical data separated from a less technical discussion? How is it separated?
5. Data sources and information.
   a. A collection of available resources
   b. Original data specifically gathered for SSE
6. How detailed are text and map descriptions
7. What features distinguish the element from other SSE's
8. Compliance with State Planning Law Regulations for SSE's
9. Compliance with CIR guidelines, especially item 2, "The Scope and Nature of the Seismic Safety Element".
10. Recommendations for implementation of SSE policies.

SEISMIC SAFETY ELEMENT REVIEW QUESTIONNAIRE

1. Procedure for Preparation (Working Relationships)

2. How is SSE Information Made Available to the Public, Planning Commission, Legislative Body?

3. How Are Basic Data Maps Maintained
   a. Scale Different From Maps in SSE
   b. Copies Available For Public: At What Scale?

4. How Widely Distributed?

5. Public Input Other Than Hearings

6. Citizen Reaction to SSE

7. Has SSE had any Impact on Decision Making?
   a. New Information to Planners and Decision Makers
   b. New Attitudes
      1) Community
      2) Staff, DPW, Planning
      3) Elected Officials

8. Use Made of the SSE
   a. Changes in other Elements as a Direct Result From SSE
   b. Probable Changes In Other Elements as a Result of the SSE
   c. Ordinances Adopted as a Result of SSE
   d. Use in EIR's
   e. Use in Administering Already Adopted Regulations. i.e., Zoning, Grading, Subdivision

f. Decision Making Process by Legislative and Planning Bodies

g. LAFCO

9. Effects on Assessments Resulting From SSE

10. Post Legislation Reaction

11. CA Div. of Mines and Geology Questionnaire: Does it Work, Help, Eliminate Overlap; Is it Useful?

12. Should the CIR Guidelines Be Changed? How?

13. Should SSE Requirements of the State Planning Law Be Revised? How?

14. Who Prepared SSE?

a. In House Professional, Disciplines

b. Consultant - Expertise

c. City Adoption of County SSE

\- 15. Size of Planning Staff

16. Population of Jurisdiction Affected by SSE

17. Budget & Costs SSE

18. Date Adopted

OVERVIEW OF THE EARTHQUAKE RESPONSE CONTINGENCY PLANNING PROGRAM

by

Ugo Morelli*
Federal Disaster Assistance Administration

The purpose of my remarks is to provide an overview of the earthquake response contingency planning program and thus put into context the presentation that follows by Mr. Richard Buck on the specific effort that was undertaken in the Puget Sound area.

This program has two main objectives:

(1) To ensure that the Federal Government will be able to bring to bear, in minimum time, all the resources at its disposal to provide relief and rehabilitation to an area stricken by a major earthquake; and

(2) To ensure a high degree of compatibility between federal and state/local response plans.

Several observations are in order on these objectives:

1. As is the case in all types of disasters, the federal assistance is supplementary to that of state and local authorities, who have primary responsibility for aiding the victims.
2. The planning concentrates on how best to marshal and apply the available federal resources--esentially a resource management and logistic support operation.
3. The planning assumes that no prediction of the event is made and no warning provided to the inhabitants of the stricken area.
4. The planning includes the private sector (represented mostly by volunteer organizations and utility companies), although the objectives do not specifically mention private entities.

The program was started in March 1971 by the Office of Emergency Preparedness (the predecessor agency to the Federal Disaster Assistance Administration), following the San Fernando earthquake that highlighted the full destructive potentiality of a temblor striking a large, modern, heavily populated area. Ten areas were selected for inclusion in the program because of the combination of heavy population and high seismic risk:

San Francisco Bay (nine counties)
Los Angeles and Orange Counties
Puget Sound
Salt Lake City-Ogden
Anchorage-Fairbanks
Hawaii
Mississippi Region
Charleston
Boston
Upper New York State

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*The author gratefully acknowledges the assistance of many individuals--too numerous to mention by name--whose reports, studies, and memoranda were heavily drawn upon in the preparation of these remarks.

The approach that is followed in the program is twofold. In a first phase of the effort, estimates of casualties and losses to key facilities on the basis of postulated, credible earthquakes are developed for each geographic area. These estimates reflect two principal inputs--scientific (seismology) and technical (construction engineering). The first input consists of isoseismal maps depicting the degree of shaking (measured on a Modified Mercalli scale) that is likely to occur in various sections of the study area in each postulated earthquake. The second input represents an estimate of the casualties and property damage that may reasonably be expected to occur as a result of the intensities described in the isoseismal maps. Experience in damage assessment and relief operations from past relevant earthquakes and engineering judgment are also applied to the analysis, in addition to the more theoretical isoseismal map information.

In a second phase, this rational and credible body of data on each geographic area is transferred to planners of all types and at all levels of government to be used as a common basis for complementary earthquake response plans. The plans identify the emergency, lifesaving, and rehabilitation functions to be performed and organize in a coherent fashion the myriad assistance actions that need to be taken after a major disaster is declared by the President.

Estimates of casualties and damage to critical facilities have been prepared on the first four areas listed above by a combined team of United States Geological Survey personnel (National Oceanic and Atmospheric Administration prior to the consolidation) and experts in the relevant disciplines, often drawn from local universities and research groups.

Federal/state/local plans to respond to an earthquake disaster are in advance stages of completion or have been completed for three of the four areas. A somewhat different method was taken in each of the areas. In the case of San Francisco and Los Angeles, there is under preparation a truly coordinated and extensive set of complementary federal, state, and local plans. In the case of Salt Lake City-Ogden, the federal plan is completed, but less elaborate than in the case of the California localities, and the Utah state emergency response plan covering all types of disaster has been adapted to cover the contingency of a large-magnitude earthquake. Both plans are thoroughly meshed. As for the Puget Sound area, only a federal plan is in existence so far.

Because of budgetary and management problems that are not relevant to the subject of this Workshop (and therefore need not be examined here), the program has met with some considerable delays. There are good indications, however, that it will now be given added emphasis, proceeding as fast as the availability of technical data and the interest and participation of state and local authorities--especially in the areas in the eastern United States--will permit. The latter consideration--interest and participation of state and local governments--is of paramount importance. If for any number of reasons (e.g., absence of awareness of hazard or risk, conflicting priorities, or lack of resources) state and local support is lacking in any one geographic area, the effort for that area will, in all likelihood, not be undertaken.

In the context of this Workshop, this program is worthy of note because knowledge transfer is an integral and critical part of the effort. In order for the effort to succeed, a sizeable amount of scientific, technical, and socioeconomic data is produced by one group and then transferred to and interpreted for a large number of very different types of users, so that it can be brought to bear on a practical application. Seismologists, geologists, earthquake engineers, sociologists, and economists produced the information basis for the use of planners, decisionmakers, and operational personnel of all types and at all level of government. How this was done will be covered by Dick Buck.

THE PUGET SOUND EARTHQUAKE PREPAREDNESS PROJECT

by

Richard A. Buck
California Seismic Safety Commission

The Puget Sound Earthquake Preparedness Project was the third of four earthquake projects sponsored by the Federal Disaster Assistance Administration (FDAA). I directed the project as a Disaster Programs Officer working out of the Region 10 office of FDAA in Seattle. The hazard analysis performed by the United States Geological Survey (USGS) under an interagency agreement with FDAA was kicked off in April of 1974 and completed in November of 1975. The bulk of activity with users on the hazard analysis occurred during 1976 and the first part of 1977.

I. INFORMATION PRODUCER/USER COMMUNITY

A. Objectives of the Hazard Analysis

The purpose of the hazard analysis is succinctly stated in the USGS report:

> This study is intended to inform those agencies serving the region of potential hazard to people, structures, and lifeline functions, in such a way that the administrators of emergency services can proceed with confidence in planning response to earthquake disaster.*

We in FDAA thought the information would serve disaster response activities in two ways: (1) It would sensitize political and administrative leadership (primarily in government) to the hazard and motivate them to devote resources to disaster preparedness programs; and, (2) it would provide enough detailed information on possible problems after an earthquake to indicate where government specifically needs to improve its disaster response capability.

B. Users of the Hazard Analysis

The purpose can be understood better by looking at the intended users. We felt that the primary users would be local, state, and federal agencies with disaster responsibilities. The focus of our thinking was on governmental agencies, but it was recognized from the first that the information would be useful to hospitals and hospital associations (or councils),

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*United States Geological Survey, A Study of Earthquake Losses in the Puget Sound, Washington Area, Open-File Report 75-375,1975.

natural gas, electric, and telephone utilities, and the American Red Cross. It was our opinion that the information would be useful to the public as well, but we made no efforts to aim the study at this group, and had no clear conception of how they might be able to use the information.

C. Ultimate Objectives

The FDAA regional staff believed that the report should result in an improved ability in the region to respond to a major earthquake. Consciously we steered away from earthquake damage reduction or mitigation for two reasons: (1) The type of report that USGS was prepared to do for us lent itself more to response concerns; and (2) we saw response as the primary function of FDAA. We further believed that it was the responsibility of FDAA to bring the information to the attention of organizations with disaster responsibilities, help interpret the information for them, and to encourage them to use the information in improving their disaster response capabilities. The momentum for doing the hazard analysis had not been generated from within the region. It was part of a national program originating with FDAA's predecessor, the Office of Emergency Preparedness, which recognized that the country was ill-prepared to deal with infrequently occuring, but potentially devastating earthquakes. Interest in this program on the part of the Office of Emergency Preparedness and subsequently FDAA was stimulated by a group of professionals in the seismological and earthquake engineering community, especially Karl Steinbrugge who developed a hazard analysis methodology with directly practical applications. Once the concept of the study was explained to the regional FDAA staff, we were convinced the project was worthwhile. At that time, the Director of the Washington Department of Emergency Services also indicated his support for doing the study.

D. <u>Constraints</u>

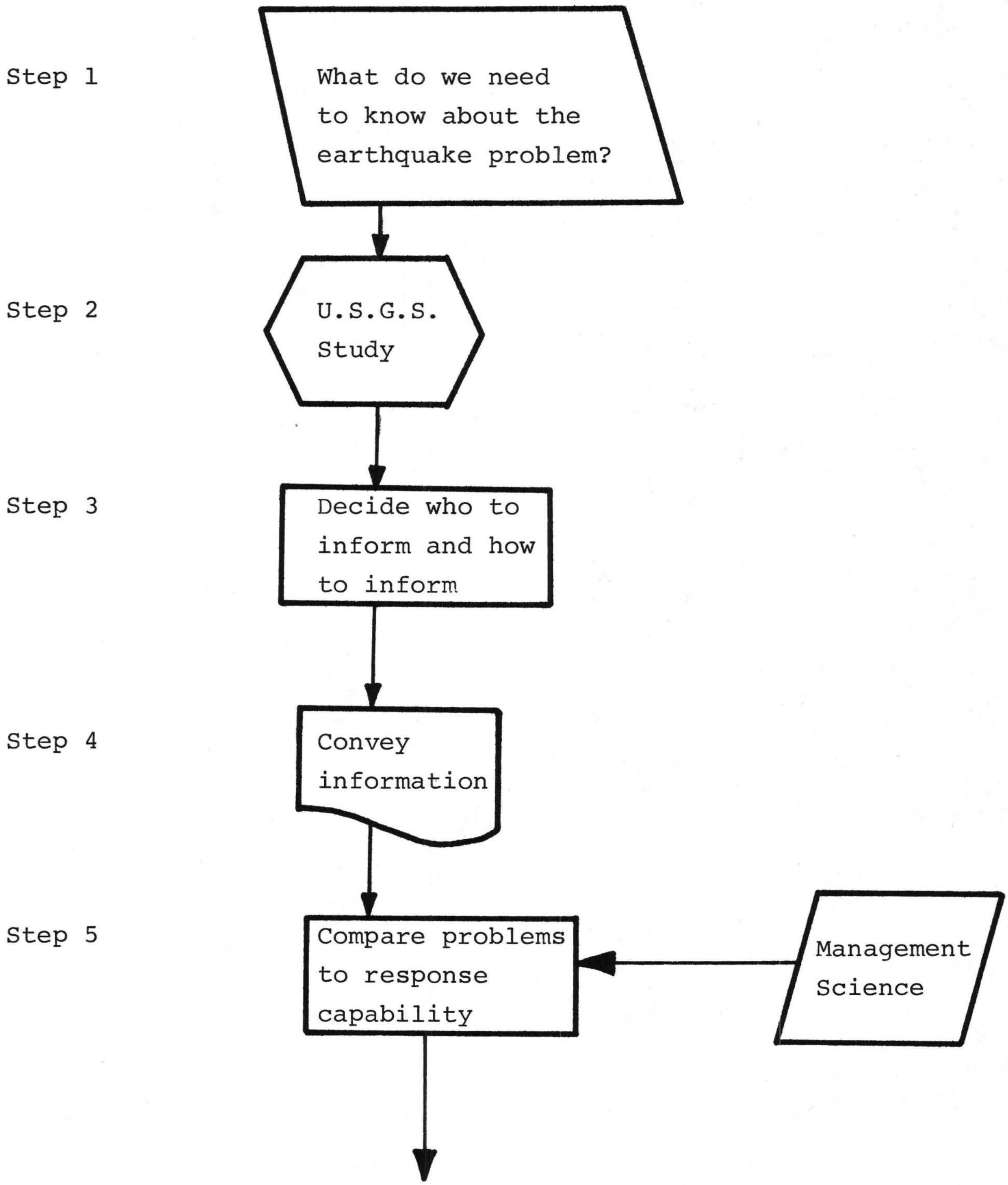
The intention on the part of all parties, producers and users, was that users would contribute to the research design. However, we were restricted in funds - about $180,000 could be devoted to the Puget Sound project. Also, the methodology had already been developed and used on two other projects, San Francisco and Los Angeles. We consequently restricted our consideration of options in research design to that which was within the existing methodology.

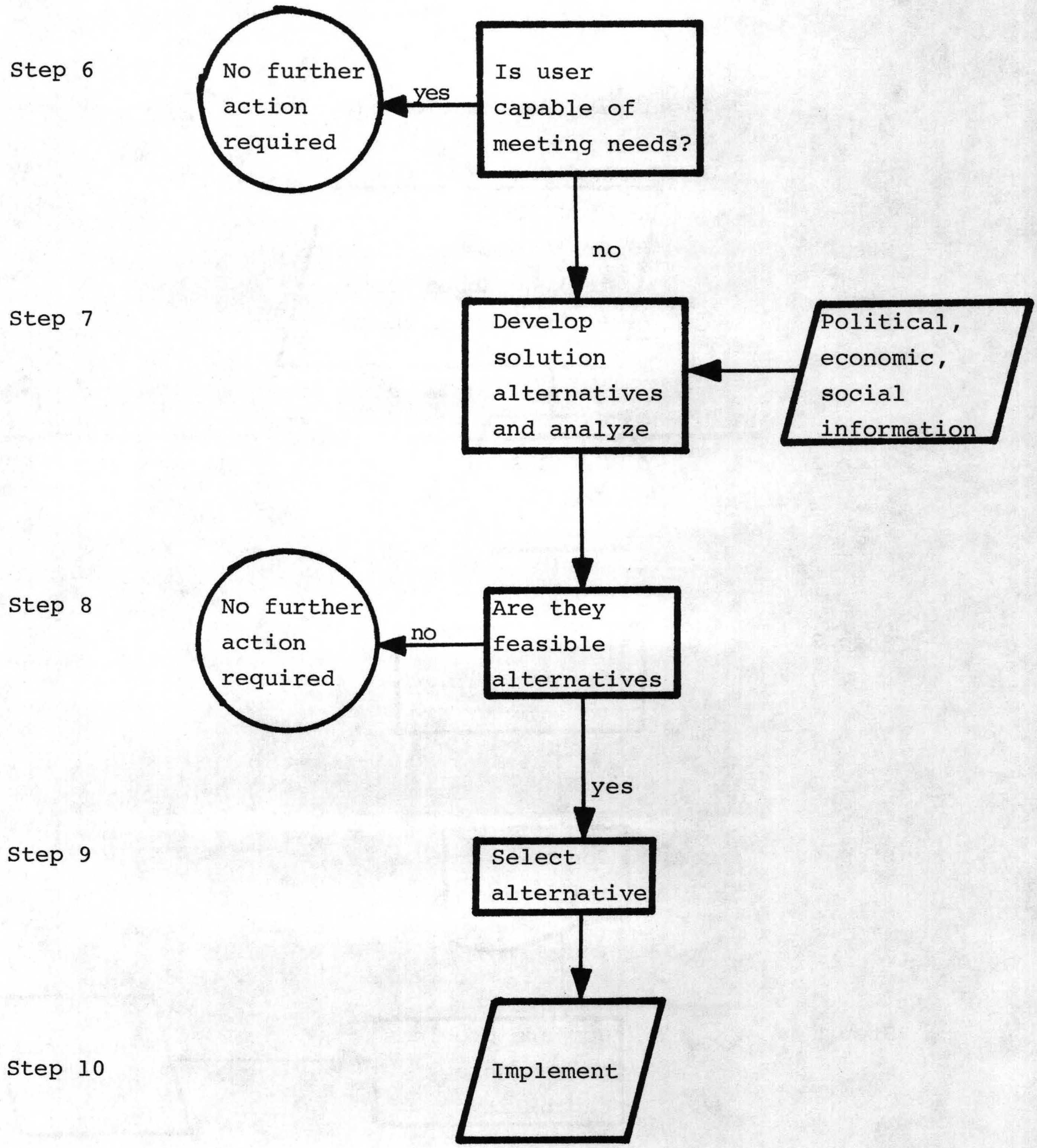
There was a major constraint in how much control FDAA could exert over the use of the hazard analysis once completed. State, local, and private users were totally beyond our directive authority. We had to rely on our ability to present a convincing case. Although we had no sticks, we had one carrot in a matching grant program for state disaster preparedness. Likewise, although FDAA was tasked with coordinating federal response to disaster by law, our authority over federal agency disaster preparedness activities was nonexistent.

II. HOW THE INFORMATION FLOW WORKED

Figure 1 is the model of the anticipated information flow in the Puget Sound project. It is divided into ten steps. I will compare the anticipated flow with what actually occurred in each step.

Figure 1. Information Flow Model



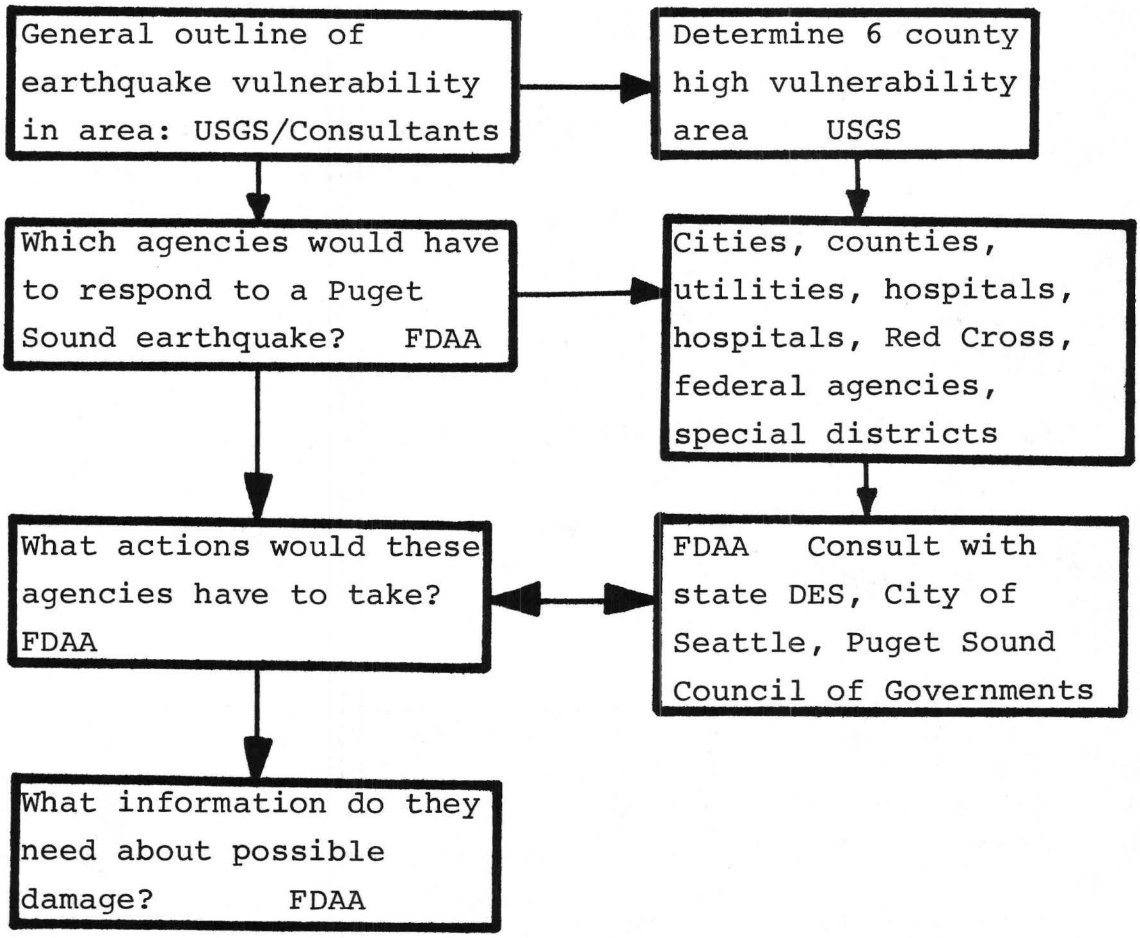


Step 6
No further action required
yes
Is user capable of meeting needs?
no
Step 7
Develop solution alternatives and analyze
Political, economic, social information
Step 8
No further action required
no
Are they feasible alternatives
yes
Step 9
Select alternative
Step 10
Implement

Step 1

This involved the preliminary determination of what we wanted out of this study. The diagram below illustrates the approach taken:

Deciding content of hazard analysis

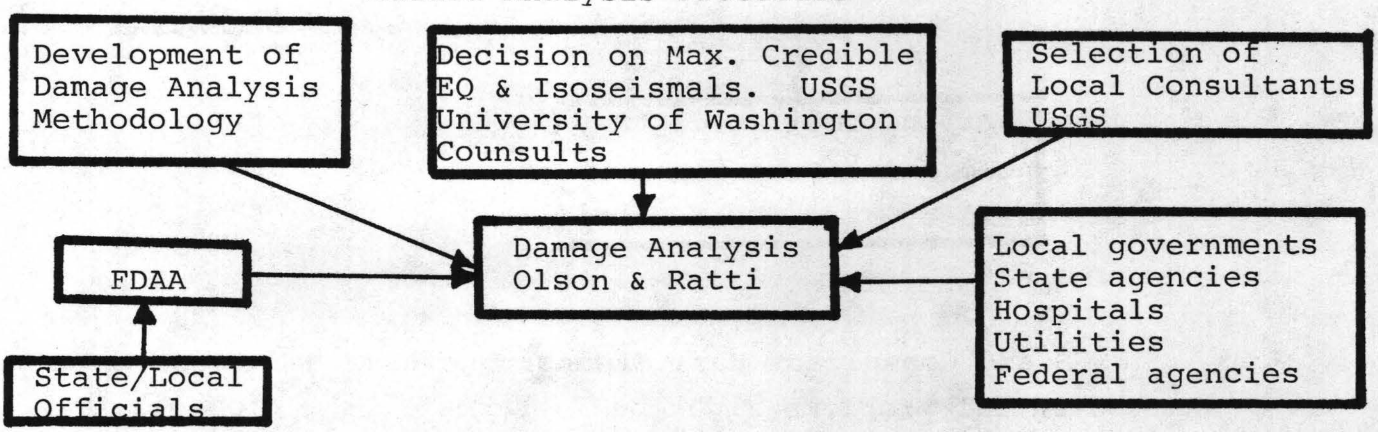


USGS and Consultant Karl Steinbrugge gave us a general idea of what potential problems might be in terms of the probability of a damaging earthquake, the type of damage we might expect, and the area of highest probable impact. The area of highest probable damage roughly fits the six county area at the southern end of Puget Sound. From this, FDAA developed a user list based on our own knowledge of the agencies and what they do. We brought the State Office of Emergency Services, and the City of Seattle Office of Emergency Services into the discussion to help us establish the type of information needed at the State and local levels. We also consulted with the Puget Sound Council of Governments, which represented the cities and counties in the area. We did not recommend major changes in the research design. However, we did recommend more aggregation of the damage estimates by political subdivisions, and by smaller geographical areas in the densely populated metropolitan Seattle area. The intent was to better pinpoint the areas of potential damage for decision-makers.

Step 2

This includes all the activities involved in doing the hazard analysis itself. Below is the diagram of Step 2.

Hazard Analysis Procedure



USGS gave the University of Washington a $5,000 contract to furnish data for the isoseismal study. As well as serving as a source of data, it served the motivational purpose of getting local seismologists involved in the project. I use the term "motivational purpose" because involvement of the local scientific community in the project would make the findings more credible to the ultimate users. This is not irrational; because who should know best about an area but the local scientists who study it every day.

A local engineering firm was selected for the damage analysis because of (1) its knowledge of the local area construction practices and the sources of information, (2) its accessibility to users after the analysis was completed, (3) the need to build a capability in the area for future studies, and (4) credibility.

The first that many of the potential users of the information heard about the project was when they were contacted by the engineering firm to get information about their facilities.

FDAA staff was continually involved with the engineering firm, reviewing findings and the format for presentation of findings. Our major contribution was in the area of getting the damage figures stated in a way most understandable to users, and in establishing the geographical areas for data aggregation. A few local and State officials were consulted about this.

Step 3

This was the decision on how to inform users about the results of the project. Part of this involved revising the list of users--based on the findings of the damage analysis. Table 1 lists classes of users and the means we decided to use to reach each of them. The USGS Report was the key vehicle, and we worked with the consultants and USGS to improve its utility as a method of transferring information. We were critical of the San Francisco and Los Angeles report because we felt users would have to dig through a lot of information to get at what was relevant to them. Therefore, the report for Puget Sound started with a three page summary of the results. This was immediately followed by a one page summary of the damage findings for each county, with county isoseismal maps. Table 2 is the summary used for King County.

For briefings, Stephanie Pulakis of our staff developed an 11 minute sound/slide presentation that gave the summary results of the study and the background on the seismicity of the area. This was used as an introduction. It covered the basic findings. We would then gear the rest of the presentation to the specific needs of the group.

An important objective was to get to the decision-makers in these organizations. To get and keep the attention of these people the presentation had to be short and to the point. Hence, the short sound/slide presentation. We found that even though we provided for overall and county summaries in the report, we needed an additional overall summary written in newspaper style for the media. For the counties, we developed detailed county summaries. We were dealing with a fact of life that people expect instant information. I think we are getting conditioned to this by television news. Most events on television are reported in one minute and 15 seconds; and an in-depth story lasts one minute and 45 seconds.

We advertised at our briefings that we had a staff member available to help agencies use the report in evaluating their response capability.

Table 1

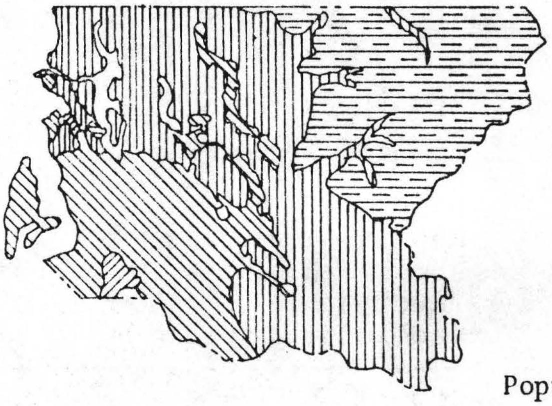
Means for Conveying Information

Informing Responsibility	User	Means
FDAA	Public	Report Summaries Press Releases Interviews Report in Libraries
FDAA	Utilities	Report Briefings
FDAA	Cities	Report & Summaries ES Directors Briefings Briefing department heads Technical Assistance
FDAA	Counties	Report & Summaries Briefing County Commissioners ES Directors briefings Technical Assistance
FDAA	Hospital Councils	Report & medical summary Briefing Technical Assistance
FDAA	Federal Agencies	Report to each agency RD Briefing agencies RDs and key staff Technical assistance Briefing Federal Regional Council and Federal Executive Board
OES/FDAA	State Agencies	Report Briefing selected agencies Brief Governor's EQ Council

TABLE 2.--ANTICIPATED DAMAGE PATTERNS FROM EARTHQUAKE DISASTER

KING COUNTY

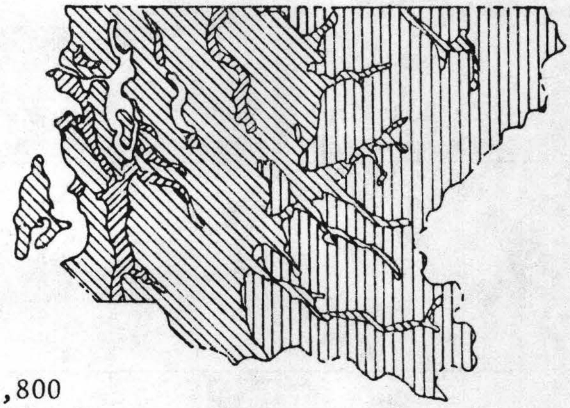
Postulated earthquake "A"



Modified Mercalli Intensity

IX
VIII
VII
VI
V

Postulated earthquake "B"



Population 1,143,800
Area in mi^2 2,128

Vital needs	Degree of impairment: Earthquake "A" Minimal	Earthquake "A" Minor	Earthquake "A" Major	Earthquake "B" Minimal	Earthquake "B" Minor	Earthquake "B" Major
Communications----------		●				●
Fire--------------------		●				●
Police------------------		●				●
Electric power----------			●			●
Water-------------------		●				●
Access roadways---------			●			●
Medical:						
Manpower--------------			●			●
Hospitals-------------			●			●
Ambulances------------		●				●
Blood bank------------		●				●
Supplies--------------		●			●	
Food supplies-----------	●				●	
Schools (as shelters)---		●				●

	Estimated losses: Earthquake "A"	Earthquake "B"
Deaths--------------------	1,500	1,650
Serious injuries----------	6,000	6,600
Homeless------------------	7,130	18,630

The Governor's Earthquake Engineering Advisory Council was briefed by FDAA, USGS, and OES. This was a council that had met only one time before; but it had the responsibility for advising the Governor on how the State should prepare for earthquakes. It consisted of university people involved in seismology or earthquake engineering, and local engineering and building officials.

FDAA assumed a primary role in informing city and council people because OES decided not to engage in a major earthquake preparedness effort. I will discuss this development later.

Step 4

This is the step where information transfer took place. There was a very intensive effort for four months after the release of the report, and it continues to this day from time to time. So to an extent it overlaps the succeeding steps. There was a kickoff news release; members of the media were invited to come by the office to pick up the report and media summary. The press and electronic media maintained interest for about one week. Almost all newspapers, television stations, and the major radio stations carried the story. A few radio stations asked for interviews. One television station was considering doing an interview, but declined when they found out we had no exciting graphic materials. Most of the County Commissions and the city people were receptive to attending a briefing.

Steps 5 and 6

The next step in our model calls for use of the information to analyze emergency response capability; that is, the user was encouraged to compare the damage projections to his capability of responding, and to arrive at a list of response deficiencies. FDAA activities in this area stopped with encouragement to the users and the offer of technical assistance (with the exception of the Federal agencies where we took a more active role). The accomplishment of Step 5 is spotty. Many of the counties and cities used the damage profile in disaster simulations, and arrived at deficiencies in this way. FDAA held a workshop of Federal agencies to arrive at some conclusions regarding Federal deficiencies. The National Guard and Ft. Lewis also used the damage profile as the scenario for disaster simulations. The goal was to have each user analyze capabilities in Step 5, and reach a decision in Step 6 on each response problem about adequacy of agency capability. If the answer in Step 6 is "yes" for a problem, then for that problem nothing further would have to be done. If the answer is no, then the user would move on to Step 7.

The process from Step 5 on was carried to completion only by the Federal Regional agencies. The Federal program was found to be primarily deficient in its ability to communicate and assure itself the support facilities necessary to perform in a coordinated manner after the earthquake. This included the following deficiencies:

1. Assessing needs for Federal assistance;
2. Receiving requests for assistance from State and local agencies;
3. Conveying instructions to Federal agencies in the region and out side;
4. Keeping Washington, D.C. headquarters informed on needs and Federal actions.

Step 7

This involves looking at the alternative solutions to the elimination of the deficiencies, and evaluation of those alternatives. Here information on the political, economic and social level should be fed in.

Step 8

This is a listing of feasible alternatives. The benefits must be greater than the costs in economic terms. The same is true of politics; they must be potentially acceptable to the political decision-makers. They also must not violate social norms.

Step 9

This is selection of the alternatives. In the case of the Federal agencies, Steps 7 to 9 were accomplished through a series of workshops with agencies, and two workshops that included all Federal agencies. The last workshop used simulation to test out some of the alternative solutions. The solution involved the development of a radio procedure, a series of automatic actions for agencies in an earthquake, and the selection of alternate operating sites.

Step 10

Two and one-half years after the USGS report came out, we are still in the implementation stage, but expect completion soon. This involves publishing the plan, and briefing each agency. Yearly, there will be a meeting to discuss plan revisions, and to refresh memories on what is supposed to happen.

III. EVALUATION OF THE PROCESS

A. What problems can be found with the process?

We saw the process break down in Step 5, the point where it came time to use the information. Let's ask five questions:

1. Were the damage figures relevant? If so, the problem originated in Step 1. In Step 1 the needs of the users were determined. This was not done systematically. FDAA did this in consultation with DES, and one city OES director. We could have had a series of workshops where the parameters of the information available would be explained, and then the users allowed to suggest what they specifically needed from the hazard study. A questionnaire to all potential users could have been employed. It would have been a good idea to do all of this, but I do not think lack of relevancy was the problem.

2. Did the users understand the information? The end products of the USGS report were statements as simple as the number of people killed or injured, and the number of bridges damaged. This was not the problem. There was difficulty in conveying an understanding of "maximum credible earthquake". As a guide to official action, the concept was not sufficient. The most frequent question asked was "When is the next earthquake?" What officials seemed to be seeking was a risk statement, such as probability of an earthquake occurring this year, or expected level of earthquake damage over the next 10 years.

Table 3

LEVELS OF INFORMATION

A Direct Damage	B Problems	C Deficiency
Number of Deaths	Need 800 body bags	Need body bag supply
Number of Injuries	Need 400 pints of blood within one hour	Need way of locating more blood outside area
Number of homeless	Number that will require shelter and feeding for 30 days.	Need to identify more shelter space
% impairment of fire stations	Number of unattended fires	Need way of getting X number of fire trucks from outside
% impairment of commo centers	Number of emergency calls not received	Need backup commo system
% impairment of State buildings	Vital State functions not performed	Outside teams of State workers must be identified
% impairment of radio stations	Number of people with no access to emergency information	Emergency information system needed
Number of bridges impaired	Number of families isolated	Need way of transporting panel bridges
Transformers damaged	Number of families without electricity for 15 days	More mass feeding facilities must be identified
Number of sewage line breaks	Number of families without sewers for 15 days	Need way of identifying location & transporting portable toilets
% classroom impairment	Reduction in shelter spaces available	Identify more shelter space
Tons of debris in streets	Vital access route blocked	Need to identify contractors with dozers

3. Was the report credible? Out of the hundreds of contracts we had, I can recall only one where the credibility of the report was questioned. This was from a soils engineer who felt that the liquification problem was not adequately considered.

4. Did the users know how to use the data? No. The cities and counties did perceive its usefulness in developing earthquake simulations. But the users did not have a methodology for discovering response deficiencies. This is much more difficult than the damage analysis. Damage analysis is dealing with a static situation with few interdependencies. It is an aggregation of what happens to individual structures right after the earthquake. The response environment is dynamic and interdependencies are the rule. Simulation is the easiest way to get at this. But the simulation must include all the relevant variables, and the results must be rigorously analyzed. Table 3 illustrates the problem agencies had in their analysis. Column A is what they got from the USGS report. Column C is what they needed to correct deficiencies. To arrive at C, intermediate result B must be developed. This is a translation of the damage statement to a problem statement; e.g., how many people will need shelter and mass feeding for how long?

5. Were they incapable of moving on to the other steps because of low level of motivation? This is not the motivation of the emergency services people so much as the political and administrative leadership. Even the analysis takes staff time. The leadership must agree that this is important before

it is done. One of the FDAA objectives for the hazard report was to provide this motivation. It did not provide enough. The critical lack of commitment to the project was at the State level. The Department of Emergency Services agreed at Step 1 that they would engage in a planning effort based on the report; and they accepted a Federal matching grant to do this. After prolonged negotiation on a work plan for use of the grant money, the State DES relinquished the grant, and decided to make no special efforts at earthquake preparedness. The reason given was that the State's general disaster planning was sufficient. As a consequence of this, there was no one to work with the cities, counties and State agencies. FDAA offered technical assistance (in the form of the time of one staff member); but this did not meet the need. Effort was also needed to encourage the local governments and State agencies--to provide additional motivation; State DES should have assumed this role.

B. The Need for an Intermediate Level of Analysis

This would be a level of analysis and information production between the physical scientists and the user. This would address the problem in question 4, and provide column B in Table 3. For the Federal efforts, the intermediate analysis was performed through the leadership of FDAA. Here is a place for management science and the use of social scientists. Notice this input is part of our model, although it did not take place to any extent.

The lack of an assessment of deficiencies at the local and State level precluded a complete analysis of Federal capability.

The Federal effort lacked knowledge of where the State and local efforts were likely to fail based on systematic analysis. Consequently, the Federal effort could get very little into substantive questions (e.g., how would the Federal agencies provide additional portable toilets), but dealt more with coordinative procedures. The Federal work was based more on the experience with local needs and deficiencies in past disasters.

C. The Need for Political Support

Even with an intermediate level of analysis, there is nothing to assure that the agency will go on to complete the process; i.e., select alternatives for solving the problems and implementing the solutions. There still must be attained a minimum level of motivation.

IV. LESSONS LEARNED AND IDEAS FOR THE FUTURE

A. For the future, we should prescribe an information flow model like that shown in Figure 2. This calls for an intermediate level of analysis, and the interjection of social and management science into the flow. It will cost perhaps more money and time. But it might be done for the same amount of money by narrowing the scope. We might have done a damage analysis just for metropolitan Seattle, and spent the savings for the intermediate level of analysis.

The intermediate level of analysis would contribute the following:

Management science	Response deficiencies Statements of risk useful to officials
Economics	Benefit/cost analysis--economic feasibility of alternative solutions
Political science	Political feasibility/strategies to gain acceptance of the information by users
Sociology/psychology	Translate damage estimates into estimates of people problems. Would be used in response deficiency analysis.

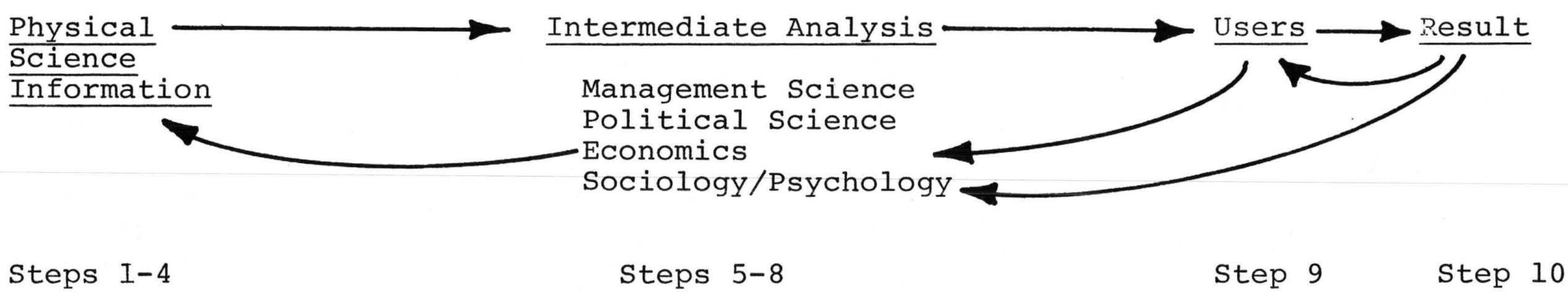
This new information flow model calls for an iterative process. The old model (Figure 1) is unidirectional--scientists to users to result. The Figure 2 model prescribes feedback loops. Although I would expect the feedback between the intermediate analyst and user to be most frequent, there would be requirements to go back to the initial information source--to get more information, to get interpretation of the information, to get qualifications of the information, to request more studies. This would mean a greater time commitment on the part of the physical scientist. He won't be able to simply turn over his report, and wash his hands of the project. He must remain accessible. This may mean that instead of one final report, as in the case of the Puget Sound study, there would be a series of reports; with each we would move closer to meeting the users total information need.

B. Users should be systematically polled on how they will use the information, and what information they need. There is a Catch 22 operating here. The scientists do not know what to study until the user says what information he needs. The user does not know what he needs until the scientist tells him what information he can provide. The iterative process allows for this. There must be a dynamic interaction between scientists and users.

C. Users should be required to commit themselves to the use of the information. USGS could require that users sign a contract to perform Steps 5 through 7. It might also help to have users contribute to the cost of the analysis. Then they would feel under an obligation to make good use of the information.

Figure 2

REVISED INFORMATION FLOW MODEL



THE COMMUNICATION OF INFORMATION FOR GEOLOGIC HAZARD MITIGATION-- THE COLORADO EXAMPLE

by

John W. Rold*

The first attempts at an overall program of geologic hazard mitigation in Colorado began in the late 1960's. At that time some 900,000 acres of land had been platted in essentially uncontrolled subdivisions throughout much of the State: the subdivision process had quietly and quickly leapfrogged from the flat-lying areas of the State into remote mountain and recreational subdivisions. The problem of fly-by-night out-of-state land sales schemes and disgruntled customers was burgeoning. Serious geological problems were existing or imminent in many subdivisions. Numerous factors contributed to the realization that geologic factors were quite important in a concerted effort to achieve a solution to the problem. The geologic profession was awakening to the new specialty of "environmental geology" and personal involvement in public decisions. Nationally, there was a widespread awakening to environmental awareness. Many people and industries alike were beginning to become aware of and utilize a land use stewardship ethic. The major South Platte floods of 1965 and 1969 created the awareness of actual and potential hazard impacts from geologic processes. California's severe problems during the storms of 1969 received wide publicity and the San Fernando earthquake of 1971 was fresh on people's minds. Through much of this critical period Colorado was still one of only three states in the nation that did not have a State Geological Survey.

The entire process of utilizing geology in public decisions began in the late 60's, is continuing to the present, and will certainly continue into the foreseeable future. Some definite milestones which can be noted along the

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*Director and State Geologist, Colorado Geological Survey

route would include the establishment of the Colorado Geological Survey in February of 1969; The First Governor's Conference on Environmental Geology sponsored by the A.I.P.G., A.E.G., and the Colorado Geological Survey in May of 1969; the Legislative establishment of the Colorado Environmental Commission with two geologist members in 1970; the establishment of the State Land Use Commission in 1971; the passage of SB-35, a stringent subdivision law which required the analysis of geological factors in 1972; and the passage of House Bill 1529, a mineral resource preservation and mined land reclamation act in 1973. In 1974 two far-reaching laws were passed by the Legislature--House Bill 1041 that charged local governments with responsibility to identify, designate, and regulate areas of state interest, specifically including geologic hazard areas. The law gave a detailed, legal definition of a series of geological processes or conditions which could be hazardous to the safety and welfare of the citizens. These were: landslides, avalanches, rockfalls, mudflows and debris-fans, unstable or potentially unstable slopes, seismic effects, radioactivity, ground subsidence, and expansive soil and rock. The law also charged the Colorado Geological Survey to write a model regulation for the identification, designation, and management of geologic hazard areas. In the same session House Bill 1034 specifically gave cities and counties the authority to consider geologic hazards in any land use decision making. House Bill 1041 further charged the Colorado Geological Survey to write, publish, and distribute "guidelines and criteria for identification and land use controls of geologic hazard and mineral resource areas." Such a publication was prepared and five hundred copies were distributed free to city, county, and state regulatory agencies. Approximately a thousand additional copies have been sold. The well-received publication has become nearly a bible of geologic factors for land use decision-makers in the State.

In short, the objectives of the new attention to geology-related land use problems were to provide for safe, economical, and efficient utilization of Colorado's land and natural resources through the recognition, mitigation, or avoidance of geologic hazards (geological processes which would be adverse to man's activities). Saying it another way, Coloradoans were concerned and wished to assure a high "quality of life" for themselves, their children, and future generations.

The strategies used by the geological community to accomplish the above objectives were to provide geological information in such a manner that it could be understood and utilized, and where such geologic information was not available, make certain that it was developed and utilized in land use decision making. In order to make certain that the needed geological information was utilized or derived for critical land use decision making, several critical statutes were passed. Continuing personal and professional involvement by geologists from various organizations helped to focus attention on geologic problems and their solutions and made sure that those important factors were not swept under the rug.

Numerous members of the geological profession working through the American Institute of Professional Geologists (now called the Association of Professional Geological Scientists) and the Association of Engineering Geologists, first worked to create and give a meaningful charter to the Colorado Geological Survey. Later, in concert with the Colorado Geological Survey, the message was carried to members of the Colorado Legislature. Other agencies which worked in various manners at various times were the State Land Use Commission, the State Division of Planning, and the League of Women Voters. The City of Boulder was the first municipality in Colorado to utilize a staff geologist when it hired a part-time graduate student in 1971.

Although several geologists employed by the United States Geological Survey were quite active and effective in many different facets of the activity, the USGS at first officially took no part on the firing line. That statement does not minimize their role as an information producer. Published USGS maps and information in some instances, such as the Front Range Urban Corridor and their engineering geology maps, were quite beneficial. Other more classical geologic reports were almost useless to the normal land use decision-maker.

After the Colorado Geological Survey was created and particularly because of its unique charges to "provide advice and counsel to all agencies of state and local government on geologic problems" and to "delineate those areas of natural geologic hazard which could affect the safety of and cause loss to the citizens," it became a spokesman for the movement as well as a lead agency.

An incident in 1969 which seems to me to be a milestone in the movement, bears recounting because it illustrates several successful principles. The late Max Gardner, a young engineering geologist with the U.S. Geological Survey, arranged for an opportunity to present testimony to an interim legislative committee on parks and recreation. Max was a personal friend and constituent of Senator Joe Schieffelin, the chairman of the committee. Max was to present testimony concerning geologic factors which would affect land values and site selection for future state parks. Max contacted me for help and together we put together a slide show illustrating many of the principles and the problems. Of even greater significance, we were invited to accompany the committee that afternoon on an inspection tour of several parks and park sites in the Denver Metropolitan and Front Range areas. With the committee as a captive audience in a Greyhound bus with a speaker system, Max and I guided the driver past many excellent examples of geological problems and numerous geological hazards. Senator

Schieffelin was so impressed with those examples that he became a convert to the concept that geology was important in land use. He was one of the architects and sponsors of Senate Bill 35 and other ensuing land use legislation which legalized and required the consideration of geologic factors.

It is dangerous to build lists of people who were active in promoting the utilization of geology because the list is long and many names would be forgotten or could not be included. However, two geologists who were in the Legislature at that time, George Fentress and Larry O'Brian, should be specifically mentioned for their efforts in promoting the utilization of geological information and its inclusion in land use legislation. Ray Robeck deserves a special mention as a tireless and hard-working volunteer lobbyist for the American Institute of Professional Geologists during that critical period. An actual list would include scores of geologists, legislators, planners, politicians, and concerned citizens throughout the State who contributed time and effort towards formulating, legislating, and implementing geologic aspects of land use policies. Fortunately, the efforts to pass land use legislation and to include geologic factors in such legislation were blessed by the Governor as well as the leadership of both political parties in both legislative houses. We were extremely fortunate that party politics never became involved in the geologic aspects of the legislation.

Several critical scientific, legal, political, and other problems had to be resolved. First, there was a definite lack of environmental geology expertise within the profession of geology here in Colorado. There likewise was a very definite lack of environmental or engineering geologic maps or other data which could be utilized for land use decision making in the State. There was a lack of understanding by decision-makers and geological professionals alike about geologic impacts on man's activities. There was a lack of legal definition of those geological processes which are potentially adverse to man's activities and that can be classified as hazardous. There was a definite lack of legal authority to require the consideration of geological and other technical information in land development and public decision making. Numerous people objected on philosophic, economic, and political grounds that the utilization of geologic or hazard information would be an infringement upon their personal and property rights. There was a definite fear by land owners and developers that geologic hazard area information would decrease land values. A fear existed that costs of geologic investigations in the early stages of a project would outweigh its benefits. Regrettably, considerable inter-professional jealousy arose between engineers and geologists. A constant, continuing problem is the turnover of administrators, particularly planning staffs and elected office holders both on county and state levels. Education, therefore, must be a continuing process. Phil Schmuck, Director of the State Division of Planning, has often stated that the "half-life of a good planner is two years."

The major strategy for resolving these critical issues was education. Many times this education had to be approached with almost missionary zeal. One had to demonstrate that geological information would save money, would lessen development time, provide a better, more efficient development and a better end product for the consumer. Geologists needed to be educated in the mechanics of land planning and planners had to be educated to the need for and the value of geological information in making their work more effective. Finally, a strategy had to be devised which would provide for the derivation or acquisition of usable, understandable geological information. We had to acquire the legal authority to require the utilization of that information by encouraging introduction and passage of needed new legislation.

Numerous component parts of the information-communication model were utilized in the activity. First and probably most important were personal contacts. Slide shows utilizing geological examples were utilized widely and very effectively. Testimony was presented to numerous legislative committees on a state level and to county commissioners and city councils. Numerous talks utilizing Kodachrome slides were delivered to professional geological groups, other professions, and service clubs. Film strips or canned talks were not utilized. Newspaper coverage was utilized on specific problems. Formal publications were written and distributed. Formal conferences and workshops with audiences of 100 to 300 people were utilized three to four times a year. Smaller informal conferences and workshops were held on numerous occasions. Field trips were conducted in many areas of the state for local planning commissions, staffs, and county commissioners. An especially effective but time-consuming strategy was to go to a town, put on a meeting in the evening for county commissioners, planning commissioners, and the public; then the next day conduct a geologic hazards field trip through their own area. This strategy was utilized numerous times. Correspondence and telephone communications were utilized in many instances. Press and media coverage were cultivated only in a few specific instances. One case which was quite successful occurred after the Big Thompson flood. The Colorado Geological Survey headlined a discussion on the problem of other hazardous canyons in the Front Range with the title "Nature's Top Ten Hit List." Press and public reaction was immediate, favorable, and widespread. Unfortunately, the funding for a program to evaluate those hazards did not materialize, but an increased public awareness of the problem did result.

An early example of unsought publicity was the proposed Marble ski area. A major ski and recreational development was proposed in an area of obvious, well-known, major mud flows, landslides, unstable slopes and snow avalanches. The

Colorado Geological Survey's objections fueled a heated controversy which raged in the press, television, and radio for many months. Local government, several state agencies, the fledgling Colorado Geological Survey, and the developer experienced more heated publicity than they bargained for. Environmental, water, legal, economic, and political factors all contributed heavily to the failure and ultimate bankruptcy of the development. However, geologic problems were the first and most dramatic issue raised and remained dominant in people's minds. An awareness of the importance of geologic factors and a grudging but widespread respect for the Colorado Geological Survey were forged from this crucible of controversy. For several years the bare mention of Marble would cause a developer or local government official to grimace. Even yet developers and local governments take extra pains to avoid involvement in a similar exercise.

Evaluation of the information and communication activities reveals a definite relationship between people and activities. Adequate discussion of the specific requirements for information by each and every member of the information producing or user-community would exceed the length of this paper. Both the producer and the user had to become familiar with and be able to produce or use geologic maps and geologic reports, as well as evaluate oral testimony at hearings and written recommendations. The user-community had to develop an understanding of when geologic information was important and where and how it could be obtained. The producer-community had to realize what type of geological information was appropriate for the specific land-use decision and what type of geological information would be utilized by these decision-makers. Many times the problem could only be solved by personal one-on-one communication on the ground with a field investigation of the specific sites in question. This was particularly true on highly controversial issues and situations which had to be resolved by a lay board of county commissioners, city council, or planning commission.

Most of the time two way communication was achieved but not always. <u>This communication was achieved best and predominately through a one-on-one situation.</u> This could entail personal visits, phone calls, and sometimes even by letter, but establishment of mutual rapport nearly always requires the personal touch. Excellent two way communication was achieved in several conferences and workshops. Four separate Governor's Conferences on Environmental Geology were held throughout the State with definite goals of involving planners, county commissioners, and city council members. A continuing education workshop to train geologists and engineers in the preparation and presentation of geologic information for land use decision-makers was quite successful and useful. In nearly every case two way communication only resulted when credibility was either accepted or could be rapidly established with the persons or agencies involved. Many times we were able to educate and then aid and utilize converts within the various user groups. The success of these converts in their particular jobs was many times an excellent example for their colleagues to follow. In all cases it was important for the user to feel strongly that the agency or person who was providing the geological information or the geological recommendations would be there in his support when the intense political heat was encountered as a result of some decision.

There was no formal focal point or information center involved in the efforts, however, the Colorado Geological Survey actually evolved to fill that purpose.

There was no special public relations or public media program. The Colorado Survey early on established a firm policy of being open, candid, frank, and helpful to all members of the press. The media were alerted on specific cases and specific problems and nearly always gave objective and fairly accurate treatment to the subject.

Standard or existing channels for communicating information were not completely adequate but no new communication channels were created or used.

There was a definite need which still exists for an intermediary individual or group to act as translator in the communication process. One must be able to bridge the gap between the information producers and the information users. This is particularly true when the information is either classical geological data or was not produced with the specific user's need in mind.

Proper information did not always get to the concerned user in a timely manner. This was caused partly by lack of staff in the Colorado Geological Survey, and was sometimes caused by a lack of adequately experienced geological consultants which could be utilized by the clients. Much of the classical geological information had to be reworked to be useful. No geological information, however, was ever completely useless unless it was completely erroneous.

The success of the information communication was not monitored or followed up adequately. Usually the problem was due to insufficient Colorado Geological Survey staff or time for adequate follow-up. The best communication monitoring again was on a one-on-one basis or when a written recommendation to a county commission or planning commission could be delivered in person with personal testimony during the hearing. Obviously with 63 counties and over a hundred municipalities this was impossible in most instances.

The particular strengths in the program were the credibility established and enthusiasm of the workers--a willingness to go one-on-one or one geologist versus an entire audience (sometimes openly hostile) in meetings throughout the State. This required long travel times and long hours. Strengths were that usually the language and the points made were pertinent to and understandable to the users. Fortunately geology in Colorado is quite important and fairly obvious. Most of the general public has some knowledge and awareness of geology. Geologic processes in many cases are fairly obvious and sometimes even exciting. Even lay persons, when geologic processes are explained to them, became quite excellent observers and were able to note those processes themselves. Fortunately, we were able to develop and utilize a large group of people including geologists who might be oil or mining specialists and even lay persons throughout the State who became almost an intelligence organization to report back to us on interesting or unique geological problems. Quick response to this information tended to strengthen a good information network and provided an excellent means of staying abreast of geologic problems as they occurred.

The weaknesses were inadequate personnel and inadequate budgetary support. Unfortunately, there was a tremendous user turn over of planners. Politicians and even community leaders seemed to be in a constant state of change. With distances and time involved it was not always possible to contact the required people and make the necessary meetings. Many times important decisions had to be made before adequate information could be developed.

The activity was not a pilot project--it was a real life project in the full sense of the word. Certainly the activities could be utilized as a model for information-communication. In general the Colorado experience has been quite successful.

Numerous lessons could be learned from the evaluation of this experience. First, one should understand the extreme importance of developing and maintaining credibility. The value of one-on-one communication, particularly on the ground where the example can be explained and shown to the user, should not be underestimated. The producer agency must be able to respond quickly to those cries for help. Maintaining communications is a continuing effort. It is extremely important to establish a linkage with those resident professionals on the ground in an area, whether they be geologists, engineers, or planners. It is important to acquire and utilize converts throughout the State. An agency cannot stand on formalities but must respond quickly and directly. An agency must maintain and constantly demonstrate an attitude of attempting to aid and help local governmental agencies rather than a posture of dictating to them. It is most important when they have made a decision based on your advice to give them adequate back-up, including oral testimony at all key hearings and other meetings on the matter.

Decision-makers were aided by the activity in many different ways. Many realized that they were able to make better decisions; that they were able to save their constituents both money and time. Many times geological information gave technical back-up for their decisions. Most decision-makers realized that geological information resulted in safer, less costly, more efficient developments and resource utilization.

Legislation not only resulted as a consequence of the activity, but was part of the activity. Legislation itself was a communication method by legally requiring that the information be utilized.

<u>REFERENCES</u>

Association of Engineering Geologists, American Institute of Professional Geologists, and Colorado Geological Survey, eds., 1970, Proceedings of the first Governor's conference on environmental geology, 1969: Colorado Geol. Survey Spec. Pub. 1, 78 p.

Colorado Revised Statutes 1973a, sec. 24-65.1-101, et seq. [House Bill 1041, 1974]

_____1973b, sec. 29-20-101, et seq. [House Bill 1034, 1974]

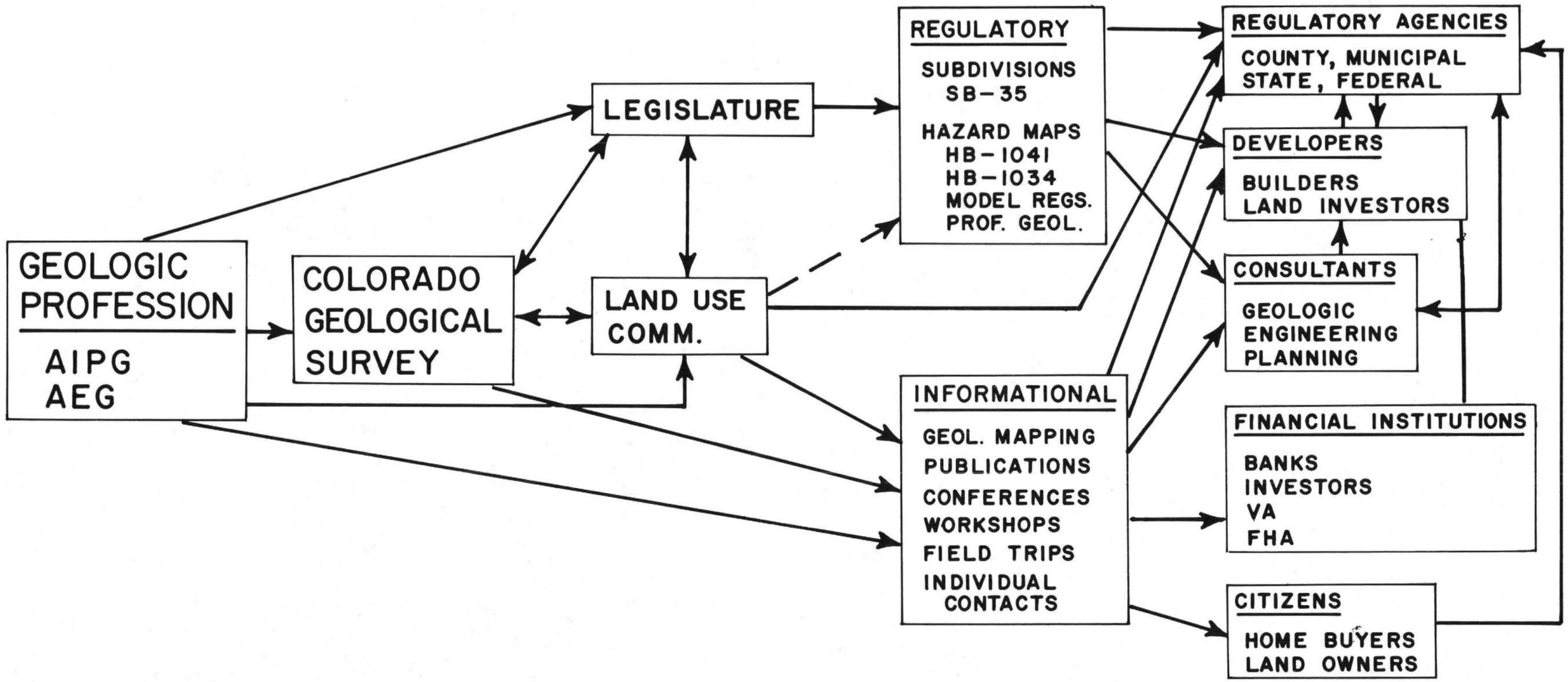
_____1973c, sec. 30-28-101, 110 (3)-(5), 133-137 [Senate Bill 35, 1972]

_____1973d, sec. 34-1-101, et seq. [House Bill 1282, 1967 and House Bill 1574, 1973]

Ladwig, Lewis R., 1975, Colorado land use laws and engineering geology--a working relationship, <u>in</u> Proceedings of the third annual engineering geology and soils engineering symposium: Idaho Transportation Dept. et al., p. 211-218.

Rogers, W. P. et al., 1974, Guidelines and criteria for identification and land-use controls of geologic hazard and mineral resource areas: Colorado Geol. Survey Spec. Pub. 6, 146 p.

Shelton, David C., ed., 1977, Proceedings Governor's third conference on environmental geology--geologic factors in land-use planning--House Bill 1041: Colorado Geol. Survey Spec. Pub. 8, 111 p.



INFORMATION AND ACTIVITY FLOW DIAGRAM
OF
GEOLOGIC HAZARD MITIGATION IN COLORADO

REGIONAL EARTHQUAKE PLANNING IN THE MISSISSIPPI-ARKANSAS-TENNESSEE AREA

BY

O. CLARKE MANN*

1.0 INTRODUCTION

1.1 Communications

Communications in a democratic society are an art. Yet if our society is to function well, we of the technical world must learn the art of communications with the whole of society no matter how difficult it is. In this paper we will report how an experimental communications structure was used to guide a seismic safety program for Memphis, Tennessee.

1.2 Seismic Mitigation Communications

Communications on seismic safety are particularly difficult. This was stated very well in the record of a workshop for land planning held in San Diego, and we quote ......

> "Mitigation is not an obvious problem without frequent seismic events. When community awareness is low, then implementing mitigation plans becomes extremely difficult."

* CONSULTING ENGINEER

Further proof of the difficulty of mitigation communications is to be found in the number of plans gathering dust on the shelves of planning agencies throughout the land.

1.3 Communications Responsibility

It is perhaps correct to say that the largest share of the responsibility for better earthquake hazard communications rests on the technical community. The leaders of this conference should be congratulated for their vision and courage in identifying the communication problem and convening this workshop. On behalf of MATCOG, regional planning agency for metropolitan Memphis, we are pleased to participate in and hopefully contribute to this communications study effort. Perhaps here, in this workshop, the rudiments of successful communication can be defined and if so, substantial progress toward seismic safety will have been made.

2.0 MATCOG SEISMIC PROGRAM

2.1 Scope

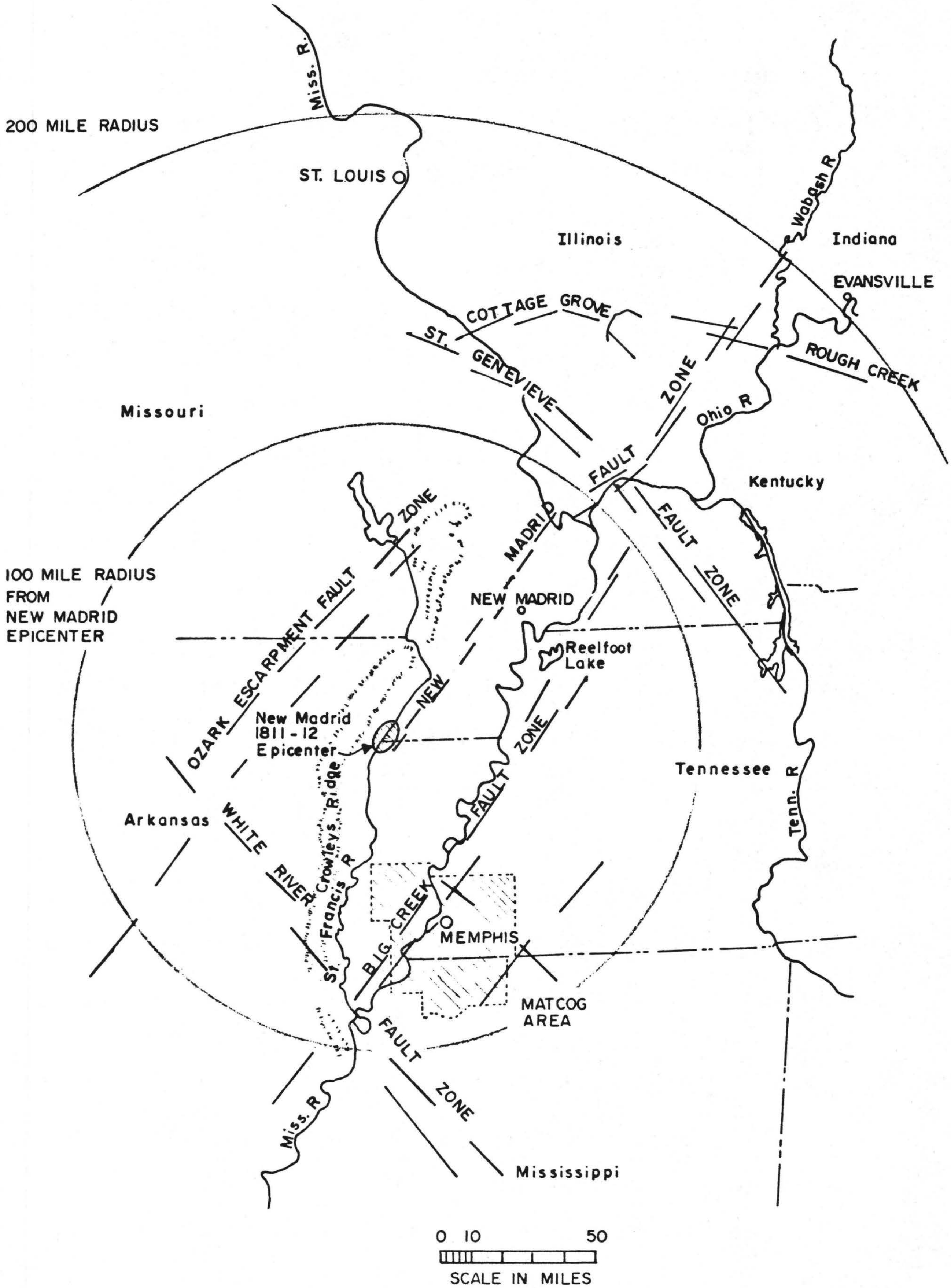
The MATCOG program, referred to throughout this paper, is a long range plan to improve the seismic safety of the metropolitan Memphis region. It is expected to ultimately embrace improvements in building seismic resistance, life line systems, planning regulations and disaster recovery plans.

2.2 Regional Seismicity

The MATCOG region is located less than 100 miles from the epicenter of the New Madrid earthquake of 1811-12 as shown in Fig. 1. The major center of population is the city of Memphis which lies along the river bluffs. These bluffs are underlain with sand, and they have a history of sliding even in the absence of earthquakes. Even when surrounded by such hazards, the city has no seismic requirements in the building code. There are no seismic constraints in the city planning regulations and, until recently, emergency services (police-firemen) had no earthquake response plan. Very few buildings and no life line systems have been explicitly designed to resist seismic loading and most people, until recently, looked upon earthquakes as something that happens in California.

2.3 MATCOG Seismic Action

Into this arena of high seismic risk and against deeply rooted public apathy, MATCOG administrators launched their seismic safety program in 1972.



NEW MADRID REGION

FIG. I

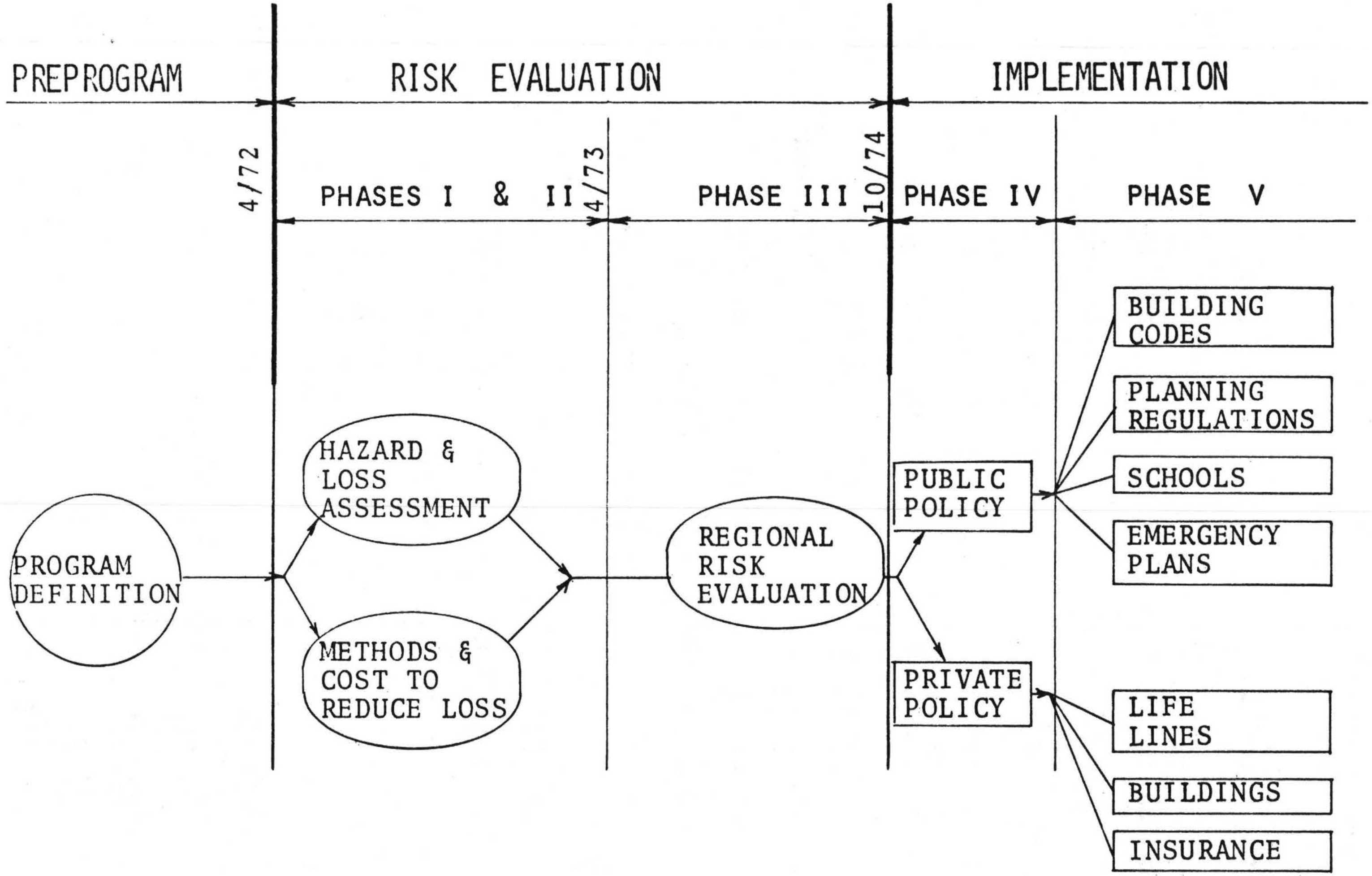
2.4 MATCOG Plan Background

Our firm had, in the early 1960s, developed an analytical approach to decision making related to aseismic structures that used "trade-off" or "benefit-cost ratioing" as a decision tool. We had found that a unique relation could usually be found between the cost to make a building stronger and the reduction in losses expected for a given set of earthquake intensities. By examining a reasonable set of strategies, one could find that strategy which promised the best payoff. Decision makers in industry had responded favorably to the results of such a rationale, and it occurred to us that it might prove equally useful when applied to the broader questions before the city planners and those responsible for public safety. If it could be shown that the cost to strengthen buildings would result in a positive payoff for the community, we reasoned that much of the opposition to aseismic requirements could be overcome.

2.5 MATCOG Plan

In 1972 a pilot risk evaluation program for a small community was carried through by our firm and the program appeared feasible. During the same period MATCOG found that HUD,[*1] the City of Memphis and the County of Shelby were seriously interested in such a planning program. Our firm then developed a full scale program that embraced the entire metropolitan area, and the essence of the program is shown in the Function Flow Diagram in Fig. 2 . The program was made up of a Risk Evaluation phase and an Implementation phase and work on the first part began in 1972 and was completed in 1974. The program is viewed by most people as a

*1 HUD - U.S. Department of Housing and Urban Development



FUNCTION FLOW DIAGRAM

MATCOG SEISMIC SAFETY PROGRAM

FIG. 2

successful start toward seismic safety, but it must be said that there is still much to be done before improved seismic safety becomes a reality.

2.6 Progress To Date

Progress toward a reasonable level of seismic safety rested first in establishing that a substantial risk did in fact exist. The results of the evaluation indicated clearly that a major earthquake would be catastrophic unless occupancy of very weak soil areas were restricted and stronger structures were constructed. The risk rested heaviest on the school population where 20% of the population would suffer 65% of the deaths. The implementation of Zone 3 UBC requirements through the building code indicated that substantial reductions in losses could be effected. The cost analysis was encouraging since it indicated clearly that attractive B/C ratios existed if stronger structures were built.

2.7 Public Response To MATCOG Plan

The public has been, in general, responsive in recognizing the seismic risk but broad support for an aseismic program has not yet been generated. Presentations made by MATCOG staff and consultants to many groups, indicate an active interest in knowing the level of risk and what can be done to reduce it. The demand for copies of the risk report have far exceeded the number available. In order to accommodate requests and to maintain communications with the interested public, the full report was summarized in non-technical language by the MATCOG staff and published in a short booklet. Request for both the full and abridged reports continue and far exceed funds for printing.

2.8 Private Sector Action

Information from the program on the level of risk has reached the private sector. Some decision makers have responded positively and aseismic structures have been built and more have been authorized. The news media has given responsible and informed coverage to both aseismic planning activities and earthquake reporting.

2.9 Public Sector Action

When the risk report was completed in 1974, it was adopted by MATCOG as their recommended planning policy. The report was then distributed to officials in City and County governments with MATCOG's recommendation for implementation. Unfortunately, in the public sector, city councils and county courts have not yet adopted any positive seismic policies. To date there are still no building code or planning regulations on seismic and we believe it is correct to say that no policy or implementation initiative currently exists within these bodies. The school executives have been repeatedly advised of the scale of their risk and all outward evidence indicates a totally negative attitude. But, fortunately some improvements in safety are evolving. The Civil Defense adopted a seismic element and, during the last year, earthquake simulation exercises have been held to test and refine the response plan.

2.10 Future Actions

While progress is encouraging in certain areas, it is unquestionably true that communications with decision makers, especially in government, must be improved if seismic safety is to become a reality.

3.0 COMMUNICATIONS DURING THE REGIONAL RISK EVALUATION

3.1 Communications During Risk Evaluation

The communication activities that are likely to be of interest to this group occurred in the final stages of the Risk Evaluation. At that time it became clear that a major communication gap existed between the risk investigators and the public and that the gap was great enough to threaten the entire program. In the following paragraphs we will describe the communication problem and how it was solved.

3.2 Early Public Response

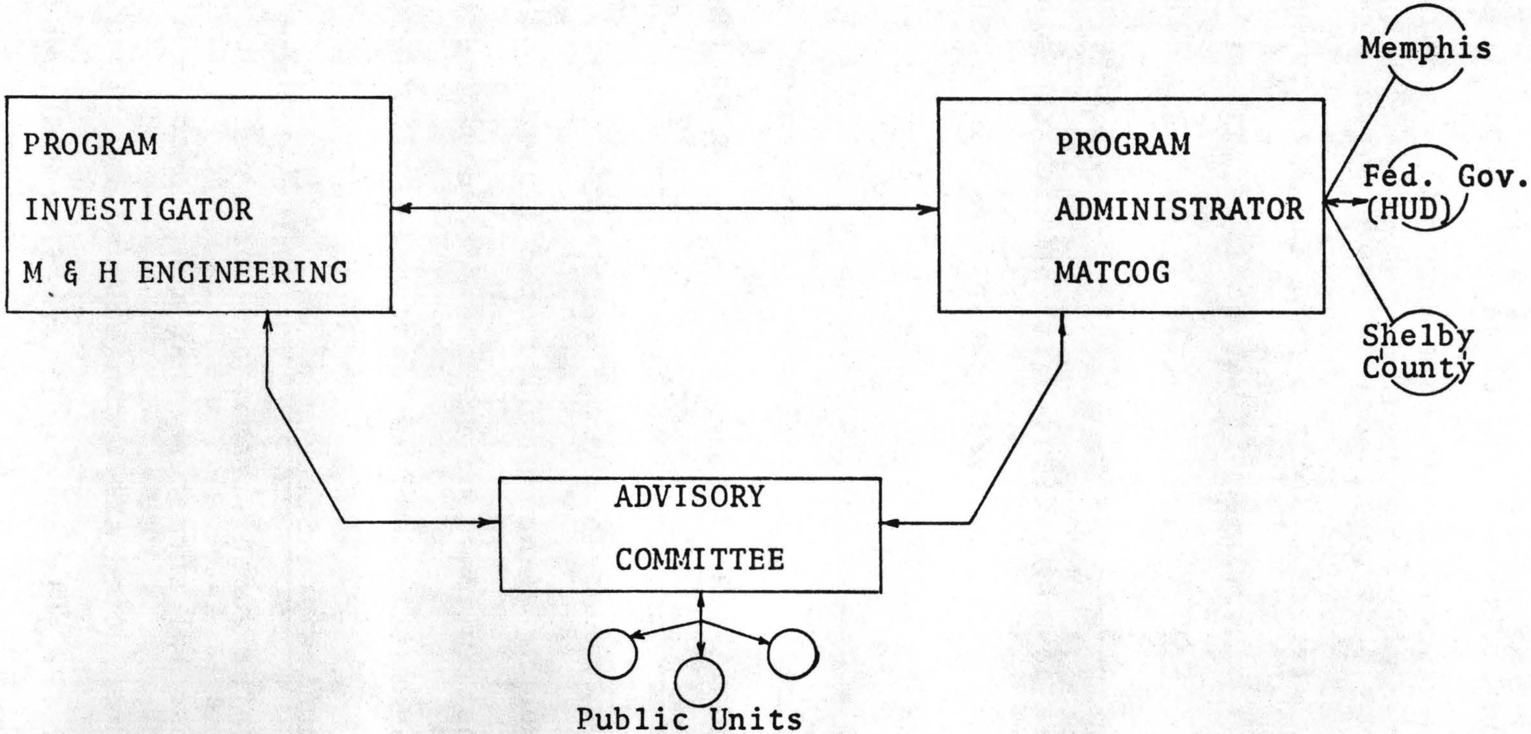
As the loss assessment by the investigator began to firm up, preliminary estimates of property losses of $1/2 billion and 650 deaths were seen as reasonable expectations. The investigator and administrator became increasingly aware that such risks to life and property were much heavier than anyone had expected and should be reported to the public. Preliminary reports were given to the public through speeches before engineers, architects, planners and other decision making groups. The response from many people in the design professions and from investors in property were found to be strongly negative. These responses indicated that under existing conditions and attitudes an influential segment of society would be likely to reject any meaningful seismic safety proposal as too complex, too expensive or still worse, as "work-makers" for the construction industry.

3.3 Response Testing Environment

In the light of these public reactions, it became increasingly apparent that a public response sensing strategy and possibly a public relations strategy must be added into the program, or public rejection of any effective seismic plan was inevitable. After examining a number of options, it was decided that a "testing environment" must be created - a small scaled situation in which response to a proposal could be tested without risking the defeat of the total program. A communications unit in which the public, program administrator and program investigator were represented and in which a meaningful bilateral dialogue could be cultivated, appeared to be the most promising option. Such a unit was made possible through the formation of an advisory committee which MATCOG impaneled through invitations to major decision making groups. This committee was a broad based group drawn from the city building department, county building department, civil defense, Red Cross, planning agencies, Corp of Engineers, public utilities, financial institutions, police and fire departments, design professions, universities and building associations.

3.4 Microcosmic Communication Structure

The advisory committee, the administrator and the investigator provided a microcosmic social structure that functioned as a central communication core and reflected the technical and lay communities. The communication lines for this core unit are flow diagramed in Fig. 3. This core group, in addition to being somewhat self-contained, had contact with the lay community, the governmental units and the technical world making it possible to reflect a broad range of views.



COMMUNICATIONS FLOW DIAGRAM - PHASE III

MATCOG SEISMIC SAFETY PROGRAM

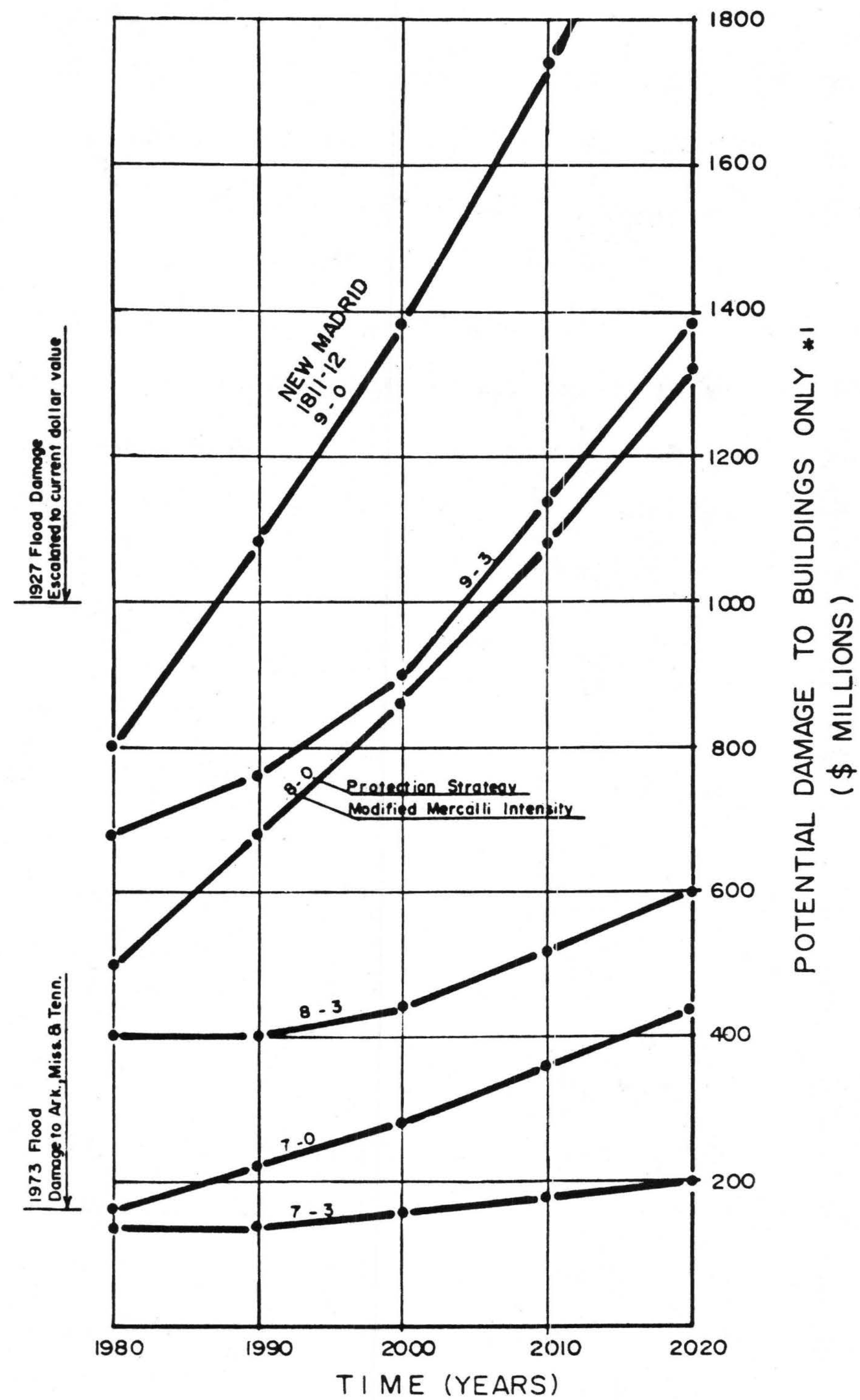
FIG. 3

3.5 Early Stage Micro Communications

Communications with the new committee were approached with considerable care. It was realized that emotions play a vital role in nontechnical thinking, and we had already seen how fear of excessive building cost could form a barrier too great to be scaled by reasonable discourse. After considerable discussion, it was decided that a "go slow" educational approach would create the best atmosphere for a bilateral dialogue. Each month a meeting of the advisory committee, administrator and the investigator was held. The early meetings were devoted to technical reports by the investigator and program descriptions by the administrator. In the first meeting the seismic history and geology of the area were discussed in laymen's language. This discussion served to acquaint the committee with the magnitude of the 1811-12 earthquake, the nearness of the New Madrid and other faults (Fig. 1) and the nature of the local soils. Also the committee was given reports of damages from previous earthquakes, especially San Fernando, which was fresh in everyone's mind. This provided a forum in which the seismic weakness of different types of construction could be discussed and failures illustrated with both reports and photographs. Questions from the advisory committee were encouraged in an effort to establish as early as possible a bilateral dialogue. The working relations thrived and soon the meetings transitioned into a fertile flow of "questions and answers". After about three months, a response-testing capability had evolved.

3.6 Micro Communications - First Iteration

When estimated damages to property were completely developed, the losses were far greater than we had expected. Remembering the strongly negative public response to preliminary reports, it was decided that tests of laymen's response to the final loss estimates were vitally needed. The loss information was presented to the advisory committee in a manner that allowed us to handle the advisory committee responses using a modification of the Nominal Group Technique method of evaluating subjective thinking. They were given the expected losses for 1980 through 2020 as shown in Fig. 4. For example, if the 1811 earthquake should recur in the year 1990 the property losses to buildings alone (no contents losses) would exceed $1 billion. They were then asked to give their reactions in an ordered group of responses. The committee's responses were a revelation for us - they varied from acceptance to surprise to confusion and to disbelief. (We have seen similar responses many times from other groups.) Even though the advisory committee had the benefit of hearing about and discussing the seismic history



*1 Increase damage values by 50% to approximate building plus contents damages.

DAMAGES TO BUILDINGS

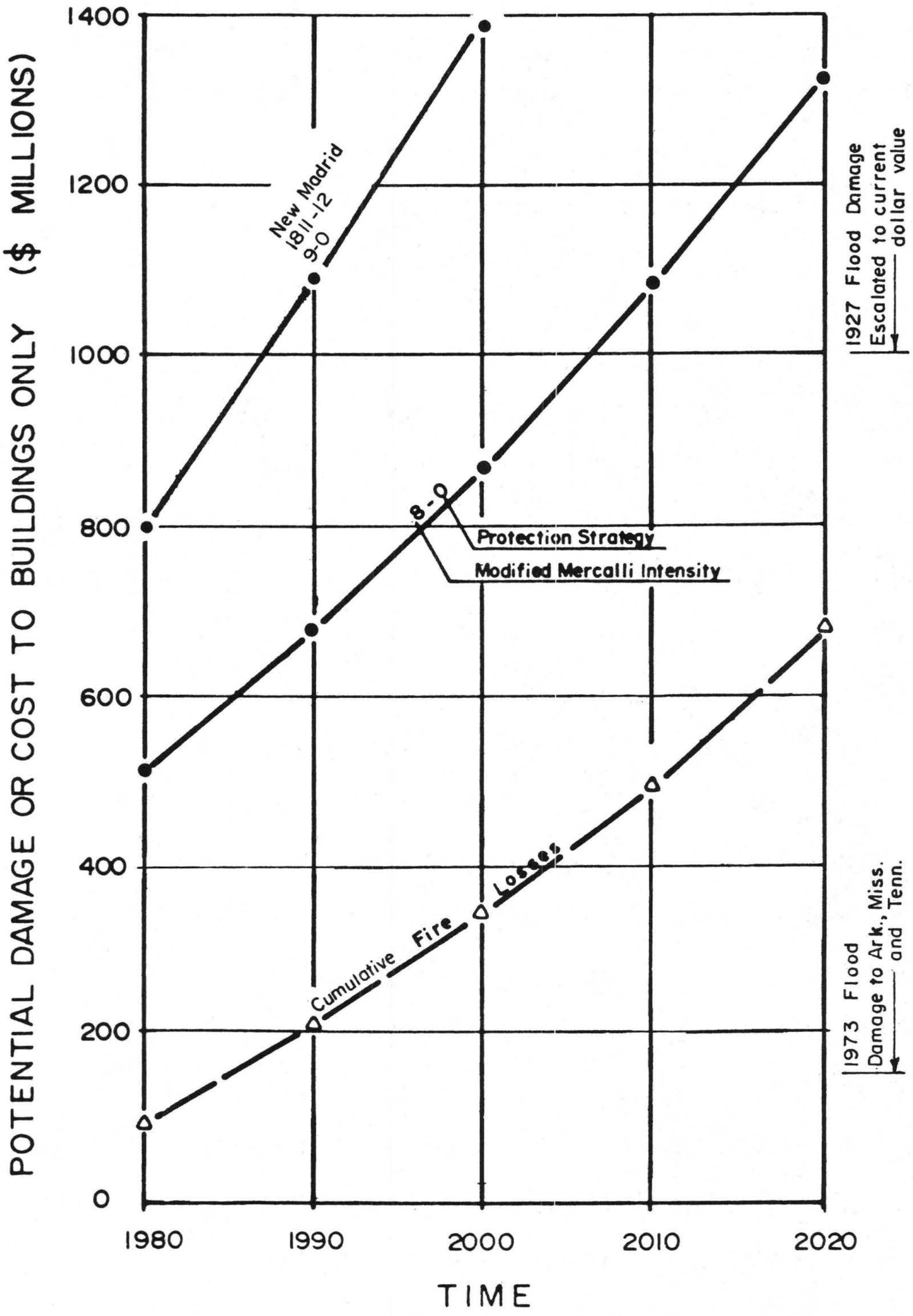
FIG. 4

and geology of the area and knowing how these estimates were derived, it was clear from their reactions that communications had not been accomplished and that no affirmative decisions could be expected to follow unless a higher level of understanding and credibility could be achieved. The advisory committee's response sounded a clear warning that the "sale" had not been made using $ losses alone as the communication vocabulary. Their responses showed that raw numbers alone were not an adequate communication in a field new to the subjective mind. After listening to the advisory committee's comments and questions, we decided to place the losses in broader perspective and to reiterate.

3.7 Micro Communication - Second Iteration

For the second iteration, the losses were presented in comparison to events with which people are familiar and against which they have been somewhat successful in protecting themselves. The worst flood in Mississippi River history, 1927, had caused a total damage of $1 billion[*1] throughout the Mississippi and Ohio River Valleys as in Fig. 4. This loss was about equal to that which Memphis alone would suffer if the New Madrid earthquake would recur. Everyone accepts the need to protect against floods by building levees and dams. These protections are considered feasible when they exhibit a B/C ratio of 1.0 or more. Fire losses were then presented which by the year 1990 are expected to total $200 million (Fig. 5) 1/5 of the earthquake losses should the New Madrid earthquake recur. No one questions that these fire losses will occur or wishes to disband the fire department and cancel their fire

*1 in 1975 dollar values



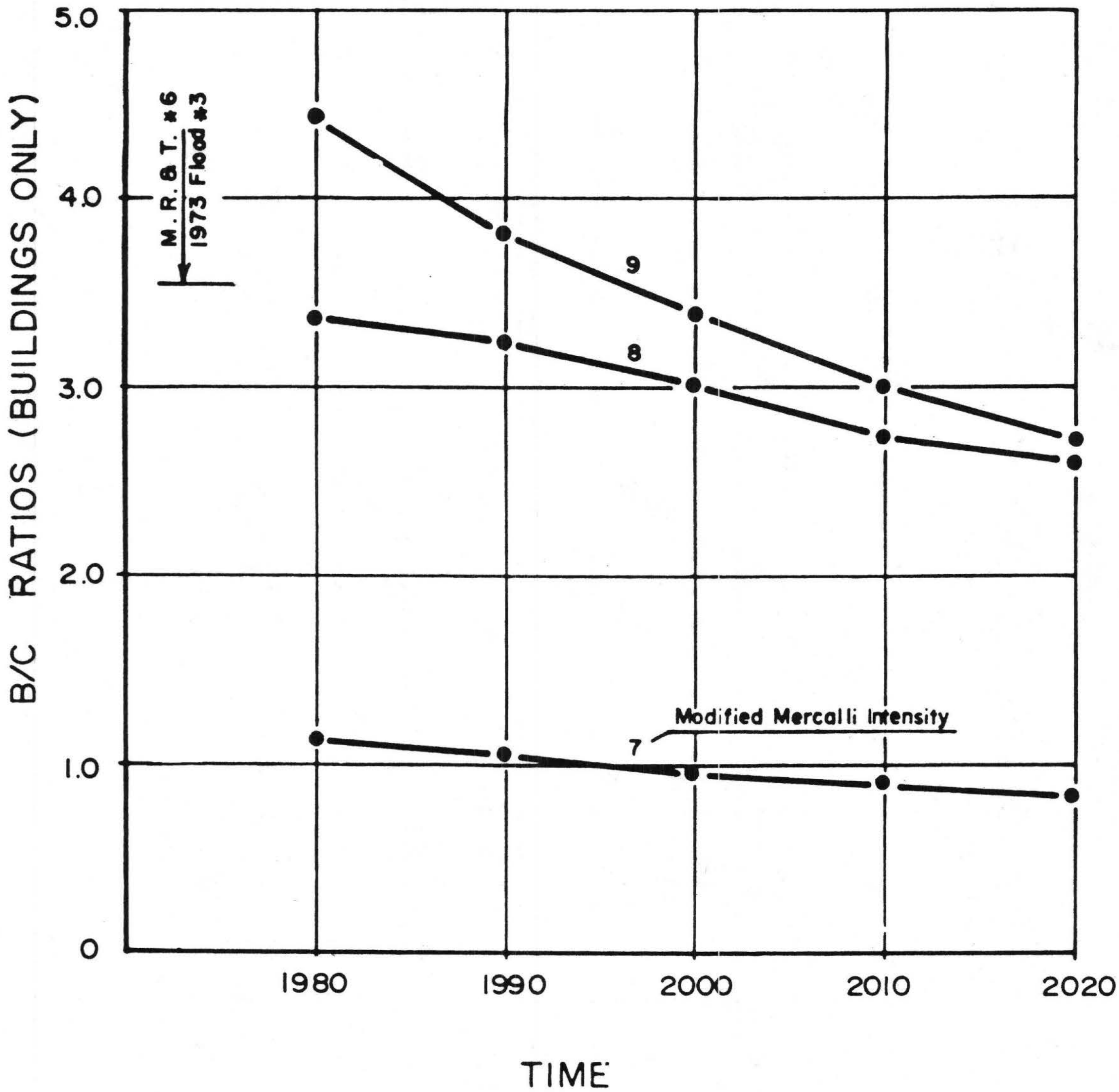
COMPARATIVE LOSSES

FIG. 5

insurance. Next B/C ratios were calculated using the benefits to be expected if new structures are built to UBC Zone 3 requirements. The analysis indicated that B/C ratios in the range of 2.5 to 4.5 were expected as in Fig. 6. The advisory committee's response to the earthquake loss estimates changed from negative to positive when seen in comparison with flood, fire and favorable B/C ratios.

3.8 Micro Communications on Life Losses

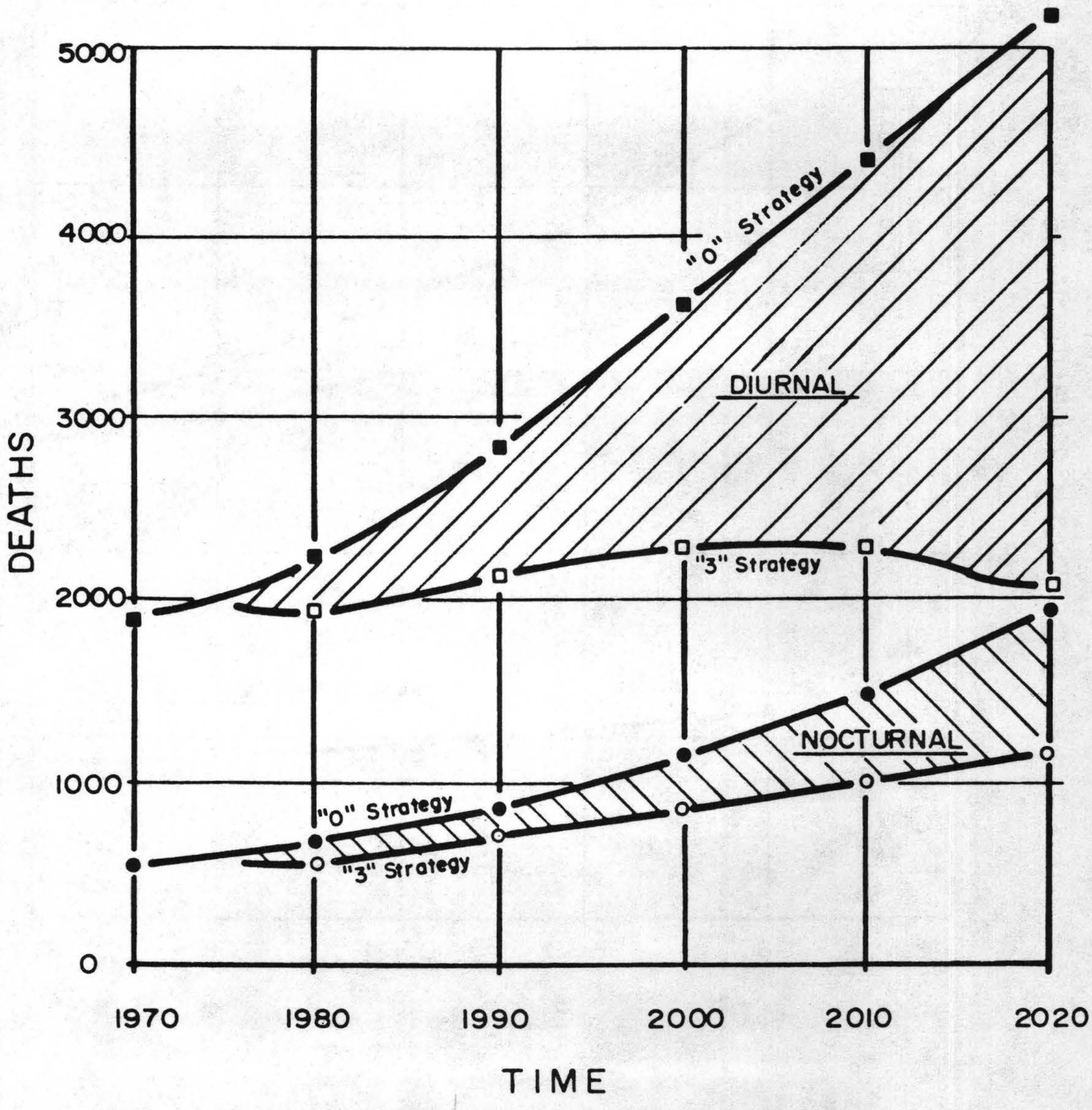
When life loss estimates were completed, they also far exceeded our earlier expectations. As shown in Fig. 7 , the losses are great enough to stagger the mind. A repeat of the 1811-12 event could cost 3000 lives should it occur during the day in 1990. The number of deaths or rather the scale of the catastrophe could not be grasped until one realized that it is four times the number that died in the San Francisco earthquake - that it is equal to the total number of deaths from all causes occurring in the Memphis area during 5.5 months. These losses were further amplified by showing that children of school age would suffer the most -65% of all deaths would occur among the school children who make up about 20% of the population. Unlike property losses which can be expressed in dollars, life loss values can not be rationally and acceptably quantified. There is no agreement on the value of a life. There is no accepted relation between value priorities for the very young, adolescent, adult or the very old. Only in the subjective process can one find responsible definition of the acceptable life loss criteria. The advisory committee was presented the life loss findings in both their absolute and comparative context. They were asked to give their total response and their response was strongly in support of seismic safety action.



1. No discounting for cost of money has been made in calculating B/C ratios.
2. Benefit is the difference between loss for "No Protection" and Zone 3 UBC Protection. Cost is the additional initial cost to provide Zone 3 protection.
3. 1973 Flood on the Mississippi River.
4. Increase by 50% to approximate building plus content damage.
5.
6. M.R. & T - Mississippi River & Tributaries Flood Control Project

BENEFIT / COST RATIOS

FIG. 6



LIFE LOSSES

FIG. 7

3.9 Micro Communications Summary

We have no intention of analyzing the working of the non-technical mind, but from our experiences it does appear that the presentation of any new risk evaluation must be presented to laymen in such a way as (1) to be credible, (2) to be seen in comparison with similar events and (3) to appear amenable to practical solution. If this three point criteria is not met, action by the lay community is not very likely to occur, and the plans to improve seismic safety become a hollow success.

3.10 Non-Rational Responses

The situations discussed have dealt with decisions as a rational product and with communications as a rational tool. There are situations in which one may question if it is possible to be rational. After discovering the high concentration of risk within the school population, the program administrator felt that the top level executives of the school system should be apprised. A meeting was planned, notices and invitations were sent to each school executive group. Cueing off what had been learned from presentation to the advisory committee, we presented the findings pertinent to the school system. The reactions were incredible; in fact, it is hard to imagine how the reactions of any group could have been more negative. There was little evidence that the seismic risk was regarded as a serious problem, and some of the highest executives reacted in anger that anyone would suggest that their building harbored a danger to the children - all this after seeing pictures of California buildings of exactly the same type of construction lying in ruins from less severe earthquakes than we can expect in Memphis. One must conclude from such an experience that under some conditions rational communications are impossible. If those conditions are to be improved, the discussions must be moved to another arena where reason can prevail.

4.0 FUTURE COMMUNICATIONS AREAS

4.1 Responsibility To Initiate Communications

Whose responsibility is it to initiate and motivate seismic safety programs? Who should start the communications? In the final analysis the responsibility for public policy and implementation rests on the local governments. During the four years since the risk findings were presented, no significant seismic action has been taken by any local governmental unit or school unit. The seismic safety program is at a stand-still. We do not subscribe to the glib phrase "Wait for a big earthquake". We consider it the responsibility of those who know about the risk to speak out, to communicate, even though it be "one way". To that end, we have prepared an implementation plan to show the public officials how implementation can be done, and when funds are available for implementation, perhaps the program will move quickly forward.

4.2 Communications Research

We believe that research in "risk-spend" profiling of people offers hope of greatly improving communications of many planned programs. If the planner could properly assess the balance between risk and expenditures that the public will accept, he could optimize planning products. For example, let us assume (1) that Plan A and B are mutually exclusive options and (2) "A" is a high yield-high cost plan, while "B" is a medium yield-low cost plan. If the planner could accurately quantify the public response to these plans, he could determine the utility of plans A and B and choose the program most apt to receive public support. One might ask what better communication is there than to propose the acceptable solution on the first trial.

5.0 CONCLUSIONS

5.1 In conclusion it may be said with assurance that communications leading to seismic safety are an elusive art. But, regardless of the difficulties the engineers and planners must accept the responsibility to initiate and maintain bilateral communications with all of our society, if our efforts to achieve acceptable seismic safety are to reach fruition.

COMMUNICATING EARTHQUAKE HAZARDS REDUCTION INFORMATION

REGIONAL PLANNING, MATCOG/MDDD

by

Warner Howe*

INTRODUCTION

In the preceding presentation O. C. Mann has outlined the MATCOG/MDDD Earthquake Risk Study undertaken for the Memphis area and the methods of communicating this information to the public and private policymakers. (Phases I - IV of Fig. 1 of Mann's paper) I would like now to address the process of communicating this information to the public and private sectors and the means available for their implementing Disaster Mitigation. After communicating earthquake risks (probabilities) and the potential consequences (life loss and property damage), the available methods for mitigating the risk were presented.

Under this contract, we were commissioned to investigate the potential earthquake risk in the MATCOG area and the means available for mitigating this hazard. There are a number of existing public and private agencies available for mitigating the earthquake hazards and the methods of communicating their policy decisions to the user are quite conventional. The methods used to communicate this study information to these agencies has been covered in the preceding paper.

In this treatise, I will attempt to enumerate all of the means available for mitigating earthquake hazards, but will primarily concentrate on building codes and standards because it is probably the most effective means for reducing earthquake risk and is the area in which I have the most expertise.

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DISASTER MITIGATION PLANNING

In the public sector, public policies may be formulated to counteract the earthquake risk thru:

(1) Land use planning to minimize and/or control the use of earthquake hazardous areas, including zoning restrictions.

(2) Government Policies - re: Essential or critical public facilities:
Protection of public buildings (hospitals, schools, fire and police facs. etc.), public utilities, urban lifelines, transportation, etc.

(3) Building Codes and Standards: Mandatory requirements for reasonable earthquake resistance for public safety in building construction (both public and private), including requirements for eliminating or strengthening of existing hazardous structures where potential extremely hazardous conditions warrant.

(4) Mandatory earthquake insurance

(5) Disaster Response: Emergency Disaster Plans, Disaster operations (direction and control), Government disaster assistance, post-earthquake recovery and redevelopment

In the private sector, incentives can be promoted to encourage voluntary protections:

(1) By educating the public, earthquake resistance in buildings reduces insurance cost and potential losses.

(2) Lending institutions may require earthquake resistance to protect investments.

(3) Tax incentives can be provided for more than minimum legally required protection.

Unfortunately, the classic methods used for mitigating earthquake hazards in California and other seismically active regions are not always totally appropriate in less seismically active areas. Because the populated areas in the West are in a highly active seismic region, they have been in the forefront of the development and promulgation of seismic safety elements, public policies, building code requirements and earthquake design standards. These have been developed for the conditions which exist in an area where damaging earthquakes have a high probability of occurrence during the anticipated lifetime of buildings (usually assumed to be 50 years). In the MATCOG area, however, the reverse probability exists - it is very improbable that any damaging earthquake will occur during a structure's lifetime, but nevertheless, one is possible and someday most certainly will come. Therefore, the MATCOG area has a different set of circumstances to contend with.

The current method of assessing the relative earthquake exposure is to determine the maximum credible earthquake intensity anticipated under the criteria of 90% probability of not being exceeded within a 50 year period, based upon a historical statistical analysis. When compared on this basis, the MATCOG has perhaps 1/10th the risk of California, but this is not the only measure of risk. The Central U.S. appears subject to equally as large earthquakes as the West Coast but with about 1/10th the frequency of occurrence. Also, when a major earthquake does occur in the Central U.S., its effect is felt over a much larger area and, therefore, widespread damage can be expected from a major quake. Ground motion attenuation with distance from source is much less in the Central U. S.; therefore, the net result is - when we do get the big one, it will produce damage over a wide area of the Central U. S.

The question then arises, how to establish appropriate public policy for earthquake disaster mitigation under these parameters of risk? A number of factors must be considered:

(1) What is an acceptable risk in terms of life loss per year (or per event); or of property loss?

(2) How large a catastrophe is tolerable? Can the local emergency services cope with the disaster?

(3) Complete protection against a major earthquake is economically unjustifiable - some risk is inevitable and anticipated.

The problem is then - how does the MATCOG area address these questions when there appears to be no authoritative source to turn to for guidance in solving its unique earthquake problem?

LAND USE PLANNING

In considering policies regarding planning for the optimum use of land, public policymakers should consider the hazards of natural phenomena, ie., floods, wind, earthquakes, etc. The MATCOG area is located in and adjacent to the alluvial valleys of the Mississippi River and its tributaries which contain unconsolidated river deposits that are very susceptable to earthquake ground motions; when so activated, they tend to loose their supporting power, settle, and/or shake like a bowl of jelly. This amplification of earthquake ground motions is particularly devastating to manmade structures which are not specifically designed for this condition. Therefore, the MATCOG study identified these areas and pointed out their vulnerability with the hope that this will influence the land use planning for these areas.

PROTECTION OF CRITICAL ESSENTIAL FACILITIES

The MATCOG Study also identified critical essential facilities which are needed for appropriate response to prevent or alleviate the problems of an earthquake catastrophy. Therefore, public policy was recommended for these facilities (usually government owned or financed) to have superior earthquake resistance so as to be operable following any reasonably expected intensity of ground shaking. These facilities, often referred to as Lifelines, include:

TRANSPORTATION

Railway - River bridges, grade separation structures, track on fill.
Harbor - Piers, docks, hydraulic fills
Airport - Control towers
Highway - Bridges & abutments, landslides, fills

COMMUNICATIONS

Telephone, Telegraph, Cable TV - Distribution Stations
Telephone switch gear. Radio & Television - Transmitter Stations

ENERGY

Electricity - Power Plants, Distribution Stations, Transformers, Electrical equipment and controls, Power lines.
Gas (natural) - Transmission lines, reservoirs, distribution lines.
Liquid Fuel - Storage tanks, refineries

WATER

Potable water - Storage tanks, reservoirs, buried pipe mains, treatment plants, pumping stations
Storage - Dams, levees, pumping stations
Sewage - Treatment plants, interceptor sewers, collector sewers
Fire water - Fire mains, loss of pressure due to broken mains or damage to pumping stations.

Also included in this classification of Essential Critical Facilities are hospitals, fire and police facilities, emergency response organizations, and emergency health care and food supplies, etc. which are needed in the disaster recovery and response operations.

EARTHQUAKE INSURANCE

Earthquake Insurance is an effective instrument in reducing the impact of a disaster on a community or individual. Such insurance offers the most effective and equitable means of providing economic assistance for individuals, institutions and businesses following a disaster. One of the recommendations of a Workshop sponsored by NSF and NBS on "Building Practices for Disaster Mitigation" recommended that banking regulatory agencies should require that the amount of money loaned or guaranteed be insured against natural disasters. Such action at the Federal and state levels regarding insurance would provide far reaching incentives for earthquake disaster mitigation. This could be accomplished with existing Legislative programs and would stimulate owners in local communities to upgrade building practices and to enjoy lower insurance premiums. Rather than depending upon Federal relief following a disaster, owners could be required by law to have some form of insurance protection against possible future losses from natural disasters.

PLANNING FOR DISASTER

Rational public policies for disaster response and post-disaster planning begin with recognition and understanding of the natural disasters likely to occur; the probabilities of their occurrence and the vulnerability of the area to those disasters. With a knowledge of the seismic risk, all levels of government can establish the means for carrying out adopted public policies. In order to be eligible for aid under the Federal Disaster Preparedness Program, it is essential to have a cooperative and concerted effort involving Federal, State and Local Governments.

Although some disaster preparedness plans have been on the books for a number of years, there has been insufficient attention given to the increasing vulnerability of communities to seismic hazards. Most programs were developed as Civil Defense programs to mitigate the fallout hazard, and have been expanded ineffectively to include all catastrophic hazards. Local and state emergency disaster plans, Federal, State and Local disaster assistance programs, disaster operation (direction and control) and post-earthquake recovery and redevelopment planning should be revised to include a realistic approach to the earthquake hazard specifically.

Since the impact on the human, social and economic well-being of the community would be extreme in a major earthquake, every effort should be made to impress the private sector with the desirability for taking voluntary protection against this risk. Unlike California earthquakes where damage is localized in a relatively small area, damage from a major earthquake in the Central U. S. will be widespread effecting many major cities, including the whole of the MATCOG area. The nature of the earthquake phenomenon makes it unique among natural hazards; earthquakes occur suddenly, without warning, and cannot be predicted with any degree of accuracy or creditability. Widespread death, damage and distruction come suddenly and within a few minutes. Other natural hazards usually provide time for advance warning and time to make some preparations.

In addition to the loss of life, numerous injuries, disrupted businesses, there is the immediate cost of establishing emergency services, providing temporary food supplies and shelter for the victims of the earthquake. Temporary replacement or repair of needed lifelines and essential facilities must be made and emergency transportation systems established, as well as measures taken to protect the health of the public. The cost of an earthquake involves not only the direct expenses of repairing the physical damage, but also the indirect cost resulting from the loss of normal economic activity and the setback of expansion of productivity. Inevitably, there are changes in the commercial and industrial structure of the community; marginal industries choose to discontinue operation rather than face the cost of reconstruction. People, business and industries may choose to leave the community out of fear. Also included in the indirect cost is the unemployment resulting from businesses temporarily put out of business.

BUILDING CODES

Experience has shown that the most effective way by far to address and mitigate the earthquake hazard, as urban areas become more densely populated, is through seismic requirements in building codes legally enforced by local government regulatory agencies. Therefore, I shall address this means of communicating public policy in more depth.

Building Codes and Standards in the U. S. have traditionally and scrupulously limited their requirements to those minimum requirements which would provide a reasonable and prudent protection for life safety without imposing unjustifiable economic hardship. Building code standards have generally been subject to a "due process" of law through the local or state legislative process where all effected interests can be heard and participate in the drafting of such regulations. But, with the increased complexity of building technology today this due process is becoming less and less effective. On the national level, vast federal bureaucracies have been created and given authority to promulgate building regulations within their areas of perview; without the normal constraints of "due process" or other controls to restrain their efforts to protect the public - often resulting in over protection or at least overlapping and conflicting regulations. Witness: OSHA constr. regs., HUD Min. Property Stds., HEW regs., Consumer Products Standards, etc.

Building standards which were meant to be voluntary industry standards of good practice are now inappropriately becoming building code requirements and the public is often being over protected to its economic detriment. Furthermore, the hodge podge of overlapping and conflicting building regulations being promulgated at the federal, state, county and local levels is thwarting and stiffeling the building owner/builder to the point of bankruptsy. And, on the heels of this dilemma, comes a push for more restrictive regulations to protect against improbable earthquakes.

Several criteria have customarily been considered in establishing building code protection against earthquake hazards even in the more active seismic zones:

1) In the event of an earthquake, there should be a minimal loss of life or serious injury from the damage or collapse of structures.

2) The cost of increased design, construction and financing which would prevent damage or collapse should not exceed the cost of repairing the damage due to an earthquake.

3) Absolute and complete protection from all hazards is often impossible and generally not economically feasible.

4) Excessive and unjustified levels of protection are wasteful and can defeat the total purpose for which a structure is planned.

5) Wherever practical, the level of acceptable earthquake risk should be consistent with other activities of society where some risk is accepted as an integral part of life.

6) Consideration must be given to the socio-economic impact of a major earthquake on the areas well-being.

7) Public regulatory policies traditionally have accepted some degree of risk to life and property in order to allow needed shelter and facilities at reasonable costs.

Not taken into consideration customarily is the possibility of differing degrees of "acceptable risk" for differing types of buildings depending upon their use and occupancy, such as, for single family dwellings or storage warehouses with very few occupants, as compared to those for essential disaster response facilities, such as, hospitals, fire stations, etc. Numerous national conferences have been held to determine what constitutes an "acceptable risk", but no criteria as yet has been set forth which is completely satisfactory to all. Some day earthquake risks may be evaluated through a

Decision Analysis Methodology which allows the decisionmaker to evaluate intangible parameters of risk by the Utility Theory for varying degrees of risk and protection. The principle objective in seeking a satisfactory method for appraising acceptable risks is to remove the decision making process from the arbitrary opinion basis, and/or politically influenced to an unprejudiced methodology which takes into account all pertinent factors and gives proper weight to each. Such an approach is obviously badly needed for an area such as MATCOG where very unique, but not so apparently pressing, earthquake risks exist.

SEAOC SEISMIC STANDARD

In this country today the universally recognized code provisions for earthquake protection are based almost exclusively on the efforts and experience of the structural engineers and researchers of the California seismic areas. Leader in this effort has been the Structural Engineers Association of California (SEAOC) with the publication of their "Blue Book" entitled Recommended Lateral Force Requirements and Commentary. This is the basic standard on which the present National Model Codes, ICBO (Uniform Code), BOCA (Basic Code) and SSBC (Standard Code) seismic provisions are based.

Structures designed in conformance with the provisions of the SEAOC standard are expected to:

1) Resist minor earthquakes without damage
2) Resist moderate earthquakes without structural damage, but with some non-structural damage
3) Resist major earthquakes, of the intensity of severity of the strongest experienced in California, without collapse, but with some structural as well as non-structural damage.

In most structures it is expected that structural damage, even in a major earthquake, could be limited to repairable damage.

The SEAOC Code principally addresses the California earthquake exposure where all buildings in the earthquake prone areas (including most all heavily urbanized areas of California) are relatively close to an active fault and are expected to experience a damaging earthquake during their lifetime. The question, therefore, is not whether to protect, but rather how much to protect, regardless of the type of use and occupancy of the building. No buildings should collapse, regardless of occupancy, and kill people in an anticipated earthquake. But, is this approach appropriate for other areas of less seismic exposure?

MATCOG EARTHQUAKE RESPONSE

None of the government jurisdictions in the MATCOG area have included any requirements for seismic resistance in their building codes because it is not felt that any of the nationally recognized model codes available today adequately address the unique earthquake problems in the Central U. S. The City of Memphis Building Code Advisory Board has debated this issue on several occasions and many members feel that the Board is derelick in not including some requirements to promote seismic safety. But, a majority of the Board members feel that the city should wait until an appropriate model code is promulgated and are opposed to adopting a locally drafted code because of the lack of time and expertise available. And after all, it is argued that the city has existed over 150 years without a damaging earthquake - so why get excited now!

EARTHQUAKE CODE TREND

The present trend in California is to upgrade earthquake standards based on the California experiences in recent earthquakes, resulting in requirements which go far beyond the traditional building code philosophy and provide more than the minimum mandatory requirements necessary to give a reasonable and prudent degree of life safety. Additional protection is being required for essential or critical facilities which are needed in time of earthquake catastrophies, especially hospitals and schools, such that they may be operable after the earthquake. Consideration is being given to the hazard of non-structural features, such as, ceilings, walls, lighting fixtures, plumbing and mechanical services that can fall on and injure occupants. Serious investigation is being given to removing or strengthening existing buildings which do not have adequate earthquake resistance. All of these have a grave impact on the economic aspects of constructing and operating buildings in earthquake prone areas.

ATC-3 COMPREHENSIVE DESIGN PROVISIONS

Two and a half years ago the National Science Foundation (NSF) and the National Bureau of Standards (NBS) contracted with the Applied Technology Council (ATC- a non-profit research arm of SEAOC) to develop Comprehensive Recommended Seismic Design Provisions for Buildings to be applicable throughout the U. S. This ATC-3 project was successful in bringing the current state-of-the-art technology on earthquake resistant design into one technical document, but unfortunately, it is much too comprehensive and complex to be a viable building code document, and in the minds of many, it far exceeds the traditionally acceptable code philosophy of minimum requirements for prudent life safety. Although this effort involved some 85 experts from many disciplines and from many parts of the nation, unfortunately, the majority were oriented to the California seismic exposure almost exclusively. As a result, these recommendations are not totally appropriate for other areas of less seismicity.

From the beginning, the ATC-3 participants felt that they could develop a document that was both a design standard of good practice and a minimum code standard. As the project progressed, it became evident to some of the participants that this was not practical - philosophically, both objectives are not compatible. In the end, the document was developed in the format of a building code standard but a preface was added which states in part:

> "BECAUSE OF THE MANY NEW CONCEPTS AND PROCEDURES INCLUDED IN THESE TENTATIVE PROVISIONS, THEY SHOULD NOT BE CONSIDERED FOR CODE ADOPTION UNTIL THEIR WORKABILITY, PRACTICABILITY, ENFORCEABILITY AND IMPACT ON COST ARE EVALUATED BY PRODUCING AND COMPARING BUILDING DESIGNS FOR THE VARIOUS DESIGN CATEGORIES INCLUDED IN THIS DOCUMENT."

The Memphis Building Code Advisory Board had hoped that the ATC-3 effort would produce the code standard that they needed, but this did not prove to be the case. In the Memphis Advisory Board's opinion, the ATC-3 standard did not answer the unique problems of an area with a very low probability of damaging earthquakes but with the possibility of a major event which could produce widespread damage.

ATC-3's first considerations for Seismic Zoning were based upon the work of Algermissen & Perkins (1976) which were based upon the principles of Seismic Risks (Cornell - 1968) and resulted in smooth contours (Fig. C 1-3 of the ATC-3 report). In developing the map the objective was established that the probability of exceeding the design ground shaking be the same in all parts of the country for the lifetime of structures. It was intended that interpolation could be made between contours to obtain values for intermediate locations. An alternate method was ultimately used producing zones comprised of county boundaries in order to facilitate adoption by political jurisdictions. This procedure implies an unjustified degree of accuracy in these maps and, therefore, discourages any re-evaluation of risks at the local level of government; whereas the smooth contours were designed to be flexible and to allow judgment by the cognizant jurisdiction in its interpretation of its own risk.

The ATC-3 document includes a very exacting structural analysis based upon an assumed ground motion principally based upon California data. No strong motion records exist in the MATCOG area and there is no way to confidently predict what the local ground motion and resulting building response will be: It may well be similar to Mexico City where the short period waves are damped out but the long period (2.0 sec.) waves are amplified due to saturated unconsolidated lake bed deposits - a condition not unlike many alluvial areas of the Mississippi River and its tributaries.

The design ground motions required are determined by the maps of Effective Peek Acceleration (A_a) and Effective Peek Velocity - Related Acceleration (A_v) which determine the Seismicity Index (SI) which in turn determines the Seismic Performance Category for each type of building occupancy, depending upon its seismic hazard exposure group. For the MATCOG area (SI=4) Table 1-A places Critical Essential Facilities under Seismic Performance Category D, and all other occupancies under Seismic Performance Category C - (same as required seismic performance categories for California). Therefore, other than having a required ground motion of one-half that of the West Coast seismic areas, the Memphis area is subject to all other design limitations imposed in the more seismically active areas. In an area of very low probability of occurrence, as the MATCOG area is, it seems to me that the least Seismic Hazard Exposure Group III should not be placed in the Seismic Performance Category C.

Buildings respond differently to induced earthquake motions, depending upon the relationship of their predominant resonating natural periods of vibration. If the predominant period of vibration of the ground is harmonic or coincides with that of the building, the motions become harmonic and the motions in the building are amplified. If they are not synchronous, most motions in the building will be damped out. Therefore, it is most important that we have a better knowledge of the ground motions to be expected in the MATCOG area before this problem can be adequately resolved. Strong motion seismographs are needed, but even if they were available, they would produce no meaningful results until a strong earthquake occurs. As the studies of earthquake ground motions progress, the technology for predicting these motions may soon give the answer to this problem. Much of the design technology contained in ATC-3 would be very pertinent if we had a better knowledge of the probable ground motions in the MATCOG area.

The ATC-3 document also goes far beyond the traditional building code philosophy for protection of life safety with some degree of acceptable risk. The concept of an essential or critical facility being operable after a major earthquake is undoubtedly appropriate public policy, particularly in the areas of high seismic risk. Certainly, design criteria and the current state-of-the-art should provide adequate guidelines for designing this type of function into these facilities. Where the public policymakers deem that this degree of protection is necessary, it certainly should be provided at the expense of the taxpayer, ie., the public. However, this type of requirement is totally not in keeping with the traditional requirements for protection against other types of hazards and is certainly improper for inclusion in the building code which is mandatory upon all building owners and where the cost of construction must be offset by revenues produced by the building's operation. In the case of private hospitals, it is totally inappropriate for the hospital patient to underwrite the cost of earthquake protection for which he probably never will be the beneficiary. If this type of protection is deemed appropriate, the additional cost for earthquake protection should be underwritten by government, which has the responsibility for responding to disasters.

ATC-3 also provides detailed design requirements for seismic protection in architectural, electrical and mechanical systems and components. Experience has shown that these elements seriously effect the usability of a building following a major earthquake, and that these elements do present a hazard for injury to occupants. Obviously, the technology for abating these hazards should be made available through such comprehensive documents as the ATC-3 project; however, are they appropriate for mandatory enforcement as a building code? Many of these provisions for strengthening non-structural elements are expensive and should not indiscriminately be required by the building code. unless there is a serious hazard to life safety involved and the costs for protection can be justified. Some risk is anticipated in every form of hazard, and there are many hazards (fires, explosions, wind storms, floods, etc.) which are more probable of occuring than an earthquake for which the building code does not require this degree of protection. If the ATC-3 standards for non-structural protection become building code requirements, then every other hazard interest would demand equal protection and the cost of buildings would become prohibitive. Somewhere in this complex matrix of protection vs. need, we must conclude that sometimes needed shelter even with some risk is more important than fewer facilities with complete protection.

EXISTING BUILDINGS

There are many buildings in seismically active areas of the United States that have primary structural systems which do not meet current seismic resistance design standards. Such buildings will suffer extensive damage or even collapse if shaken by ground motion of an intensity that is considered likely for their locations; thus, these buildings may cause injury or death to their occupants, or people in the vicinity, in the event of an earthquake.

There are several reasons for the existence of such buildings:

a) Buildings that were designed prior to the introduction of reasonably adequate earthquake requirements into building codes, and buildings that were not designed to resist any earthquake forces (pre-code).

b) Types of building construction that destructive earthquakes have shown are more vulnerable to earthquake forces than had been realized when they were designed and built.

c) Buildings in which the earthquake resistance has deteriorated due to such factors as: damage sustained in past earthquakes, decrease in strength of construction materials, fire damage, foundation settlement, and alterations that have weakened structural elements.

Most, if not all, local building codes in existence today only require upgrading of the building to current code requirements when:

a) Occupancy has changed to a higher risk classification

b) When major additions, alterations and/or modifications are made,or

c) When unsafe deterioration exists.

Generally, baring the above conditions, an existing building is deemed to meet the current code requirements if it conforms to the existing requirements when it was designed and built.

Obviously, this does not answer the situation where an area is found to have an earthquake hazard and increased seismic requirements are added to the code which regulates new buildings. Justification for strengthening many of these older structures to resist an improbable earthquake is a sticky problem, when frequently these buildings are being operated on a very thin margin of profitability and are deficient in many other areas of safety which may demand even more pressing attention.

Identification of buildings not meeting certain minimum earthquake standards is necessary if steps are to be taken to reduce the hazard. However, the social and economic impacts upon a community caused by the identification, evaluation and subsequent required repair or demolition of many building in a single area or neighborhood cannot be ignored. Obvious economic and physical hardships can occur unless the seismic hazard reduction program is carefully planned and aided by financial incentives and community participation.

Any seismic abatement program should be designed to focus upon the buildings apt to be most seriously deficient, most important to the community, and/or because of occupancy present the greatest risk. The criteria for requirements on retro-fitting should be somewhat less than that required for new buildings, and take into consideration the length of time that the building may be expected to exist as a hazard and the risk of life associated with its occupancy.

The ATC-3 recommendation has addressed these problems in

1) Chapter 13 - Systematic Abatement of Seismic Hazards in Existing Buildings

2) Chapter 14 - Guidelines for Repair and Strengthening of Existing Buildings, and

3) Chapter 15 - Guidelines for Emergency Post-earthquake Inspection and Evaluation of Earthquake Damage in Buildings.

Chapter 13 includes procedures for the evaluation of seismic hazards in existing buildings and the determination of the extent of remedial work required. The ATC-3 document recommends that the cognizant jurisdiction shall: Identify types of buildings which require evaluation, see that qualitative evaluations are made of buildings assigned to seismic performance Category C, require analytical evaluation prepared by registered Structural Engineers for all buildings assigned to seismic performance Category D, and for those buildings assigned to seismic performance Category C whose degree of hazard is judged uncertain by qualitative evaluation, and to require the hazards be abated by removal or by strengthening when the location has a seismicity index of 4 (this includes all buildings in the MATCOG area).

In the MATCOG area, all buildings which have an earthquake resisting capacity less than the minimum acceptable Earthquake Capacity Ratio - r_c = 0.5 (the seismic shear force capacity computed for the existing system or component/the seismic shear force required to meet the provisions for new buildings) would be judged in non-compliance and required to be made to comply with the requirements for new construction under the code. This would seem to be a rather stringent requirement for buildings in an area of infrequent earthquakes where earthquakes have a very low probability of occurrence during the lifetime of a structure, particularly older structures with a short anticipated life span.

Because of the probable reduced time of exposure and the economic burden of major strengthening, it is suggested that existing buildings should not be required to be brought up to the same level of earthquake resistance as new construction. Long Beach, California, has addressed this problem by considering the anticipated life of the structure and the nature of its occupancy in determining the required resistivity for retro-fitting. Some approach similar to this would seem more equitable and justifiable, in our opinion. If you make the codes economically too stringent, it will end up being self-defeating in that (1) people will either tear down the building, thus eliminating needed shelter, or (2) it will end up with the requirements being contested in court or resisted so vigorously as to defeat their purpose.

There are methods being developed for many types of old structures - methods of reinforcing the buildings that would produce a very high level of safety which would provide protection against smaller quakes that have a higher probability of happening within the life of the structure. Studies are now being conducted under the direction of ATC that indicate that this will be a very beneficial approach. It appears amazing what a small amount of reinforcing to some types of construction will do to their relative earthquake safety.

Although the ATC-3 - Chapt. 13 - seems to provide a comprehensive approach to this problem, it does not adequately address the problems existing in the Central and Eastern U. S. where damaging earthquakes are most improbable during the life time of existing structures. Here again, it seems appropriate to take a different approach from that considered for the California exposure, and this is not available today.

QUALITY ASSURANCE

Building failures during earthquakes which are directly traceable to poor quality control during construction are innumerable. The literature is replete with reports pointing out that collapse might have been prevented had proper inspection and quality control been exercised.

The remarkable performance during earthquakes by California schools constructed since 1933 is due in part to the rigorous supervision of construction required by state law. Independent special inspection, approved and supervised by the office of the state Architect, is an important feature of those requirements.

Recognizing that there must be coordinated responsibility during construction, the ATC-3 provisions set forth the role each party is expected to play in construction quality control. The building designer specifies the quality assurance requirements, the contractor exercises the control to achieve the desired quality, and the owner monitors the construction process through special inspection to protect the public interest and safety of buildings. The approach used in preparing these provisions was to borrow liberally from the pattern already established by the ICBO Uniform Building Code (UBC) 1976 Edition, which details Structural Quality Provisions under the administrative portion of that Code, Chapter 3, Sect. 305 "Special Inspections". These provisions, for the first time, place minimum quality assurance requirements on installation of non-structural components which are designated as deserving special attention during construction. The designer, the one most familiar with the requirements of each system, must spell out in a Quality Assurance Plan those components which will require special inspection and tests during construction to assure their ability to perform satisfactorily during earthquakes. The number of such inspectors actually employed will very widely depend upon the size and complexity and function of the building. Both the special inspector and the contractor are required to submit to the regulatory agency a final certification as to the adequacy of the completed work. Provision is also made for the special approval of manufactured designated components, such as, mechanical or electrical equipment manufactured off site and delivered to the job in its own container. It is expected, therefore, that a system of approvals in labeling must be established by the regulatory agency in much the same way as labeling of fire doors is presently being done.

NATIONAL INSTITUTE OF BUILDING SCIENCES

In recent years, because of the building industry's importance, public commissions, government tasks forces and private research groups regularly have investigated the reasons for rising building costs. Just as regularly, the investigators cite the crazy quilt of codes and regulations as one of the main causes for these increased costs. In order to establish a more orderly system, Congress with the support of the building community created the National Institute of Building Sciences (NIBS) in the Housing Act of 1974. Therein Congress commissioned the Institute to work with the building community to devise a more uniform, efficient and quicker way to introduce the benefits of science and technology into housing and building. NIBS, a non-government institute, supported by both the public and private sector, is dedicated to becoming the national "authoritative source" for the evaluation of building technology and will supply its findings to existing bodies for the development of more rational codes and standards.

Shortly after the NIBS Board of Direction was appointed by the President, it set forth objectives to guide its work:

(1) To set up a system for evaluating materials, components products, systems and sub-systems, on the basis of performance capability.

(2) To devise uniform testing and evaluation procedures for performance standards development.

(3) To work with the Model Code Groups and regulatory bodies to develop uniform building codes based on performance standards wherever appropriate.

(4) To speed the flow of new products and systems into the building market with a system for qualifying innovations that meet the performance standards.

(5) To devise an equitable way of handling disputes that arise from the development of new standards.

The Institute is in the process of developing ways of implementing these objectives. In addition to these general goals, the Institute will undertake specific projects, such as, identification of areas where national or uniform standards are needed, promotion of appropriate code philosophy, including guidelines for code drafting bodies, classification and definitions for standards, and the development of a national data collection and dissemination system. Various topical issues confronting the public, such as, energy conservation in new and old buildings, earthquake hazards reduction and improved fire safety will be addressed. NIBS will achieve these objectives by working with existing research organizations, testing facilities, voluntary standards organizations and model code groups, with the continuing advice of the entire building community and the public.

To provide advice and communication with the building industry, the Institute is establishing a Consultative Council, comprised of representatives of all affected groups, including industry trade associations, building trade unions, professional design and engineering societies, regulatory agencies, consumer groups, public and private testing and standards writing organizations, etc. The primary function of the Consultative Council will be to provide a two-way communication with all public and private bodies concerned with housing and buildings, as well as conduct hearings on matters being considered by the Institute.

NBS CONFERENCE ON ATC-3

On April 21st of this year, the National Bureau of Standards (NBS) held a conference where affected groups were requested to review the ATC-3 "Tentative Provisions for Development of Seismic Regulations for Buildings" and assist the Bureau in formulating an implementation plan for these Tentative Provisions. It was generally agreed by the participants that the document needed to be tested for its workability, practicability, enforceability and impact on cost before being promulgated as a mandatory standard. It was further suggested that this evaluation could be done under the auspices of the National Institute of Building Sciences because of its mandate from Congress and its structure to get the needed input from all affected groups within the building community through its Consultative Council. Hopefully, the Bureau will see fit to avail itself of the Institute's capabilities in this area of code improvement.

VOLUNTARY STANDARDS SYSTEM

Building code standards today are the product of the "Voluntary Standards System" in the U. S. wherein the private sector (industry and the professions) develop the standards without any external guidance or constraints. Outside of some loosely designed procedures for achieving "consensus", most organizations developing building standards have no guidelines for classifying standards as to whether their intent is to be: (1) industry standards of good practice, (2) minimum building code standards for protection of life safety, or (3) procurement standards for government or industry. The American National Standards Institute (ANSI), which in the past has taken the lead in classifying standards of all types, has been negligent in identifying building industry standards as they relate to mandatory requirements in building codes. As a result, all standards are classified as "Voluntary Standards" meeting the ANSI requirements for due process as it relates to consensus and involvement of opposing interests, but no attempt is made to classify standards for intended usage. Until adequate definitions and appropriate code philosophies are promulgated by a nationally recognized authoritative source and recognized guidelines are promulgated, this problem will persist. Hopefully, NIBS will become that authoritative non-government authoritative source before the Federal Bureaucracy completely takes over the promulgation of building regulations throughout the country.

PROBLEM POSED TO WORKSHOP

Now, how does all this relate to the subject of this workshop on Communicating Earthquake Hazards Reduction Information? Obviously, the appropriate criteria and information must be available before it can be communicated. The question at this point then is - are the Model Codes or ATC-3 appropriate for promulgation as mandatory building code regulations in all parts of the country, and specifically, in the MATCOG area? It is my contention that at present they are not.

In years past, local communities attempted to write their own building codes, and this proved disastrous in an industry leaning toward mass production for economy. The result has been pressure for a Federal (uniform) building code promulgated by the Federal Government.

In lieu of this, in order to promote uniformity and to forstall Federal takeover, local governments have been pressed to adopt one of the nationally recognized Model Building Codes without major local modifications. One of these codes, the Uniform Building Code (ICBO), was the leader in adopting provisions for seismic resistance based on the SEAOC recommendations previously mentioned. The other two model codes, BOCA and SSBC, have followed suit and patterned their provisions after the Uniform Building Code. Presumably, they are now taking a hard look at the ATC-3 document for possible inclusion in their codes. Hopefully, they will show the same restraint that they historically have shown in resisting adopting code regulations which unduly constrain building construction. In the meantime, those communities which have adopted one of the National Model Building Codes would find it difficult to modify their code until the model group has appropriately integrated these provisions into the model code. In the meantime, communities in the MATCOG area wait for a code which appropriately addresses their situation.

Let us examine the ramifications of adopting the earthquake provisions of the Uniform Building Code or the ATC-3 document for the MATCOG area. Both of these documents would require protection against a moderate earthquake but not the maximum earthquake anticipated for the region. Both require equal protection in all types of construction, regardless of the use or occupancy.

Now when you examine the increased costs of construction attributable to earthquake protection, you find that the largest increase in cost occurs for that type of construction and occupancy which present a low risk to life safety, that of masonry bearing wall construction commonly used in light commercial, industrial and residential uses where the occupancy is generally low and frequently limited to the daytime use only. Contrasted with this is the fact that the additional cost of earthquake protection in high-rise construction which has the most occupancy in terms of density of population and, therefore, most hazardous to life safety, requires the least additional costs for protection.

In an area of low probability of damaging earthquakes, does it make sense to impose the maximum economic burden on that element of construction which has the least risk? These and similar inequities which would result from adopting a West Coast oriented seismic regulation in the MATCOG area must be resolved before they are indescriminately enacted into law. Hopefully, the Bureau of Standards, possibly with the help of NIBS, will resolve these questions before recommending methods of implementing the earthquake hazard mitigation provisions of ATC-3, or any other inapplicable standard promulgated by any of a myriad of similar organizations which are seeking an opportunity to perform under the Hazards Mitigation Legislation recently enacted by Congress.

The MATCOG study indicates that existing buildings in this area, which predominantly have not been designed to resist seismic forces explicitly, will present a continuing major hazard for many years to come. Until these buildings are replaced by earthquake resistant structures as the result of normal attrition, or made to conform to future earthquake code requirements, this hazard will exist unless the building code mandates strengthening, demolition or limits occupancy to a less hazardous classification. Even with the California seismic exposure, cities there have found it very difficult to enact retroactive provisions for strengthening or limiting use of existing buildings. So called parapet laws have been enacted but loosely enforced. Long Beach has enacted perhaps the first comprehensive hazards abatement law which is based upon probable useful life of structure and inherent risks of occupancy. It will be even more difficult to require strengthening of such existing pre-earthquake code buildings in areas outside California where the risks are much less. Some method must be devised to determine impartially just how far it is prudent to require strengthening or demolition of older hazardous structures in areas of improbable damaging earthquakes.

Until appropriate building code standards for earthquake protection are developed which address the unique problems of the regions of less seismic hazards of the U. S., these areas will continue to ignore this hazard and fail to enact appropriate laws and public policies to mitigate this hazard. That is, until a damaging earthquake shakes them into action.

CONCLUSIONS

The MATCOG area has not taken affirmative actions to cope with the seismic hazards brought to their attention by the MATCOG Earthquake Risk Study. Why? Well, this probably can be explained by the fact that there is no compelling urgency on the part of the public policymakers to make this a number one priority issue. There are just too many other pressing problems, and after all, there has not been a damaging earthquake in the Memphis area in the 150+ years of its existence and the probabilities of one occurring during their future lifetime is quite remote. Furthermore, those who prepared the study or who otherwise are knowledgeable are reluctant to press for mandatory building code requirements for seismic protection since there are no totally applicable guidelines for making such a drastic change for such areas of low probability.

The MATCOG study indicates that even a drastic change in the building code which relates only to new construction, will not make a great reduction the the earthquake hazard for many years to come - the existing hazards will persist until existing structures are either adequately strengthened or demolished and replaced. And when one begins to talk of retrofitting old existing buildings which frequently are operating on a very low margin of profitability already, and most are also otherwise deficient in their life safety elements which may present an even more urgent hazard, it hardly is expedient to go overboard for protection against a very improbable danger when considering the probable expected short life exposure of the structure.

Therefore, the MATCOG area is becoming aware of the earthquake hazard and need for its mitigation, but has not yet found the appropriate means for accomplishing it. Nothing really constructive has been done by the public policymakers to mitigate the earthquake hazard.

USE OF GEOLOGIC DATA IN LAND-USE PLANNING AND WATER-RESOURCE MANAGEMENT, NORTHEAST UNITED STATES

by

Fred Pessl, Jr.
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The following is based on my experience (1971-76) as a project geologist and later as project director of the USGS Connecticut Valley Urban-Area Project (CVUAP), southcentral New England. The project began in 1971 as part of the then new USGS Urban-Area Pilot Program which was stimulated in part by the success of the USGS-HUD sponsored San Francisco Bay Region Project. Objectives of the Urban-Area Program were 1) to demonstrate for areas of diverse natural settings the importance and usefulness of incorporating knowledge of earth resources into the regional planning process, and 2) to provide scientific knowledge of earth processes and resources in new formats so that it could be better understood and used by decision makers unfamiliar with traditional earth-science terminology and maps.

On a national level, this program reflected a USGS response to emerging environmental awareness, increasing urban growth, and the growing need for technical information as required by new legislation such as the National Environmental Policy Act. These same factors also were stimulating institutional, legal, and attitudinal changes at state and regional levels. In Connecticut, for example, a change in political leadership was accompanied by a vigorous cost/benefit analysis of state/federal programs and substantial reorganization of some state agencies. The value of traditional scientific products with limited readership was seriously questioned and the continuation of long-standing geologic mapping and date-collection programs was threatened. Clearly, it was a propitious time to introduce a program in which the applications of earth-science information to significant problems of public concern was a primary objective.

Emphasis of the project was directed to the utilization of already existing geohydrologic data generated by on-going geologic and hydrologic programs such as the USGS (Geologic Division)-Connecticut cooperative geologic-mapping program and the USGS (Water Resources Division)-Connecticut cooperative water-resources inventory program. Minimum project effort was spent on collecting new basic data--an appropriate strategy for an area where fundamental data-collection programs had been active for several decades and where the value of traditional products from these programs was being challenged.

Critical problems of environmental concern in the Northeast focus, for the most part, on noncatastrophic, rather undramatic processes which, because of their low profile, are frequently not widely nor accurately perceived by the general public. The most common problems usually are the consequence of processes acting over a long time and often with indirect effects; problems such as leachate contamination, septic-system failures, and degradation of sensitive areas. Such problems require considerable educational effort to increase public awareness and to insure reasonable public understanding of complex natural systems. This contrasts to a situation in which the problems are related to more dramatic processes or short duration with direct, very visible effects such as earthquakes, landslides, or volcanic activity.

The appropriate means for communicating earth-science information to aid in formulating resource-management policies was a matter of some controversy in the early 1970's. In part, the controversy concerned the degree to which resource-planning and -management policies were or should be dependent on geothechnical information. That is, what was the proper balance between the earth-science information input to the decision-making process and the imput of other germane disciplines. There was a tendency on the part of some earth scientists to assume that the geotechnical dimension was preeminent and that, if followed, would produce a wise and harmonious set of land- and water-use policies. A common result of this attitude was the suitability map showing--usually in stop/go colors--areas suitable or unsuitable for a particular use. Such maps were, initially at least, attractive to many users, especially those with little technical background in the earth sciences. It was gradually realized, however, that most suitability maps were limited in scope, reflecting a too narrow technical perspective on the part of the map compilers, and tended to ignore, for example, possibilities for engineering-design solutions to contraints imposed by existing natural conditions. Similarly, these maps generally did not consider alternatives of competing land uses, nor sequential land-use schemes. Other considerations of importance to the policy-formulating process such as economics, statutory regulations, and social attitudes were also usually not considered in the compilation of suitability maps. Most important of all, these maps tended to frustrate, if not deny, decision making at the local, grass-roots level, bringing down a heavy technocratic dictate on what should be a gradual, comprehensive process at the level of authority most directly affected by the proposed action.

The CVUAP approach was to instead develop a series of simplified, single-subject maps, each showing a selected geologic or hydrologic characteristic of some relevance to local or regional information needs. Subjects such as unconsolidated materials, depth to bedrock, drainage areas, slopes, and floodprone areas were prepared at a scale of 1:24,000 and published as black and white maps in an informal USGS format that permitted project preparation of camera-ready copy and a printing schedule of 6 to 8 weeks from final map compilation to public distribution. These maps were also made available as mylar transparencies to facilitate their use as overlays in composite analyses of resource characteristics. The maps form a folio of earth-science information which serves as a flexible data base that can be used in different ways, according to local or regional priorities, and that can be easily adapted to changing planning requirements. Map overlays showing a vareity of subjects pertinent to a particular management problem can be selected by the decision maker according to local priorities regarding earth-science factors and other significant considerations. The individual maps can be revised as new information becomes available and additional subjects suitable to the map format, but outside the earth-science disciplines, can be added to the folio.

CVUAP was reasonably successful in demonstrating the usefulness of these maps at both local and regional levels. This was particularly true in Connecticut where the State Natural Resources Center, part of the Connecticut Department of Enviromnental Protection, has been fundamental in the development of management and regulatory programs which are firmly based on an understanding of the nature and distribution of the natural resources. CVUAP was intimately associated with the evolution of these ideas through a close working relationship with the Natural Resources Center directed by Dr. Hugo Thomas. However, it became clear as we learned more about the nature of problems confronting planning authorities and regulatory agencies that information on the nature and distribution of separate geohydrologic parameters, such as depth to bedrock, water-table configuration, and surface materials, is not enough. A capability to predict the potential effects of alternative land-use schemes on natural-resource systems is essential to successful planning and resource management. Such capability depends on detailed knowledge of the natural system within which the various geohydrologic elements interact. Unfortunately, we do not presently know enough about the dynamic interaction of earth materials, ground and surface waters, the biota, and the atmosphere to support systematic modeling of the entire natural-resource system. Effective communication of natural-hazard information, as well as most other earth-science input to resource-management policies, would be greatly enhanced by such a comprehensive understanding of our natural system. Studies directed toward this understanding represent a most significant research challenge for the future.

In New England, local town government has traditionally been the principal unit of authority for managing earth resources and protecting public health and safety. New England towns vary considerably, ranging in size from 60 square miles to less than 6000 acres and representing a wide range in available economic and human resources. Local commissions such as Planning, Zoning, Wetlands, and Conservation regulate land and water use through a project-review and permitting system. In addition, state agencies provide longer-term, and perhaps more comprehensive perspectives for resource management and regulation at state and regional levels. Counties in New England are not viable units of government in terms of planning and management of natural resources.

In order to meet the planning needs of local and state authorities, CVUAP chose two map scales to present earth-resource information: 1:24,000 (1 inch = 2,000 feet) for local (town) use, and 1:125,000 (1 inch = approximately 2 miles) for regional and state use. The difficulty in establishing precise ground locations for data presented at these scales emphasized the further necessity of on-site studies in the planning and development process. For example, a 40-acre circle is about the size of a dime at 1:24,000. Therefore, our information was clearly for planning purposes and was not a substitute for detailed on-site investigation. While it might have been desirable to present information at a larger scale to aid in many local planning decisions, more detail was precluded because the available basic data were mapped at 1:24,000; moreover enlargement of such maps to locally attractive scales of 1:10,000 or 1:12,000 was technically unsound.

A primary information need, especially at the local level, was for specific geologic or hydrologic parameters in support of regulatory statutes. For example, regulations established 4 feet as the minimum distance between the bedrock surface and the base of a sanitary landfill; and similarly, a 4 foot-separation was required between the water table and the base of a sanitary landfill. CVUAP maps provided two relevant units: 1) bedrock 0-10 feet below land surface, and 2) water table 0-10 feet below land surface. While these units were not nearly as precise as the regulation required, they did provide the basis for a preliminary evaluation of bedrock and water table conditions, and thereby aided in the early planning stages for new solid-waste disposal facilities.

The most effective earth-science input in support of regulations and implementation of management policy required that necessary map parameters be presented at a common scale, and that map coverage extend to the boundaries of the planning authority. The CVUAP area was about 5,000 square miles, including parts of 4 states and more than 50 independent planning jurisdictions. While the CVUAP map series provided common scales appropriate to the areas of principal planning activity, the maps were prepared in a quadrangle format, and the project area was defined according to lines of latitude and longitude. This resulted in some maps showing parts of as many as 6 local planning jurisdictions, with no single jurisdiction covered completely. Clearly, such arbitrary boundaries tend to frustrate rather than aid the planning process.

The Natural Resources Center of the Connecticut Department of Environmental Protection was established in 1972 and from then on served as the focal point, information center, and principal contact between CVUAP and the state, Figure 1. The fundamental importance of the Natural Resources Center to the success of CVUAP cannot be over emphasized. Not only did we have in that organization sensitive, techniqually qualified, and creative counterparts at the state level, we also had a partnership in the committment to insure that the dissemination of earth-resource information was accomplished as widely and effectively as possible. This partnership permitted CVUAP to concentrate on the preparation of single factor maps with confidence that the critically important educational dimension was being effectively pursued by the Natural Resources Center. We could be confident that, in the long run, public awareness of the importance of earth-resource information and the public ability to utilize such information wisely would grow significantly. At present the Natural Resources Center is the focus for Connecticut's activities in expanding CVUAP map preparation for selected topics in parts of the state outside the project area, and is the source of new, innovative programs for resource management which may in part derive from experience with CVUAP, but which clearly go well beyond the capacity and commitment of the original project.

The success of CVUAP in Connecticut contrasts considerably with its relative lack of significant impact on the other states within the project area: Massachusetts, Vermont, and New Hampshire. In none of these was there a state institution such as Connecticut's Natural Resources Center with which CVUAP cooperated. It appears critically important to the success of a federal program such as CVUAP with limited duration and limited geographic extent, that some state or regional agency exist to carry out information-dissemination services and public education during the life of the project, and to provide continuity in data collection, interpretation, and application of earth-sciences information after the federal project has been completed.

Since 1976 and the completion of CVUAP field activities, a new USGS Project with similar objectives has been started in the Puget Sound region of the Pacific Northwest. Although the geologic and hydrologic setting is quite different than that of central New England, and although many of the natural hazards and current or anticipated environmental problems are quite different than those addressed by CVUAP, there are important similarities between the two projects and the transfer value of lessons learned from CVUAP is considerable.

First, it is clear that a resident staff of earth-scientists is critical to the success of programs designed to contribute relevant earth-science information to aid in the solution of local and regional environmental problems. A purely scientific, basic-research program may be appropriately located outside the field area, and in fact such a program may benefit by such an arrangement. But it is a fundamentally different situation when a primary responsibility for the use and applicaton of technical data is included in the project objectives. This responsibility requires frequent, and direct contact with the user community, and the ability to respond quickly to sudden events of local and regional concern.

Second, in order to efficiently handle the desired dialogue with the user community while still providing an appropriate atmosphere for technical-data collection and interpretation, a public information officer(s) should be an integral part of each project team. Ideally, an experienced planner should be part of the project team also, particularly during the early stages of program design, and later when products become increasingly available.

Third, a user-advisory committee, or some other means of channeling recommendation and evaluation from the user community, should be established early to insure adequate knowledge of critical issues and local planning priorities. Later, as earth-science products become available, the user-advisory committee can serve as a sounding board to test the effectiveness of specific products.

Fourth, an earth-sciences applications project should encourage the development of some local and/or regional institution(s) which can participate directly or be trained initially for later participation in project activities. Ideally, this should include all activities including prepartion of technical products, but highest priority should be given to participation in product dissemination and user education. Such an institution(s) is then prepared to continue, expand, and improve on products and methodologies long after the project has ended.

Fifth, of more product-oriented concern, maps with common scales appropriate to the intended level of use are desirable, as are products with coincident mapping and planning-authority boundaries.

Finally, to more effectively meet future needs for natural-resouces information to aid in formulating resource-management and hazard-warning policies, process-oriented basic research in the earth sciences, directed toward comprehensive understanding of natural systems, should be encouraged.

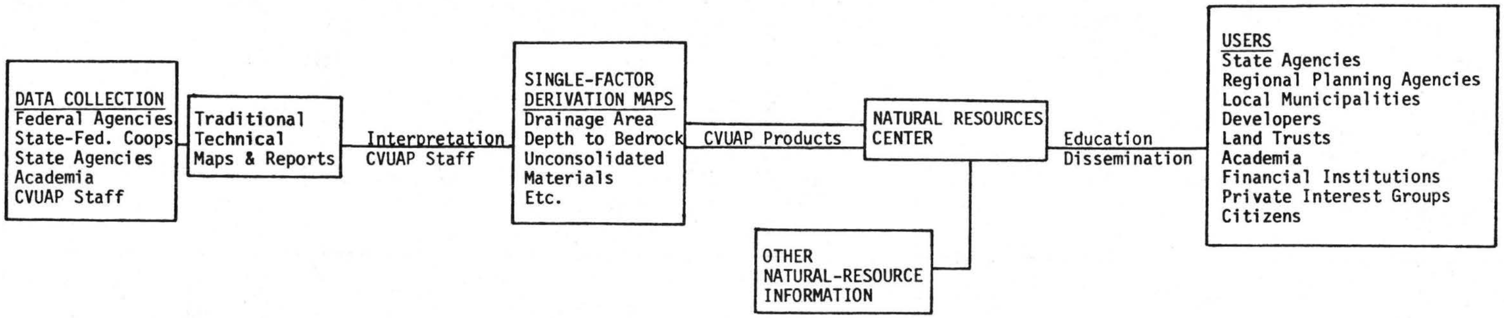


Figure 1. Flow diagram showing data sources, principal users of USGS earth-science information, and communication linkages for the Connecticut Valley Urban Area Project, 1972-1976.

POSTEARTHQUAKE FIELD INVESTIGATIONS: ACQUISITION AND TRANSFER OF SCIENTIFIC AND ENGINEERING DATA

by

Ted Algermissen

U.S. Geological Survey

Damaging earthquakes provide unique opportunities for improvement of the understanding of the nature and distribution of earthquake-related losses and often provide important new insight into the mechanism of earthquake occurrence. Surprisingly, only a comparatively few damaging earthquakes have been carefully investigated in the field, the majority of them within the past 15 years.

Major damaging earthquakes are relatively infrequent in the United States. Consequently, it is important to investigate foreign earthquakes whenever possible. Foreign earthquakes are becoming increasingly important as sources of information on building performance. Many earthquake-prone areas are undergoing rapid industrial and commercial development. Earthquake-resistant construction is becoming increasingly common throughout the world and many buildings are being designed using principles similar to those used for design and construction in some parts of the United States. Thus, foreign, as well as earthquakes in the United States, provide an important source of scientific data on the nature of earthquake occurrence, the resulting ground motion and geological effects, engineering data on the nature and distribution of damage, and the economic and social changes caused by the event.

Nature of the Data Obtained in Post-Earthquake Field Investigations

Unique seismological, engineering, economic, and sociological data are available after a damaging earthquake. Table 1 describes some of the types of information that can only be obtained from post-earthquake field investigations together with the applications of the data and the transfer of the resulting technology. No attempt has been made to make Table 1 exhaustive but it is representative of the type of information available from these studies.

It has only been in recent years that interdisciplinary post-earthquake investigations have been undertaken and comprehensive reports are comparatively rare. Table 2 lists some important earthquakes of the past 15 years together with significant information obtained through post-earthquake investigation. Only the data judged to be most important is listed for each earthquake and no attempt has been made to make the table comprehensive. Deficiencies still exist in the completeness of post-earthquake investigations. Funding limitations, logistics problems (particularly for foreign earthquakes), and availability of personnel all impose limitations on the studies.

An important deficiency in almost all post-earthquake investigations is the lack of statistical damage surveys based upon class of construction. The emphasis on damage surveys has tended to be on rather complete analyses of engineered buildings of interesting design and construction. In general, surveys are not made of the percentage of buildings of a particular class exhibiting a particular level or range of damage over the area affected by the earthquake. Data of this type are essential for disaster preparedness and risk studies but are expensive and time consuming to obtain. Another deficiency is the lack of investigation of the secondary losses (for example, economic losses resulting from loss of function) associated with earthquakes as well as studies of the sociological and related effects of earthquakes. Meaningful estimates of the costs of earthquakes to the economy and to society can hardly be approximated until these effects are evaluated through field investigations and analyses.

Figure 1 is a flow chart indicating the manner in which post-earthquake investigations are initiated and carried through. Information concerning the occurrence of large damaging earthquakes is usually first widely disseminated by the National Earthquake Information Service (NEIS) of the U.S. Geological Survey. Figure 1 shows the typical sequence of events (and information flow) after the occurrence of a major earthquake. In the case of foreign earthquakes, the U.S. Geological Survey and other government agencies normally must receive State Department approval before fielding a team. This approval usually depends upon an invitation for a team from the country involved. In some instances, an official team representing the United States is sent. Such was the case following the destructive earthquake in Romania in March 1977. Teams from the National Academies, the Earthquake Engineers Research Institute (EERI), universities, other organizations, and from the private sector are frequently fielded. The U.S. Geological Survey attempts to cooperate with other groups in the publication of scientific results of foreign earthquake investigations. In the case of the November 23, 1977, earthquake near San Juan, Argentina, the USGS and the Earthquake Engineering Research Institute (EERI) both sent teams to study the earthquake's effects and the two organizations have agreed on a joint publication of the results of their investigations.

Large damaging earthquakes in the United States are normally studied by a number of teams from various federal agencies, universities, and other groups. In the case of the 1964 Alaska earthquake, nearly all of the scientific and engineering papers resulting from studies of the earthquake were published by the National Academy of Sciences (many reprinted from earlier publications) in a series of volumes.

At the present time, even minor damage associated with small earthquakes is field investigated and documented by the USGS. The field studies are usually made either by the Survey group in Golden, Colorado, or Menlo Park, California, depending upon the geographic location of the earthquake and the availability of personnel.

Conclusions

Post-earthquake field investigations provide an indispensable source of data critical to nearly all phases of earthquake hazard and risk evaluation and improved earthquake-resistant design for structures of all types. Important damaging earthquakes should be investigated regardless of their location in the world. Several areas of post-earthquake investigation such as statistical studies of damage distributions, secondary economic effects and the sociological aspects of earthquakes are rarely investigated even at the present time. The results of field investigations are normally disseminated through technical papers and scientific and engineering conferences. There is perhaps a need for more popular articles prepared for wide distribution which describe the general nature of earthquake effects, the associated damage, economic, and sociological effects.

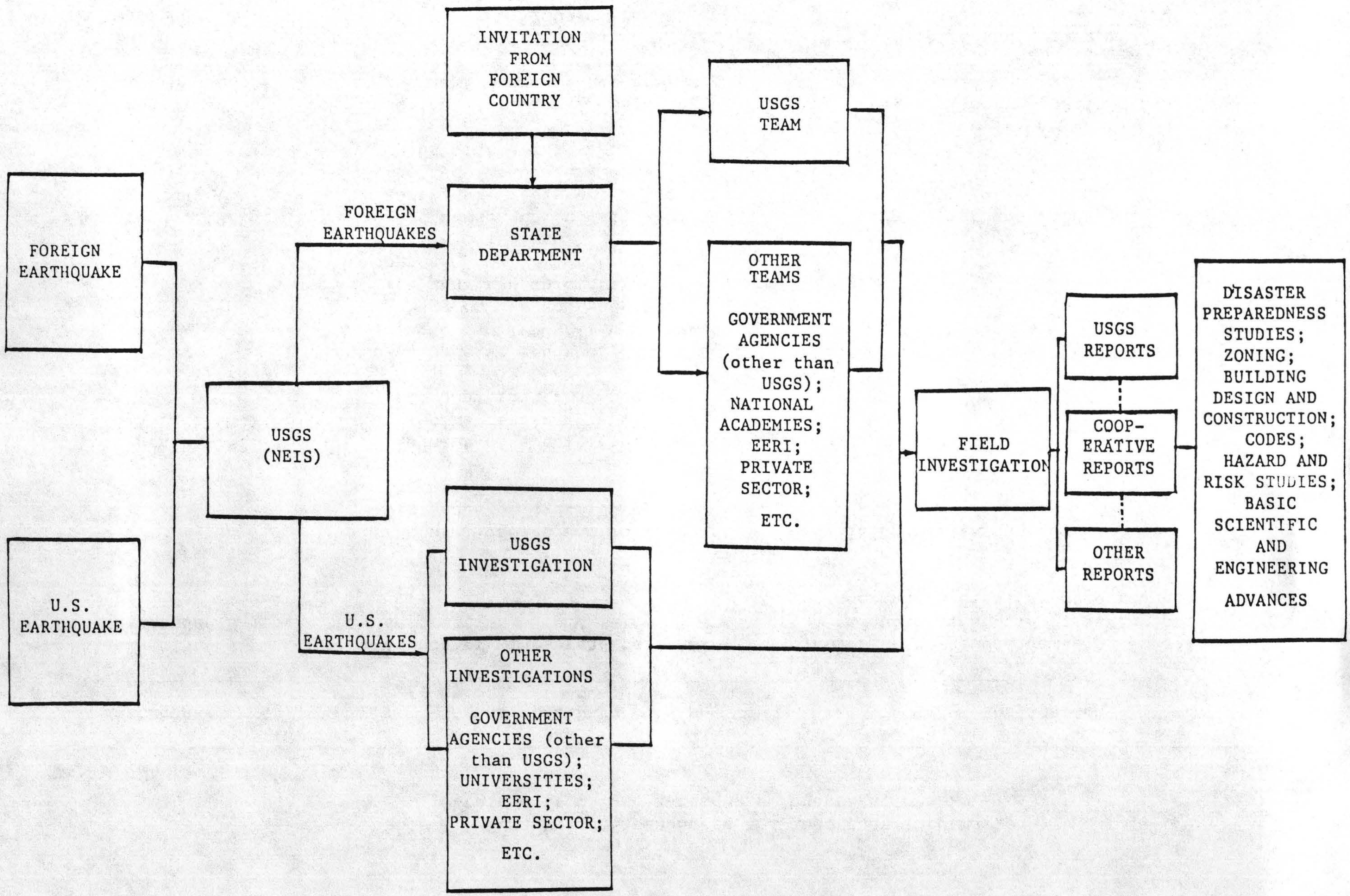
Table 1.--Representative Data, Applications, and Information Transfer Resulting from Post-Earthquake Investigations

Type of Field Investigation	Data Obtained	Application	Information Transfer
Temporary network of portable high sensitivity seismographs	Improved locations of aftershocks; corrections to travel times of seismic waves to seismic stations of the global network; mechanism of aftershocks	Identification of earthquakes with tectonic elements; direction of faulting in earthquakes; Identification of active tectonic elements through relocation of known earthquakes in the area	Technical papers; hazard maps
Temporary network of strong motion seismographs	Records of strong ground motion at short distances from earthquakes	Improved knowledge of ground motion parameters; Correlation of ground motion with damage; improved building design	Technical papers; hazard maps; building codes
Damage survey	Nature, degree, and distribution of damage to buildings, lifeline facilities and other facilities	Improved design and construction practice	Technical papers building codes; disaster preparedness studies;
Geological studies	Nature, degree, and distribution of geological effects such as faulting, landslides, liquefaction, etc.	Improved understanding of the mechanism of occurrence of faulting and other geological effects	Technical papers and popular articles; land use planning, hazard and risk studies; zoning and microzoning disaster preparedness studies

Table 2.--Some Major Earthquakes and Important Information Obtained from Post-Earthquake Investigations

Earthquake	Significant Data	Application
Alaska, 1964 Magnitude (M_s)=8.3	Evidence of widespread regional deformation	Deformation caused damaging flooding and uplift; should be taken into account in disaster preparedness studies
	Structural damage and collapse at distances of over 100 km from the earthquake	Building design and codes
California, 1971 Magnitude (M_s)=6.4	Deployment of special seismograph networks resulted in important soil amplification studies	Zoning, hazard maps
	Comprehensive study of damage to single family dwellings; severe damage to new code-designed building near the epicenter of the main shock	Economic loss studies, building design and building codes
Nicaragua, 1972 Magnitude (M_s)=6.2	Severe damage to buildings with earthquake-resistant design located immediately above the focus of the main shock	Building design and codes
Guatemala, 1976 Magnitude (M_s)=7.5	Important strike-slip faulting and associated damage pattern	Faulting similar to possible faulting in California
Argentina, 1978 Magnitude (M_s)=7.4	Significant liquefaction at distances of more than 200 km from the epicenter of the main shock	Hazard mapping and zoning

Figure 1.--Information Flow from Post-Earthquake Investigations



Collection and Dissemination of Intensity Data from U.S. Earthquakes

by Carl W. Stover
U.S. Geological Survey

I. The Information Producer/User Community

Motivation. The original motivation for collecting and evaluating intensity data was to map the damaging effects of earthquakes and to assign an epicenter. Collecting felt and damage data was the earliest method of studying an earthquake before the advent of the seismograph which we now use to record earthquake waves. The earliest intensity scales were developed in Italy about 1783 with 39 different scales in various parts of the world being used previous to the publication of the 1931 Modified Mercalli Scale which is now used in the United States. Our motivation for collecting intensity data is to learn more about the damage pattern and how the shaking correlates with surface soil conditions and where these soil conditions cause anomalously high intensity ratings. These data, in terms of a numerical value, are made available to anyone who needs it; such as researchers, land planners, for power plant sitings, dam sites, etc.

The collection of earthquake effects by means of a questionnaire began in the mid-1920's in California and became a nation-wide governmental operation in 1929. This data has been collected annually since the 1920's and published in the booklet, "United States Earthquakes." The present procedure is to initiate a questionnaire canvass or field studies, when necessary, following each earthquake in the United States of about magnitude 3.5 or larger.

Objective. The objective of the canvass and field studies are to obtain information that will define the degree of damage and describe the effects of each community in the area affected by the earthquake. Some of the effects to be analyzed, for example, are: what type of buildings were damaged; what was the damage to the outside walls, inside walls; why did some chimneys sustain more damage than others; and what was the total area affected and to what extent.

Methods. The canvass is primarily accomplished by means of a questionnaire which is addressed via computer using a program that searches a file of all the post office addresses in a given radius from the earthquake. The questionnaires are mailed to postmasters who complete the questionnaire and return it to the National Earthquake Information Service (NEIS) where it is evaluated using the Modified Mercalli Intensity Scale of 1931. The intensities evaluated are then used to compile isoseismal maps which are published along with the more important damage and felt effects in a USGS Circular and in the annual publication "United States Earthquakes," published jointly by the Department of the Interior and Department of Commerce.

Data are also collected from collaborating citizens who voluntarily agree to complete questionnaires after they have experienced an earthquake. These collaborators are located primarily in the conterminous United States with most being located in California. Another source of data is the personnel in field offices of the U.S. Geological Survey, National Park Service, Forest Service, National Weather Service, and U.S. Air Force weather observers.

When an especially damaging earthquake occurs, a field team will be sent to make an on-site inspection of the damage and to make a detailed street by street survey of populated regions for purposes of mapping the degrees of damage. This data may be used to correlate damage with ground conditions or geologic features. All of these data are evaluated and used in the same procedure as mentioned above for the postmaster questionnaire.

Issues and Problems. The critical problems that had to be solved in collecting intensity data were the legalities of sending government questionnaires to private citizens and the accessibility of private property to government scientists evaluating the damage. The questionnaire problem was solved by getting OMB approval which allows private citizen canvasses. However, the private property question is unresolved and access is only allowed by owner's approval. Also, the question of insurance claims may become an involvement for the field team because of the estimate of the degree of damage by the scientist and the estimate by the owner and/or insurance agent. This has not surfaced in the past but must be considered for future damaging earthquakes.

Component Parts. The component parts of the activity described above can be labeled as data acquisition, data reduction, and data dissemination. Acquisition is the collection of the raw data using questionnaires, personal communication, collaborators, and field inspections; reduction is the evaluation of the data collected in terms of the effects to man-made structures, people, and ground effects (landsliding, faulting, etc.,); and dissemination is the means used to get the final results into the hands of the user (publication, maps, letters, personal communications, etc.).

II. A. Evaluation of Information Communication Activities

Information and Communication. The requirements for information depend on the intended use. Some users want the raw data so they can make their own interpretation; others need the final results after all the interpretations have been made and published. Sometimes the data dissemination can result in feedback in terms of new interpretations of published data. For example, the Geological Survey of Kansas recently did a report on the historical earthquakes of Kansas and suggested not only a different location but a different intensity for an earthquake that had been published previously.

Two-Way Communication. A series of state seismicity maps is being prepared by the USGS which is of interest to the state geologists in each state. Two-way communication is achieved in the production of these maps by involving the state geologist's office in the compilation of the data and the review of the maps before publication.

Focal Point. The focal point for earthquake intensity data in the U.S. Geological Survey is the U.S. Earthquake project, Branch of Global Seismology, Golden, Colorado where all the operations described above are performed.

Public Media. The public media is utilized indirectly. The initial information concerning an earthquake that was felt or caused damage is frequently first reported by the news media, thus our decisions on canvassing or making field studies are based on this initial information. This project has no direct contact with the public media; however, the data is disseminated indirectly through the Earthquake Alerting (Warning) Service System of the National Earthquake Information Service. The Earthquake Alerting Service System usually disseminates the preliminary intensity data rapidly; the more complete results are made available from one to six months after the event. The maximum intensity would be made available in one to two weeks if a field inspection had been made.

Communication Channels. The standard channels for communication of intensity information are by telephone, letter, publications, and maps. These channels are sufficient for this purpose because they span the range of time between personal communication immediately following the earthquake to the finalized written publication months after it. Some of the channels for communication are: Earthquakes in the United States, a quarterly USGS circular containing seismicity and isoseismal maps, earthquake hypocenters by state, and intensity data describing the effects of each earthquake on the communities; and state seismicity maps showing the earthquake history of each state (the first is Maine).

B. Performance Evaluation

Timeliness of the Information. The intensity data is disseminated as quickly as possible under the system presently used as described in section I. The preliminary results are available in a timely manner; however, the publication of the final results is interlocked with the publication of the earthquake hypocenters program published by the NEIS and is therefore dependent upon their publication schedule. The data are only worked once for publication in a USGS Circular, but additional data may be added at a later time when United States Earthquakes is published.

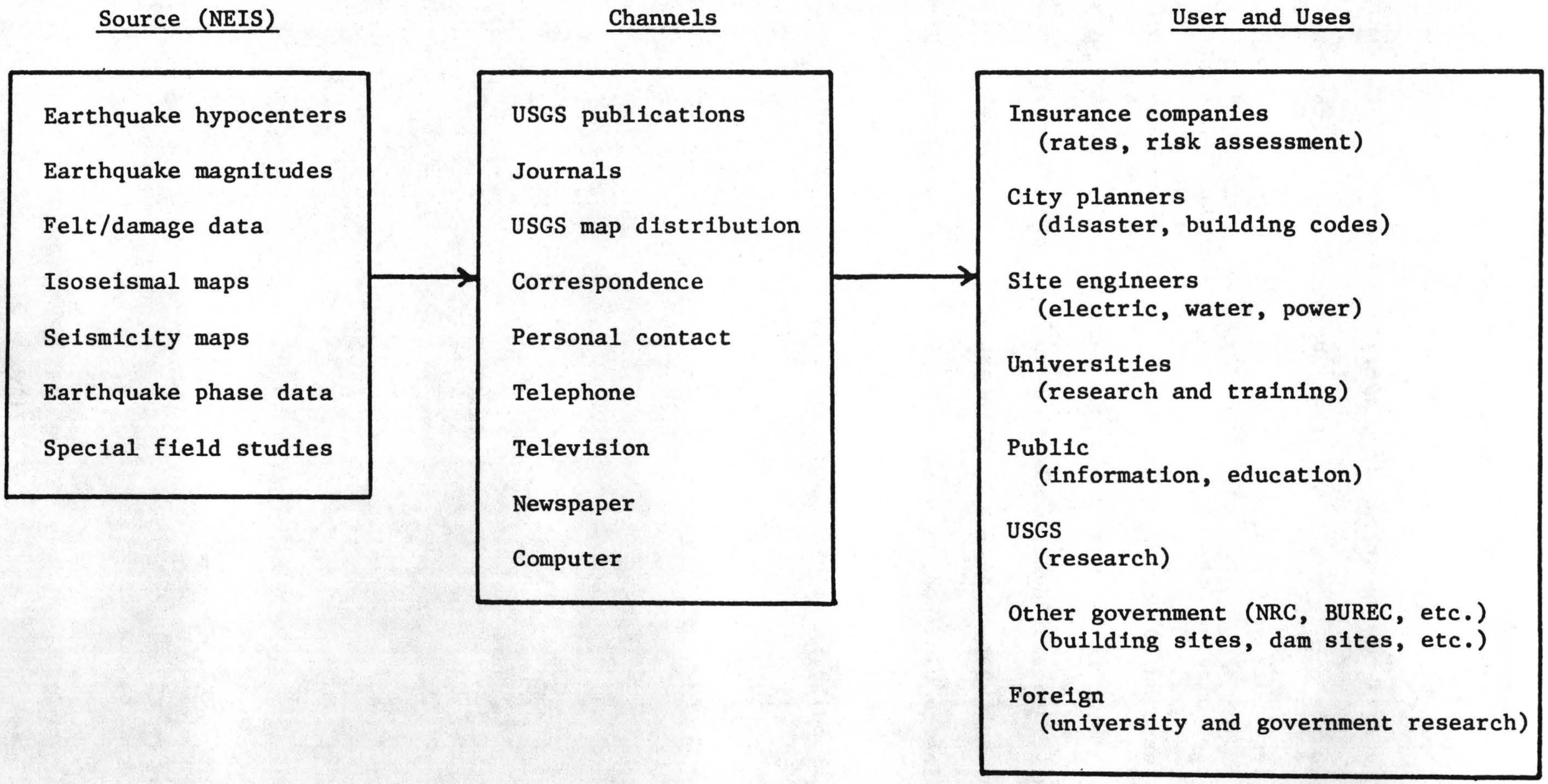
Communication Monitoring. There is no formal monitoring of the communication of the intensity data between the producer and user; however, the feedback by means of correspondence and telephone indicates that it is well used. Many requests are received from insurance companies, engineering companies, government researchers, university researchers, and land use planners.

Strengths and Weaknesses. The strength of this system is that there is a source of intensity data for United States earthquakes that is available from a single source, both in a preliminary stage and in the final published form. The weakness is not being able to publish the data within a set time frame so that the data is available in the printed form within a reasonably short period after the earthquake.

Lessons Learned. One of the important lessons learned in developing the canvassing methods now used in collecting intensity data was the type of format of the questionnaire to be used. When designing a new questionnaire, consideration had to be given to how the public would interpret the questions so that the replies would mean the same to the person filling out the questionnaire and the person evaluating the data. For example, the question of structural damage must not be interpreted as cracked and fallen plaster by the person filling out the questionnaire.

Uses. Intensity data can be used in many ways. Some of the more important uses of intensity data are in hazard reduction that applies to risk zone mapping and related building codes for the construction industry; and in land-use planning where it relates to the building of dams, nuclear power plants, and other building sites.

Information Flow Diagram - National Earthquake Information Service (NEIS)



EFFECTIVENESS OF THE EARTHQUAKE EARLY REPORTING SERVICE OF THE USGS, NEIS

by Waverly J. Person

U. S. Geological Survey

EARTHQUAKE ALERTING (WARNING) SERVICE SYSTEM

A. The Information Producer/User Community

People, Activities and Strategies

1. Motivation for the Earthquake Alerting Service System was scientific, socio-economic, and political, in many cases.

2. This activity began in 1966 when the NEIS was with the Department of Commerce (NOAA) in Rockville, Maryland and several Congressmen wanted to know about an earthquake in North Carolina. We were unable to furnish the information wanted because the earthquake had occurred during non-working hours. Since 1966 the NEIS has provided this early reporting service on significant earthquakes around the world.

3. The objectives of this system are to determine earthquake epicenters and magnitudes as rapidly and accurately as possible for release to disaster relief, scientific groups, groups planning aftershock studies, other government agencies, and to public information channels.

4. The system is activated by the sounding of an alarm, triggered by the recording of large amplitudes, at the National Earthquake Information Service (NEIS) or by visual observations by NEIS personnel during normal working hours. The NEIS system is alerted by telephone or telegraph when similar alarms are triggered at each of the other participating observatories: Guam (GUA), Newport, Washington (NEW), NOAA Observatories (Tsunami Warning Centers), Honolulu (HON), and

Palmer, Alaska (PMR). The NEIS is also advised by telephone or telegraph of strongly felt earthquakes by National Weather Service observers, other participating meterologists, the Civil Defense National Warning System (NAWAS), and inquiries from the press, citizens, or other sources.

5. The federal-state-local-private sector groups and individuals all have critical roles or responsibilities in the communication of information. The conditions under which each of these groups may be involved depends on where the earthquake is located, its magnitude, and other circumstances; that is, all earthquakes in the United States that are felt strongly or may cause damage.

The following agencies are alerted when a significant or potentially damaging earthquake occurs anywhere in the world:

USGS

Frank McKeown - Field Studies

Bob Hamilton - Reston

John Derr - Latest procedures

Bob Engdahl - Emergencies

H. Fleming - International Geology

R. Mattiesen - Branch of Seismic Engineering

Frank Forrester - Public Information

Ruth Simon - Felt report canvass

Emergency Services

Duty Officer

FDAA

Bill Belford - Headquarters

John Swanson - Region 8

Bob Stevens - Region 9

Duty Officer - Region 10

FPA

Harry Thomas - Dams

DCPA

T. A. Baxter - Civil Preparedness
Pentagon NORAD, Colorado Springs

State/AID

Bob Clary - Damaging, foreign
or Duty Officer

Red Cross

Roy Popkin - Damaging, U.S.

Smithsonian

Richard Golob - Cambridge CSLP

T. E. Simkin - Washington

U.S. Senate

Ted Stevens - Substantial damage, Alaska

U. of Western Ontario

R. Mereu - Near London, Ont.

NBS

Sam Kramer - Damaging worldwide

Bu. Rec.

A. Viksne - Western States

S. Shimamoto or H. Gunnarson

C.U.

Eugene Haas - Tsunamis

Army

Walt Sherman - Dams & Waterways

Nels Jahren - St. Louis engineers

McDonald Observatory

Eric Silverberg - Lunar Laser

Press

AP

UPI

Reuters

Suitland - RAWARC

Honolulu - Tsunami

EERI

E. F. Moran

Dept. Water Res. Idaho

C. Stephen Allred or Law Enforcement Bur.

Earthquakes in Utah, magnitude 4.0 or greater--state geologist is notified, Ben Everitt or Bruce Kaliser

From this point, the local-private sector groups and individuals may become involved.

Potentially damaging earthquakes worldwide--Bob Clary or Duty Officer, State AID.

6. The critical scientific, socio-economic, and legal-political issues and problems will vary depending on the state or country in which the destructive or potentially destructive earthquake is located. In many cases, the local, state, or federal governments may be involved. It would be their responsibility to make the decision on what should be done, depending on the severity of the earthquake or whether the earthquake was near a dam or a nuclear plant.

The critical scientific, socio-economic, and legal-political issues and problems that had to be resolved are as follows:

The Oroville earthquake of August 1, 1975, magnitude 5.7:

(a) Who will do the aftershock studies--the U.S. Geological Survey, the University of California (Berkeley), the California Division of Mines and Geology, or will it be a joint effort?

(b) Who will do the damage survey?

(c) What about the Oroville dam?

(d) Did the loading of the dam cause the earthquake?

(e) What about the aftershocks? How large are they expected to be?

(f) Is the dam in immediate danger? What do we tell the local officials and people living in the area?

The Guatemala Earthquake of February 4, 1976 was an example where all the critical conditions had to be resolved as mentioned above. At the time we located this earthquake, we knew that loss of life and considerable damage had occurred. Many American citizens were in Guatemala at the time of this earthquake. In this case most of our dealings were with the federal government (The State Department). For several days after the earthquake, we had to deal extensively with state authorities, press, news media, and individual citizens who had relatives in the area. We must be sure we follow the chain of command in accordance with the list of people who are to be notified under certain conditions. Foreign countries are usually handled through the State Department.

8. The main strategy for resolving critical issues involving earthquakes is utilizing the news media effectively. The releases should be made in a way that will not cause the people in the area of the earthquake to panic. During television and radio interviews concerning an earthquake, it is important to be careful as to what is said about aftershocks, and to consider the effects these statements may have. You shouldn't let the interviewer tell you want to say; stay with the facts. It is important at all times to keep the population from going into a state of panic.

The components of the information communication used in these activities are the press and news media, National Weather Service (RAWARC), National Warning System (NAWAS), telegraphic releases and the telephone.

B. Evaluation of Information Communication Activities

Relationships of People and Activties

1. The specific requirement for our group as information producers is to give all information pertaining to a damaging or potentially damaging earthquake as quickly and accurately as possible to all people concerned. Then this information must be updated as often as possible for the user.

2. In most cases, we do have two-way communication. When information on a specific earthquake is given to the press or radio stations, they will, in turn, give us information about damage reported by individual citizens. In the United States, the Weather Service, in many cases, gives us information about damage reported to their office or alerts us on a small earthquake. Two-way communication is achieved in some cases from the Civil Defense National Warning System (NAWAS). Cooperating universities and colleges are utilized when earthquakes are located in their areas or recorded by the network of stations they are operating. The press is very helpful in getting felt and damage reports from an area affected by an earthquake.

3. The focal point or information center involved is located at the NEIS in Golden, Colorado. In our war room, 1711 Illinois Ave. #544, we have a Western Union Teletype where telegraphic information is received and can be sent out when required.

4. The public media is used extensively during and immediately following an earthquake in or near a populated area. Radio and television are the prime means of communicating information to the public about the earthquake's location, magnitude, and aftershocks. The media is also valuable for use in calming fears when necessary.

5. The standards and existing channels for the communication of information have been sufficient for the United States but there is room for improvement in foreign communication.

6. We have had no need for translators, individuals or groups, in the communication process in order to bridge the gap between us and the users. The present communications system is doing the job.

C. Performance Evaluation

1. The initial information reaches the concerned users in a very timely manner (within three hours for earthquakes magnitude 6.5 or greater world-wide and for earthquakes in the United States much faster). The initial release of information for many areas is very preliminary; therefore we are constantly updating our information whenever possible. The location of earthquakes can usually be improved with additional data. Epicenters are re-computed and passed on to our users whenever additional data becomes available. For aftershocks studies, the best location is very important.

2. The information communicated to users is monitored by the feedback we receive from the public media and personal conversations with individuals receiving our information.

3. A few of the strong points in our communications process are the notification list we have on file telling us who to notify when an earthquake occurs in certain areas, and having access to the civil defense warning system (NAWAS), the hot line to NORAD in Colorado Springs. This access allows us to get timely information from areas where damage is suspected. If telephone service was knocked out in an area, there would be a definite weakness in our communications process.

4. The early reporting service is a continuing service and we are always looking for improved lines of communication on a two-way basis. For U.S. earthquakes we would like to get each state geologist involved.

5. Lessons Learned - Domestic Earthquakes

(a) Give accurate media release of initial information; e.g. location, magnitude, etc.

(b) Avoid semantic confusion; e.g. magnitude, intensity in news releases.

(c) Tell the truth, but don't panic the public (through the media).

(d) Involve the local experts (other government agencies, civil defense, state surveys, universities, engineering firms, EERI) to define the scientific problems and to resolve local political problems.

(e) Success in communicationg accurate earthquake information generates long lists of agencies, people to be notified.

(f) Repeat of the 1906 San Francisco or the 1811-1812 New Madrid earthquakes would be the ultimate test of NEIS capabilities.

Lessons Learned - Foreign Earthquakes

(a) The more information you give the more you receive.

(b) The state department (aid) is the key to effective communication and response initially.

(c) Scientific counterparts are essential to productive research.

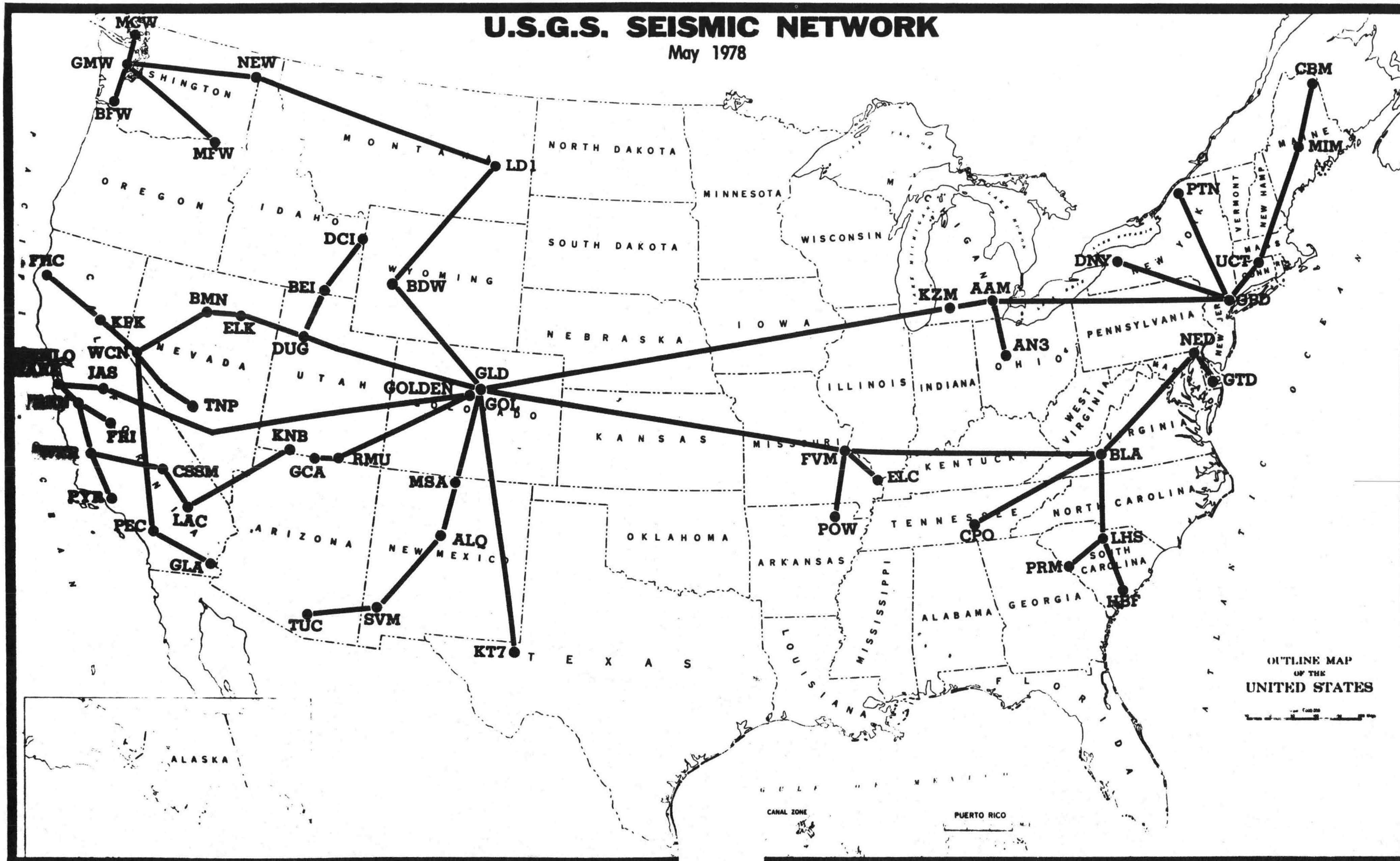
6. Decision makers have been helped in many ways. Knowing where the earthquake is located and its magnitude, in most cases gives, an indication of what to expect in the way of casualties and damage before reports are received from the area. This may give an indication of the needs of an area: medical help, food, shelter, water supplies, and many other needs. At the time of the 1971 San Fernando earthquake, the decision makers knew immediately that medical aid and supplies would be needed because of the magnitude of the earthquake and its location. Other questions were also generated. How large are the aftershocks? Are they increasing in magnitude? The dam is about to break--will the aftershocks finish it off? Should we evacuate the people in the valley?

The Bureau of Reclamation has been helped by knowing when an earthquake has occurred near one of the dams and if the magnitude is such that emergeny action need be taken. Decision makers were helped during the time of the Idaho-Utah border earthquake of March 27, 1975, magnitude 6.1. The earthquake was felt strongly in parts of Utah; we were able to say that the quake was not centered in the Salt Lake area and damage would be light in the Salt Lake area.

The state AID has been helped in many instances on foreign earthquakes by our activity in the following manner. On the Guatemala earthquake February 4, 1976, the state AID was able to make the decision immediately that medical aid, food, shelter and clothing were needed. Information was given to the embassy in Washington, D. C. about the severity of the earthquake.

We have helped in many foreign earthquakes by information we have given the State Department.

7. We are not aware of any legislation being generated as a result of our operation.


U.S.G.S. SEISMIC NETWORK
May 1978
MCW
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GRD
CBM
MIM
WASHINGTON
OREGON
IDAHO
MONTANA
WYOMING
NEVADA
UTAH
COLORADO
ARIZONA
NEW MEXICO
TEXAS
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
MINNESOTA
IOWA
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LOUISIANA
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INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
PENNSYLVANIA
NEW YORK
VERMONT
NEW HAMP
MAINE
MASS
NEW JER
ALASKA
CANAL ZONE
PUERTO RICO
OUTLINE MAP OF THE UNITED STATES

ENGINEERING RESPONSE TO RECENT DESTRUCTIVE EARTHQUAKES

by

Peter I. Yanev* and Roger E. Scholl

1. INTRODUCTION

Since the 1906 San Francisco earthquake, the various professions concerned with earthquakes have studied the aspects and consequences of most destructive United States earthquakes and selected foreign destructive earthquakes. The scientific and engineering lessons from these events have been published and have received steadily increasing attention. Since the 1933 Long Beach, California, earthquake, these engineering lessons have found their way into the building codes, which has resulted in increased building safety and reduction of potential earthquake losses. Architectural layouts, structural details, and building practices, however, have also undergone transformations. Often, the codes have been slow to react to major changes in building practices, which has resulted in large numbers of unsafe modern buildings. For example, the 1971 San Fernando earthquake clearly illustrated the inadequate resistance of certain types of modern commercial buildings (i.e., tilt-up buildings) and several types of residential single-family dwellings (i.e., split-level and some two-story houses). Thus, we are still learning from earthquakes -- from the basic earthquake mechanisms to failure mechanisms in buildings.

This paper discusses the acquisition of scientific and engineering information after two destructive earthquakes (the San Fernando, California, earthquake of 1971 and the Managua, Nicaragua, earthquake of 1972) and the response of the involved professions, including the exchange of information among the professions on the lessons learned. In addition, the paper discusses the use of specific portions of the information for predicting the effects of hypothetical earthquakes on urban areas, how some of the information can be used to predict the effects of these earthquakes, and what information is currently missing and needs to be collected.

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* URS/John A. Blume Associate Engineers

2. SUMMARIES OF THE EXAMPLE EARTHQUAKES

2.1 The San Fernando, California, Earthquake of February 9, 1971

The San Fernando, California, earthquake occurred at 6:01 a.m., local time, on February 9, 1971. This magnitude 6.6 shock was not a great earthquake, but it centered on the northern edge of the Los Angeles metropolitan area, which has a population of more than 8 million people. Approximately 400,000 persons were subjected to very strong ground shaking (0.25g or greater) and approximately 2 million more to moderately strong shaking (0.15g to 0.25g). Most of the metropolitan area was not strongly affected by the earthquake, and its resources were available to assist in counteracting the damaging effects of the shock.[1]

The strong motion of the main shock lasted about 12 seconds. Because the earthquake occurred near the center of the largest concentration of strong-motion recording instruments in the world, the 340 available instruments provided the largest number of strong-motion records ever recorded from any earthquake.

A total of 58 deaths and over 2500 hospital-treated injuries were recorded; 47 of the deaths were a result of the collapse of a single non-earthquake-resistive structure at a Veterans Hospital. The early hour of the shock greatly diminished life losses and injuries.

Direct damage to buildings and other structures exceeded one-half billion dollars. This amount was divided about equally between private and public property. Most of the severe damage and the major building losses were along the southern foothills of the San Gabriel Mountains and along the band of surface faulting that runs east-west on the San Fernando Valley floor.

Because of the short duration of strong shaking, many severely damaged buildings managed to survive without collapsing. Also, the San Fernando Valley is a relatively new urban area, and over 95% of its houses and buildings were constructed since 1933, when the first earthquake design requirements were incorporated into the local building code. Most modern buildings, designed to the requirements of the building code, performed well; however, a number of modern buildings in the region of strong shaking were severely damaged. Extensively damaged modern buildings included residences, light industrial buildings, apartment houses and other smaller commercial buildings, hospitals, several high-rises, and others. Service structures and lifelines in the strongly shaken areas also suffered severe damage.

Fortuitous circumstances limited the losses from the earthquake. The most striking example is the structural failure of the Van Norman Dam. Despite a near-total failure of the dam, the impounded water was not released, and it was possible to evacuate the 80,000 persons living below the dam until the water was drained. Had this and other circumstances of the earthquake been adverse, the casualties could have been in the thousands and could have been comparable to life losses generally experienced in developing countries.

2.2 The Managua, Nicaragua, Earthquake of December 23, 1972

Managua is the capital and largest city of Nicaragua, with a population of about 500,000. The city is also the business and industrial center of the country, with approximately 80% of Nicaraguan industry centered near and in the city. Managua was struck by three moderate-sized earthquakes within less than an hour in the early morning of December 23, 1972. The first and largest earthquake, which had a magnitude of about 6.2, occurred at 12:30 a.m. The two largest aftershocks occurred within an hour of the main event and caused additional damage. The earthquake destroyed most of the central district of the city, severely damaged most buildings, interrupted essential services, and severely disrupted the entire economy of Nicaragua.

The main shock and some strong aftershocks were recorded by a strong-motion accelerograph at the Esso refinery west of the city. The accelerogram exhibited a maximum horizontal ground acceleration of 0.40g. Numerous surface fault breaks occurred throughout the city. A surface fault break about 6 km long, with left lateral displacement up to 38 cm, extended in a northeasterly direction through the central district.

Parallel to this surface break were three other major breaks, one of which crosses the city through the most densely populated part of the downtown area.[1]

Official casualty figures are not available. Various publications reveal estimates of between 6,000 and 11,000 persons killed and about 20,000 persons injured. About 75% of the city's housing units were destroyed or rendered uninhabitable, leaving between 200,000 and 250,000 people homeless. The local taquezal (wood framing with adobe walls) construction suffered particularly heavy damage. Many public buildings, hospitals, schools, commercial buildings, and residences collapsed or were seriously damaged. Public utilities -- including water, power, telephone, and sewer systems -- did not function for various periods of time. The total property damage is estimated to exceed a billion dollars (U.S.). Also lost was some 30% of the gross national product for that year.

The severity of the damage caused by the earthquake was unusual for the moderate size of the earthquake, especially when compared to the 1971 San Fernando earthquake. The reasons for the relatively high damage are: (1) the earthquake and the aftershocks occurred at shallow depth under the city, (2) surface ruptures occurred on at least four surface faults, and several additional minor faults, in and near Managua, and (3) most buildings had little resistance to seismic shaking.

3. COLLECTION AND DISSEMINATION OF ENGINEERING AND OTHER INFORMATION

The response of the professional disciplines to the San Fernando and Managua earthquakes examined here is limited to the response that occurred within about one year after each earthquake. It includes earthquake damage investigations, seismologic and geologic investigations and data collection, and other field work relating to the causes, effects, and consequences of the earthquakes.

The two earthquakes were selected because they are the most thoroughly documented events since the 1964 Alaska earthquake. Approximately one year after each event, the Earthquake Engineering Research Institute (EERI), a nonprofit professional corporation established in the public interest, held conferences on the earthquakes and the information gathered about them. Since these conferences were held, much additional information has been analyzed, voluminous data have been published, and many advances have occurred in seismology, geology, engineering, planning, disaster preparedness, and other disciplines.

3.1 Method of Communication

The three conferences that are reviewed are:

1. National Conference on Earthquake Engineering -- Investigation of the San Fernando Earthquake of February 9, 1971, which was held in Los Angeles, California, on February 7 through 9, 1972.
2. EERI conference on the Managua, Nicaragua, Earthquake of December 23, 1972, which was held in San Francisco, California, on November 29 and 30, 1973.
3. Sixth World Conference of Earthquake Engineering (6WCEE), which was held in New Delhi, India, on January 10 through 14, 1977.

The first two conferences were held to establish a forum of information exchange on the San Fernando and Managua earthquakes. The third conference is one of a series held every four years; the scope of the papers presented is unlimited, so long as it pertains to the general subject of earthquakes. The exchange of information has been in the form of invited papers, submitted papers, and panel discussions. Extensive volumes were published on the Managua earthquake conference and the 6WCEE.[2,3] Most of the papers presented at the San Fernando earthquake conference were subsequently published in the technical literature.

All information presented at the two conferences was collected, processed, and analyzed within about a year after the events. In the case of the San Fernando earthquake, damage and related information was collected by teams of engineers from a multitude of private engineering companies, governmental agencies, professional institutes and organizations, insurance companies, universities, and others. The location of the earthquake and relative lack of damage to the Los Angeles metropolitan area made it quite easy for anyone interested in surveying the damage to do so. Thus, many engineers from outside Southern California were able to see, firsthand, the effects of a strong earthquake on all types of structures. In the case of the Managua earthquake, the EERI organized a reconnaissance team, which spent about seven days in Managua, beginning three to four days after the earthquake. As a result of their immediate reports of the engineering significance of the earthquake, the EERI assembled another four teams (a total of 13 investigators), who undertook more detailed studies. Many other organizations sent teams into Nicaragua, including those that had investigated the San Fernando earthquake. In addition to United States participation, all Nicaraguan government agencies and a number of private engineers participated extensively in the investigations, and the EERI conference was organized by representatives of these various groups of investigators.

3.2 Summary of the Collected Information: A Statistical Breakdown

A total of 47 technical papers were presented at the San Fernando Earthquake Conference, and 42 papers were presented at the Managua Earthquake Conference 18 months later. A summary of the general topics addressed by these papers is presented in Table 1, together with the number of papers concerning each topic. Note that one paper may be assigned to one or more of these topics: for example, a high-rise building is often a steel building, hence it is included in both items 9 and 10 of Table 1, and the total number of papers is less than the sum of the columns.

TABLE 1

RELATIVE EMPHASIS ON VARIOUS EARTHQUAKE-RELATED TOPICS
AS MEASURED BY NUMBER OF PAPERS DEALING WITH
SPECIFIC TOPICS PRESENTED AT TWO EERI CONFERENCES

Topic	Number of Papers	
	San Fernando Earthquake Conference	Managua Earthquake Conference
Earth Sciences		
1. Seismicity and Seismology	5	5
2. Geology and Geological Effects	6	4
3. Intensity and Ground Motion	8	5
4. Soils and Soils Effects	5	3
5. Zoning	0	1
Response		
6. Structural Damage Surveys - General	5	5
7. Response of Masonry Structures	1	2
8. Response of Concrete Structures	9	11
9. Response of Steel Structures	5	1
10. Response of High-Rise Structures	12	10
11. Response of Low-Rise Structures	3	5
12. Response of Industrial Structures	1	2
13. Response of Lifelines	4	5
14. Response and Testing of Structures	2	2
15. Response of Nonstructural and Equipment Items	3	3
Cultural Effects		
16. Economic Aspects of Earthquakes	2	3
17. Sociological Aspects of Earthquakes	0	3
18. Engineering and Architectural Practice	0	3
Total Number of Papers Presented	47*	42*

*Because some papers treat more than one topic, this total is not the sum of the numbers in the column above.

In general, the same type of audience attended both meetings. For the Managua Earthquake Conference, professionals from the United States benefited from the viewpoints of their peers from Nicaragua. Table 1 shows that the distribution of professional interests (as they are expressed through the EERI) remained more or less the same at the two conferences: for example, interest in high-rise structures heavily outweighed interest in low-rise structures. The ratio of papers dealing with earth sciences topics remained roughly unchanged in the two meetings. One important difference is that in the Managua conference, zoning and the economic and sociological aspects of earthquakes were emphasized. Unlike the San Fernando earthquake, the Managua earthquake was a major Nicaraguan disaster, perhaps comparable to the effect of the San Francisco earthquake and fire of April 18, 1906, in the San Francisco Bay Area. The EERI reconnaissance team was impressed with the total lack of planning and seismic hazard zoning, inadequate building codes, and inadequate disaster preparedness, which had left the city completely unprotected and vulnerable to earthquakes. Ten of the 42 papers presented during the Managua conference dealt with these subjects, as compared to only 3 out of 47 in the San Fernando conference. Since 1973, the EERI and the involved professions in general have placed a much greater emphasis on the zoning, economic, and sociological aspects of earthquakes. With current progress in the area of earthquake prediction, interest in those areas of earthquake engineering is expected to increase further.

More than 600 technical papers were presented at the 6WCEE in India. Fewer than half of the papers were by United States authors, and these papers, again by topic and applicable papers, are summarized in Table 2. The general distribution of interest was similar to that of the San Fernando conference. Heavy emphasis was again given to defining the dependencies and nature of ground motion and ground motion design criteria, the seismic analysis and design of buildings, and the testing of buildings. Four papers were presented in the areas of repair of buildings damaged by earthquakes and the strengthening of existing buildings against earthquakes. This topic is now receiving much attention, which is expected to increase in the future. The information presented in Table 2 is treated further in Table 3. Only the papers

TABLE 2

RELATIVE EMPHASIS ON VARIOUS EARTHQUAKE-RELATED TOPICS AS MEASURED BY NUMBER OF UNITED STATES PAPERS DEALING WITH SPECIFIC TOPICS PRESENTED AT SIXTH WORLD CONGRESS IN EARTHQUAKE ENGINEERING, NEW DELHI, INDIA, 1977

Topic	Number of Papers
1. Seismicity	5
2. Ground Motions	
Descriptions, Properties, Classifications, Models	22
Dependence on Source and Path of Propagation	22
Dependence on Local Soil Conditions	13
3. Siting, Zoning, Planning, Research Programs	6
4. Building Instrumentation and Records	6
5. Seismic Analysis and Response, Damage	
Liquefaction	5
Earth Structures	5
Piles and Caissons	5
Foundation and Soil-Structure Interaction	15
Structural Analysis Methods	17
High-Rise Buildings	15
Low-Rise Buildings	2
Steel Members and Frames	2
Concrete (and Concrete Masonry) Members and Frames	14
Large Industrial Structures	4
Nuclear Power Plants and Equipment	14
Ocean Structures	3
Dams, Bridges, Lifelines, Stacks, Tanks	13
Building Nonstructural and Equipment Items	4
6. Testing of Structures and Soils	
Soil Testing Procedures and Material Properties	9
Modeling and Testing Methods	4
High-Rise Buildings	8
Low Rise Buildings	3
Steel Members and Frames	3
Concrete (and Concrete Masonry) Members and Frames	12
Stacks, Tanks, Piles, Dampers	3
Nonstructural and Equipment Items	1
7. Seismic Design	
Ground Motion and Design Spectra	4
Design Criteria	4
Design and Analysis Procedures	8
Probabilistic Design	3
High-Rise Buildings	1
Low-Rise Buildings	1
Nonstructural and Equipment Items	1
8. Strengthening and Repair of Earthquake Damage	
Concrete Structures	3
Concrete Masonry Structures	1
9. Seismic Risk and Cultural Effects of Earthquakes	
Hazard Analysis	11
Risk Analysis	5

TABLE 3

RELATIVE EMPHASIS ON VARIOUS EARTHQUAKE-RELATED TOPICS AS MEASURED BY NUMBER OF UNITED STATES PAPERS DEALING WITH STRUCTURAL ENGINEERING TOPICS PRESENTED AT SIXTH WORLD CONGRESS IN EARTHQUAKE ENGINEERING, NEW DELHI, INDIA, 1977

Topic	Number of Papers Presented
1. Analysis and Design of High-Rise Structures	39
2. Analysis and Design of Low-Rise Structures	6
3. Analysis and Design of Major Industrial Structures	4
4. Analysis and Design of Industrial Structures	0
5. Analysis and Design of Concrete Structures	30
6. Analysis and Design of Steel Structures	5
7. Analysis and Design of Structures of Other Materials	0
8. Analysis and Test Methods for Structures	38
9. Nonstructural and Equipment Items	6
10. Analysis and Design of Civil Engineering Structures	21

dealing with structural engineering are summarized. Most of the professional attention and interest is directed toward high-rise buildings (defined here as 6 or more stories) and the analysis and design of concrete structures. Because much information on concrete structures is applicable primarily to high-rises, the high-rise seems to dominate the attention of the structural engineering profession.

4. IMPLEMENTATION OF THE COLLECTED INFORMATION

Two types of damage evaluations, engineering and statistical, conducted during earthquakes have been applied very differently. Engineering studies are most commonly used to re-evaluate and, if necessary, improve design codes and guidelines. Statistical studies are useful for performing future earthquake effects forecasting.

4.1 Applications of Engineering Studies

Following the basic premise of codes and standards, engineering evaluations of building damage typically involve studying detailed structural behavior to identify framing techniques and materials that are hazardous to life. Results of these studies commonly find their way into practice either through code changes or through the publication of design guidelines. Some of the more prominent developments in this regard that have occurred since the San Fernando, California, earthquake of 1971 are summarized next.

Within about one year after the San Fernando earthquake, Los Angeles adopted more stringent earthquake design forces and design detailing requirements. Concurrently, the shocking loss of major hospitals during this moderate earthquake caused legislation (Senate Bill 519) by which the state preempted new hospital construction from local control. The main implication of this bill is that future hospitals constructed in California must remain functional after an earthquake. This contrasts with the philosophy of seismic design for typical buildings in California, whereby buildings are required to remain standing during a major earthquake but, by implication, are not required to remain functional. In 1975[4] the Structural Engineers Association of California (SEAOC) proposed more conservative seismic design requirements for typical buildings. For example, for shear-wall type, low-rise buildings, the design forces were changed from 0.133g to 0.186g, an increase of about 30%. These recommendations were subsequently adopted by the International Conference of Building Officials in its 1976 *Uniform Building Code*,[5] and these recommendations are being used by those parts of the nation that use this code.

On a broader scale, the Applied Technology Council of San Francisco, California, has undertaken to develop nationally applicable seismic design provisions. Sponsored by the National Science Foundation and the National Bureau of Standards, the ATC-3 project (as it is commonly called) was undertaken with local California direction but was developed by consultants recognized for their expertise in earthquake engineering and drawn from the entire nation. The ATC-3 project also included participation of the three national Building Official's model code agencies -- the International Conference of Building Officials, the Southern Building Code Congress, and the Building Officials Conference of America. The ATC-3 seismic design recommendations will be available in mid-1978. While the recommendations bear a certain resemblance to past SEAOC recommendations, two noteworthy changes have been made:

1. the seismic hazard is quantitatively identified in the form commonly seen from instrumental ground motion data;
2. the ability of various types of structural framing to survive inelastic response excursions is quantitatively identified in terms of common definitions of ductility.

Explicit inclusion of these two parameters means that the project team met its intended goal, that of developing rational seismic design provisions. Because of its significant departure from previous seismic design codes, the ATC-3 provisions will have to go through an evaluation process, and it is likely to be several years before it can be adopted.

Federal agencies have also responded to the lessons learned from the recent San Fernando earthquake. Notable among these are the Veterans Administration; the Department of Housing and Urban Development; and the Army, Navy, and Air Force. Each of these agencies has undertaken a review of its particular seismic design requirements and has produced new or revised requirements or guidelines.[6-8]

Highway bridges have also received special attention as a result of the San Fernando earthquake. Immediately after the earthquake, the California Department of Transportation (CalTrans) and the U.S. Federal Highway Administration (FHWA) sponsored substantial research directed at improving the seismic resistance of bridges. The CalTrans criteria have been published,[9] and the FHWA criteria are currently being developed by the Applied Technology Council in its ATC-6 project.

4.2 Applications of Statistical Damage Studies

Statistically based observations of damage to various types of structures are the most reliable and directly applicable means for forecasting the future effects of earthquakes. Such forecasting is synonymous with risk analysis and can be done for a single structure, a class of structures, or for the many types of structures found in a given community or geographical area. Risk, as it is most commonly defined, is the chance of loss (property damage, incidental loss, human injury, or life loss) that might result from a seismic hazard.

In general, statistical damage data useful for making risk evaluations are scarce; the most complete data sets currently available are for high-rise buildings[10] and low-rise buildings.[11-16] While there are numerous methodology-type examples of risk analysis procedures available in the literature,[17-19] specific application of empirical data is limited. Whitman et al.,[20] using high-rise building damage data and a model statistical decision analysis procedure, determined the optimum seismic design strategy for high-rise reinforced concrete buildings in Boston. The study reveals quantitatively that, without consideration of injury and life loss, the optimum cost investment for Boston is achieved with no consideration for specific seismic resistance considerations in design. Personal injury and life loss pose significant complications for decision making; the authors present two ways of assessing these effects but make no judgment on the best course of action.

On a broader scale, two notable works deal with predicting the effects of future earthquakes. The principal objective of these studies is to provide essential data for effective predisaster planning for major damaging earthquakes that might affect metropolitan areas. One work describes the effects of two major earthquakes on vital human facilities in the Los Angeles area (similar reports have been prepared for San Francisco, Seattle, and Salt Lake City).[21]

On an even broader scale, a study recently completed by URS/John A. Blume & Associates, Engineers (URS/Blume), and sponsored by the U.S. Geological Survey, illustrates the use of virtually all damage information available from past earthquakes to predict the effects for a probable future event.[22] This report, *Damage Prediction for an Earthquake in Southern California*, estimates the nature and distribution of damage to structures in the southern California area caused by a hypothetical earthquake that is located on the San Andreas fault, has a rupture length of 300 km, between Cholame to the north and Cajon Junction to the south. Its magnitude was given as 8.1. Data from the San Fernando earthquake were extensively used along with various extrapolations in order to predict damage.

Where possible, the Blume Engineering Intensity Scale procedure was used for making the effects predictions.[17] Because of the scarcity of rigorous statistical damage data, other data from past earthquakes had to be incorporated. Because of the large geographical area involved, various simplifications were made to minimize the effort and to complete the project at a reasonable cost. One of these was to characterize hypothetical communities by identifying the number of types of structures for communities of various size (Table 4). Using this information and empirically and theoretically developed motion-damage relationship information for various building types, damage cost was estimated for various Engineering Intensity (EI) levels, as indicated in Table 5. (EI is similar to other seismological intensities, e.g., Modified Mercalli Intensity and Rossi-Forel Intensity; the difference is that EI is based on quantitative response spectrum amplitudes of instrumental ground motion recordings.)

Tables 4 and 5 show the overwhelming impact that low-rise, particularly residential, structures have on the total damage cost because a large percentage of the total monetary investment is concentrated in low-rise buildings. In Los Angeles county, the value of high-rise buildings is about 10% of the value of low-rise buildings. It is interesting to compare this statistic with the relatively great emphasis placed on high-rise building damage investigations, as reflected in Tables 1 and 2 for the San Fernando and Managua earthquakes.

TABLE 4

STRUCTURE DISTRIBUTION FOR HYPOTHETICAL COMMUNITIES[40]

Type of Structure	Population: 200,000		Population: 75,000		Population: 25,000		Population: 5,000	
	Units	Structures	Units	Structures	Units	Structures	Units	Structures
Single-Family Dwellings	50,000	50,000	20,000	20,000	7,000	7,000	1,400	1,400
Mobile Homes	2,000	2,000	800	800	300	300	50	50
Multifamily Dwellings								
Low-Rise	10,000	1,000	3,000	300	1,000	100	200	20
Intermediate Height	2,000	40	500	10	100	2	--	--
High-Rise	500	5	50	1	--	--	--	--
Commercial Buildings								
Typical Low-Rise*	--	2,000	--	750	--	250	--	50
Unreinforced Masonry	--	200	--	100	--	30	--	10
Intermediate Height	--	30	--	10	--	1	--	1
High-Rise	--	10	--	3	--	5	--	--
Public Buildings**	--	20	--	10	--	--	--	2
Hospital Buildings**	--	5	--	2	--	--	--	--

*Also includes light industrial buildings.

**Small communities sometimes share the facilities of adjacent communities.

TABLE 5

DAMAGE ESTIMATION FOR A HYPOTHETICAL[22]

COMMUNITY IN THREE-DIGIT EI 6,7,7 AREA

(Population: 75,000)

Type of Structure	Vibration Period Band	EI	m_{DF}	Replacement Value*	Damage Cost*
Single-Family Dwellings	I, II, III	6	0.09	960	86.4
Mobile Homes	I, II, III	6	0.045	20	0.9
Multifamily Dwellings					
Low-Rise	I, II, III	6	0.09	90	8.1
Intermediate Height	I, II, III	6	0.09	10	0.9
Intermediate Height / High-Rise	IV, V, VI	7	0.065	10	0.7
High-Rise	VII, VIII, IX	7	0.002	3	<0.1
Commercial Buildings**					
Typical Low-Rise	I, II, III	6	0.09	150	13.5
Unreinforced Masonry	I, II, III	6	0.5	20	10.0
Intermediate Height	I, II, III	6	0.09	25	2.3
Intermediate Height / High-Rise	IV, V, VI	7	0.065	50	3.3
High-Rise	VII, VIII, IX	7	0.002	20	<0.1
			Total	1,358	126.1

m_{DF} (Damage Cost Factor) for the Community = 0.09

$$\text{Loss per Capita} = \frac{\$126,100,000}{75,000} = \$1,680$$

*In millions of 1977 dollars.

**Includes light industrial, public, and emergency buildings.

5. SELECTED EXAMPLES OF NEEDED INFORMATION

With the recent increased interest in earthquake hazard mitigation, it has become apparent that much information is needed for overall planning to reduce earthquake risks. The remainder of the paper discusses three such areas of needed additional information.

5.1 Primary Losses

Primary losses are defined in the context of this paper to include the damage to the structure and those elements of the structure that are integral with the structural framing, including nonstructural components and mechanical and electrical equipment. The brief data summarized in Tables 1 and 2 indicate that most attention in the past has been directed only to the primary effects of earthquakes.

Tables 1 and 2 also indicate that most of the damage information collected after earthquakes is in the category of engineering data -- studies of failure mechanisms and dynamic response behavior. This information is valuable for improving engineering analysis, and design and data acquisition along these lines must be continued in the future. However, this information is not so directly applicable for risk evaluation, particularly for estimating the total impact of a future event.

Statistical damage data has thus far been rigorously obtained for only the general categories of low-rise and high-rise buildings. Even for these types of buildings, more detailed statistical data are needed. In addition, more detailed statistical information is needed for overall damage costs from an earthquake, defining what losses are incurred for what structures. An example of perhaps the most complete overall damage cost summary available for the San Fernando earthquake is given in Tables 6 and 7. More detailed information showing the relative damage cost of such facilities as lifelines, transportation structures, and utilities is needed for making reliable future damage estimates.

In the aftermath of future earthquakes, a master list of structures such as that shown in Table 8 should be used for collecting overall

TABLE 6a

SUMMARY OF EARTHQUAKE LOSS[23]

(San Fernando Earthquake, 1971)

Economic Sector	Dollar Loss
Private Sector	
Buildings, excluding land and contents:	
Los Angeles City	$154,000,000
San Fernando City	36,000,000
Elsewhere	15,000,000
Nonbuilding structures, excluding land	35,000,000
Public Sector	
Los Angeles City	180,000,000
San Fernando City	34,000,000
Los Angeles unincorporated	13,000,000
Other cities	24,000,000
Porter Ranch (aftershock damage)	8,000,000
Utilities	12,000,000
Total	$511,000,000

TABLE 6b

LOS ANGELES CITY DAMAGE[23]

(San Fernando Earthquake, 1971)

Damage Classification	Units	Buildings	Estimated Dollar Loss
Unsafe for Human Occupancy -- posted "unsafe"			
Single-family dwellings	0	522	$ 13,100,000
Apartments	1,149	54	11,500,000
Nonresidential commercial and industrial	0	190	19,000,000
Major and Moderate Damage -- remaining occupied			
Single-family dwellings	0	2,469	24,700,000
Apartments	0	192	7,700,000
Nonresidential commercial and industrial	0	883	17,700,000
Minor Damage			
Single-family dwellings	0	13,711	6,900,000
Apartments	0	1,748	17,500,000
Nonresidential commercial and industrial	0	5,698	5,700,000
Other Damage (estimated)			
Unreported damage	0	0	30,000,000
Personal property and inventory	0	0	50,000,000
Total	1,149	25,467	$203,800,000

TABLE 7

BUILDING DAMAGE* OUTSIDE OF CITY OF LOS ANGELES[23]

(San Fernando Earthquake, 1971)

City	Buildings Damaged	Posted Unsafe	Buildings Demolished or To Be Demolished			Damaged Chimneys	Estimated Total Dollar Loss
			Residential	Commercial	Churches and Schools		
Alhambra	55	15	0	5	0	400	$ 2,000,000
Beverly Hills	135	0	0	2	0	1,000	800,000
Burbank	445	25	3	3	1	500	4,000,000
Compton	0	0	0	0	0	0	10,000
Glendale	**	31	13	23	5	3,250	2,000,000
Pasadena	10	4	0	0	1	2,000	2,500,000
San Gabriel	0	0	0	0	0	30	9,000
Santa Monica	20	1	0	0	0	30	50,000
South Pasadena	20	1	0	0	0	300	275,000
Vernon	30	5	0	0	0	0	100,000
San Fernando Valley	**	270	95	123***	3	390	$35,500,000

*Does not include publicly owned structures. Data from various sources.

**No data available.

***Posted "unsafe."

TABLE 8

TYPICAL CATEGORIES AND EXAMPLES OF STRUCTURES*

A. Buildings

1. Residential (houses, apartments)
2. Agricultural (farmhouses, barns, outbuildings)
3. Commercial (stores, gasoline stations)
4. Institutional (schools, hospitals, churches)
5. Industrial (refineries, mills)
6. Special (shrines, ruins)

B. Utility and Transportation Structures

1. Electrical power structures (lines, transformers, switch gear converters, beacons)
2. Communication and microwave stations (reflectors, towers, equipment)
3. Roads, railroads, bridges, overpasses, tunnels, retaining walls
4. Air navigational facilities (beacons, marker stations)
5. Airfields and parking areas
6. Marine and waterfront structures (piers, bulkheads)

C. Hydraulic Structures

1. Earth, rock, or concrete dams, outlet works, control structures
2. Reservoirs, lakes, ponds, sumps, forebays, afterbays, and adjacent shores and slopes (for wave generation)
3. Canals, pipelines, siphons, surge tanks, elevated and surface storage tanks, distribution systems
4. Water storage, cisterns, distribution, processing stations
5. Petroleum products (liquid and gas) storage, handling, piping, processing stations

D. Earth Structures

1. Earth and rock slopes (for potential instability determinations and predictions of damage to roads, fields, stream contamination, hazards to persons
2. Major existing landslides, land creep areas, snow, ice, or earth avalanche areas, subsidence areas
3. Natural or altered sites with scientific, historical, cultural, or ecological significance (pueblo dwellings, scenic rock formations, historical landmarks, archaeological sites)
4. Berms, dikes, banks

E. Special Structures and Items

1. Conveyor systems, tramways, cableways, flumes, ski lifts, trestles, headframes, personnel lifts
2. Ventilation systems, stacks
3. Mobile equipment, rolling stock, vehicles, drillrigs
4. Towers, poles, signs, frames, antennas
5. Material storage, ore heaps, elevated bulk storage, tailings piles, gravel plants, tailings ponds, corrosive fluid storage
6. Agricultural equipment, irrigation lines
7. Furnishings, shelf goods, roof-mounted air conditioners, bric-a-brac, dishes

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*URS/John A. Blume & Associates, Engineers, *Effects Prediction Guidelines for Structures Subjected to Ground Motion*, JAB-99-115, July 1975.

damage cost summaries. More detailed statistical damage studies for all the structure types listed in Table 8 should also be conducted. The engineering profession has consistently neglected to collect this type of information in the past.

A number of recent occasions have offered the opportunity to collect some of this data. For example, recent earthquakes that caused extensive damage to reinforced masonry construction and a wide variety of industrial structures included the Managua, Nicaragua, earthquake and the Romanian earthquake of 1977. However, insufficient funding and limited interest have prevented compilation of this useful information.

5.2 Secondary versus Primary Losses

Secondary effects of earthquakes include damage to furnishings and inventories in commercial buildings, loss of function, life losses, injuries, and other effects. These effects are considered secondary because they are caused by the primary earthquake effects -- structural damage -- and are largely controlled by the response of the structure to the ground motion of the earthquake. The secondary effects of earthquakes have generally received little attention.

The importance of the secondary effects and the resulting losses, excluding the human toll and general economic disruptions such as loss of time and gross national product, is illustrated by the statistics of Tables 9 and 10. The two tables summarize estimated primary and secondary losses, in millions of dollars (U.S. 1973), from the Managua earthquake of 1972. Table 9 summarizes all losses, whereas Table 10 summarizes the losses of one major category -- the infrastructure, or the permanent structures required for civic functions (including hospitals, schools, lifelines, and power facilities). The total estimated primary losses from the Managua earthquake, Table 9, are estimated to be $527.7 million. The housing losses dominate the category, with a cost of $312.3 million. The total secondary losses are $317.4 million. Thus, the secondary losses represent over 60% of the primary losses. The secondary loss for the infrastructure category is $60.7 million, compared to a primary loss of $101.4 million, about 60% of the primary

TABLE 9

ESTIMATED PRIMARY AND SECONDARY LOSSES FROM THE MANAGUA, NICARAGUA EARTHQUAKE OF DECEMBER 23, 1972*

(in millions of 1973 U.S. dollars)

Structure Category	Primary Loss	Secondary Losses				Total Dollar Loss
		Direct		Indirect	Subtotal, Secondary Losses	
	Buildings	Equipment and Furnishings	Inventory	Miscellaneous**		
Government	22.5	9.0	1.0	68.9	78.9	101.4
Industry†	3.0	15.0	2.9	19.7	37.6	40.6
Commerce††	60.0	12.0	31.5	24.3	67.8	127.8
Housing	312.3	50.0	2.1	--	52.1	364.4
Services#	28.5	11.4	4.5	4.4	20.3	48.8
Infrastructure##	101.4	30.8	4.8	24.1	60.7	162.1
Total	527.7	128.2	47.8	141.4	317.4	845.1

*From Reference 23.

**Includes emergency costs, accounting costs, etc.

†80% of the industrial production of Nicaragua is concentrated in Managua; of that, 10% was lost.

††60% of the nation's commercial activity was concentrated in Managua, employing 20,000 persons. 90% of this distribution capacity was lost. An estimated one year is needed to normalize activities.

#Office facilities for 9,000 employees were lost.

##The infrastructure breakdown of losses is presented in Table 10.

TABLE 10

ESTIMATED INFRASTRUCTURE PRIMARY AND SECONDARY LOSSES FROM THE MANAGUA, NICARAGUA, EARTHQUAKE OF DECEMBER 23, 1972

(in millions of 1973 U.S. dollars)

Type of Infrastructure	Primary Loss	Secondary Losses				Total Dollar Loss
		Direct		Indirect		
	Structures	Equipment and Furnishings	Inventory	Miscellaneous**	Subtotal, Secondary Losses	
Hospital	13.7	18.4	5.0	15.0	38.4	52.1
Urbanization	17.1	0	0	0	0	17.1
ENALUF (Power Co.)	1.0	1.0	0.5	3.8	5.3	6.3
Distrito Nacional (City)	3.5	1.0	0	4.0	5.0	8.5
Universities	2.0	0.6	0	0	0.6	2.6
Expressways	30.0	0	0	0	0	30.0
Highways	10.0	0	0	0	0	10.0
TELCOR (Communications)	0.9	0.5	0.3	1.3	2.1	3.0
Schools	23.2	9.3	0	0	9.3	32.5
Total	101.4	30.8	5.8	24.1	60.7	162.1

*From Reference 23.

**Includes emergency costs, accounting costs, etc.

loss. If the primary and secondary losses for housing are excluded from these figures, the importance of the secondary losses increases dramatically. The total primary loss now becomes \$215.4 million, and the secondary loss becomes \$265.3 million. Although secondary loss is greater than primary loss outside the housing sector, minimization of this loss usually receives only minor engineering attention.

Thus, the nature of secondary losses deserves much more attention, as do engineering and other methods for minimizing such losses in earthquakes. Solutions could range from (1) minimizing the primary losses in order to limit further the secondary losses, i.e., use the structural systems of the buildings to reduce secondary losses, to (2) directing efforts to limit those secondary losses that are less dependent on the primary losses (for example, loss of inventory and furnishings).

Much additional information should be obtained in future destructive earthquakes on the nature of the secondary losses, particularly life loss, and their dependence on the primary losses. For example, Figure 1 illustrates the type of information that is currently lacking for the relationships between the primary losses and the different types of secondary losses, such as damage to building internals and life losses. What is the relationship to secondary losses of a 10% loss to the structural system of a high-rise? The collection and reduction of this type of information should be one of the main goals of future investigations of the effects of destructive earthquakes. In particular, the estimation of such losses in future earthquakes is vital for accurate and realistic overall loss predictions.

5.3 New Types of Construction and Lack of Engineering Attention

The engineering profession has consistently neglected to stress that new types of construction and new types of building details require different attention to assure adequate performance during earthquakes. For example, we learned from the damage in San Fernando that tilt-up buildings, as they were constructed up to that time, are very easily damaged. The same lesson was learned for split-level, single-family residences. The weaknesses of these types of buildings are ob-

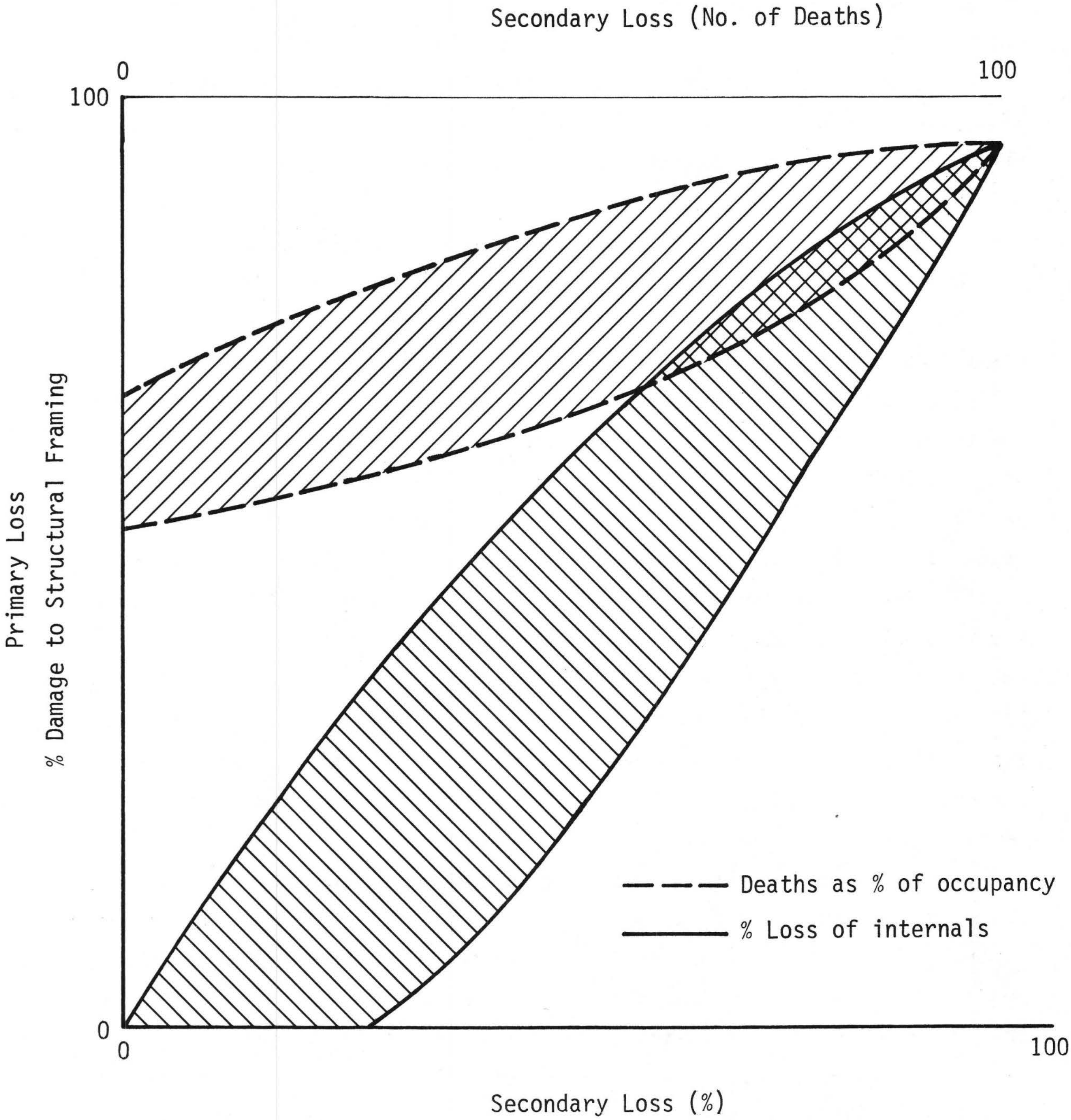

FIGURE 1 HYPOTHETICAL VARIATIONS BETWEEN PRIMARY AND SECONDARY LOSSES FROM EARTHQUAKES

vious and should have been recognized quickly. However, significant professional attention was extended only after spectacular damage brought the problems to our attention. Such new developments in building details should be addressed as they find their way into general practice. There is no current organization that can effectively track such changes and that can immediately require added attention to details in the codes to preclude or alleviate possible future problems.

The impact of this type of mismanagement of engineering attention can be significant. For example, much of the high-precision microelectronics industry of the United States is centered in the southwest San Francisco Bay Area. Most of the production facilities are housed in tilt-up buildings of the type that suffered so much damage from the San Fernando earthquake. Should a major earthquake occur on the nearby San Andreas fault or the Hayward fault, much of the capacity of the industry can be affected for a long period of time. The economic impact (secondary loss) would far exceed the direct losses from the building damage. Such a case occurred in Managua after the 1972 earthquake.[23] The Pepsi Cola and Coca Cola companies had been in keen competition for dominance of the soft drink market in Nicaragua. The structure housing the Pepsi Cola bottling equipment failed completely during the earthquake, whereas the structure of the Coca Cola plant survived with some minor damage. While the Pepsi Cola Company spent nearly six months removing the building debris, fixing the equipment and piping systems, and building a new structure around the existing equipment, the Coca Cola Company spent a few days cleaning up the minor damage and then had a near-complete monopoly of the market for about six months. At the end of the six months, Coca Cola had market dominance that is probably undiminished to this day. Thus, to Coca Cola, both the primary and the secondary losses were minor, whereas for Pepsi Cola the primary losses, while substantial, were only a small percentage of the consequent secondary losses, particularly when viewed in a long-term perspective.

6. CONCLUSIONS

Until recently, the acquisition of scientific and engineering information from destructive earthquakes was conducted in an unorganized fashion by a variety of private engineering firms, interested professionals, and government organizations. Despite the lack of a coordinating organization, much useful data have been collected and incorporated into building codes and design guides that are now available. Since the San Fernando earthquake of 1971, the EERI has undertaken the responsibility to assist in the coordination of earthquake damage and data collection investigations. This new direction in the acquisition of data has already resulted in greatly improved data content and a wider scope of available information. However, additional efforts are required to redirect some of the attention of future investigations toward collecting data not currently available -- specifically, data useful for forecasting damage from future earthquakes in the United States (and elsewhere) and for conducting detailed seismic risk evaluations for individual structures or types of structures.

REFERENCES

1. Jennings, P. C., *Engineering Features of the San Fernando Earthquake, February 9, 1971*, EERL 71-02, Earthquake Engineering Research Laboratory, California Institute of Technology, Pasadena, California, June 1971.

2. Earthquake Engineering Research Institute, *Managua, Nicaragua, Earthquake of December 23, 1972* (conference proceedings), San Francisco, California, November 1973.

3. Indian Society of Earthquake Technology, *Proceedings of the Sixth World Conference on Earthquake Engineering, New Delhi, India*, January 10-14, 1977.

4. *Recommended Lateral Force Requirements and Commentary*, Seismology Committee of the Structural Engineers Association of California, San Francisco, 1975.

5. *Uniform Building Code*, Vol. 1, International Conference of Building Officials, Pasadena, California, 1976.

6. *Earthquake Resistant Design Requirements for VA Hospital Facilities*, Office of Construction, Veterans Administration, Handbook H-08-8, Washington, D.C., June 1973 (revised March 1974).

7. Goers, R. W., and Associates, *A Methodology for Seismic Design and and Construction of Single-Family Dwellings*, prepared for the Applied Technology Council and the U.S. Department of Housing and Urban Development, September 1976.

8. *Seismic Design for Buildings*, Departments of the Army (TM5-809-10), Navy (NAVFAC P-355), and Air Force (Air Force Manual No. 88-3, Chapter 13), April 1973.

9. Gates, J. H., "California's Seismic Design Criteria for Bridges," *Journal of the Structural Division*, ASCE, December 1976.

10. Whitman, R. V., *Damage Probability Matrices for Prototype Building*, Seismic Design Decision Analysis Report No. 8, Department of Civil Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1973.

11. Scholl, R. E., and I. Farhoomand, "Statistical Correlation of Observed Ground Motion with Low-Rise Building Damage," *Bulletin of the Seismological Society of America*, Vol. 63, No. 5, 1973.

12. Scholl, R. E., "Statistical Analysis of Low-Rise Building Damage Caused by the San Fernando Earthquake," *Bulletin of the Seismological Society of America*, Vol. 64, No. 1, 1974.

13. Scholl, R. E., "Low-Rise Building Damage for Low-Amplitude Ground Motions," *Bulletin of the Seismological Society of America*, Vol. 64, No. 6, 1974.

14. Scholl, R. E., and J. A. Blume, "Damaging Response of Low-Rise Buildings," *Proceedings of the Sixth World Conference on Earthquake Engineering*, New Delhi, India, January 1977.

15. Blume, J. A., *The Spectral Matrix Method of Damage Prediction: Description and Status*, NVO-99-33, prepared for U.S. Atomic Energy Commission, Nevada Operations Office, URS/John A. Blume & Associates, Engineers, San Francisco, March 1968.

16. Hafen, D., and F. C. Kintzer, *Correlations between Ground Motion and Building Damage: Engineering Intensity Scale Applied to the San Fernando Earthquake of February 1971*, JAB-99-111, prepared for U.S. Department of Energy, Nevada Operations Office, URS/John A. Blume & Associates, Engineers, San Francisco, November 1977.

17. Blume, J. A., "An Engineering Intensity Scale for Earthquakes and Other Ground Motion," *Bulletin of the Seismological Society of America*, Vol. 60, No. 1, February 1970.

18. Lee, L. T., and J. D. Collins, "Engineering Risk Management for Structures," *Journal of the Structural Division*, ASCE, September 1977.

19. Pate, E., W. Linville, and H. Shah, "Public Policy in Effects Mitigation: Earthquake Prediction and Earthquake Engineering," *Proceedings of the Sixth World Conference on Earthquake Engineering*, New Delhi, India, January, 1977.

20. Whitman, R. V., J. M. Biggs, J. E. Brennan, C. A. Cornell, R. L. de Neufville, and E. H. Vanmarcke, "Seismic Design Decision Analysis," *Journal of the Structural Division*, ASCE, May 1975.

21. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Research Laboratories, *A Study of Earthquake Losses in the Los Angeles, California, Area*, Washington, D.C., 1973.

22. Blume, J. A., R. E. Scholl, M. R. Somerville, and K. K. Honda, *Damage Prediction for an Earthquake in Southern California*, prepared by URS/John A. Blume & Associates, Engineers, for U.S. Geological Survey, San Francisco, California, February 1978.

23. Yanev, P. I., and R. O. Marsh, "Industrial and Power Plant Damage from the Managua, Nicaragua, Earthquake of December 23, 1972," *Proceedings of the Specialty Conference on Structural Design of Nuclear Plant Facilities*, American Society of Civil Engineers, Chicago, Illinois, December 17-18, 1973.

DEVELOPMENT, USE, AND REVIEW OF GEOLOGIC AND SEISMOLOGICAL INFORMATION FOR THE SITING OF NUCLEAR POWER PLANTS

By

Joe Bennett* and Phyllis Sobel*

This paper describes the flow process of earthquake hazard information pertaining to nuclear power plants from the viewpoint of a technical reviewer with the Nuclear Regulatory Commission (NRC). To help focus this presentation, we first briefly comment on the seismologist's role in the aseismic design of nuclear power plants, and then we return to the format describing the information flow.

The seismic and geologic siting criteria for use in nuclear power plant design are set-down in the Code of Federal Regulations, 10 CFR Part 100 Appendix A. These criteria were adopted in 1973 in recognition of the fact that additional explicit criteria and guidance dealing with earthquake hazard at nuclear power plants was needed. At about the same time the NRC (then AEC) began to expand its own geosciences staff in the areas of geology, seismology, and geotechnical engineering. Previously, the U. S. Geological Survey and National Oceanic and Atmospheric Administration had reviewed geoscience aspects of nuclear power plant siting.

Appendix A contains criteria for the investigations and determinations to be made in siting of nuclear power plants to resist seismic and geologic hazards. We will focus here on the seismic hazard. It is the seismologist's role to specify for the engineer the vibratory ground motion for use in design of the plant.

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The Appendix A criteria, unlike criteria used in designing other facilities, provide a site-specific deterministic procedure for assigning the design ground motion in contrast to the probabilistic methods or building code maps often found. This deterministic procedure involves four main elements:

Item 1. Definition of tectonic provinces and identification of structures which might localize earthquakes in the site vicinity.

Item 2. Identification of historical earthquake activity associated with the tectonic provinces or structures.

Item 3. Assessment of seismic or geologic information to determine whether earthquakes in excess of maximum historical events should be considered for these provinces or structures.

Item 4. Determination of the ground motion at the nuclear power plant site from potential earthquakes assumed to occur in provinces or on structures at their point of closest approach to the site.

While these requirements appear straight-forward on the surface, there are numerous decision points at which judgment supported by scientific data must be exercized to reach a conclusion. It is the role of the technical reviewer to assure that judgments made in this decision process are soundly based on consideration of all relevant earthquake hazard information.

This brings us back to the information acquisition and transmission process. We have sought to describe this according to the format established for the workshop.

Motivation

Clearly, critical facilities such as nuclear power plants have the potential to worsen the consequences of natural hazards. On the other hand, adequate consideration of the expected hazard in designing the facility can mitigate the consequences. The Nuclear Regulatory Commission has been empowered by the Congress to assure that the public is adequatley protected from radiological hazards. Specifically, with regard to seismic and geologic hazards, the Code of Federal Regulations 10 CFR Part 100 Appendix A prescribes methods and criteria which guide the Commission in assessing the suitability of proposed seismic designs. It is through the implementation of this methodology that the desired assurance of public health and safety is achieved.

Objective

To implement the regulation two types of information are required: 1) raw data, and 2) interpretation. The more important information in the decision process pertains to geologic structure, seismicity, tectonic activity, and earthquake strong motion. This information is required and reviewed on a case-by-case basis for the license application at each site and serves as the basis for decisions on the critical elements described earlier - that is: (1) identification of tectonic provinces and structures which might localize earthquakes, (2) identification of maximum historical earthquakes associated with the tectonic provinces and structures, (3) assessment of whether the maximum earthquake associated with the structures or provinces should be larger than historical earthquakes, and (4) determination of the expected ground motion assuming such earthquakes occur.

Strategy and Participants

In the information acquistion and transmission process it frequently turns out that individuals or organizations are both information producers and information users. In nuclear power plant siting, we can consider the involovemnt of nine distinct organizations. These are listed in order of the flow of geologic and seismic information into the licensing process in Figure 1.

As part of its license application the utility in cooperation with its consulting firms prepares a report presenting the data that has been gathered and describing the rationale and conclusions for determining the vibratory ground motion to be used in designing the plant. This information is included in a report called the Safety Analysis Report, which is made available to the public and becomes the subject of review by the NRC Geosciences staff. During the review, the Geosciences staff frequently calls upon the services of outside consultants such as the U. S. Geological Survey, Army Corps of Engineers, State Geological Surveys, university staff, or other private individuals or companies who have unique knowledge of the geological or seismological characteristics of the site region. These organizations usually are asked to provide information or comments on some specific aspect of the Safety Analysis Report.

At the conclusion of its review, the Geosciences staff prepares the geology and seismology input to the Safety Evaluation Report (SER) which contains staff findings regarding the adequacy of the information and conclusions presented in the Safety Analysis Report (SAR). These staff findings are published and copies sent to the Advisory Committee on Reactor Safeguards (ACRS), a panel of independent experts which reviews staff decisions and provides independent advice to the Commission regarding nuclear power plant siting and design considerations. Decisions of the ACRS are based on information in the SAR and the staff SER.

The next stage in the licensing process is a legal decision on the plant license and involves public hearings. This stage is performed by the Atomic Safety and Licensing Board (ASLB). All interested parties, including the license applicant, the NRC staff, consultants, and the public, have the opportunity during the hearings to offer testimony relating to the license application. At the conclusion of these hearings the appropriate licensing action is taken based on information contained in the hearing record.

All information used by the staff, except in some cases for proprietary data, is available to the public, as published papers or as part of the record compiled during the license review. This information is available in the public document room in Washington, D. C. and, for a particular facility, near the site of the facility.

Examples of Important Issues

The following examples are given to illustrate the review process and the required information. In 1973, NRC began the review of a site in southeastern New England; subsequently, the USGS was asked to provide an independent review. Little is known about the mechanism of earthquake generation in the eastern United States. Of particular concern at the start of our review was the fact that the source of the 1755 earthquake, offshore at Cape Ann - the largest historical earthquake in the region - could not be determined. As a result, the applicant was required to undertake a study program to better establish seismicity patterns in the region and identify offshore geologic structures which might have been responsible for the earthquake. At the conclusion of these studies which involved a detailed search of primary literature sources and a major aeromagnetic survey of the offshore region, we and the USGS were able to conclude that structures existing in the epicentral area of the earthquake did not extend into the site vicinity. Several possible mechanisms for localizing earthquakes in New England were identified. Subsequently, the Advisory Committee on Reactor Safeguards found our conclusion acceptable and the case was later presented to the Atomic Safety and Licensing Board in a public hearing.

Another case involved a site on the California coast. In this case, seismic reflection surveys offshore near the plant identified faulting. The U. S. Geological Survey at about the same time completed a study involving relocation of earthquakes in the area which identified the offshore fault as the possible source of earthquakes. As a result, the applicant was required to gather extensive primary data specifically for the purpose of assessing the tectonic significance and earthquake hazard posed by the fault.

Components and Information Communication Model

The component parts of the information model can be analyzed on two levels:

First, from the viewpoint of data analysis and synthesis, basic data and information relating to geology, seismology, tectonics, and earthquake strong ground motion are gathered. This information is then synthesized in an interpretation phase to reach an assessment of earthquake sources, earthquake potential of each source and ground motion at the site. Finally, this information is used to develop vibratory ground motion for use in plant design.

Next, from an overall viewpoint, the information gathering is carried out by the utility and its consultants who frequently draw on published information in addition to data gathered in site studies. This information is transmitted through the Safety Analysis Report to NRC technical reviewers, ACRS, associated consultants and the general public. Supplemental information is frequently submitted by updating the Safety Analysis Report. The results and conclusions of the NRC staff review are transmitted through a Safety Evaluation Report and occasionally through oral presentation to the ACRS, its consultants, and the general public. Finally, all sources of information including the applicant, NRC, and intervenors are brought together in a hearing process conducted by the ASLB in which information is presented in the form of testimony by the various participants.

Evaluation of Information Communication Activities

Relationships of People and Activities

Information Requirements

The information requirements of the participants in the information process vary as to the needs and responsibilities of those participants. The applicant's needs include both the ground motion for use in designing the plant and information to support this determination to the satisfaction of the NRC, ACRS, and the ASLB. In most cases, the most detailed requirements for technical information are imposed by the NRC staff. The NRC Geosciences staff arrives at an independent interpretation of the tectonics, earthquake potential of the site region, and expected ground motion based on all available information. The ACRS is usually interested in reviewing interpretations put forth by the applicant and the NRC staff to see if they conform with their knowledge, but their information requirements are usually less detailed and frequently generic in nature. The Atomic Safety and Licensing Board needs information to support legal decisions on the adequacy of plant designs. A high degree of demonstrated certainty based on detailed presentation of information is required. Further, complicating the information process at this stage is the need to have the information in a form understandable to non-specialists.

Two-Way Communication

Two-way communication is generally achieved through a series of written requests for information and responses between NRC and the applicant, telephone contacts, meetings between the various participants and the hearing process.

Information Center and Focal Point

Current information on all licensing actions is maintained in the NRC Document Room. In addition, information on particular sites is made available at Local Public Document Rooms near the sites.

Public Media

Public media are used on a very limited basis in the information transmission process. Public notice of ACRS meetings and ASLB hearings are published in the Federal Register and these meetings are open to the public with occasional coverage by the news media.

New Communication Channels

A new channel of information has been established through the review process itself. Information in this process is conveyed through the Safety Analysis Reports prepared by applicants, the Safety Evaluation Reports prepared by the NRC staff, the questions and responses during the review, consultants and advisors reports, and through ACRS meetings and ASLB hearings.

Intermediaries in Communication Process

To some extent the NRC review staff serves as an intermediary in communicating information. This function is performed through the assimilation of the detailed information from the Safety Analysis Report and the interpretation of this information in a form meaningful for subsequent technical and legal decisions by the ACRS and ASLB. This interpretation is contained in the Safety Evaluation Report and hearing testimony presented by the staff.

Performance Evaluation

Timeliness and Degree of Reworking

One of the problems which has been a major concern is the timeliness of the information transmission process. The formal process of questions and answers to acquire additional information and the lengthy studies required to obtain added geologic and seismic data frequently are not conducive to timely decisions. The reviewer is frequently faced with a situation requiring that a decision be made using the data, knowledge, and experience available to him at the time. In these situations the staff may require an added margin of conservatism to account for the absence of data.

Information Monitoring

The review process is monitored by the management functions within NRC, by the ACRS review of the conclusions of the staff and applicant, and finally the ASLB hearing process. Occasionally, additional monitoring results from response to inquiries by Congressmen and the general public.

Strengths and Weaknesses of Information Process

Among the strengths of the process is that most technical information which exists pertaining to geology, seismology, tectonics, earthquake strong ground motion, and seismic hazard at a site is made available to the decision process. In addition, the rationale behind the staff's decision is provided in the Safety Evaluation Report and tested in the subsequent hearing process. Weaknesses in the process are the timeliness of information already described and occasional difficulties in conveying scientific and engineering issues in a meaningful way to the public and in providing interpretations of such issues which meet legal needs.

Frequency of Activity

There are currently approximately 70 nuclear facilities under review. The form of the review has changed throughout the history of the AEC and NRC. Figure 2 summarizes some of the milestones. Note especially that until 1973 the AEC depended on its consultants for seismic review. The development of Regulatory Guide 1.70 (Standard Format and Content of Safety Analysis Reports) and the Appendix A to 10 CFR Part 100 siting criteria have standardized the review process to a much greater extent.

Lessons Learned

The major lesson learned is that detailed information is needed to reach conclusions about the seismic and geologic hazards of proposed sites for nuclear facilities. Reviews prior to development of Appendix A to 10 CFR Part 100 and the Standard Format and Content of Safety Analysis

Reports generally relied on much less information than that currently required. As the licensing process has been tested, it has become clear that technical information to support decisions must be available as a common basis for reaching a decision. In consequence, the more detailed requirements have evolved. In addition, we have learned that it is useful to define issues early in the review process in order to give necessary focus to information requirements. Finally, and very importantly, we have recognized the need to take into account information and interpretation from a multiplicity of sources in reaching licensing decisions. Toward this latter goal, we have on a regular basis established communication with state geological surveys and universities to solicit reviews on siting problems.

Decision Making

The final decision on nuclear power plant safety and licensing is the responsibility of the Commission, though as a regular practice the Commission delegates this authority to the ASLB. The review by the NRC Geosciences staff serves as a principal input in establishing the basis for the decision on the adequacy of the plant to resist earthquakes.

Legislation

As we have previously noted, the Regulation governing decisions on earthquake design of nuclear power plants is Appendix A to 10 CFR Part 100, Seismic and Geologic Siting Criteria for Nuclear Power Plants. This Regulation was adopted in 1973. Since that time, the experience using the Criteria has revealed some deficiencies. The NRC Office of Standards

Development with the assistance of the technical review staff is presently taking a critical look at methods for improving the seismic and geologic siting criteria. It is the general view of the staff that improvement could be achieved by simplifying the Regulation and providing added guidance in the form of Regulatory Guides.

Information Flow Diagram

Figure 3 summarizes the information flow process. Since all the information producers and users can interact, the flow of information can best be seen in the licensing process. During NRC's review, the staff is aided by questions to the applicant and reports from consultants. The NRC staff, the applicant, the consultants and the intervenors are all present and contribute at the ACRS meetings and in the ASLB hearings where decisions are made.

The staff also reviews new geologic and seismic information that comes to light as it impacts existing plants. One source of such information is the extensive research program sponsored by the Nuclear Regulatory Commission. Examples of this research are the NRC seismic network studies and studies to better define the intensity-acceleration relationship.

PARTICIPANTS IN INFORMATION PROCESS

- UTILITY OR LICENSE APPLICANT
- ARCHITECTURAL AND ENGINEERING AND GEOLOGICAL AND GEOPHYSICAL CONSULTING FIRMS
- NUCLEAR REGULATORY COMMISSION GEOSCIENCES REVIEW STAFF
- CONSULTANTS AND ADVISORS TO NRC AND RESEARCHERS SPONSORED BY NRC, INCLUDING OTHER FEDERAL AGENCIES (U. S. GEOLOGICAL SURVEY AND ARMY CORPS OF ENGINEERS), STATE GEOLOGISTS, UNIVERSITY STAFF, OR PRIVATE INDIVIDUALS OR COMPANIES UNDER CONTRACT TO NRC
- THE ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS) AND ITS CONSULTANTS
- THE ATOMIC SAFETY AND LICENSING BOARD (ASLB)
- INTERVENORS
- THE COMMISSION
- THE PUBLIC

FIGURE 1

SEISMOLOGY AND GEOLOGY REVIEW HISTORY FOR NUCLEAR POWER PLANTS

- FIRST APPLICATION FOR COMMERCIAL NUCLEAR POWER PLANT (INDIAN POINT 1)	1956
- FIRST SEISMOLOGY REVIEW (SAN ONOFRE)	1963
- DRAFT OF APPENDIX A SEISMIC AND GEOLOGIC SITING CRITERIA MADE AVAILABLE	1971
- REGULATORY GUIDE ON STANDARD FORMAT AND CONTENT OF SAFETY ANALYSIS REPORTS	1972
- ADOPTION OF APPENDIX A SEISMIC AND GEOLOGIC SITING CRITERIA	1973
- NRC GEOLOGY/SEISMOLOGY STAFF DEVELOPED	1973
- STANDARD REVIEW PLAN ADOPTED	1975

FIGURE 2

INFORMATION FLOW

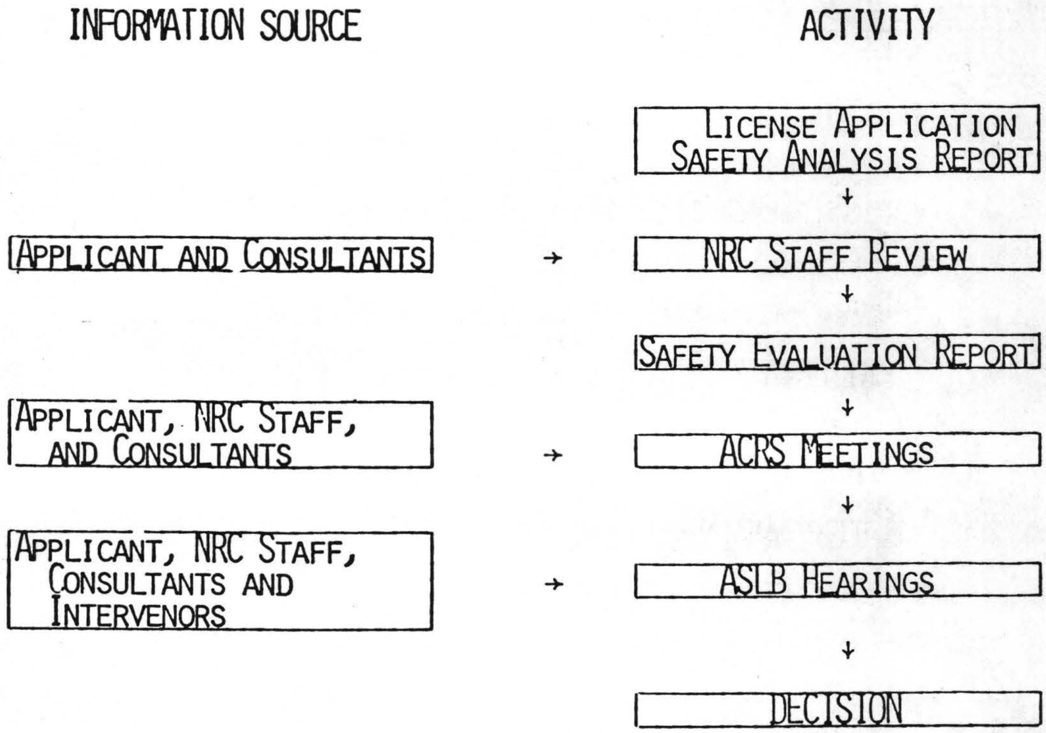

FIGURE 3

THE DEVELOPMENT, USE, AND REVIEW OF GEOLOGIC AND SEISMOLOGIC INFORMATION FOR THE SITING OF NUCLEAR POWER PLANTS

by

Jay Smith*

INTRODUCTION

Geologic and seismologic criteria have achieved early top priority, at least in earthquake-prone regions, in identifying and verifying sites for nuclear power plants. This is because of the potential for adverse impact on safety and design/ construction costs posed by faults and earthquakes. Such issues, if treated lightly and without effective communication among parties involved, can lead to misinformation, misunderstanding and lack of credibility, which in turn can yield delay or even project abandonment.

It is important to acknowledge the difference between "siting" and "site justification" regarding nuclear power plant sites. Siting is the exhaustive multiphased search for a viable site and its alternates where earth conditions and processes can be demonstrated to be adequate for safety and cost objectives. Specifically this means finding locations having stratigraphic and structural environments where (a) capable faults can be proven to be absent within at least five miles, (b) where ground motions from earthquakes will not exceed limitations in design state-of-the art, and (c) where foundation support conditions can be

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accomodated by facility design or remedial treatment in the field.

Site justification, on the other hand, is the attempt to determine whether a site is acceptable when the site has been selected without prior methodical geologic/seismologic study. This commonly occurs because (1) such studies are considered by some persons to be subordinate, and (2) it is presumed that whatever conditions are discovered can be accomodated somehow. Site justification tends to be loaded with surprises, smacks of trial-and-error, encourages advocacy and slanted reporting among scientific investigators, and jeopardizes credibility, all of which contribute to ineffective communication, and often to licensing failure.

The most successful cases of siting and licensing of nuclear power plants have taken place when communication was established early to open up information networks, and when timely transfer of data and interpretations were maintained throughout the siting, design and construction process. In these cases communication was most effective when it was established at different levels among the parties involved and when it used language and degrees of detail desired respectively by the parties.

The following discussion will present a consultant's viewpoint of the communication process in siting and licensing. Because of the complexity, number of communicators, and years of duration, the description will be generalized, with particular focus on the evolution of earthquake-hazard information among the participants and its communication to the public.

Information Producer/User Community

The chief communicators in nuclear power plant siting typically fall into five major categories:

- o Applicant - one or more electric utility companies applying to the NRC for a license, a principal consultant on geology/seismology/earthquake-engineering/soil-engineering, and an architect-engineer;
- o Nuclear Regulatory Commission (NRC) - including the Geosciences Group of the Site Analysis Branch (SAB), Advisory Committee on Reactor Safeguards, and the Atomic Safety and Licensing Board (ASLB);
- o U.S. Geological Survey (USGS) - including various branches as appropriate to each case;
- o State and local agencies - those having knowledge or authority in geologic/seismologic matters, and including educational institutions; and
- o The public - in general, including intervenors and special interest groups.

The Applicant is motivated by legal and economic obligations to assure continued electric service to its customers in a timely and cost-effective manner. Consequently, Applicant's primary objective in siting a nuclear power plant is to find and develop a site that will promote licensing and startup in a short period of time and within affordable cost ranges.

In achieving this, Applicant hopes to avoid or keep to a minimum social, political, and scientific controversy that might delay progress. The siting process is initiated by the Applicant and carried on for three to five years, to be followed by about 6 to 8 years of hearings, design, and construction. Significantly-adverse findings on geologic/seismologic hazards at any time during this period could hamper or halt the project. For this reason the strategy of the Applicant is to investigate exhaustively in the early phases and to encourage openness by all parties in identification of existing or potential problems and needs for information.

Phases of the siting process can be described briefly as follows:

Phase I - Reconnaissance of a large region (all or a major part of a state and larger) to characterize its seismotectonics, and to identify subregions where stratigraphic conditions are favorable for dating of faults and evaluating the potential of earthquakes. Involves chiefly literature review with some limited field observation, and requires approximately 4-6 months.

Phase II - Detailed reconnaissance of subregions to verify or deny favorable indications of Phase I, and to identify two or three candidate siting areas where the greatest assurance exists of favorable stratigraphic/structural demonstration of the absence of capable faults and of sufficient distance from large earthquake sources. Involves extensive geologic mapping at several scales, moderate amounts of subsurface exploration by geophysical methods, borings and trenches, and some absolute dating. Time required varies with the number of siting areas being examined, but is in the range of 9 to 12 months.

Phase III - Very detailed site-specific investigations at two or three sites of 5-mile radius to confirm in great detail the absence of capable faults and other geologic hazards, and to determine earthquake and soil engineering parameters for design. The chief communications product is the Preliminary Safety Analysis Report (PSAR) on one site, and identification of one alternate site. This is the most extensive phase because of comprehensive subsurface exploration and thorough review by the NRC, USGS, and others. Time required is 12 to 18 months.

Phase IV-The time of formal exchange of questions and answers between Applicant and Regulators, including the public hearing process with federal and state agencies. Involves testimony and oral presentations on the geologic/seismologic aspects of the site, and is the time during which public controversy and participation is strongest. Can last 6-12 months or more.

Phase V - The construction process during which geologic and seismologic monitoring activities are carried out, e.g. mapping of plant excavations, measuring settlement, recording and interpreting earthquakes, etc., some of which activities continue well into the operational phase of the plant.

The NRC (in particular the Geoscience staff of the Site Analysis Branch) and the USGS are critically important groups in the communication chain. Of course, the Commission is the ultimate authority in licensing, but the Geoscience staff is also in a very strong position to interpret the NRC's siting criteria, to provide guidance in site selection of Phases I and II, and to critically judge the adequacy and correctness of findings in Phase III. Experience has shown that communication with the Geoscience staff of plans and activities started in Phase I, and maintained at two or more levels on an individual basis, has opened up helpful information flow and has helped to establish Applicant/Consultant credibility in the eyes of the NRC.

As the largest and most knowledgeable source of geologic/seismologic data in most parts of the United States, the USGS contributes useful general information to the Applicant, commonly by direct communication with Applicant's principal consultant at several levels. During Phases I and II the USGS staff plays a very informal review role, while understandably being very cautious or even reluctant to provide guidance or conclusions, except to identify possible hazards to be explored. During Phase III they are critical reviewers and judges of Applicant's work. If the sites selected in Phase III are in areas where the USGS has not been active previously, it is likely that investigations will be idependently undertaken by the USGS. Such investigations can be helpful, but there is also the potential that they will not proceed at the same pace and with the same attempt at conclusiveness as Applicant's investigations, in which case they might tend to delay decision making.

State and local agencies, as well as universities, are other sources of information, sometimes in more detail than that from federal agencies. Where fault and earthquake study programs are underway by state geologic surveys, new data that confirm or contradict published findings are commonly discussed and exchanged between the Applicant and the state survey.

Communication with technical staff of the NRC, USGS and State Surveys extends well into the field exploration of Phases II and III, with invitations from the Applicant to observe significant trenching or drilling operations. In Phase II this is often done as more of a professional courtesy and opportunity for idea exchanges. In Phase III, however, such observations are performed to positively demonstrate critical relationships to reviewers who must judge the Applicant's case.

Except when there is controversy, and groups or individuals intervene in the proceedings, the public is a rather passive participant in nuclear siting. However, the public can interfere in many ways, such as denying the Applicant access to land for exploration, or to water for cooling, or to a site through the referendum process. While intervenors have an axe to grind and are not receptive to any but negative arguments for the plant, the public and nearby landowners are sometimes very cooperative and in favor of the plant. Efforts at positive communication with the public vary from Applicant to Applicant, and have included public and private meetings, field trips, brochures describing the project, and presentations in layman's terms on technical issues, particularly the geologic and seismic studies. Some Applicants, on the other hand, communicate as little as possible, particularly about earthquakes, on the theory that the less said the better. In my opinion, the latter approach tends to be counterproductive and to weaken credibility at all levels of the communication process.

EARTHQUAKE HAZARD STUDIES AND BUILDING CODES

by

S. T. Algermissen

U.S. Geological Survey

One of the most important ways in which the results of research are introduced into the design and construction of earthquake-resistant structures is through building codes. Many aspects of the Earthquake Hazards Reduction Program of the U.S. Geological Survey have a bearing on the development of building codes. This paper will be restricted to a discussion of how studies in seismology, especially ground motion studies, have affected those building codes that tend to be national in scope. This is taken to mean codes that may be used nation wide or applied to certain types of structures across the country. The Geological Survey's Earthquake Hazard Reduction Program in California, particularly with respect to the evaluation of geological hazards associated with earthquakes, has had considerable impact on land use planning and zoning of various types in California but these applications are beyond the scope of this paper.

A brief review of the various earthquake hazard maps that have been used in building codes is perhaps the best way to illustrate how research results have been applied to this important problem.

Hazard Maps and Building Codes

In 1948, a "Seismic Probability Map" was developed by Franklin P. Ulrich of the U.S. Coast and Geodetic Survey. This map divided the contiguous United States into four zones numbered 0, 1, 2, 3. Zone 3 was considered to have the greatest potential for earthquake damage. The map was adopted in 1949 by the International Conference of Building

Officials (ICBO) for inclusion in the Uniform Building Code. This map is, I believe, the first national zoning map used for building code purposes in the United States. The numbered zones were used in the code to develop the lateral force provisions that would apply in various parts of the country. Despite the fact that Ulrich developed his map with the aid and advice of some of the leading seismologists in the country at that time, the exact basis for the map was never made entirely clear by Ulrich in published papers. The zones were apparently drawn on the basis of the maximum magnitude earthquake estimated to occur in each zone. The zones are more or less geometrical in outline and do not represent differences in ground motion. Thus, at some places on the map, zone 3 adjoins zone 1, etc. Within a few years, the map was withdrawn by the Coast and Geodetic Survey as being misleading and subject to misinterpretation. The map, however, remained in editions of the Uniform Building Code until 1970.

The 1970 edition of the Uniform Building Code used a map developed by Algermissen (1969) which has the same numbering scheme (0 through 3) as the Ulrich map. This map is based largely on the maximum Modified Mercalli intensity observed historically in each zone but includes some generalization for regional geological structure. The paper accompanying the map contained an analysis of the frequency of occurrence of earthquakes throughout the country. The ICBO, while adopting the new map for the Uniform Building Code did not make use of the frequency of earthquake occurrence information that accompanied the map. The result in the code was that the same lateral force provisions specified in California also were applied in some parts of the eastern United States.

This created some difficulty because of the much lower frequency of occurrence of large damaging earthquakes in the eastern portion of the country as compared with California.

The original map of Algermissen was changed in California in the 1976 edition of the Uniform Building Code. Portions of zone 3, principally in the control areas of California were changed to a new zone 4. This change had the effect, qualitatively, of taking into account the greater frequency of earthquakes and the greater maximum magnitude of earthquakes that are perhaps possible in California.

The Department of Housing and Urban Development (HUD) and the Department of Defense (DOD) have both followed the lead of the ICBO in their use of seismic provisions for structures. HUD uses the Algermissen map in its Minimum Property Standards for Single Family Dwellings and Minimum Property Standards for Multifamily Housing. They have not adopted the zone 4 in California used by the UBC since 1976.

The Department of Defense in its "Seismic Design for Buildings," used by the Departments of the Army, Navy, and Air Force, has closely followed the UBC with regard to seismic zoning maps. Their current design manual contains the same zone map in the current issue of the UBC.

The Applied Technology Council (ATC) was organized by the Structural Engineers Association of California (SEAOC) in 1971 as a tax-exempt, non-profit corporation to: (1) coordinate research efforts in earthquake and other aspects of structural engineering; (2) review and evaluate published research results; and (3) translate research results into forms usable and understandable by practicing structural engineers.

A proposal from ATC to the National Bureau of Standards (NBS), Department of Commerce, entitled "Development of Comprehensive Seismic Design Provisions" (ATC-3), was accepted by NBS in 1973. Funding for the project was from the National Science Foundation and NBS. The basic purpose of the ATC-3 project was to present, in one document, current state-of-knowledge in the fields of engineering seismology and engineering practice as it pertains to seismic design and construction of buildings.

The ATC-3 project has recently been completed and a draft report entitled "Tentative Provisions for the Development of Seismic Regulations for Buildings," is being circulated for comment. The report contains two ground motion maps termed an Effective Peak Acceleration and an Effective Peak Velocity map which are used to obtain "design ground shaking" and compute lateral force coefficients. For the contiguous United States, these two maps are based on a map of estimated acceleration in rock in a 50-year period at the 90-percent probability level developed by Algermissen and Perkins (1976). The Algermissen and Perkins map is also contained in the ATC report. The ATC-3 Effective Peak Acceleration map is very similar to the Algermissen and Perkins acceleration map with the exception that the largest values of ground acceleration shown on the ATC-3 map are 0.4 g in California while the Algermissen-Perkins map has accelerations as high as 0.8 g in California. The ATC Effective Peak Velocity map was derived from the Algermissen-Perkins acceleration map using principals and rules-of-thumb outlined in the report. The ATC-3 report is an excellent example of the use of recent research results to produce seismic design provisions of considerable sophistication and flexibility.

Figure 1 illustrates schematically the U.S. Geological Survey input to the codes and building provisions already discussed. In all the cases shown in Figure 1, USGS personnel have worked with the appropriate technical group or committee responsible for developing estimates of ground motion for the code or building provision in question.

Conclusions

The development of seismic design provisions and building codes is complex and necessarily, an evolutionary process. Nevertheless, it is apparent that great progress in the development of seismic design provisions and codes has been achieved over the past 30 years. In every case, the technical groups associated with the development of building design provisions and codes have been well aware of developments in research and technology that are pertinent to the seismic design problem and have made use of these developments in a very timely manner.

References

Roberts, E. B., and Ulrich, F. P., 1951, Seismological activities of the U.S. Coast and Geodetic Survey in 1949: Seismol. Soc. America Bull., v. 4, no. 3, p. 205-220.

Algermissen, S. T., 1969, Seismic risk studies in the United States: World Conf. on Earthquake Eng., 4th, Proc., Santiago, Chile, 1969.

Algermissen, S. T., and Perkins, D. M., 1976, A probabilistic estimate of maximum acceleration in rock in the contiguous United States: U.S. Geol. Survey Open-File Rept. 76-416.

______1978, Tentative provisions for the development of seismic regulations for buildings: App. Tech. Council (Draft Report), 507 p.

______1973, Minimum property standards for one and two living units: U.S. Dept. of HUD, Pub. 4900.1.

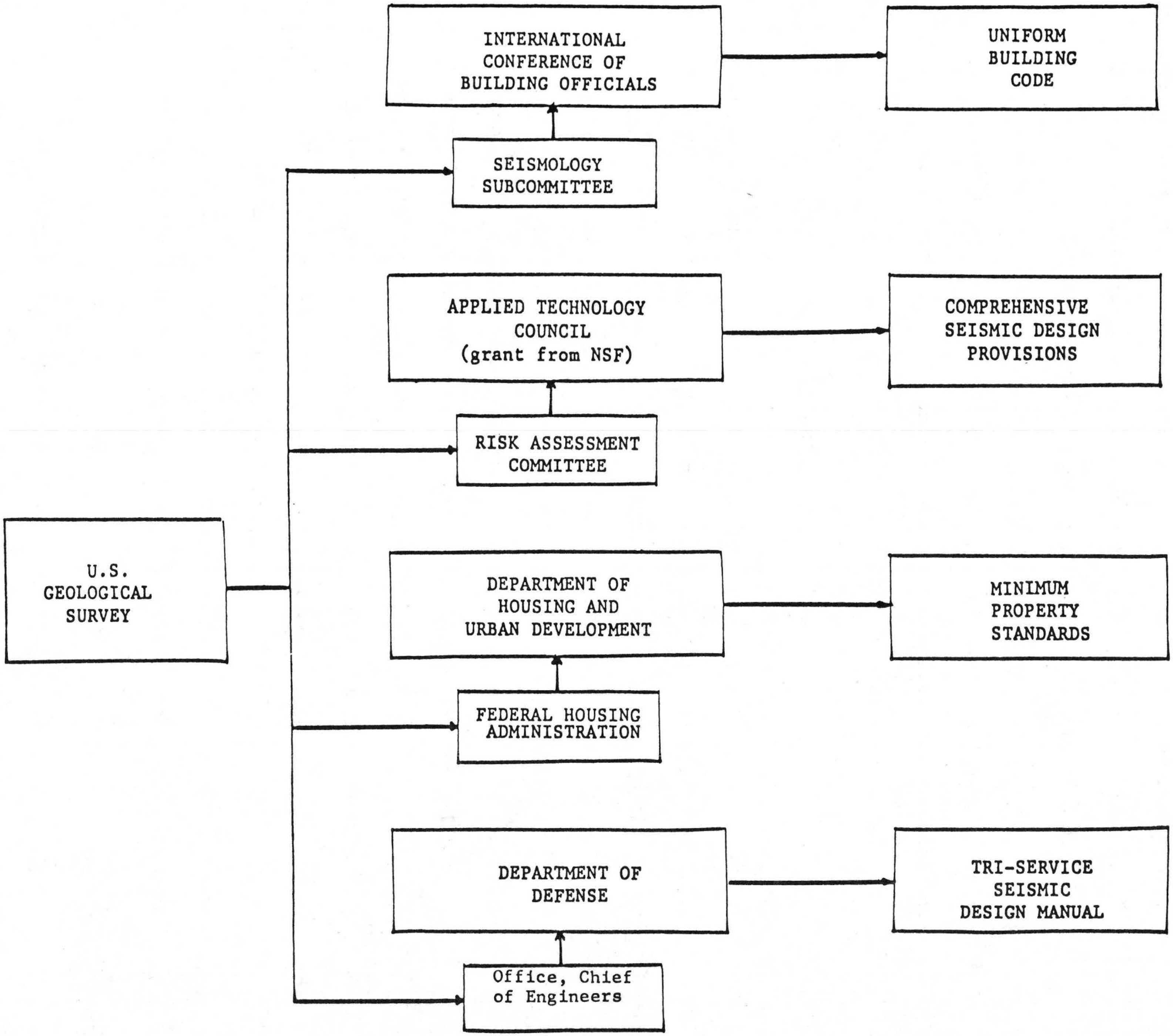
______1973, Minimum property standards for multiple family housing: U.S. Dept. of HUD, Pub. 4910.1

______1973, Minimum property standards for CARE-TYPE housing: U.S. Dept. of HUD, Pub. 4920.1.

______1973, Manual of accepted practices: U.S. Dept. of HUD, Pub. 4930.1.

______1973, Seismic design for buildings: Depts. of Army, Navy, and Air Force (Army, TM5-809-16; Navy, NAU FAC P-355; Air Force, AFM 88-3, Chap. 13), Office of the Chief of Engineers, Washington D.C.

Figure 1.--Application of Hazard Studies to Building Codes and Standards



INFORMATION FLOW IN THE DEVELOPMENT OF
EARTHQUAKE PROVISIONS FOR BUILDING CODES

by

James Robert Harris*

Increasing attention is being paid to the hazards created by the reaction of our built environment to earthquake. This study examines the workings of one control system that society uses to reduce that hazard, the building code. The flow of information among the various sectors of society that influence, and are influenced by, building codes is complex. This complex information flow must be understood in order to improve the protection provided to the public by building codes.

THE BUILDING REGULATORY SYSTEM

In the United States the authority to regulate the construction and use of buildings rests with the state governments because the Constitution does not specifically assign that authority to the federal government. Traditionally, however, the states have not exercised that authority, but it has been exercised by local governments. Even though many states have enacted statewide building codes in recent years (1), most legal building codes are the laws of cities and towns, and each one has the potential to be, and often is, unique. This tremendous diversity has been decried by many as a millstone around the neck of the construction industry, impeding innovation and efficiency. (2, 3, 4) While there are unifying influences on building codes that tend to reduce the diversity (which will be examined shortly) the fact is that there are a great many diverse building codes. That fact should be considered when planning a reform of any provisions in building codes.

Where building codes exist, and nearly all cities with a population over 10,000 have them, they exert strong control over how buildings are built and what they are built with. (5) Because of this, building codes have

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been the subject of much interest and study. (6,7,8) There are many sectors of society that have an influence on the built environment, (design, construction, manufacture, research) yet much of the information they produce must pass through the building code "funnel" before it has a tangible affect. (See figure 1). This funnel concept applies to two processes, the construction of a single building and the establishment of provisions that will govern construction of all buildings within the jurisdiction where a given building code is used.

It is important to note that there is one individual, practically speaking, at the neck of the funnel. Although most building departments include more than one employee to review the plans and inspect the construction of buildings, the chief building official retains overall responsibility. He is essentially the same individual who makes important decisions about what is in the code. This decision making power is actually tempered by the statutory control of a higher government entity (for example, a city council) in the case of the adoption of new provisions into legal codes, but the building official is usually a strong influence on the statutory control body. The fact that one individual is in many cases the personification of the building code has important implications for any proposed changes. The breadth and depth of technological knowledge required to use building code provisions must not exceed the capacity of the individual building official, or it is unlikely that the provisions will be enforced.

Because the drafting of a building code is usually far too big a job for any but the largest cities to undertake, model codes are in widespread use as the basis for most legal codes. Individual jurisdictions often adopt one of the models as their legal code, but frequently the models are amended, so diversity still exists. There are four model building codes produced in the U.S.:

1) The National Building Code, published by the American Insurance Association, New York, N.Y.
2) The Uniform Building Code, published by the International Conference of Building Officials, Whittier, CA.
3) The Standard Building Code, published by the Southern Building Code Congress International, Birmingham, AL.
4) The Basic Building Code, published by the Building Officials and Code Administrators International, Chicago, IL.

All but the first of these are produced by associations of building officials who have joined together in an effort to produce better codes with less duplication of effort. These model codes are influenced by essentially the same sectors of society as the local codes, with some obvious differences in scale (for example, an individual engineer might try to influence a decision on a local building code, whereas a national association of engineers would be an analogous influence on a model code.) Although the three model code associations permit nearly any interested party to participate in the committee meetings they conduct, the final decision on what the model code contains is made by vote of the building officials who are members of the association.

There are many other building code related organizations; some function to improve building codes, some to increase the uniformity of building codes and some to raise the professional stature and competence of building officials. Among these are the Council of American Building Officials (CABO), the Model Code Standardization Council, the National Academy of Code Administration, and the National Conference of States on Building Codes and Standards (NCSBCS). In addition, the three model code producing associations have recently announced their joint intent to explore the possibilities of merging their efforts. So the current trend is moving away from the great diversity of thousands of different building codes, but there is still a great distance to go.

The model code associations are not the initial authors of all things in their codes. Indeed, the bulk of the provisions governing buildings today come directly or indirectly from hundreds of national standards that deal with engineering practice, material specifications, and test methods. Some standards are used as resources for the writers of model codes. For example, many of the provisions for emergency exiting in the building codes come from The Life Safety Code, published by the National Fire Protection Association. (Although this document is named a code, it is not law since NFPA is not a governmental entity, and it is more properly called a standard.) Many other standards are referenced in the model codes. For example, the Basic Building Code requires that the provisions of ASTM Standard C33 be followed (American Society for Testing and Materials Standard C33 deals with specifications for aggregates for concrete.)

These standards are produced by over a thousand different committees in hundreds of different organizations. Large standards generating organizations in addition to ASTM and NFPA include the U.S. Department of Commerce, the Institute of Electrical and Electronics Engineers, the American Society of Heating, Refrigeration, and Air Conditioning Engineers, and many other professional societies. In addition, many trade associations produce standards, such as the Brick Institute of America, the American Iron and Steel Institute, and so on. The American National Standards Institute (ANSI) has generated a large number of standards for many years, but is now moving into a role of coordinating the efforts and policies of many organizations involved in generating standards.

The individuals who sit on standards generating committees and make decisions about the content of the standards come from many different sectors of society. Standards can be divided roughly into two groups based on who the decision makers are and how decisions are made. The first group is characterized by:

i) balanced representation from all interested parties, including in the case of building standards for example, materials suppliers, product producers, contractors, labor, designers, researchers, consumers, and representatives of government from federal, state, and local levels.

ii) concensus as a basis for decision making, which implies substantially more than a bare majority, but not necessarily unanimity.

iii) due process in the hearing and resolution of all issues, including the allowance of adequate time and notice for voting and the public resolution of all dissenting ballots.

ANSI standards fall into this first group, and ANSI also certifies other organizations that generate standards following procedures with these characteristics, such as ASTM, NFPA, and others. The second group of standards are all those that are not part of the first group, and the prototypical example is a proprietary standard issued by a trade association, as for example the Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings, published by the American Institute of Steel Construction. The characteristics that these standards typically do not possess is balance and due process. Both kinds of standards are widely used and quite important.

Thus model codes and standards are important cogs in the communication of information in the construction industry. They are applied less rigorously than legal building codes, or even contracts, because no force of law stands behind them. They have a much broader range of applicability than any legal code, however, because legal building codes in the U.S. do not apply over more than one state, and most are local (with some exceptions like the Federal Mobile Home Construction and Safety Standards.) Figure 2 shows how these various instruments fit on an overall scale of applicability and rigor.

The total flow of information in and out of building codes is summarized by figure 3. The principal input to most building codes is the model code, although pressure usually exists for local amendments. The principal outputs from the building code are the influences it has on professional building designers and the judgements rendered by building officials during plan review and building inspection. The strongest control on the information in the model codes is exerted by the local building official, since he alone may vote on the content of the model code. (Note that the model codes, then, do not have the balanced representation characteristic in their decision making that many national standards do.)

A strong resource of information for the model codes is the national standards system. Research from all sectors inputs into building codes, model codes, and national standards, with perhaps the greatest emphasis on national standards. All of these components shown in figure 3 also exchange information with one another, but the emphasis in this study is on those paths that have the strongest ties to the building code.

EARTHQUAKE PROVISIONS IN BUILDING CODES

The impact of the information flow just described on the development of building code provisions that address seismic risks is large. To begin understanding the impact, it is helpful to examine the history of earthquake provisions in building codes. Most of that history has occured in California, and much of it is in reaction to particular earthquakes. There have been many steps in the evolution of present provisions (5), but the following seem to be the most significant:

1) In 1906 the San Francisco Building Code began requiring all buildings to withstand a wind force of 30 psf with the intent that these buildings would also resist the lateral forces of earthquakes.
2) In 1927 the first edition of the Uniform Building Code required that all buildings resist a static lateral force equal to 8% of their effective mass, with a provision for doubling the force required for buildings on soft ground.
3) In 1933 the State of California passed the Field Act which established special review and inpection procedures to assure the seismic resistance of school buildings.
4) In 1943 the Los Angeles building code incorporated a formula making the required force inversely proportional to the building height (and thus, the period of vibration) and set a limit of 160 feet on the height of all buildings.
5) In 1956 San Francisco adopted a building code with no upper limit on building height that became the forerunner of the earthquake provisions of SEAOC (The Structural Engineers

Association of California). SEAOC's standard is the basis for most earthquake provisions today.

6) In 1967 the Uniform Building Code followed the 1966 SEAOC standard with detailed provisions for providing ductility in reinforced concrete frames, thus allowing tall concrete buildings.

7) In 1976 the Uniform Building Code followed the 1974 SEAOC standard by making the required lateral force depend on the use (importance) of the building. A factor for the influence of the soil at a site was also introduced, the soil factor of the 1927 UBC having been dropped long ago.

The current interest in improved building code provisions for earthquake hazards began with the San Fernando earthquake of February 9, 1971. Among the recommendations made in a report on that earthquake (9) were that the adequacy of existing codes and standards should be reviewed and that the process of updating building codes should be expedited. Evidence offered for the second recommendation was that the legal building code in San Fernando in 1971 (and all of Los Angeles County) incorporated the provisions of the 1956 edition of the American Concrete Institute's Standard ACI 318 for reinforced concrete buildings, even though a subsequent edition of that standard was issued in 1963, eight years before the earthquake. The difference between these two standards did make a significant difference in the resistance of some buildings to the earthquake.

In the spring of 1972 the National Bureau of Standards joined with the National Science Foundation in the Cooperative Federal Program in Disaster Mitigation. This program sponsored a workshop in the summer of 1972 entitled Building Practices for Disaster Mitigation that brought together 45 design professionals and researchers within the context of hazards created by earthquake and wind for three objectives:

1) evaluate the current design practices,
2) define opportunities that exist for improved design practices by using existing knowledge,
3) identify gaps in existing knowledge that would require research.

The workshop attendees made 61 recommendations in two areas: the practices necessary for effective disaster mitigation and the policies necessary to authorize the implementation of those practices. These recommendations ranged from the very general, which wese addressed to government policy makers, to the specific, which were addressed to researchers. In between were recommendations for the design practitioners and the codes and standards community. A large number of recommendations were made and over twenty of them related in some way to earthquake provisions in building codes. However the "top priority" was assigned to the recommendation to update earthquake provisions in building codes using knowledge available at that time and to provide a commentary for those updated provisions.

The workshop attendees perceived a large gap between the knowledge produced in the research community over the previous twenty years and that which was in the building codes. It now appears that there is a double gap: the most up to date earthquake provisions are found in the Uniform Building Code, and they do not fully reflect recent research findings, but an even larger gap exists in that many cities in the East and Midwest have essentially no earthquake provisions in their building codes even though a repeat of past earthquakes (New Madrid, Missouri, of 1811 or Charleston, South Carolina, of 1886) would cause severe damage and loss of life. This latter gap is strikingly parallel to the situation that existed in Managua, Nicaragua, before the earthquake in 1972.

The proceedings of the workshop (10) received wide distribution, as did the report on the San Fernando earthquake (9). Some representative portion of all the groups of decision makers that control the information flow in the building regulatory system were sent copies (that is, the building officials, designers, contractors, manufacturers, researchers, government policy makers, and so on.) In all, a few thousand copies were distributed.

It is difficult to be confident that the information generated in the workshop has in fact been communicated as best it might. A few thousand copies is a small number when compared to the total number of professionals, researchers, material and product suppliers, designers, contractors, and officials that make up the construction community. The mailing list that was used for the workshop proceedings attempted to indirectly reach the large number of individuals involved through direct contact with the smaller number of organizations they belong to. Thus, building officials were addressed through the technical directors and research committees of the model code organizations and through other organizations like CABO and NCSBCS. Likewise researchers and designers were reached indirectly through the various professional and technical societies. The direct mailing of the reports was also supplemented by the issue of a press release, and in the case of the workshop proceedings only, a press conference announcing the release. This information was picked up by some of the technical press, and the resulting articles brought the availability of the proceedings to the attention of more people than the initial mailing. Another problem with the distribution of the proceedings is that the total package was rather imposing for many of the intended audience. In addition to the 61 recommendations, the publication contained 15 background and review articles (taking 430 pages) that discussed the issues in some depth. The recommendations might have received more attention from particular individuals if they were packaged with only one or two of the review articles that dealt specifically with issues of interest to that individual. Tailoring a family of related publications to better reach different sectors of an audience is more work than issuing one large document to all, but the effort might have been worthwhile in the case of that workshop.

One result is clear. The recommendations of the workshop have guided the program planning of the National Bureau of Standards and the National Science Foundation in the ensuing years, and this has resulted in of a new set of provisions for the development of regulations for design and construction of buildings to resist earthquake by the Applied Technology Council (ATC). ATC's provisions will be published for consideration by the building codes and standards community in June, 1978. The development of these new provisions by ATC has been a large undertaking. It began in 1974, after a planning effort that took place shortly after the workshop in 1972. This project, which involved the collaborative effort of about 90 individuals from several technical and professional disciplines in research, design, and building regulation, can be viewed as an intermediate step between research and standards. A great deal of information was gathered from research and actual practice, philosophies of control (regulation versus insurance, and so on) were debated and resolved, and a coordinated package was produced.

This package is now available for the writers of standards and model codes to consider. But do not expect to see it cause changes in building codes by next year. More information about the technical and practical viability and about impacts (such as on construction cost) of the proposed changes must be gathered.

A current project at the National Bureau of Standards is to plan how this assessment and implementation of ATC's provisions might be carried out. Representatives of over 40 organizations from all sectors of the construction community participated in a meeting on April 21, 1978, to begin this planning activity. It remains to be seen just how the plan will develop, but it is now obvious that a large number of organizations and individuals are vitally concerned with the activity.

As one example of the kind of wide impact of ATC's provisions and the resultant information flow that will be generated, consider Figure 4. The figure shows how the standards in the field of structural design for buildings are currently partitioned: one standard covers all loads and several other standards cover the resistance of individual materials independent of the load. In contrast, the ATC provisions cover one load, earthquake, and the resistance of all conventional structural materials to that one load. Thus the new earthquake provisions overlap all of the existing standards, and in all likelihood, they will be considered separately by each of these standards committees. It is apparent that a hierarchy of decision making and information flow needs to be established among these committees.

In addition to affecting the National Bureau of Standards and the National Science Foundation, it is probable that the recommendations of the workshop have had an effect on the Congress of the United States. The Earthquake Hazards Reduction Act of 1977 (Public Law 95-124) establishes several objectives for a program of earthquake hazard reduction, two of which are related to buildings:

"the development of technologically and economically feasible design and construction methods and procedures to make new and existing structures, in areas of seismic risk, earthquake resistant..."

"the development, publication, and promotion, in conjunction with State and local officials and professional organizations, of model codes and other means to coordinate information about seismic risk with land-use policy decisions and building activity;"

The act also instructs the President to develop an implementation plan, which shall provide for among other things,

"the development and promulgation of specifications, building standards, design criteria, and construction practices to achieve appropriate earthquake resistance for new and existing structures;"

CONCLUSION

It is apparent that the information flow through the building regulatory system is complex, and that for technological changes, progress is quite slow. It would be optimistic to expect that more than a few buildings codes will be updated in accordance with recommendations of the 1972 workshop before 1982. It took six years just to get to the point of having provisions based on knowledge supposedly available in 1972 (in fact, ATC found it necessary to do developmental work in several areas.) It will take a few more years to assess the new provisions, and then several years after that to see them through the affected standards, the model codes, and into the legal building codes. This is an illustration of a situtation where the action at the federal level has moved faster than it has at the state and local levels: even though the Earthquake Hazard Reduction Act was passed by Congress, few, if any, legal building codes have changed yet. Persistence has been and will continue to be required to affect the building codes.

ACKNOWLEDGEMENT

Special thanks are due to James Pielert, James Gross, Pat Cooke and Charles Mahaffey for their aid in describing the building regulatory system, and Richard Wright and Charles Culver for their discussion of the recent work in disaster mitigation at NBS.

REFERENCES

1. Cooke, Patrick W., and Robert M. Eisenherd, A Preliminary Examination of Building Regulations Adopted by the States and Major Cities, NBSIR 77-1390, National Bureau of Standards, Washington, D.C., November 1977.

2. Advisory Commission on Intergovernmental Relations, Building Codes: A Program for Intergovernmental Reform, Washington, D.C., January 1966.

3. U.S. National Commission on Urban Problems, (The Douglas Commission), Building the American City, Washington, D.C., December 1968.

4. The Presidents Committee on Urban Housing (Kaiser Committee), A Decent Home, Washington, D.C., December 1968.

5. Ventre, F.T., Social Control of Technological Innovation: The Regulation of Building Construction, Unpublished Doctoral Dissertation, Massachusetts Institute of Technology, June 1973.

6. Cooke, Patrick W. (ed.), Research and Innovation in the Building Regulatory Process, Proceedings of the First NBS/NCSBCS Joint Conference, Specil Publication 473, National Bureau of Standards, Washington, D.C., June 1977.

7. Field, Charles G., and Steven R. Rivkin, The Building Code Burden, D.C. Heath and Company, Lexington, Massachusetts, 1975.

8. Schoen, Richard, Alan Hirshberg, and Jerome Weingart, New Energy Technologies for Buildings, Ballinger Publishing, Cambridge, Massachusetts, 1975.

9. Lew, H.S., E.V. Leyendecker, and R.D. Dikkers, Engineering Aspects of the 1971 San Fernando Earthquake, Building Science Series 40, National Bureau of Standards, Washington, D.C., December 1971.

10. Wright, Richard, Samuel Kramer, and Charles Culver, (eds.), Building Practices for Disaster Mitigation, Building Science Series 46, National Bureau of Standards, Washington, D.C., February 1973.

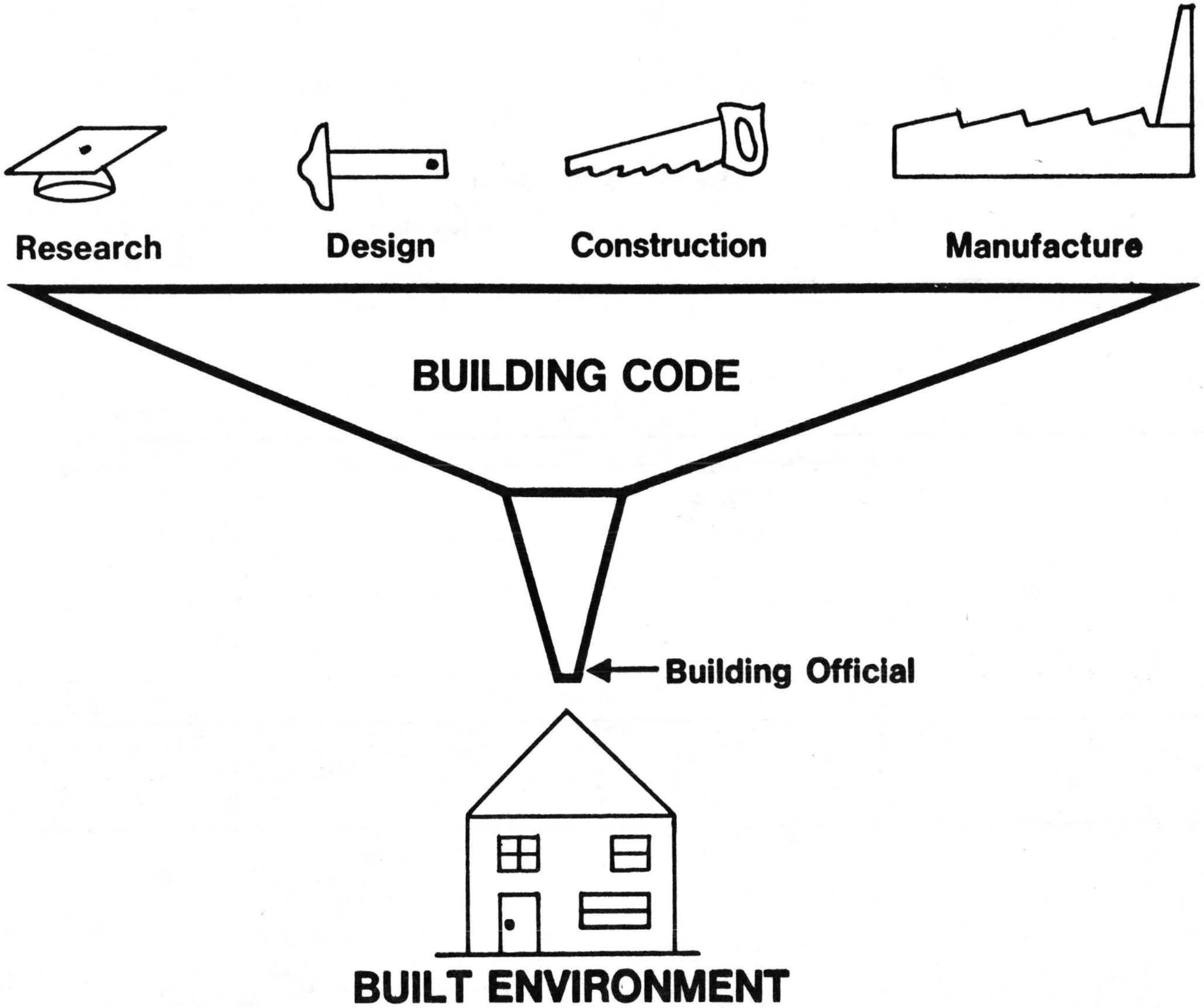

Figure 1: The Building Code Funnel

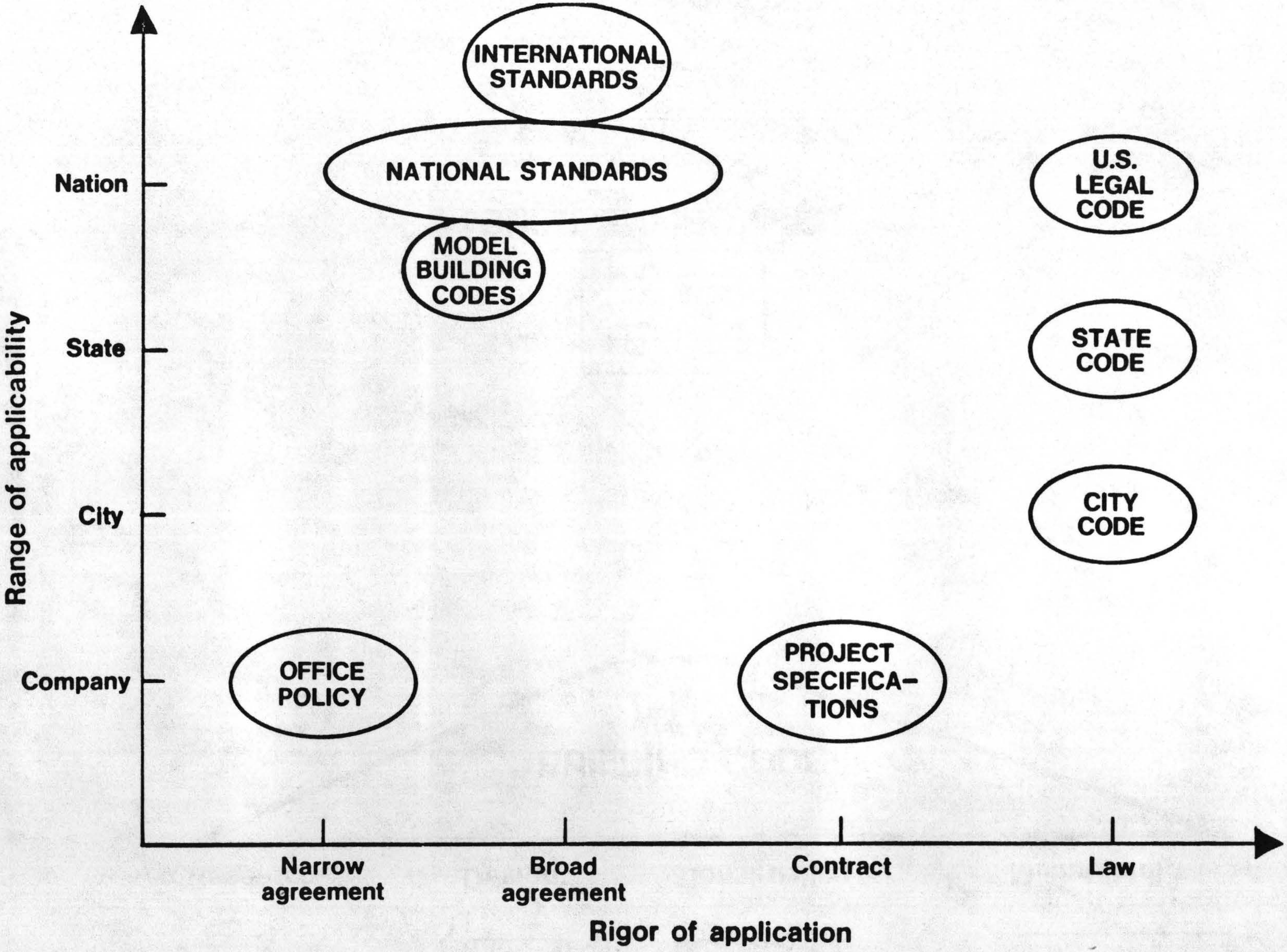

Figure 2: Range and Rigor of Standards

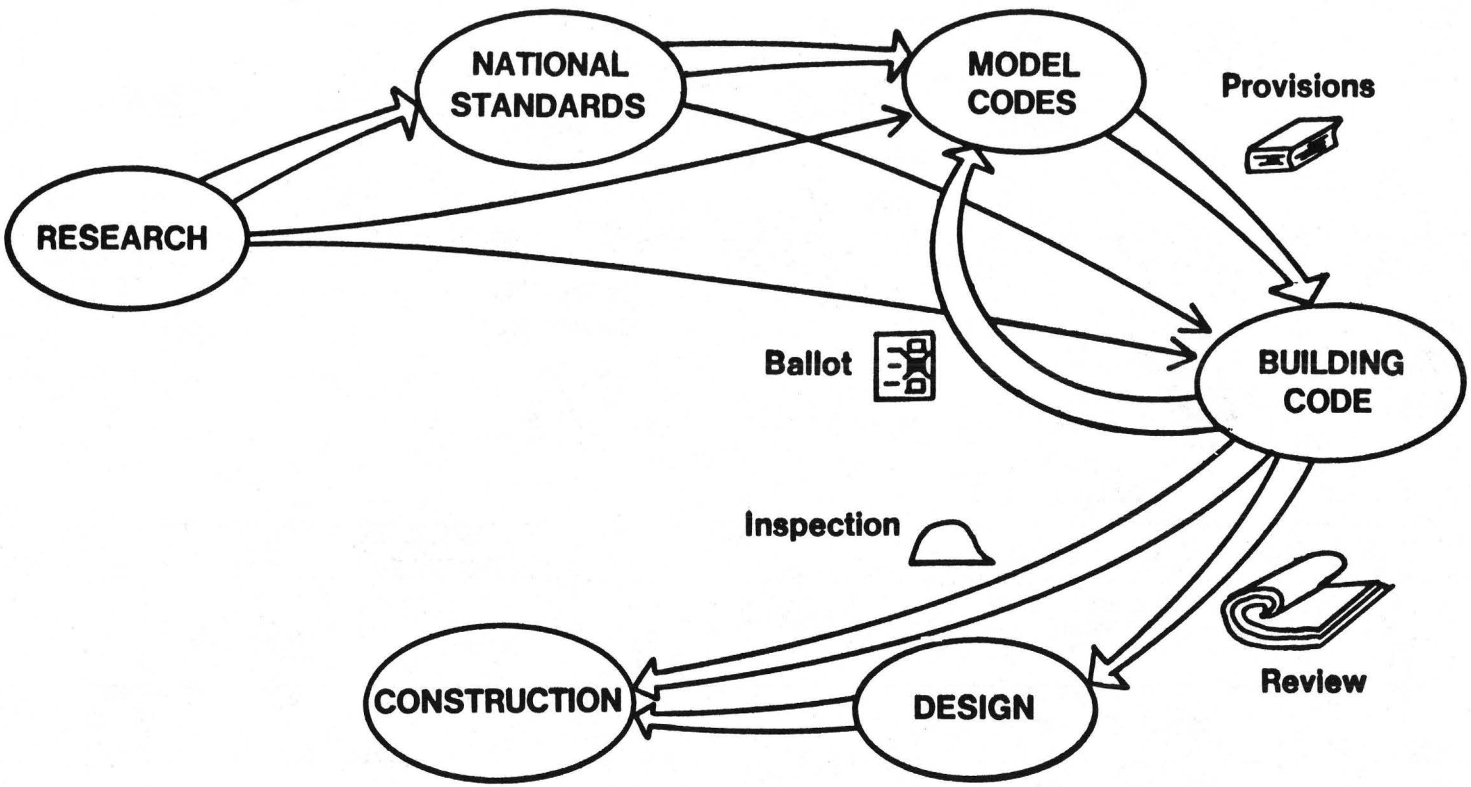

Figure 3: Information Flow Through Building Codes

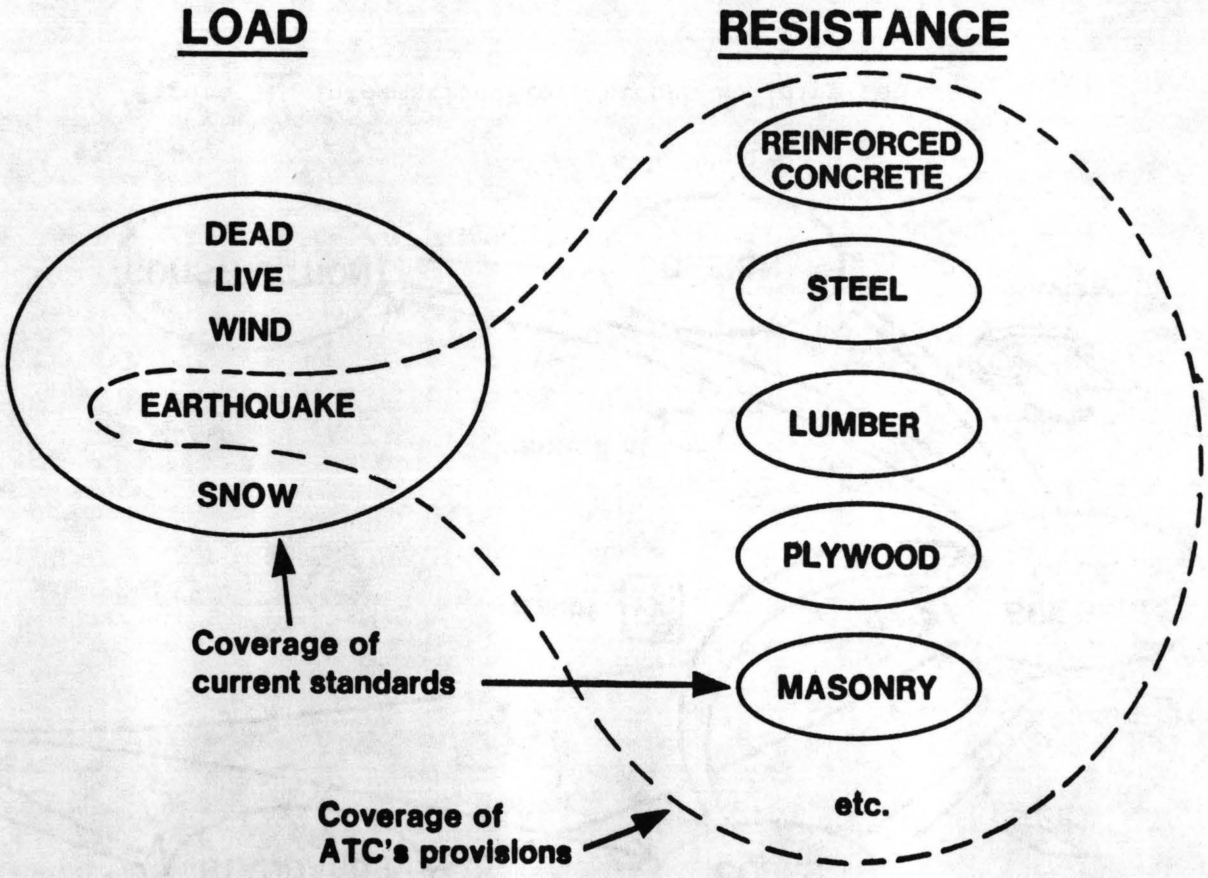

Figure 4: Standards for Structural Design vs. ATC's Provisions

COMMUNICATING RESEARCH PRODUCTS DEVELOPED BY THE SAN FRANCISCO BAY REGION ENVIRONMENT AND RESOURCES PLANNING STUDY

William J. Kockelman*

The earth-science profession has become more aware of the need for the application of earth-science information to problems concerned with urban and regional planning and development.

San Francisco Bay Region Study

As a result of this awareness, the U.S. Geological Survey and the Department of Housing and Urban Development jointly supported a program to demonstrate how earth-science information could be used in planning and development in the nine-county San Francisco Bay Region. The San Francisco Bay Region Environmental and Resources Planning Study (SFBRS) was a six-year (1970 - 1976) program, funded at about four million dollars.

The goal of SFBRS was to identify and provide basic and interpreted earth-science information needed in making land-use decisions for regional planning, to provide a comprehensive array of data at a regional scale, and to test and evaluate the ways in which these data are being used for planning and decisionmaking.

Bay Region

The nine-county San Francisco Bay region was selected as a demonstration area because of its geologic and hydrologic problems and the

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environmental awareness of its citizens and government institutions. With an area of 7,416 square miles, it is larger than the state of Connecticut, and its 1970 population was more than five million. The region contains the San Francisco Bay, a major and complex estuary comprising about 680 square miles, and contains over 150 miles of coastline. The area (fig. 1) is both large and complex enough to show how earth-science information can be applied to planning and decisionmaking.

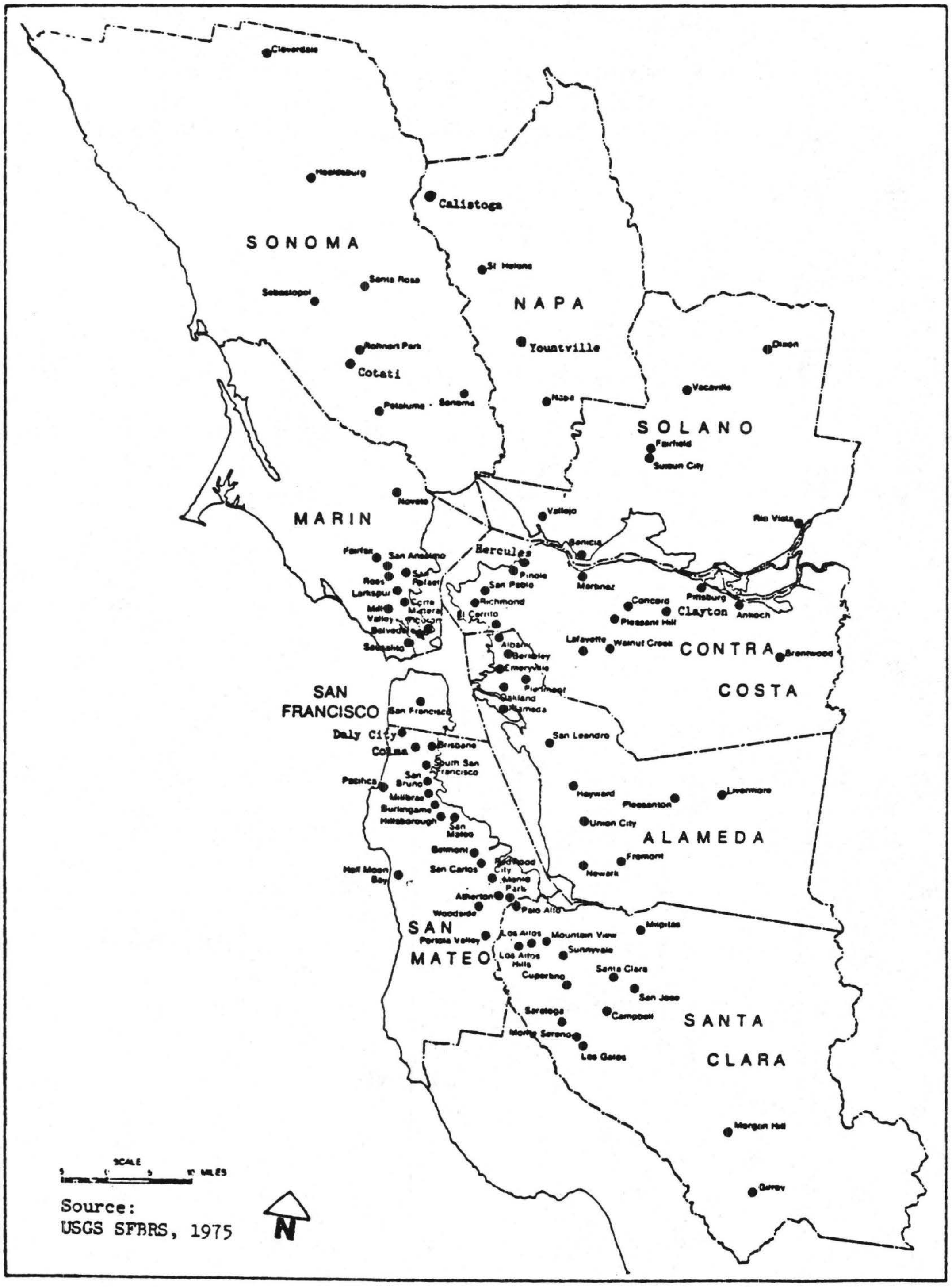
SFBRS Products

Between 1970 and 1976 SFBRS published and distributed to planners, scientists, engineers, teachers, public officials, and others more than 100 maps and reports. These publications illustrated new ways of depicting topography and slope; interpreted the results of new and previously available research in geology, geophysics, and hydrology; and showed in some cases how the research findings could be used to improve land-use planning and decisionmaking.

Some products evaluated and delineated potential problems such as earthquake faults, landslides, and flood-prone areas. Others explained how geologic processes can be adversely affected by man-made changes; how sediment is eroded, transported, and deposited; how the quality of the San Francisco Bay is affected by the inflow of fresh water during runoff; and how the intensity of shaking during earthqakes depends on the local geology.

FIGURE 1

Seven-county San Francisco Bay Region



Information Flow

Figure 2 presents the information flow or communication model for the SFBRS. It is deliberately simplified into two parts: (1) devices used to convey users' needs to the producer, and (2) devices used to convey the USGS products to the users.

User Needs to the Producers

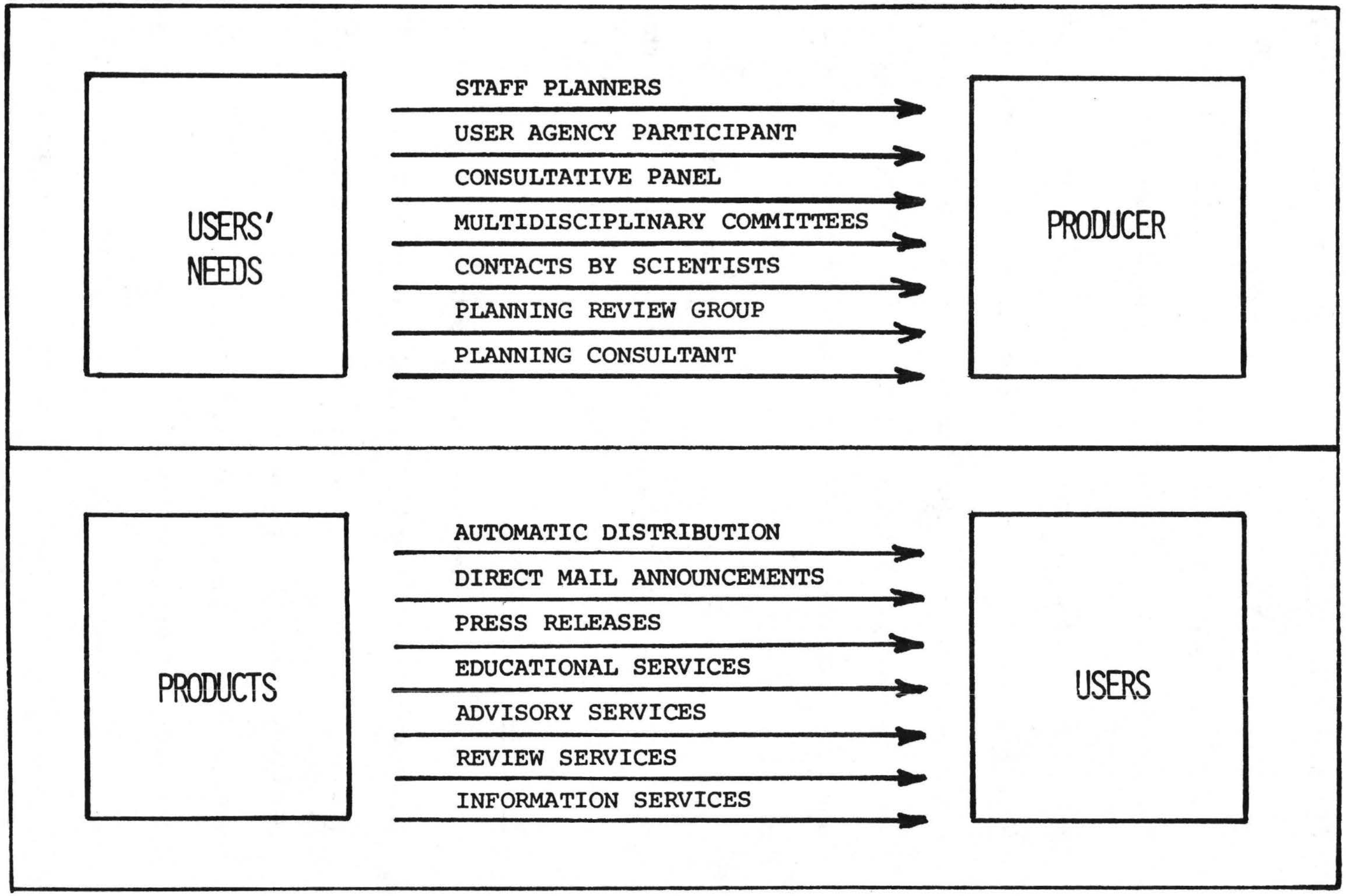
Several devices were used to ensure that the SFBRS work program and its products met the needs of planners and decisionmakers. It was recognized at the outset that user participation would be crucial to the successful completion of the SFBRS. Planners were assigned to the SFBRS to serve as liaison to users and to evaluate applications of products. The Association of Bay Area Governments -- a regional council of governments -- was an active partner. A consultative panel was established. This panel, with a membership of about twenty, consisted of representatives from the planning and development community at all levels of government and representative professionals from the private sector.

For the design of specific products, however, several multidisciplinary committees were formed. Each of these committees addressed a specific topic and was comprised of experts on that topic.

FIGURE 2

Information Flow Devices

San Francisco Bay Region Environment and Resources Planning Study



Many USGS scientists are interested in local and regional application of earth-science information for hazard avoidance, damage mitigation, resource conservation and environmental protection. These scientists had developed professional and civic contacts with local and regional planners and decisionmakers which proved very valuable.

The regional perspective of the consultative panel was supplemented by a planning review group of five academic and practicing planners from other parts of the United States. The group was assembled to provide a broad perspective of planning needs, to assist in review of publications and to ensure that products of the SFBRS would be useful in other parts of the country.

Lastly, the SFBRS contracted with an urban and regional planning consultant to review the state-of-the art and to coauthor several interpretive reports.

Products to the Users

Several devices were used to ensure that the earth-science information was promptly and effectively conveyed to users. A computerized mailing list was established and the professional discipline and institutional affiliation of those receiving SFBRS products were monitored. Automatic distribution was made free to about five hundred individuals, most of them affiliated with public agencies. In addition, announcements of new products were sent to about fifteen hundred individuals. Press releases to the news media served as a third method of announcing our products. In all, about ninety thousand copies of SFBRS products were distributed during the six years of the Study.

Many scientists involved in the SFBRS have provided educational advisory and review services on a limited and informal basis. D. R. Nichols has estimated that some USGS scientists involved in urban studies "have spent between 20 and 50 percent of their time working with users" (Written Commun. 1971).

In addition, the USGS provides services on a formal basis through cooperative agreements or of an informational nature through map sales offices, geologic inquiries staff, public inquiries offices, National Cartographic Information Centers, and ordinary day-to-day contacts with the public.

Evaluation

Both the original "Program Design" (1971) and the "Plan for Completion of Study" (1974) provided for a report on the application of the SFBRS products to planning and decisionmaking. In partial fulfillment of this requirement, inventories of four discrete user groups-- 91 cities, 8 county planning departments, 8 county flood control and water conservation districts, and 7 selected regional agencies-- in the San Francisco Bay region were completed (Kockelman, 1975, 1976, 1978). The inventories were designed not only to document applications of the SFBRS products but to evaluate the extent of applications and to suggest ways to achieve greater and more effective use of the products.

Method

Briefly, the method consisted of (1) identifying all potential users of the products in the Bay region, (2) selecting discrete user groups, (3) ascertaining all planning activities required by state statute or customarily performed by the user groups, (4) selecting those planning studies, plans, implementation and other planning activities which require earth-science information, (5) using three interviewers, and (6) interviewing the staff person most experienced in using earth-science information or who had a need for such information. The number of persons interviewed in each city ranged from 1 to 4 and totaled 120. The number of persons interviewed in each county planning department ranged from 8 to 18 and totaled over 100. The number of persons interviewed in the seven selected regional agencies ranged from 2 to 15 and totaled over 50. Lastly, the inventories and interviews were recorded and verified (figs. 3 and 4). The thoroughness of the methodology and the coverage of every city and county in the Bay region were important to unequivocally substantiate the following findings, conclusions, and suggestions.

Findings

The inventories showed that (1) three-fourths of the cities, all of the counties (table 1) and all of the selected regional agencies were familiar with, and had made use of, SFBRS products, (2) over half of the cities, all of the counties, and all of the selected regional agencies had prepared planning documents citing SFBRS products, (3) geologic hazard studies, water quality studies, physical resource studies, safety plans, open-space plans, potential site evaluations, and environmental analyses were the specific uses most often made of the products, (4) eighty-five percent of all products were used at least once for a wide variety of city, county, and regional planning activities, (5) the eleven products that were used the most were small-scale, large-areal coverage, hazard-type products, and (6) ten of the eleven were interpretive-type products.

The responses of the over 270 city, county, and regional personnel interviewed indicated a need for larger-scale maps, additional data and interpretations, technical assistance in their use, and greater staff capability to interpret the products.

FIGURE 3

Typical Completed Inventory Form

COUNTY OF NAPA

Population 87,000 (1974)

Area 79.5 sq. mi.

1"=1,000',1"=2,000'
1"=5,000' Work Maps

1"=100',1"=200'
1"=500',1"=800' Implementation Maps

	Study, Plan, or Device	USGS Product Used	SFBRS Product Used	Products Used: Group a/ or Topic	Products Used: Map or Report No.
PLANNING STUDIES					
Circulation	*				
Geologic Hazards (part of Seismic Element)	O	/	X	F,FP,G,H,L,LU, M,WD,WQ,WS	BDC 5,7,9,11,15,33,37,52,54, 56,67, other USGS
Land Use	O				
Physical Resources	O	/	X	F,FP,L,G,H,LU,L, M,WQ,WS,Topo	BDC 7,9,11,15,21,24,25,50,51, 54,TR 3,4,IR 1,2, 7½ quad
Public Site Evaluation					
Sub-County Areas					
OTHER					
PLANS					
Circulation	*				
(Copy) Conservation	O	/	X	F,FP,G,H,L, M	BDC 7,9,11,15,25, 54
(Copy) General Plan	O	/	X	F,FP,G,H,L,M,WD,WQ, WS,Topo,Reg. Slope	BDC 4,5,9,11,15,32,37,47,50, 52,54,56,67, IR 4, 7½ quad
(Copy) Land Use	O	/	X	F,FP,G,H,L,M,WD,WQ, WS,Topo,Reg. Slope	BDC 4,5,9,11,15,32,37,47,50, 52,54,56,67, IR 4, 7½ quad
(Copy) Open Space	O	/	X	F,FP,G,H,L, M	BDC 7,9,11,15,25, 54
Public Safety	*	/	X	F,FP,G,H,L, M	BDC 7,9,11,15,32,37, 52,54,56,67
Scenic Routes	*				
(Copy) Seismic Safety	O	/	X	F,FP,G,H,L, M	BDC 7,9,11,15,32,52, 54,56,67
Solid Waste Management	*	/	X	7½ quad Reg. Slope	
Sub-County Plans					
OTHER-Housing, Noise	*				
ORDINANCES					
Ordinance Administration	O	/	X	F,FP,G,H,L, M,WD,WQ,WS	BDC 4,5,7,8,9,11,15,25,32,37, 47,50,52,54,56,67,69, IR 4
Building	O				
Grading	O				
(Copy) Subdivision	O				
(Copy) Zoning	O				
(Copy) OTHER-Riparian Woodland	O				
OTHER ACTIVITIES					
Community Assistance	O				
(Copy) EIS/EIR Preparation	O	/	X	Topo,Reg. Topo,F,FP, G,H,L,M,WD,WQ,WS	BDC 4,5,7,9,11,15,25,32,37,47, 50,52,54,56,67,69,IR4,Other USGS
EIS/EIR Review	O	/	X	Topo,Reg. Topo,F,FP, G,H,L,M,WD,WQ,WS	BDC 4,5,7,9,11,15,25,32,37,47, 50,52,54,56,67,69,IR4,Other USGS
Environment Analysis	O	/	X	Topo,Reg. Topo,F,Fp, G,H,L,M,WD,WQ,WS	BDC 4,5,7,9,11,15,25,32,37,47, 50,52,54,56,67,69,IR4,Other USGS
General Reference	O	/	X	F,FP,G,H,L,M, WD,WQ,WS	BDC 4,5,7,8,9,11,15,24,25,32,37, 41,47,50,52,53,54,56,67,69, IR 4, TR 3
Potential Problem Area					
OTHER					

a/ These letters indicate the following SFBRS product groupings: F-Faults, FP-Flood-prone Areas, G-Geology, H-Hydrology, L-Landslides, LU-Land Use, M-Miscellaneous, WD-Waste Disposal, WQ-Water Quality, WS-Water Supply. * - Indicates "In Process", O - Indicates "Completed".

FIGURE 4

Typical Completed Interview Form

COMMENTS ON EARTH SCIENCE APPLICATIONS IN THE BAY REGION

1. Planning Staff
   (Number of professional planners 11 ; engineers 1 ; geologists 0 ; total staff 22)
   (Geologic, hydrologic or engineering background of professional staff) None

2. Receipt, Distribution and Custody of SFBRS Products
   Received, circulated, and filed by topic in Environmental Protection Section

3. Reasons for Failure to Use SFBRS Products
   (Not received, not distributed, not accessible, no staff capability, lack of interest, interdisciplinary communication, etc.)

   Unaware of orthophotos with contours
   Have more detailed flood data from the County Flood Control District

4. Problems in Using SFBRS Products
   (Map scale, legend or text; technical assistance; level of detail; local staff capability; planning area coverage; accuracy, etc.)

   Scale too small
   Three of 15' topographic quadrangles have been discontinued or are unavailable
   7½' quadrangles not up-to-date
   Photorevised 7½' quadrangles lack revised hypsography
   Most BDC's do not cover the County, e.g. landslide data is not available

5. Contacts with USGS Personnel to Obtain Products or Assistance
   (Name, topics, type of assistance)

   Ed Helley, Ken Fox; Information and review of seismic safety element
   Bill Brown; Information on sedimentation
   George Schlocker; Information and review of EIR
   Saul Rantz; Information and advice on precipitation
   Loren Young; Information on ground water yields

6. Anticipated Use of Published USGS/SFBRS Products in Future
   (Identify products and use)

   All topical interpretive reports except coastal processes
   Orthophotos with contours
   Old aerial photographs (1:12,000)

7. Data or Products Needed or Desired
   (Topic, scale, land uses, etc.) (Changes or improvements in future SFBRS products)

   Data Needed: Land-use capability, engineering interpretations, 1:62,500 topo maps, 1:24,000 slope maps, more detailed fault locations, liquefaction data, and landslide data.
   Suggestions: Keep text simple, conduct more cooperative studies with other agencies, use more color, provide UTM grid tick marks on slope and orthophoto maps, publish products at larger scale - at least 1:24,000 and explain the methodologies used.

8. Outstanding Illustrations of the Use of SFBRS Products
   (e.g., maps, methodology, ordinance wording, etc.)

   Multiple acetate overlays of geologic and hydrologic hazards and resources for the land-use element and general plan.
   Staff feels comfortable in using USGS data

9. County Officials, Employees, and Consultants Interviewed:

Lou Archeleta	Associate Planner	Planning
Bruce Baracco	Assistant Planner	Planning
Ronald Guderson	Civil Engineer	Flood Control
James Hickey	Director	Planning
Robert Jones	Civil Engineer	Flood Control
J. B. Klein	Associate Civil Engineer	Public Works
Anthony McClimmons	Senior Planner	Planning
James O'Loughlin	Associate Planner	Planning
Steve Rae	Associate Planner	Planning
John Stewart	Civil Engineer	Public Works
A. R. Van Woerkom	Sanitarian III	Environmental Health

Address: 1121 First St., Napa, CA 94558 — Telephone: 707-224-8388
Interviewers: W. J. Kockelman, M. M. Trembley — Dates: 1/19/75; 11/22/74

TABLE 1

Use of SFBRS and Other USGS Products by County and Type of Planning Activity

COUNTY	POPULATION			STUDIES							PLANS										ORDINANCES						OTHER ACTIVITIES						
	1960	1970	Change 1960-1970	Circulation	Geologic Hazards	Land Use	Physical Resources	Public Site Evaluation	Sub-County Areas	Other	Circulation	Conservation	General Plan	Land Use	Open Space	Public Safety	Seismic Safety	Solid Waste Managment	Sub-County Areas	Other	Administration	Building	Grading	Subdivision	Zoning	Other	Community Assistance	EIR/EIS Preparation	EIR/EIS Review	Environmental Analysis	General Reference	Potential Problem Area	Other
Alameda	908,209	1,073,184	18.2	*	X	/	X		X	X	*	X	X	X	0	*	X	X		**X**	X	0	0	0	0		X	X	X	X	**X**	X	X
Contra Costa	409,030	558,389	36.5	X	**X**	X		X	X		0	/	0	0	/	*	X	X	X	*	X	0	0	0	0		X	**X**	X		X	X	X
Marin	146,820	206,038	40.3	0	X			0	**X**	0	0	0	0	0	0	X	X	X	0	X	X	0	0	0	0		X	X	X	X	X	X	X
Napa	65,890	79,140	20.1	*	X	0	X				*	X	X	**X**	X	X	X	X		*	X	0	0	0	0	0	0	X	X	X	X		
San Mateo	444,387	556,234	25.2		X	X	X	X	X		X	X	0	X	X	**X**	**X**	X	X	*	**X**	0	0	0	**X**	0		X	X	X	X	X	X
Santa Clara	642,315	1,064,714	65.8	X	X	X		X	X	X	X	**X**	X	X	X	X	**X**	X	X	0	X	**X**	**X**	**X**	0	0	X	X	X	X	X	X	**X**
Solano	134,597	169,941	26.3		X	/		**X**		X	/	/	/	/	/	X	X	*	X	X	/	0		0	0			**X**	X	X	X		X
Sonoma	147,375	204,885	39.0	*	X	X	**X**	X			X	X	**X**	X	**X**	X	X	*		0	X	0	0	0	/		X	X	X	X	X		X

Legend

0 Indicates no identified use of SFBRS or other USGS products.

X Indicates identified use of SFBRS products.

/ Indicates identified use of other USGS products.

* Indicates preparation or major revision underway with no identified use of SFBRS or other USGS products.

X Indicates those applications illustrated in the report on counties.

[illegible]

Conclusions

From the inventories and responses to the interviews, it is concluded that the cities, counties, and regional agencies in the Bay region are very familiar with, have made frequent use of, and will continue to use SFBRS products for a wide range of planning activities. The cities exhibited a remarkably high degree of familiarity and a high-incidence of use considering that the products were designed to provide information for regional planning at a regional scale;and considering that 30 of the 91 cities had populations less than 10,000, 18 had no planning staff, only 23 were on the mailing list, and few had staffs with any training or experience in either earth science or engineering. The findings, conclusions, and suggestions relating to products, their use, and their problems were confirmed by a national management consulting firm--A. D. Little, Inc. (1975).

Suggestions

Several suggestions to ensure more effective use of earth-science information were developed by the author based upon the inventories and interview responses. The suggestions directed to producers of earth-science information include (1) monitoring and analyzing emerging critical issues and the enactment of state and federal laws and regulations so that USGS and its scientists, engineers, and planners can better anticipate and respond to local government needs, (2) creating a users advisory committee composed of selected existing and potential local, regional, state, federal, conservation, and corporate users prior to detailed program design, data collection, and data analysis, (3) making a greater effort to provide engineering interpretations and land- and water-use capability ratings, (4) studying those areas which are, or will be, impacted by development so as to husband limited scientific, engineering, and planning staffs, (5) making an effort to provide earth-science information at those scales and level of detail commonly used by local and regional governments, (6) releasing the earth-science information needed to address critical issues early through verbal briefings, seminars, map-type interpretive inventory reports, open-file reports, and publications and reports of cooperating agencies, and (7) providing educational, advisory, and review services along with any new earth-science data collection and analysis program designed for planners and decisionmakers (Kockelman, May, 1976).

Selected Applications

Three applications to county planning activities have been selected for discussion and illustration -- a seismic safety plan, a geologic hazards map ordinance, and a public information activity.*

Plan

A Seismic Safety Plan was prepared by the Santa Clara County Planning Department (1975) in compliance with California State legislation that requires all city and county planning agencies to prepare, and all their governing bodies to adopt, a general plan for the physical development of the city or county. The State Legislature further requires that the general plan include a "seismic safety element" consisting of identification and appraisal of seismic hazards.

The plan was unanimously adopted by the County Planning Commission and Board of Supervisors, and has been implemented by the adoption of an amendment to the county's subdivision, building, and grading ordinances.

The plan is based upon data published by the USGS and contains over 70 references to USGS, many of which are to SFBRS products. All figures are based upon USGS data. A slope zone map especially prepared for the county at a scale of 1:125,000 by the Topographic Division of the USGS is used in the plan (fig. 5). The plan was prepared with assistance or contributions from the California Division of Mines and Geology, private consultants, and members of the USGS.

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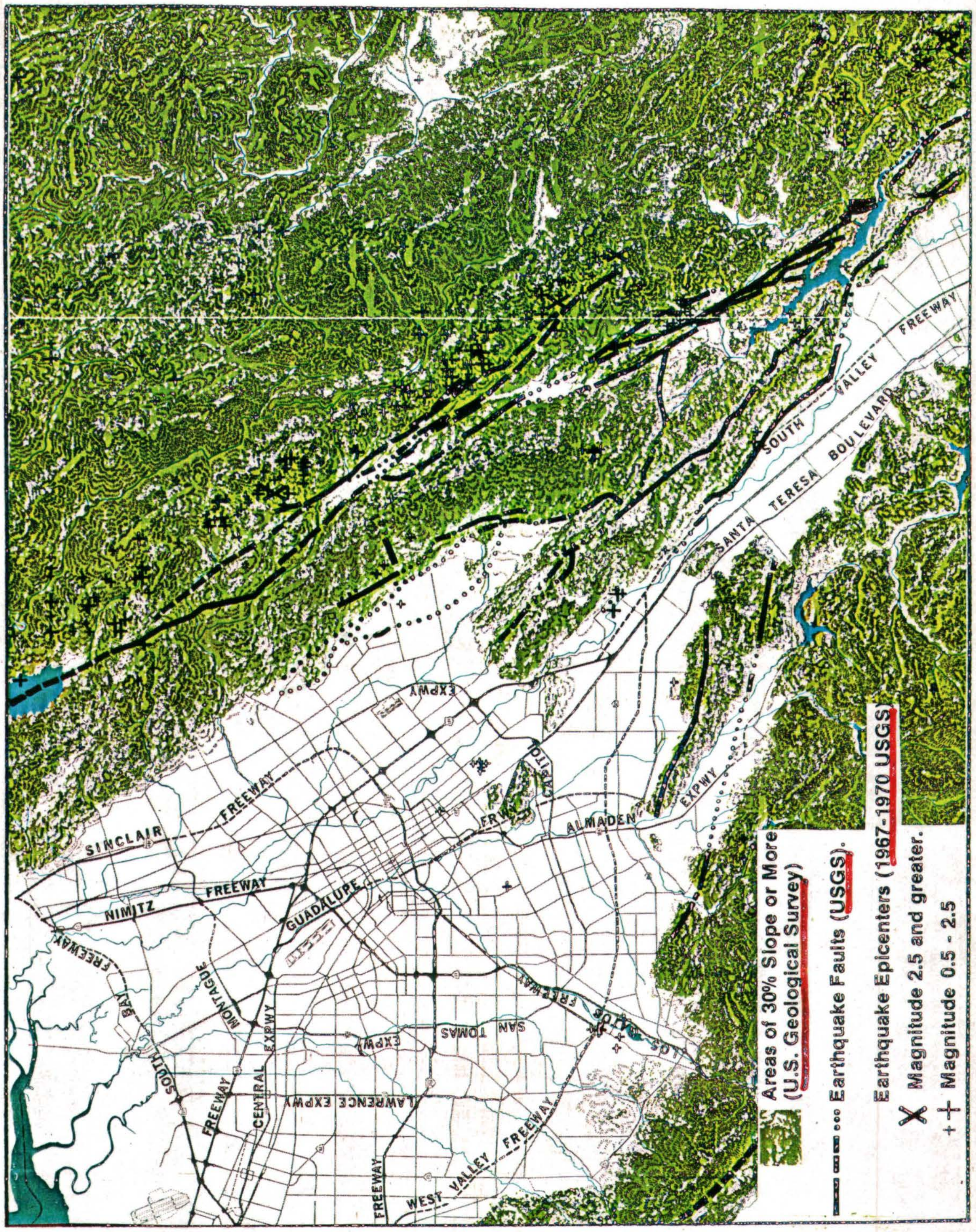
*These applications are taken from the seventeen examples of planning and decisionmaking applications discussed and illustrated in the report on counties (Kockelman, 1976). Another fifteen examples are discussed and illustrated in the report on regional agencies (Kockelman, 1978).

FIGURE 5

Slope and Seismicity



Part of S. C. Co. Seismic Safety Plan (Plan. Dept., 1975)

All the potential earthquake hazards -- namely ground shaking, ground failure, surface displacement, mass movement, tectonic creep, tsunami, dike failure, and seiche -- were composited on a map on which the relative hazards were divided into three zones. The zones are simply indicated in red, yellow, and green colors -- the requirements for geologic investigation varying with the level of hazard (fig. 6). Although the map is at a scale of 1:125,000, a note appears on the map that more detailed maps at a larger scale are available.

The composite-hazards zone map is used as a base map for several other maps upon which utilities, transportation structures, community facilities, and urban development have been overlaid. The visual impact on citizens and decisionmakers of pipelines, canals, power lines, freeways, railroads, bridges, hospitals, fire stations, and urban development laying on the "red" hazard zones is effective (figs. 7 and 8).

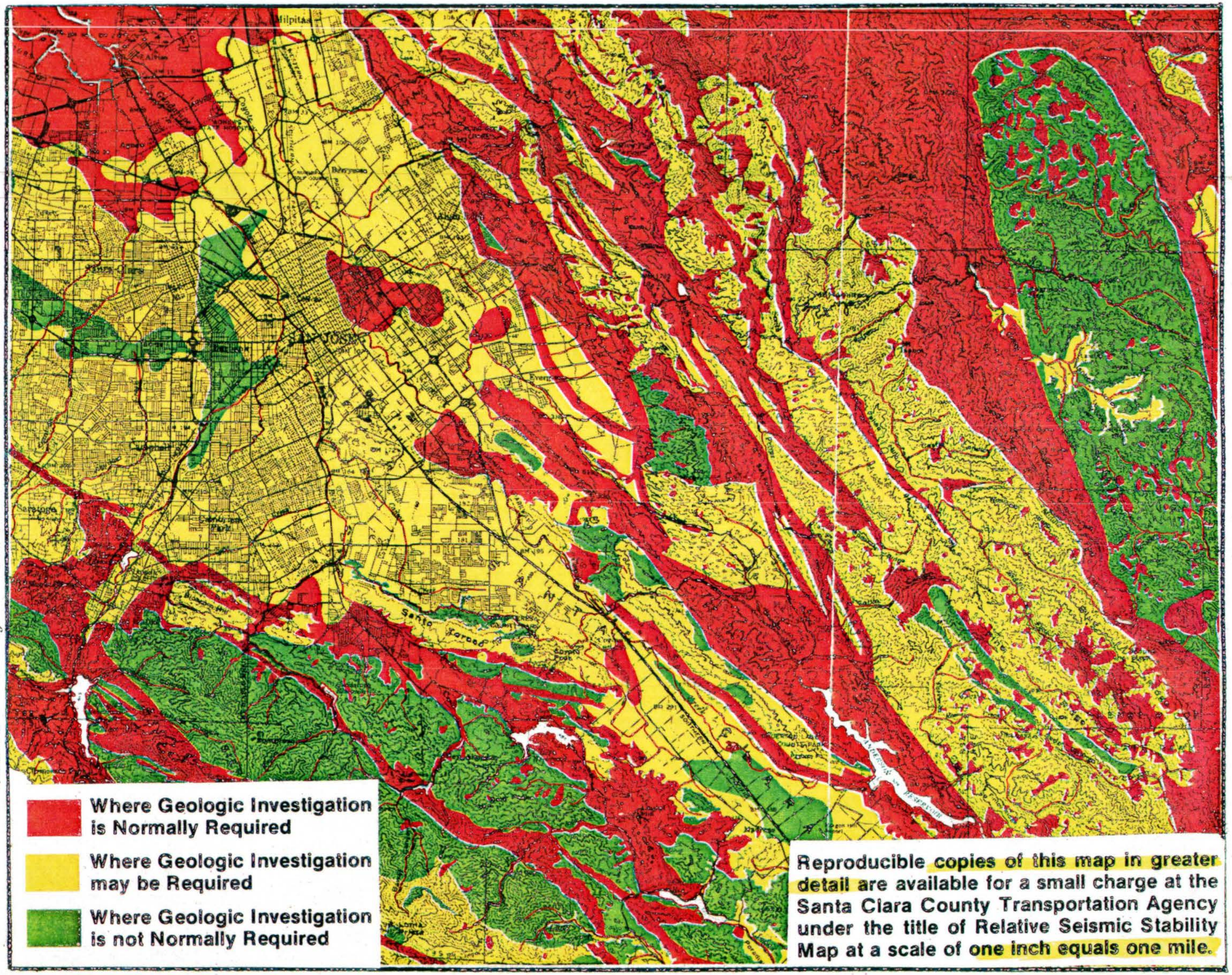
Ordinance

In addition, the Santa Clara County Board of Supervisors (1974) unanimously amended the County Ordinance Code to require site investigations and geologic reports based on the composite-hazards zone map. Four sections of the code were affected; namely, major subdivisions, minor land divisions, building sites, and grading (fig. 9).

The code now requires site investigations and geologic reports based on the proposed land use and the official County composite-hazards zone map. The need for such reports is determined by a designated building

FIGURE 6

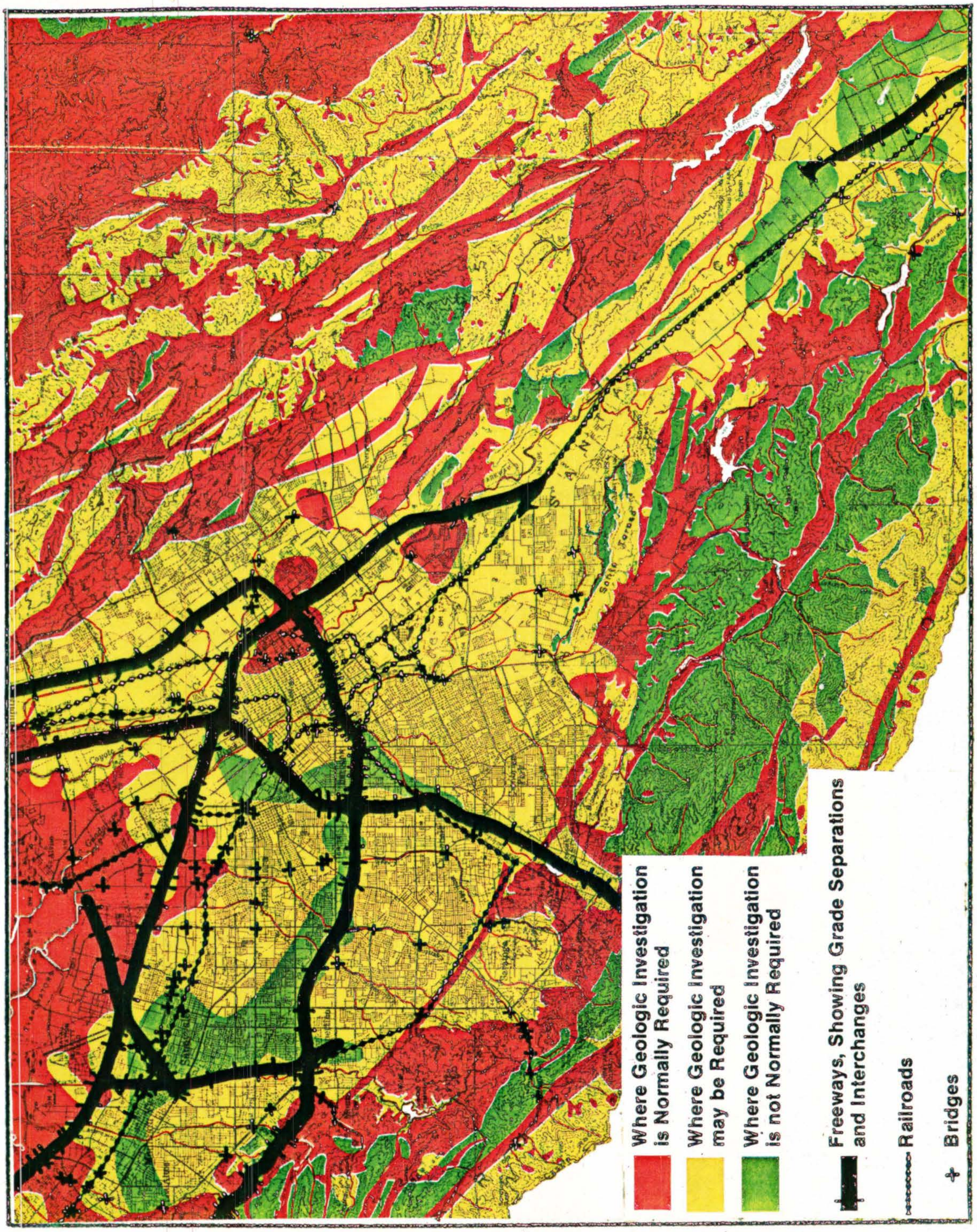
Seismic Safety Zones



Part of S. C. Co. Seismic Safety Plan (Plan. Dept., 1975)

FIGURE 7

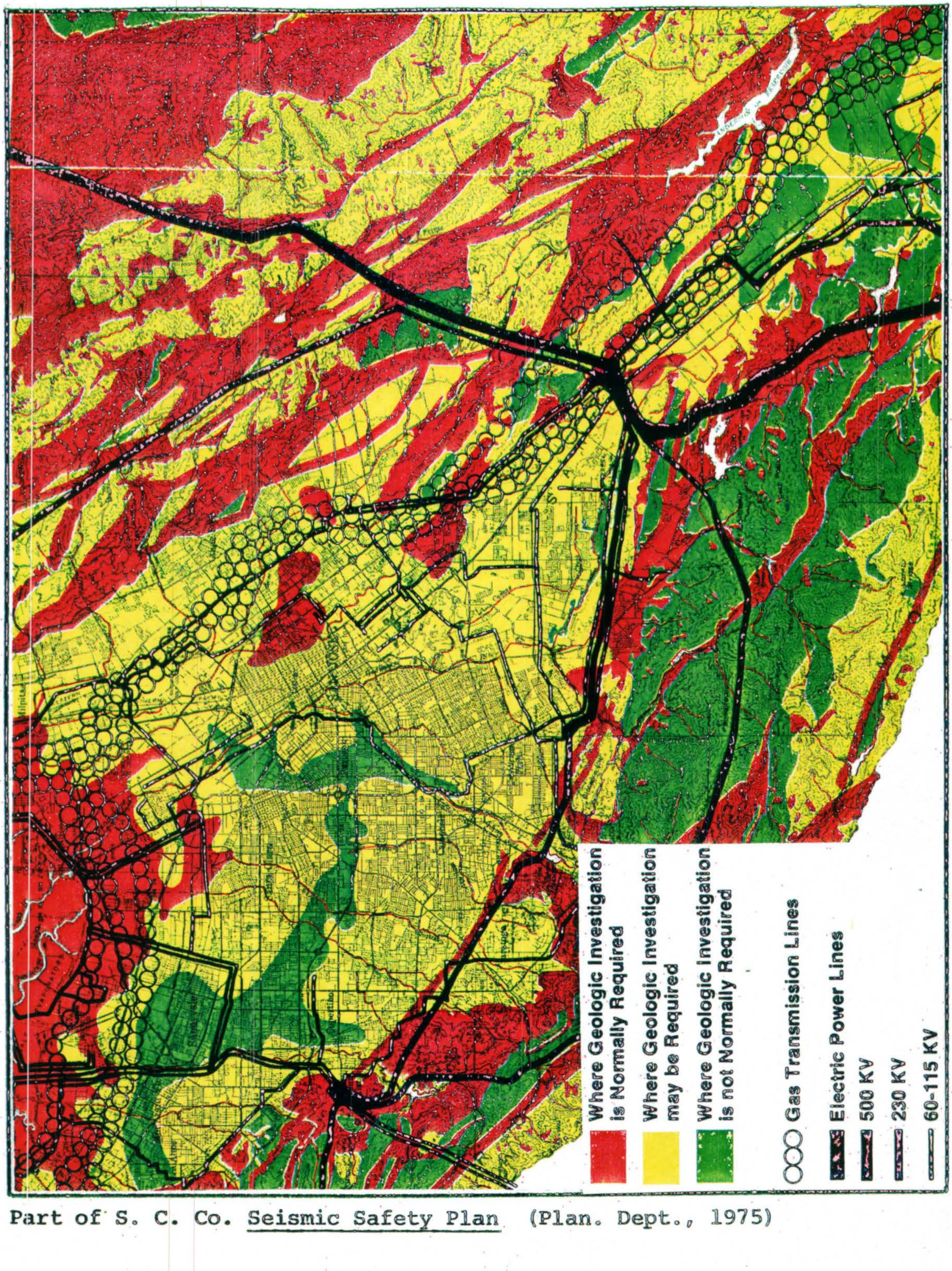
Major Transportation Facilities



Part of S. C. Co. Seismic Safety Plan (Plan. Dept., 1975)

FIGURE 8

Major Gas and Electric Lines



Part of S. C. Co. <u>Seismic Safety Plan</u> (Plan. Dept., 1975)

FIGURE 9

Subdivision, Building, and Grading Ordinances Amendment

The Board of Supervisors of the County of Santa Clara, State of California, do ordain as follows:

SECTION 6: Building Permits.

Section C3-36 of the Santa Clara County Ordinance Code is added to read:

C3-36: Geologic Report.

Section 301(b)7 is amended to read:

Section 301(b) 7. Give such other information as reasonably may be required by the Building Official, such as a geologic report, which shall be necessary where the County determines that such report is needed on the basis of the County hazard maps.

SECTION 7: County Hazard Maps.

Article 3 is added to Chapter IV of the Santa Clara County Ordinance Code to read:

Article 3. County Geologic Hazard Maps.

Section C12-277. Definition. Whenever the land development regulations refer to County hazards maps, the reference is to the official Santa Clara County geologic hazards maps as herein adopted and which may be amended from time to time by resolution of the Board of Supervisors, which maps are the basis for determining whether a geologic report shall be required. The adopted maps are identified as follows:

Map Number and Name	Relative Geologic Stability Code (See Notes Below) Red	Yellow	Green
1. Alquist-Priolo Geologic Hazards Zones (State of California - Special Studies Zones Official Map)	Entire Zone		
2. Relative Geologic Stability of Santa Cruz Mountains	Category,W,S earthquake shear zones	P,L,H	D
7. U.S. Geological Survey Maps for San Francisco Bay Region Environment and Resource Planning Study (HUD)	Evaluate each map as applicable		

a. Basic Data Contribution 2 - Geologic Map of Palo Alto 7.5 Minute Quadrangle San Mateo and Santa Clara Counties, California, by E.H. Pampeyan 1970

b. Basic Data Contribution 6 - Preliminary Geologic Map of the Central Santa Cruz Mountains, California, compiled by Earl E. Brabb 1970

c. Basic Data Contribution 7 - Faults That Are Historically Active or That Show Evidence of Geologically Young Surface Displacement, San Francisco Bay Region, A Progress Report: October 1970, by Robert D. Brown, Jr.

d. Basic Data Contribution 9 - Preliminary Map of Historic Margins of Marshland, San Francisco Bay, California, compiled by Donald R. Nichols and Nancy A. Wright 1971

e. Basic Data Contribution 30 - Active Faults and Preliminary Earthquake Epicenters (1969-1970) in the Southern Part of the San Francisco Bay Region (Miscellaneous Field Studies Map MF-307) by R. D. Brown, Jr. and W.H.K. Lee 1971

f. Basic Data Contribution 13 - Geologic Map of the Sargent Fault Zone in the Vicinity of Mount Madonna, Santa Clara County, California, by Robert J. McLaughlin 1971

g. Basic Data Contribution 39 - Preliminary Geologic Map of the Franciscan Rocks in the Central Part of the Diablo Range, Santa Clara and Alameda Counties, California, by William R. Cotton 1972

h. Basic Data Contribution 40 - Preliminary Photointerpretation Map of Landslide and Other Surficial Deposits of the Mt. Hamilton Quadrangle and Parts of the Mt. Boardman and San Jose Quadrangles, Alameda and Santa Clara Counties, California (Miscellaneous Field Studies Map MF-339) by Tor H. Nilsen 1972

i. Basic Data Contribution 45 - Preliminary Photointerpretation and Damage Maps of Landslide and Other Surficial Deposits in Northeastern San Jose, Santa Clara County, California (Miscellaneous Field Studies Map MF-361) by Tor H. Nilsen and Earl E. Brabb 1972

k. Basic Data Contribution 63 - Isopleth Map of Landslide Deposits, Southern San Francisco Bay Region, California (Miscellaneous Field Studies Map MF-550) by Robert H. Wright and Tor H. Nilsen 1974

NOTES:

1. Official hazard maps are on file with Santa Clara County.
2. Color Legend for Relative Geologic Stability:
   - Red: A Geologic Report is normally required.
   - Yellow: A Geologic Report may be required.
   - Green: A Geologic Report is not normally required.
3. For statutory construction of the maps, a general provision is controlled by a specific provision, more detailed maps over general, and later maps over earlier maps.

PASSED AND ADOPTED by the Board of Supervisors of the County of Santa Clara, State of California, on November 6, 1974, by the following vote:

AYES:	Supervisors	5
NOES:	Supervisors	0
ABSENT:	Supervisors	0

Part of S. C. Co. Ordinance No. NS 1203.31 (Bd. of Supv., 1974)

official on the basis of the hazards maps. The code further requires that the report shall (1) be prepared by an engineering geologist registered in the State, (2) be submitted to the county for approval, and (3) specify the remedial measures that will make a safe development.

The seismic safety plan and code are significant for the following reasons:

1. The county is one of the largest in the Bay region and has the fastest growing population.
2. It is a relatively undeveloped county, and the most hazardous areas are comparatively undeveloped.
3. Most of the geologic hazards have been identified, mapped, composited, and placed in hazard zones which require varying levels of geologic investigations.
4. The composite-hazards zones map has been unanimously adopted as the official "County Geologic Hazards" map in the county's subdivision, building, and grading ordinances.
5. The county has a state certified engineering geologist in its Land Development Engineering Department who participated in the development of the plan and the ordinances, and who has major responsibility for their day-to-day administration.

Public Information

Maps showing various geologic and hydrologic hazards were prepared for public information by the Santa Clara County Planning Department (1973). These maps are based upon SFBRS products covering active faults, historic marshlands, slope zones, and flood-prone areas.

The geologic and hydrologic hazard data shown on figures 10 and 11 at a scale of 1:250,000 are merely collected and composited on a base map, attractively presented in color, and widely distributed as a pass-out to the general public.

The preparation and distribution of these hazard maps took place prior to the preparation and adoption of the county's seismic safety plan and ordinances' amendment previously discussed. The wide distribution to, and early familiarization of, the general public with geologic hazards is partly the reason for the unanimous adoption of the seismic safety plan and ordinances' amendment used to implement the plan.

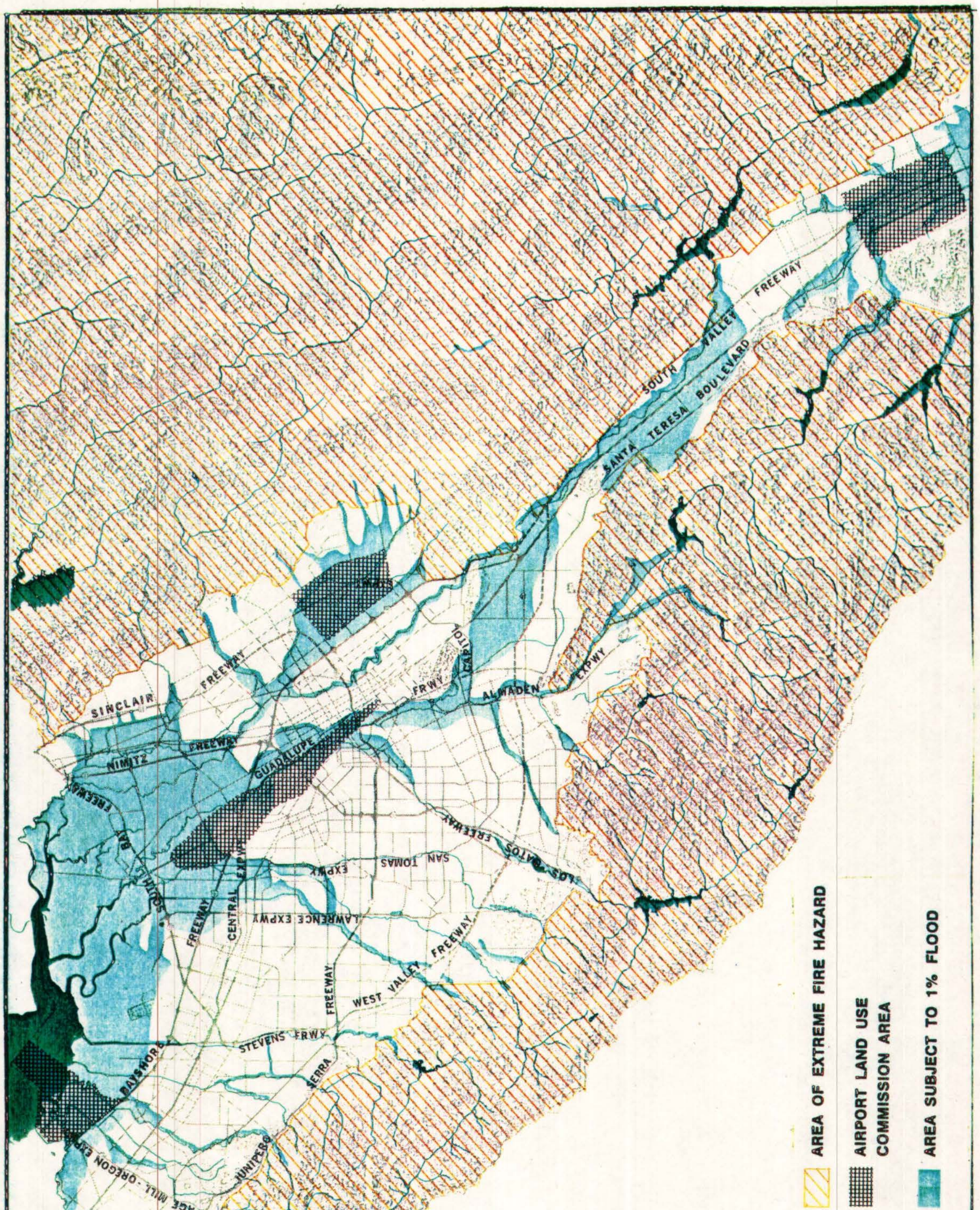
FIGURE 10

Geologic Hazard Map for Public Information

Part of S. C. Co. "Public Safety Map No. 1" (Plan. Dept., 1973)

FIGURE 11

Hydrologic Hazard Map for Public Information



Part of S. C. Co. "Public Safety Map No. 2" (Plan. Dept., 1973)

Concluding Remarks

Earth-science products should be of an interpretive type,for example, estimated recurrence interval for geologic and hydrologic hazards; location, extent and quality of energy, mineral, and water resources; and geologic unit capabilities for selected land uses. Ideally, the products should be designed for one common user group,for example, intelligent and interested citizens, thereby meeting almost all user-needs as to content, scale, and detail and having a common basis for discussion and agreement during public hearings. If the products are designed for this one common-user group, it is not necessary to select target users and user groups.

In a democratic community, the support needed by planners and decisionmakers to take actions in the best long-range interests of the people requires understanding by the people. This understanding necessitates that earth-science products be designed for the interested, intelligent citizen, not for some "intermediate supplier" or "transfer agent" who will make subsequent interpretations.

This approach would free all -- the scientist, planner, and decisionmaker from making their own varied and individualized interpretation. Such interpretations lack credibility when made hurriedly, incompetently, or addressed to only one issue.

The scientist would be free to continue his scientific work, returning to the community only when his work is questioned by other scientists; the planner would be free to do his presentation and application work; and the decisionmaker, his negotiating work between various interest groups in the community. All three would be able to refer to the same product -- already interpreted for the common user, namely, the interested intelligent citizen.

SELECTED REFERENCES

Kockelman, W. J., 1975, Use of USGS earth-science products by city planning agencies in the San Francisco Bay region, California: U.S. Geological Survey Open-File Report 75-276, 110 p.

_____1976, Use of USGS earth-science products by county planning agencies in the San Francisco Bay region, California: U.S. Geological Survey Open-File Report 76-547, 186 p.

_____May 1976, Educational, advisory, and review services: U.S. Geological Survey Administrative Report, 25 p. (unpublished).

_____1978, Use of USGS earth-sciences products by selected regional agencies in the San Francisco Bay region, California: U.S. Geological Survey Open-File Report 78-_____, ____ p. (in process).

Little, Arthur D., Inc., 1975, An evaluation of the San Francisco Bay region environment and resources planning study: Report to the U.S. Department of Housing and Urban Development, Office of Policy Development and Research, 93 p.

Santa Clara County Board of Supervisors, 1974, Ordinance No. NS 1203.31, adopted November 6, 1974, amending the subdivision, building, and grading ordinances and adding geologic hazard maps to the County Ordinance Code: San Jose, CA, 11 p.

Santa Clara County Planning Department, 1973, Public safety maps: San Jose, CA.

_____1975, Seismic safety plan, An element of the general plan: San Jose, CA, 119 p.

U.S. Geological Survey, San Francisco Bay Region Environment and Resources Planning Study, 1974, Plan for completion of study and program design for fiscal years 1974-1975: unpublished, Menlo Park, CA, 22 p.

U.S. Geological Survey and U.S. Department of Housing and Urgan Development, 1971, Program design 1971: San Francisco Bay Region Environment and Resources Planning Study, Menlo Park, CA, October 1971, 123 p.

ABAG'S Use of Research Products

Developed in the San Francisco Bay Region Study

in Regional Planning

by

Jeanne Perkins

Regional Planner

Association of Bay Area Governments

ABAG participated in the San Francisco Bay Region Study (SFBRS) and provided a liaison with county and local governments from the Study's beginning in January 1970. Because of that early and continuing involvement, ABAG has been able to use SFBRS and other USGS products successfully in several planning programs, including its Earthquake Preparedness Program.

THE INFORMATION PRODUCER/USER COMMUNITY

The Agency

ABAG is a regional comprehensive planning agency that is owned and operated by the local governments of the San Francisco Bay Area. It was established in 1961 to meet regional problems through the cooperative action of its member cities and counties.

ABAG may receive special funding for specific projects. This money is used indirectly to establish new programs and to develop regional policies that can be implemented using ABAG's three main planning and coordinating functions:

1. Plan and Project Review - As the designated areawide clearinghouse, ABAG reviews local plans and projects that propose to use Federal and State funds.

2. Services to Local Government - ABAG assists local government in obtaining information and developing local programs.

3. Advocacy - As an advocate for regional concerns at the State and Federal level, ABAG works to have the region's policies implemented through such means as suggesting new legislation and taking positions or commenting on proposed legislation and regulations.

<u>A History of Recent Information Uses--Why, Where and How</u>

In January 1976 ABAG, under a contract with USGS, completed a report, <u>Land Capability Analysis: A Method of Applying Earth Science Information to Planning and Decision Making</u>. Thus, one major motivation for using USGS products in this instance was that ABAG was being paid to do so! In addition, the USGS information covered our entire nine county planning area while other sources of similar data covered only a part of the region. The quality of USGS information was excellent, as well.

The objective of the project was to develop a method of combining several maps, each representing an individual geologic hazard or resource, into a single map useful to planners and decision makers. The method developed used information on costs of geologic studies and mitigation, resource loss, and risk of damage to weight the degree of concern for each hazard or resource; then the costs associated with each were added to obtain a single map representing the overall level of earth science concern or land capability. The project provided ABAG with an excellent opportunity to develop a more effective Environmental Safety and Resource Management Program by:

- o helping local governments in the Bay Area use USGS information,
- o using earth science information more consistently in ABAG's plan and project review work, and
- o providing a viable way of using earth science information in other ABAG programs.

Ultimate agency policy and program direction lies with our local member governments. ABAG's General Assembly is composed of an elected official from each of the 96 member cities and counties in the Bay Area; it meets at least once a year. A small grant from the National Science Foundation allowed ABAG to provide expert speakers and information on earthquakes at the General Assembly in February 1976. Local government representatives passed a resolution at that meeting that provided the political rationale and support for ABAG's newly emerging Earthquake Program. That program, together with the continuing ability to perform land capability analyses, have become the driving force behind our use of earth science information.

The major objective of the Earthquake Program is to assist ABAG's member governments in minimizing the loss of life and property damage and in averting the economic and social instability that could result from a major earthquake. These strategies are the same plan implementation tools mentioned earlier and are similar to ABAG's strategies for integrating the land capability analysis project into an ongoing ABAG program.

ABAG's services to local governments consist of referring local staff to the appropriate agency and person to get the information they need, helping them use ABAG's reports, such as the one on land capability analysis, and helping them revise their seismic safety and safety programs. The program has also offered assistance to other ABAG programs. A recent product of the program, consisted of a set of maps and an explanatory report, Earthquake Intensity and Expected Cost in the San Francisco Bay Area. The project used ABAG's computer-based mapping system to expand the USGS method of predicting maximum earthquake intensity from the southern Bay Area to the entire region. This intensity map and other USGS information have helped in:

- o locating general areas for further study as potential Class I disposal sites for hazardous wastes,
- o mapping potential industrial sites in a study requested by the California Governor's Office of Planning and Research,
- o updating of ABAG's Regional Plan, and

- o assessing impacts in a planning study for the Santa Clara Valley that ABAG is performing in conjunction with the regional transportation planning agency for the Bay Area.

The Actors

Throughout this process of integrating earth science information into regional planning, Federal agencies, such as USGS, DCPA, EPA, NSF, and HUD have provided funding for various projects and programs. USGS, SCS, and HUD/FIA also provided extensive earth science information. This information was supplemented by additional information from the California Division of Mines and Geology.

As mentioned earlier, ABAG's General Assembly served as a catalyst for action. In addition, special review committees composed of interested individuals and groups advise ABAG staff. For example, the policies developed for ABAG's earthquake program were reviewed and modified by an ad hoc Technical Advisory Committee with representatives from the following groups:

Bay Conservation and Development Commission
Radio Amateurs
Local Citizens Groups
U.S. Geological Survey
Local Elected Officials
Associated Building Industry of Northern California
Structural Engineers Association of Northern California

California Seismic Safety Commission

Association of Engineering Geologists

California Office of Emergency Services

By involving a mixture of people, ABAG has improved the quality of the strategies for implementing the earthquake program and enhanced the legitimacy of the final product.

Communication Obstacles and Some Strategies for Solving Them

The main obstacles to use of earthquake information are not related to the lack of that information, but to misconceptions that the information is expensive, slow and difficult to collect, as well as impossible to understand.

The money problem is most easily handled by offering services "free" when the information would be valuable. This tactic is used by the Earthquake Preparedness Program when offering services to ABAG's member local governments and when introducing to other ABAG programs the idea of incorporating earthquake information. The earthquake information hopefully will expand the capabilities of the program's next user. This informal system also aids in bookkeeping and administration. If the service of providing this information was charged to each program in which it was used, too much time would be spent filling out time sheets!

The greatest ease in obtaining the information has been achieved through building the analysis methods and mappable information into

ABAG's computer-based data management system. This system has been named BASIS, for Bay Area Spatial Information System. If the data are available alongside information that is commonly used by planners, such as census data, they can perceive that access to the earth science information will be simple. When they might have incorporated only one earth science factor, such as faults, into their analysis, they now have access to information on faulting, ground shaking, landsliding and flooding.

The problem of understanding data can be oversimplified by talking of strategies such as education and translation. Although these strategies are valid, the problem is more complicated. Continuity in an information communication system is especially valuable. At ABAG continuity has been established by incorporating the projects into an overall program. Information is not used once and then discarded. Education does not occur overnight. The slowness with which information is incorporated also calls for considerable patience on the part of the people doing the communicating, educating, or translating.

Communication System Components

Thus, ABAG's use of earth science information occurs at several levels and in several forms. It involves data management, projects, programs and plan implementation (Figure 1).

EVALUATION OF INFORMATION COMMUNICATION ACTIVITIES

Information Requirements

The requirements for information and the objectives for using that information within ABAG depend greatly on whether the information is needed for a special project or an ongoing agency program. Each project requires specific information and requires that the information be analyzed differently. Our experience with several projects in the past couple of years, has made at least two data requirements apparent:

1. Data, whether in the form of maps or statistical information, need to be uniform in coverage. It is important to know that the reason one county has more mapped landslides than another is because it has more slides, not because two people did the mapping for two slightly different purposes. ABAG has combined the two worst categories of USGS slope stability because the occurrence of the worst category varies in rectangular patterns depending on the person mapping.

2. The data must cover the entire planning area. We use Soil Conservation Service data on erosion, even though the USGS data would be better, because we do not have erosion maps for all nine counties. We are working with a 1975 USGS map of flood-prone areas instead of the more accurate and recent HUD flood insurance maps because some unincorporated portions of our region have not yet been mapped for the National Flood Insurance Program.

Two-Way Communication

ABAG has been reasonably successful in achieving two-way communication with USGS. Our involvement with the San Francisco Bay Region Study and our work on the USGS-funded Land Capability Study have given us invaluable contacts that we call to get needed information. We have maintained these USGS contacts easily through frequent calls for a various types of information.

Information Centers

The Earthquake Preparedness Program has become the central focus of both the agency's and our member governments' formal access to all earth science information, mainly as a result of the program's visibility:

- The State legislation requires local governments to prepare seismic safety elements.

- The Federal government has made money available for earthquake programs.

Local governments and managers of other ABAG programs seeking earthquake information first approach earthquake program staff. On at least two occasions, I have convinced them also to deal with flooding, slope stability and other geologic and hydrologic hazards and constraints.

Media

Except for the February 1976 General Assembly workshop on earthquakes, our Earthquake Program has not made use of high visibility media such as television and radio. An ABAG newsletter, published 10 times a year, is mailed to several thousand people, including elected officials, local government staff, special interest groups, and interested citizens. Articles have been included on specific products of both our Earthquake Preparedness and our Safety Programs. In addition, ABAG has many mailing lists for specific interest groups so that copies of these products are automatically mailed to the appropriate groups.

Communication Channels

Standard communication channels usually have been used within ABAG, in our service function to ABAG's member local governments, and with Federal and State agencies. Institutionalizing the communication of information into ABAG's normal program structure has given me the opportunity to use many services available at ABAG.

Translators

Because of my background in geology, my role in a planning agency is to facilitate use of earth science information. I often view myself more as a proponent for using earthquake and other earth science information than as a translator. I am the person that uses and disseminates earth science information for both the earthquake and safety programs. But I also deal with many other programs and projects in the agency, encouraging the program managers to use the information which the Earthquake and Safety programs can provide. Before you interpret information you need to convince potential users that their programs will benefit.

Many times USGS has been criticized for supplying information that cannot be used directly by local governments because it requires translation. Occasionally this criticism is valid, but more frequently the data is not used because there is no staff lobbyist to convince the others of its usefulness.

Information Timing

The State of California passed a law requiring that by September 1974 each city and county in the State had to have Seismic Safety and Safety Elements in its General Plan. The requirement led to considerable interest on the part of many local governments in data from the San Francisco Bay Region Study. Two factors have led to frustration: not having complete regional coverage for all products and not having most of the later products available. Fortunately, ABAG's uses of USGS data have not been to fulfill that requirement; therefore, we have had more flexibility in waiting for the data we need and in molding our needs around currently available information. In addition, USGS has been helpful in providing us with information that has been completed but has not been published.

Direct Usefulness of Information

Some of the information used by ABAG was of direct use, other information had to be modified before it could be used, and some data will probably never be used.

For our purposes, the information that has been of greatest use has been that which has regional coverage. The relative slope stability maps, the geology maps, the map of flood-prone areas, the isohyetal map of average annual precipitation, and the map of expected well yield fall into this category.

The information needing modification in some way usually must be expanded to cover the entire region. The map of maximum expected earthquake intensity falls into this category. Other maps still need to be completed, including the erosion maps.

Some data will probably never be used because the methods are outdated, such as some early slope stability maps. Other data does not relate to current planning issues.

Communication Monitoring

ABAG has never initiated the monitoring of the communication of USGS information. However, several ABAG staff, along with staff of other regional agencies, cities, and counties have been interviewed by Bill Kockelman of USGS.

Strengths and Weaknesses of the Communication Process

From ABAG's perspective, the main strength of USGS's communication of information to ABAG has been the cooperation of all USGS staff that have been contacted. ABAG staff also have been asked to comment on many USGS reports prior to publication. Some of the weaknesses include the great delay between the report are preparation and publication. The slope stability and the land capability analysis reports, both completed over two years ago, have yet to be published.

Although ABAG staff has been able to use these draft reports in the interim, the delay decreases the legitimacy of ABAG products based on these reports. These findings are not based on a sophisticated survey, but on my perception of the communication process.

<u>Some Lessons</u>

1. An outside motivation, such as California's requirement for Seismic Safety and Safety Elements, is needed.

2. A staff translator, or lobbyist, with much patience is needed.

3. Services need to be provided inexpensively.

4. The provision of information needs to have continuity, perhaps through the structure of an ongoing program.

5. The information provided needs to be uniform in coverage and apply to the entire planning area.

6. Access to USGS staff to answer questions and provide support is needed.

<u>Help for Decision Makers</u>

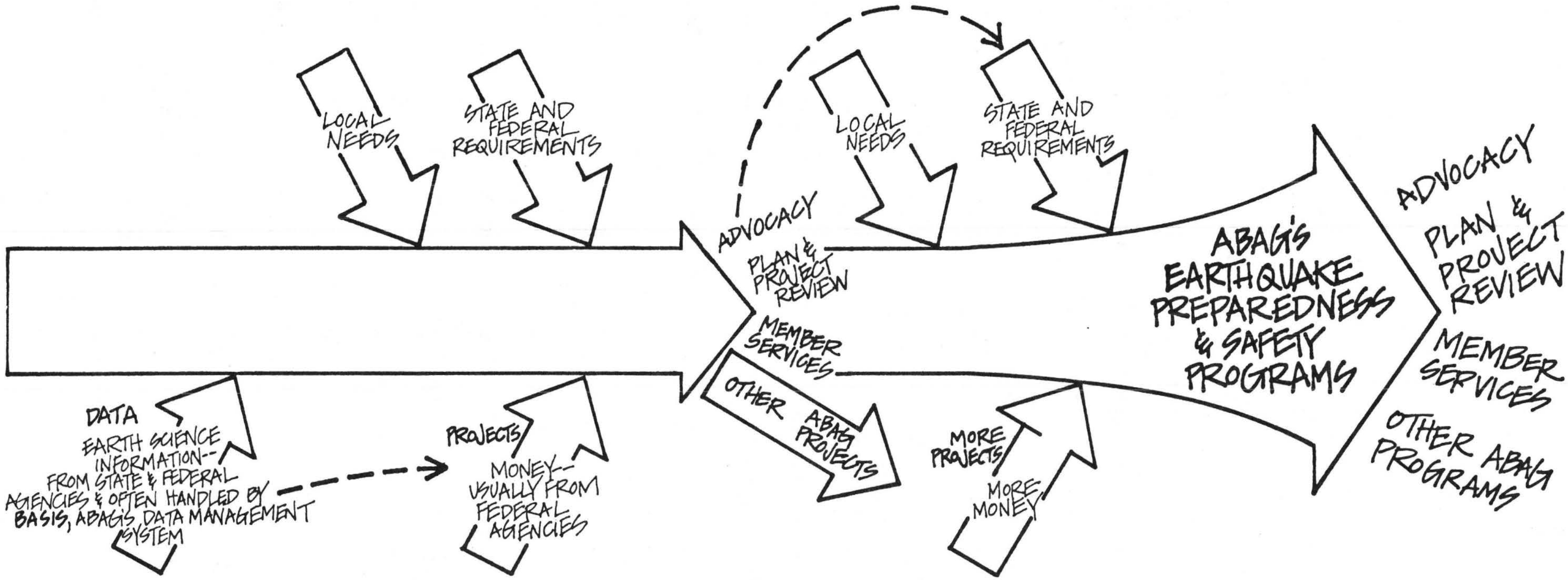
The information that ABAG uses and provides is handled on a staff-to-staff basis. Usually only the results of analyses are provided to local elected officials. We provide information on impacts; the elected officials compare the impacts of physical hazards and those of other concerns and make the decisions.

Legislation

ABAG cannot trace its actions directly to State and Federal legislation. However, through our advocacy, we have supported the Cranston Earthquake Hazard Reduction bill and several State bills related to geologic concerns.

FIGURE 1

ABAG'S USE OF EARTH SCIENCE INFORMATION OVER TIME



ACHIEVING LANDSLIDE HAZARD REDUCTION

Robert W. Fleming
U.S. Geological Survey
Denver, Colorado

INTRODUCTION

Landslides include a variety of types of downslope movement of earth materials such as falling, toppling, flowing, spreading, and sliding. On a regional basis, the susceptibility of areas to landsliding varies with material types and properties, physical configuration of the slope, climatic factors, and triggering agents including unusual storms, earthquakes, and activities of humans.

The variety of types of movements and the factors responsible for the movement would seem to make the technical problem of landslide hazard reduction inordinately complex; but this is not so. Leighton (1976) has estimated that, in California, a reduction in damaging failures of 95 to 99 percent is technically attainable through the use of three levels of investigation. The three levels are regional, tract or community, and site, with progressively greater detail obtained in the investigations of the smaller areas. However, the solutions to the technical problems are only a part of the process of achieving landslide hazard reduction. The implementation of information into a governmental system to reduce hazards and damages is perhaps a more formidable problem than the technical one. Implementation of technology is subject to a range of pressures from groups that dislike regulation or interference to those that do not consider landslides amenable to loss-reduction measures or do not consider landslides a serious enough economic problem to justify the effort required to make a program work. The inevitable discussion and debate over the implementation of landslide hazard reduction technology assures that the measures are indeed in the best interests of the public.

SCOPE OF THE PROBLEM

Landslides are widespread throughout the United States. In a recent survey of the distribution of landslide problems in the 48 conterminous United States, Radbruch-Hall and others (1976) found significant problems in every state except Rhode Island. The landslide problems on Hawaii, Alaska, and Puerto Rico are well known.

Information on the cost of damages resulting from landsliding in the United States is widely scattered and difficult to obtain. In a study of the direct losses caused by landsliding in 1969 in the nine-county area of the San Francisco Bay Region, Taylor and Brabb (1972) documented more than $25 million in losses. Taylor reexamined the data and discovered several additional sources of information that led him to conclude that the actual damages in the area in 1969 were probably about $50 million (Taylor, oral commun., 1976). Schuster (in press) made a national survey of landslide damages and concluded that direct and indirect losses from landsliding in the United States average in excess of $1 billion annually.

LANDSLIDE HAZARD REDUCTION BY LOCAL GOVERNMENT

Several communities in the United States are making a concerted effort to reduce damages and the risk of damages by landsliding. Of these communities, only the experience of Los Angeles, California, has spanned enough time and been documented well enough to evaluate the effectiveness of a hazard reduction program. Cincinnati, Ohio, has adopted regulations governing cuts and fills that is patterned after the Grading Regulations of Los Angeles. An attempt to reduce hazards is also being made, but in a different way, in the Greater Pittsburgh Area, Pennsylvania. The programs in Los Angeles and

Cincinnati rely heavily on regulation of grading while the approach in Pittsburgh is characterized by an absence of regulation. Each of these programs is described to show how it is intended to function.

Cincinnati, Ohio

The Cincinnati, Ohio, area has a long history of landslide problems. Damages in recent years have averaged several million dollars per year. The City of Cincinnati has initiated a program of landslide hazard reduction built around an ordinance regulating cutting and filling of hillside property. Work on the ordinance was started by the City in 1967, and a draft ordinance was completed in 1973 (Krusling, 1975). The ordinance was prepared at the request of City officials by a task force of the Engineering Society of Cincinnati. Members of the task force included geologists and engineers from local government, private industry, and the University of Cincinnati. The ordinance is based on Chapter 70 of the Uniform Building Code, a product of the Building Codes Committee of the Association of Engineering Geologists resulting from field experience with grading regulations for the City of Los Angeles. The ordinance was modified slightly during debate and adopted by City Council; It was amended to overcome some objections, largely by homebuilders, in 1975 (Krusling, 1975). The ordinance is now in effect and being enforced. Areas that are most susceptible to slope problems have been at least crudely identified, and the stage is set for effective reduction in losses. Unfortunately, an appraisal of the effectiveness of the program must await the next rash of landslide activity to compare the performance of hillsides developed before and after the ordinance.

Los Angeles, California

The best example of the success of a landslide hazard reduction program in the United States is that enacted by the City of Los Angeles. In an unprecedented series of activities that required coordination and cooperation among geologists and engineers working closely with city agencies and elected officials, Los Angeles responded to citizen pressure for protective regulations for the development of hillside land. Development of the basic program spanned the period 1952 to 1963. Since 1963, the program has been reevaluated and modified several times. Portions of the history of the Los Angeles program to reduce landslide damages are summarized below.

The winter of 1951-1952 produced more than 26 inches (66 cm) of rainfall in downtown Los Angeles compared to an average of 10 inches (25 cm) during the preceding 7 years. One severe storm during January 1952, produced 7.5 inches (19 cm) of moisture. A great deal of grading and construction had been done during the post-WW II period, with little or no regulation of the process. The result was the creation of many high, steep cuts and large, poorly compacted fills. The resultant erosion, sedimentation, and landslides caused property damage estimated at $7.5 million (Jahns, 1969).

According to a published account, "the citizens of Los Angeles, in conjunction with the grading industry and professional people in private industry and city government wrote a grading ordinance which was adopted into law on October 17, 1952" (Mayor's Ad Hoc Landslide Committee, 1967, p. 44). This ordinance was based on state-of-the-art practices for large grading projects such as earthen dams and required the expertise of soils engineering and "very limited geology" (Slosson, 1969, p. 9).

The first real test of the new ordinance occurred in 1956 when, although the total rainfall for the season barely exceeded the long-term average, about 8 inches (20 cm) of rain fell during a 36-hour period. The resulting massive erosion led to a change in the ordinance that required compaction of the sloping surface of fills. At the same time, in response to special landslide problems, the City required geologic reports before issuing certain grading permits. This requirement was made even though there were no geologists on the staff of the Department of Building and Safety, which was charged with administering the regulations.

Another event in 1956 undoubtedly affected the course of future programs to reduce landslide damages. In the Portuguese Bend area of Los Angeles County, a large, old landslide was reactivated, causing damage or destruction to more than 150 private residences and associated roads and utilities. Prior to this event, limited insurance coverage was available for landslide damages. However, immediately following the Portuguese Bend Landslide, landslide insurance was all but discontinued (Yelverton, p. 15, 1973; Hayes, p. 17, 1974). Also, in the aftermath of the Portuguese Bend Landslide, the concept that many destructive geologic processes are Acts of God was questioned and tested in the courts. In succeeding years, the courts have gradually come to the position of applying the concept of strict liability to developers, engineers, and geologists. This concept holds that, in the interest of public welfare, a manufacturer or in this case a developer, grading contractor, engineer, or geologist is strictly liable for defects in products, workmanship, or professional advice.

The next test of the hillside Grading Regulations of the City of Los Angeles came during the winter of 1957-1958. More than 21 inches (53 cm) of rain, nearly 50 percent above normal, fell in the City, causing considerable landslide damage. The Grading Regulations were modified slightly to accommodate some special stability problems within one geologic formation.

At about the same time, the Department of Building and Safety of the City of Los Angeles established an Engineering Geologists Qualification Board to evaluate and certify the training and experience of the engineering geologists wishing to practice their profession in the hillside areas of Los Angeles. This action provided a measure of quality control over the technical community associated with hillside grading. Two years later, the Qualification Board prepared a general guide and checklist of the desired contents of geological reports submitted to the City.

The winter of 1961-1962 provided yet another test of the effectiveness of the Grading Regulations. Total rainfall for the season was 18.8 inches (48 cm), only a few inches above the long-term average. However, one storm in February 1962 produced about 8 inches (20 cm) of rain. Even though 40,000 new homes had been constructed since enactment of the Grading Regulations and this storm caused less damage than the storms of a decade earlier, deficiencies in existing regulations became apparent (Jahns, 1969). Groups were organized to rewrite the Grading Regulations and, in October 1963, a new ordinance was adopted. The new ordinance provided (1) a more restrictive grading code and (2) geologic and engineering participation in design, construction, and final inspection and certification of the adequacy of a grading project.

Subsequent to the adoption of the new Grading Regulations and related ordinances of 1963, recurring landslide problems provided the impetus for modification of the Grading Regulations. At least two committees were formed by the Mayor to examine landslide problems and make recommendations. One committee, the Committee on Geological Environment in the City of Los Angeles, was largely composed of experts on the technical aspects of landslide problems in the Los Angeles area. The other, known as The Mayor's Ad Hoc Landslide Committee, consisted of representatives of city government, industry, and homeowners as well as professional geologists and engineers. Both committees made recommendations, some of which were adopted.

The winters of 1968-1969 and 1977-1978 have provided stern tests of the effectiveness of the regulations. The Los Angeles Department of Building and Safety conducted a thorough analysis of the damage and slope failures in the hillside areas caused by the storms in 1969. The results have been reported by Slosson (1969) and are in table 1. The study compared the distribution of damage to developed sites according to when the site was graded. It was previously noted that sites developed before 1952 were without a grading code and that sites developed between 1952 and 1962 were based on the first code and modifications. Sites developed after 1962 had benefit of the revised Grading Regulations and stringent requirements for engineers and engineering geologists.

Table 1 near here.

Comparing the data for damage to sites constructed after 1963 to those constructed before 1952, the older sites sustained 18 times as much total damage as did the sites developed with stringent controls. Less than 3 percent of the total damage occurred to sites developed under the strong grading regulations. Although the published analysis did not separate landslide damage from the other types of damage, the losses from landslides were apparently reduced at least proportionally.

TABLE 1

Damage associated with destructive storms of 1969 in hillside areas of Los Angeles

	Sites developed prior to 1952	Sites developed 1952-1962	Sites developed 1963-1969
Number of sites constructed	10,000	27,000	11,000
Total damage	$3,300,000	$2,767,000	$182,400[2]
Average damage per site	$330	$100	$7[2]
Percentage of sites damaged	10.4%	1.3%	0.15%

1. More than $100,000 of the $182,400 occurred to sites that were currently being graded. Even the best of grading projects are susceptible to damage during construction.
2. If the total damage value is used, the average damage per site is about $17. The value of $7 per site was obtained by deducting the damages to sites under construction.

3. Slosson (1969) noted that the storms of 1952, 1957-1958, 1962, 1965, and 1969 produced similar total losses associated with similar destructive storms.

(Adapted from Slosson (1969))

The results of the near-record rainstorms in 1977-1978 are incomplete. A preliminary analysis of the distribution of damage by the Los Angeles Department of Building and Safety suggests that more than 93 percent of the landslide damage to sites involved those graded before the Grading Regulations of 1963 (J. T. McGill, oral commun., 1978).

This discussion has focused on the regulations enacted and the climatic events that created tests of their effectiveness. The results of the tests clearly indicate that the Grading Regulations are working and that a dramatic reduction in landslide losses in Los Angeles is possible and has been achieved.

Drafting and adoption of regulations was only part of the entire process, and mention should be made of the other activities essential to the success of the program. Perhaps as important as the creation of regulations is the enforcement of the regulations. As the regulations were developed and refined, so were the procedures for policing grading projects. A flow chart of procedures for tract grading as of 1967 was prepared by The Mayor's Ad Hoc Landslide Committee and is reproduced as figure 1. The procedures require

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Figure 1.--NEAR HERE.

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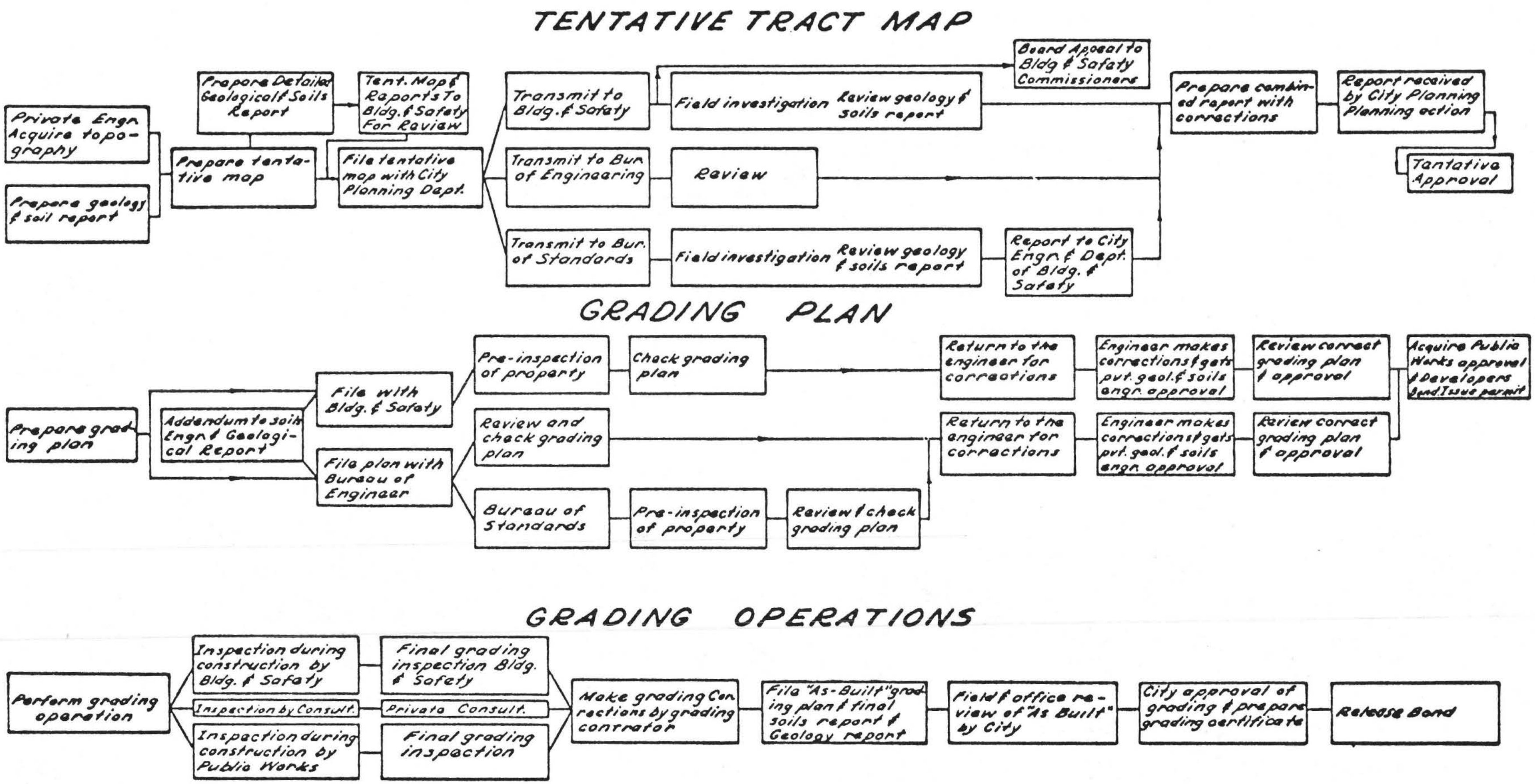
review of plans and construction by several departments and approval at two stages before beginning grading. Following grading operations the site is inspected and an "as built" grading plan and technical reports are submitted for review and approval. If all the reports and plans are acceptable, the City prepares a grading certificate and releases the bonds. (See fig. 1.) The procedure is not as complex for some other types of development, such as single lots, where questions regarding zoning and easements have already received attention.



NOTE: Erosion control is required during winter months. Erosion plan must be approved by Nov. 1st and all associated work must be completed by Dec. 1st.

Figure 1-- Simplified procedures for tract grading in the City of Los Angeles

(From The Mayor's Ad Hoc Landslide Committee, 1969)

Another activity critical to the success of landslide hazard reduction was the accumulation of the necessary scientific information to understand hazardous locations and situations. Intensive programs of geological and special purpose mapping were conducted by Federal and State agencies, in some cases in cooperation with the City and County of Los Angeles. A great deal of work was also accomplished by university faculty and students and the various private consulting firms in the area. Local meetings of the Association of Engineering Geologists and the American Society of Civil Engineers provided a forum for exchange of ideas and information. Members of both professional societies served on committees and contributed to preparation of the regulations. Other individuals and organizations contributed similarly. These included builders, homeowners' associations, and interested citizens.

The news media did their part as well. Landslides and related hazards became headline stories. The activities of the groups working on evaluating the problem and preparing the Grading Regulations were treated with in-depth stories that held the landslide issue before the public when their hillsides were not sliding.

These appear to have been the ingredients for the successful experiment in Los Angeles. The story is simplified and does not convey the countless hours spent by many segments of the community in formulating and implementing the program, the range of strategies proposed, and the debate among everyone concerned. The storms of 1977 and 1978 soberly demonstrated that the program does not completely eliminate damages and hazards and can be further improved. Yet, at the same time, without the program in Los Angeles, losses would have been many times greater; and the efforts of the past 25 years will continue to pay dividends both in Los Angeles and in other communities looking for solutions.

Even though the Los Angeles experience in dealing with landslide hazards must be considered a solid success, it is not without its deficiencies. The development of the basic program required more than a decade to become really effective. This is understandable for Los Angeles, because virtually every change in the Grading Regulations was without precedent elsewhere. It is hoped that other communities can avoid some of the early mistakes and proceed directly to a sound program. One still unresolved problem concerning damages in Los Angeles is the amount of damage inflicted on developments made before enactment of the Grading Regulations. These older developments have and will continue to suffer the worst of the damages from the severe winters.

The experience of Los Angeles in reducing landslide hazards can be summarized into three generalizations that may be applicable to other areas:

1. Damages and hazards from landslides can be significantly reduced. The technology is available in geology, engineering, construction, and government. Achievement of hazard reduction requires the perception of the necessity and the will to reduce the risk and damages.

2. Opportunities for progress arise during and immediately following crises accompanying the hazardous processes.

3. The development and implementation of the successful landslide hazard reduction program in Los Angeles contained at least three key elements that must be emulated for success in other parts of the United States. These are (a) an able and concerned local government, (b) a solid base of technical information about the hazards and a technical community able to apply and build on the information, and (c) a citizenry that, on balance, advocates rather than fights increased regulation.

Greater Pittsburgh Area, Pennsylvania

Programs to achieve landslide hazard reduction in the Greater Pittsburgh

Area, Pennsylvania, are different from either those at Los Angeles or Cincinnati. The Greater Pittsburgh Area is made up of six counties containing 412 townships, boroughs, and cities. Each of these governmental units controls its own land use, and technical information must be effectively transmitted to each. In Allegheny County alone, there are 129 such muncipalities.

In 1973, the U.S. Geological Survey, in cooperation with the Appalachian Regional Commission, undertook a number of studies aimed at providing regional information about geologic hazards for land-use planning. The studies concentrated on subsidence over mined land and landslides, particularly in Allegheny County, but developed limited data for the other five counties as well. Landslides alone are a multimillion-dollar problem in the area.

During the next three years, information was developed on the distribution of landslides, relative susceptibility of slopes to landsliding, and other useful geologic characteristics including nature and distribution of bedrock, mined areas, and various topics related to surface and subsurface water. The landslide information identified landslides and areas susceptible to landsliding to a degree suitable for application to county-wide land-use planning in Allegheny County (Briggs, 1977). Products of the study were routinely mailed to each of the 129 muncipalities in the county.

In effect, the project produced the regional data necessary for the hazard reduction strategy described by Leighton (1976) and summarized at the beginning of this paper. Technical information on subdivisions or tracts and sites is normally obtained by consultants and regulated by ordinances.

Two studies were made to learn whether and how geologic data are being used by county and municipal officials. One of these was conducted by the Center for the Study of Environmental Policy of The Pennsylvania State

University for the Appalachian Regional Commission (Wissel and others, 1976). The study examined how well the geological information was communicated to individuals in government who have responsibility for land-use decisions.

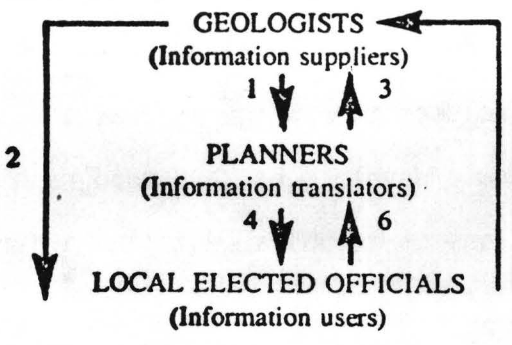
Three groups, the information suppliers, translators, and users, were identified as key parts of the process. Figure 2 is a diagram of the groups

Figure 2.--NEAR HERE.

and the six communication links. The purpose of obtaining the original geologic data was to provide unbiased technical information to assist governmental officials, and the ultimate users, in land-use decisions. The communication between all the groups was found lacking, and the critical link between the suppliers and ultimate users was practically non-existent.

As a result of the study, Wissel and others (1976) made 11 recommendations intended to improve communication and insure that basic data are more effectively used to reduce hazards. The recommendations called for educational programs and seminars; closer ties with regional and State agencies of consumer affairs, economic development, and topographic and geologic survey; reference collections of technical data and available consultants; and an intensive test of a small area.

Figure 2.--Diagram of key groups and communication links.



From Wissel and others (1976)

The U.S. Geological Survey also conducted a survey of the effectiveness of mailing unsolicited information to municipalities (A. L. Carter and R. P. Briggs, written commun., 1976). The study ascertained what happened to the information after it was received by a muncipality. In general, the information reached the most likely potential user, but the ultimate usefulness varied a great deal. In some instances the materials were used consistently and in others, use was sporadic at best. The larger and more populous municipalities tended to make more use of the data than smaller ones. Direct contact with the municipality by the author or a technical translator of the data improved the effectiveness of use.

Whether or not the collection and distribution of regional geologic data significantly reduces landslide damage and hazards will not be known for some time and will be difficult to measure. There is no doubt that the information will affect land-use decisions in some municipalities and wise decisions there would create interest among other governmental units. Another positive result of the studies was the establishment of a Geotechnical Center in the Allegheny County Department of Planning and Development. The Geotechnical Center has assumed responsibility for several of the functions recommended by the study of Wissel and others (1976). In particular, the center serves as a resource and eduction center, data bank, and point of contact for individuals and agencies with questions or problems.

Initiation or major changes in landslide hazard reduction programs in Los Angeles occurred during or immediately following crises. The Pittsburgh area has a highly qualified community of consultants and a solid base of technical information to undertake a regulatory program in the event of a crisis and if the communities deem it worthwhile. In general, the existing grading of codes in the Pittsburgh area were developed to qualify communities for participation in the program for National Flood Insurance and are not specifically designed to reduce landslide damage or hazards (W. R. Adams, oral commun., 1978). The current approach in the Greater Pittsburgh Area is apparently an alternative to other, more regulatory programs.

REFERENCES

Briggs, R. P., 1977, Environmental geology, Allegheny County and vicinity, Pennsylvania--Description of a program and its results: U.S. Geological Survey Circular 747, 25 p.

Carter, A. L. and Briggs, R. P., 1976, The effectiveness of mailing unsolicited environmental maps free of charge to municipal governments--An evaluation in Allegheny County, Pennsylvania: Unpublished report of study, 73 p.

Hays, W. V., 1974, The present--Landslide litigation: Who should pay the cost if damage occurs?, in Proceedings, Workshop Physical Hazards and Land Use: A Search for Reason: The SABER Society, San Jose State University, San Jose, Calif., Sept. 27-28, 1974, p. 8-14.

Jahns, R. H., 1969, Seventeen years of response by the City of Los Angeles to geologic hazards, in Proceedings, Geologic Hazards and Public Problems: Office of Emergency Preparedness, Santa Rosa, California, May 27-28, 1969, p. 283-296.

Krusling, J. R., 1975, Cut and fill ordinance as adopted by the City of Cincinnati, in Slope Stabitity nd Landslides: Proceedings 6th Ohio Valley Soils Seminar, Ft. Mitchell, Kentucky, Oct. 17, 1975, p. 1-11.

Leighton, F. B., 1976, Urban Landslides: Targets for land- use planning, <u>in</u> Urban Geomorphology, Coates, D. R., ed., Geological Society of America Special Paper 174, p. 37-60.

Mayor's Ad Hoc Landslide Committee, 1967, Landslides and attendant problems: A report to the Mayor of the City of Los Angeles, Los Angeles, California, 186 p.

Radbruch-Hall, D. H., Colton, R. B., Davies, W. E., Skipp, B. A., Lucchitta, I. and Varnes, D. J., 1976, Preliminary landslide overview map of the conterminous United States: U.S. Geological Survey Miscellaneous Field Studies Map MF-771.

Schuster, R. L., in press, Introduction, <u>in</u> Schuster, R. L. and Kryzek, R. J., eds., Landslides--Analysis and Control: Washington, Transportation Research Board Special Report 176, National Academy of Sciences.

Taylor, F. A. and Brabb, E. E., 1972, Maps showing distribution and cost by counties of structurally damaging landslides in the San Francisco Bay region, California, winter of 1968-69: U.S. Geological Survey Miscellaneous Field Studies Map MF-327.

Wissel, P., O'Connor, R. and Cigler, B., 1976, The use of geological information in the Greater Pittsburgh Area: Appalachian Regional Commission, Report ARC 74-19-2564, 23 p.

Yelverton, C. A., 1973, Land failure insurance, in Moran, D. E. and others, eds., Geology, Seismicity, and Environmental Impact, Association of Engineering Geologists Special Publication, p. 15-20.

OVERVIEW COMMENTS ON COMMUNICATION

by

Claire B. Rubin*

KNOWLEDGE DISSEMINATION, EDUCATION AND TRAINING

The acceptance and effectiveness of the earthquake hazards mitigation plan will largely depend upon the public's perception of the need and utility of the measures which have been developed to implement that plan.

At this time, however, there is clearly a gap between technological information about the nature of earthquakes and the threat they pose to a large proportion of the population of the United States, and the serious lack of knowledge about seismic matters one finds in the non-scientific community. Moreover, the public agencies that are in a position to plan for seismic disasters, and thus alleviate the widespread socio-economic upheaval and disruption which could result from an earthquake, appear to be unaware of the need to implement measures which could substantially reduce the loss, destruction and disruption which might occur.

° To close the gap between the perceived remoteness of the threat of earthquakes, and the knowledge that 39 states are vulnerable to the hazards of earthquakes, it is crucial to build an effective knowledge dissemination link between scientists and the public officials responsible for taking protective and preventive measures that will lessen the impact of an earthquake, should it occur.

° To effectively inform those who can act on the technological knowledge which is already available on seismic matters, and to utilize the results on the on-going research which is being conducted to improve man's knowledge about the nature and behavior of earthquakes, it will be necessary to :

= Identify what information is available:

You have no knowledge to transfer until it is accumulated, and there is a lot to do, particularly in the Eastern United States. Information in high risk areas throughout the country is badly needed. "It makes no sense to talk to people unless you can advise them of risk of their community," one participant commented.

= Identify the audience(s):

There is a need to identify a network of people to whom information would be disseminated on a need to know basis. From the point of view of this discussion, the audience to be reached is, of course, government officials at all

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levels. An effective way of reaching them is through national associations, whose memberships include elected and appointed government officials, local government department heads, and specialized professionals who work for and with various levels of government.

= <u>Identify Dissemination Strategies to Reach the Selected Audience</u>

Effective dissemination needs intermediaries between those who have the information -- National Science Foundation, for instance -- and those who use the information.

State and local officials usually do not go to research documents for the information they need. They go to sources they know provide information in their language, and in "bite size" chunks. Public interest groups are often called upon to translate program and policy developments into useful information for state and local officials. Peer exchange is also a common communications strategy.

For education and training purposes, there are at least two ways to reach the defined audience of public officials. You can get city managers and department heads together to discuss strategies they will have to tackle together, or you can get officials from both state and local governments together to share information, for instance.

Fire and police officials are geared to responding to emergency situations and are familiar with emergency preparedness operations. They would be a most receptive audience for training and information programs to reduce earthquake hazards. In an emergency situation, it usually is more difficult to work with planning and finance departments, for example, since they are not staffed on a 24-hour basis.

Research results often undergo a translation process, after which they are produced in several dialects. To effectively reach the various audiences, information must be put in the idiom of the users. It must also be in different forms, on a need to know basis, for different audiences.

You also need "appetizers" -- short articles, which can be edited for various audiences by intermediaries. These kinds of articles raise the interest of leaders in various branches of government, who, in turn, alert their subordinates to current problems.

Full-length prepared articles, or press releases, for professional associations to use in their house organs, newsletters, etc.

- Granted that the second front of dissemination of earthquake hazards reduction information is various kinds of national associations, the first front is the Federal government. The two principal organizations for dissemination of this kind of information currently are the National Science Foundation and the United States Geological Survey. Neither one has a field network.

- It would be possible to to set up an operating group which has dissemination capabilities within NSF or USGS to carry out the responsibility for dissemination of technical information on a regional basis. But these organizations do not have an effective link with state and local governments at this time. And, clearly, any Federal agency which is given the responsibility for the earthquake hazards reduction plan must develop effective ways to exchange information with state and local officials. At this point, neither NSF nor USGS have this capacity, however.

- The criteria for an existing Federal agency to carry out the operational and dissemination functions called for in the national implementation plan are:

  = the ability to assimilate new technology
  = capability of disseminating it to the right constituencies
  = current functions not focused on day-to-day operations

  Agencies identified which fulfill these criteria were:

  = The Department of Agriculture (except for subject -- although it has considerable experience in dealing with drought patterns). This agency would be appropriate,particularly because it has extension offices throughout the country.

= The Department of Commerce.

= U.S. Army Corps of Engineers, which has a history of involvement with civil preparedness and disaster relief. These could easily be expanded to include earthquake mitigation elements.

= The Department of Housing and Urban Development, which houses the Federal Disaster Assistance Administration and is involved in all phases of housing.

° Finally, it was suggested that the Federal agency ultimately selected to operate the implementation plan must provide a repository for new users and arrange to update all information about earthquake hazards reduction on a continuing basis for all users.

"Some Factors to Consider In Communicating Information On Earthquake Hazards Reduction"

By

William A. Anderson
National Science Foundation

Introduction

Extensive research is now being conducted on earthquakes and other hazards by persons from such varied disciplines as seismology, engineering and the social sciences. This development is likely to continue in the foreseeable future. Yet this does not necessarily mean that the new knowledge that is rapidly being accumulated will be applied. Among other things, for this to occur continued attention must be devoted to communicating the increasing information on earthquakes to relevant user groups and organizations. Producers of information must learn how to communicate their findings to such users as private practitioners and government decision makers at all levels. This is no easy task, but it can be done if sufficient attention is devoted to several key factors, including those which we will briefly discuss here.

For many years the National Science Foundation (NSF) has sponsored a research program on earthquake engineering through its Research Applications Directorate, now known as ASRA. More recently it has also supported architectural investigations and social science studies on disasters and natural hazards. Regardless of the disciplinary base of the studies supported through ASRA, they are all expected to develop an information communication and utilization component to complement their research activity. Also, some of the projects supported by ASRA are strictly dissemination and education type activities. NSF's role in earthquake research and information dissemination was given renewed emphasis with the passage of the Earthquake Hazards Reduction Act of 1977.

There are several known factors which require attention when attempting to facilitate the communication of information to user groups. Some of these have been identified for the earthquake hazards mitigation field in the recent report by the Office of Science and Technology Policy's Working Group on Earthquake Hazards Reduction entitled Earthquake Hazards Reduction: Issues for an Implementation Plan. NSF is encouraging its grantees to consider the following factors when establishing programs to disseminate information on earthquakes and other hazards:

- Two-way communication between producers and users produces the best results.
- User groups vary in their need for information.
- Users require opportunities to update their skills.
- Several channels or formats should be used to transmit information to users.
- Dissemination programs should be evaluated to determine their usefulness and ways in which they might be improved.

Making Dissemination More Effective

Two-way communication

The best results in the application of information on earthquakes are likely to be achieved when producers and users have had the opportunity to interact on a face-to-face basis. Unfortunately, given time, financial and other constraints, too much reliance is often placed on one-sided communication, such as final reports and other written materials. While researchers are accustomed to relying primarily on such means for acquiring information, many users are not. The timing of face-to-face interaction is also important in improving the chances that research results will be used. Thus when researchers seek user input early during the research process, it enhances the chances that the research will be relevant to user needs.

In recognition of the importance of close contact between producers and users, NSF has encouraged many investigators to form user or advisory committees comprised of representatives from relevant user groups. Such groups are useful not only because they enable researchers to become familiar with user needs but also because they provide a channel for transmitting information to user groups.

Practitioners and other users are not the only ones who benefit from face-to-face interaction with producers of information. Such producers also greatly benefit from this form of contact with each other and for this reason NSF has attempted to facilitate such opportunities. A good example of this type of sponsorship by NSF are the national meetings of the Universities Council for Earthquake Engineering Research (UCEER). These meetings are open to university researchers with an active interest in earthquake engineering. The meetings provide a vehicle for the exchange of new information on earthquake engineering.

Differences between users

One factor which should always be kept in mind when dissemination efforts are being developed is that users vary significantly in the kind of information they need on earthquakes and other hazards. For example, such practitioners or professionsals as engineers and architects have different needs than such users as Federal, State and local decision makers. The practitioners require in-depth technical information which will enable them to reach appropriate design decisions. State and local officials, on the other hand, tend to need less technical detail than practitioners but nevertheless require information which is sufficiently comprehensive to enable them to make decisions on such matters as land use-planning, emergency preparedness and building standards. It is frequently necessary to interpret the implications of research results on earthquake hazards for such non-technical users as State and local government officials. Often researchers have difficulty translating their findings into terms that are meaningful to these users. Thus, this translation function often can best be performed by intermediate groups such as public interest organizations, who understand the needs of the non-technical users and are accustomed to working with them.

Because of their potential for serving as disseminators of information on earthquakes and other hazards to such users as State and local government officials, NSF has encouraged public interest groups to assume this role. For example, NSF is currently supporting a Council of State Governments project which, among other things, is attempting to articulate some of the major implications of the developing knowledge on earthquakes and earthquake prediction for State and local government. Such projects complement the strictly research activities funded by NSF.

Opportunities to update skills

Like other professional groups, practitioners in the earthquake field need to periodically update their skills and familiarize themselves with new developments. Those who do this are obviously more likely to integrate the appropriate knowledge on earthquake hazards mitigation into their professional activities.

NSF has sponsored a number of activities which fall under the category of continuing education for practitioners and professionals. For example support has been provided the Earthquake Engineering Research Institute (EERI) for regional seminars for practicing engineers and government officials who want to increase their ability to evaluate and resolve earthquake engineering problems. The two day seminars have offered in a capsule form the significant areas of recent progress in earthquake engineering and procedures for the utilization of earthquake engineering technology. Similarly, support has been given to AIA Research Corporation for summer seismic institutes for faculty members from schools of architecture throughout the country. The major thrust of the institutes has been to present basic seismic knowledge to the participants during a period of several days, to allow them an opportunity to apply this knowledge, and to develop strategies for using this knowledge to educate future professionals. These and other types of minicourses supported by NSF provide an alternative for busy professionals and practitioners who feel that they cannot devote more time to continuing education because of other commitments.

Multiple forms of dissemination

No single format should be relied upon informing users of developments in the earthquake hazards mitigation field. Most users require a variety of exposures to new information before they can appreciate its implications for their own activities. Thus the use of several types of dissemination approaches, including conferences and workshops, seminars, newsletters, abstracts and reports, enhances the likelihood that knowledge will be received and implemented.

NSF has encouraged researchers and disseminators in the hazards field to use a variety of formats to transmit information to users. Thus many of the NSF supported research projects have developed more than a single dissemination approach. Additionally, NSF has supported strictly dissemination programs which have developed multiple strategies to reach users. For example, NSF sponsors the National Information Service for Earthquake Engineering (NISEE) at the University of California at Berkeley. NISEE provides information on a variety of earthquake topics through a library service, a computer applications system, an abstract journal, and a quarterly newsletter. Another example of a dissemination program supported by NSF which uses multiple approaches is the Natural Hazards Research and Applications Information Center (NHRAIC) at the University of Colorado. Among the formats NHRAIC has developed to communicate hazards information to users has been an annual national workshop, a quarterly newsletter and other publications.

In transmitting information on earthquakes and other hazards to users, then, purposeful redundancy can be very useful. It may be only after the second or third time around that users see the significance of some information for their own situation and begin to put it to use.

Evaluation of efforts

Not only should various dissemination modes be developed, they should be evaluated for their effectiveness as well. Only when this is done in a systematic fashion can confidence be maintained in them. Methods to evaluate dissemination strategies include surveys and interviews with users, and case studies of the long-term impact of various approaches.

In line with this concern, many of the NSF sponsored projects have been subjected to some form of evaluation. In some cases, such evaluations have been conducted by project staff members themselves and in other instances they have been done by other persons. The evaluations have included telephone surveys of users, reviews by advisory committee members, and solicitations of the views of conference and workshop participants and recipients of publications.

Such feedback is a prerequisite for developing sound programs to transmit information on earthquakes and other hazards to users. A mechanism designed to secure such feedback should be built into every dissemination program. It is a recognition that communication, after all, is a two-way street and that producers of information must be alert to the reactions of users to their efforts.

Conclusion

Considerable research is being done by physical scientists, engineers and social scientists which have important implications for earthquake hazards mitigation. Yet the findings from this work must be carefully communicated to a varied audience, which includes private practioners, Federal, State and local decision makers as well as other researchers, if its potential impact is to be realized. Researchers in the hazards field are likely to see their findings implemented when they use multiple channels of communication to users which permit a two-way flow of information and perspectives. In many cases, intermediate groups, such as public interest groups and professional associations accustomed to working with certain users, can serve as vital links between producers and users. Implementation is also likely to be furthered when disseminators periodically evaluate their communication strategies and when users are given the opportunity to update their skills and ability to use new information.

These and other factors that should be considered when attempting to disseminate information on earthquakes and other hazards point to the complexity of this task. While various programs have incorporated such principles to some degree in the past, much more emphasis should be placed on them.

COMMUNICATING SEISMIC SAFETY INFORMATION FOR PUBLIC POLICY DEVELOPMENT

by

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ABSTRACT

This paper discusses considerations in the transfer of technical information on earthquake hazards reduction to user groups in Utah from the perspective of a state seismic safety policy development program. Purposes of such communications, characteristics of the various user groups having interest in seismic safety policy in the state and local levels and the private sector, functions and goals of the Utah Seismic Safety Advisory Council, and particular information transfer situations are described. Also included are the author's views regarding preferred methods and media for communicating different types of technical and general seismic information to groups of different interests and technical competencies.

The paper is organized in four sections. The first section discusses some basic considerations for communications and relates these to objectives of the Utah Seismic Safety Advisory Council. The second section provides a detailed description of the Utah Council, including specific legislative charges. The third section describes the work programs, current activities, and longer-term activities of the Council. Included are the resources available to the Council for carrying out its work -- both budgetary and manpower resources. The last section describes the information transfer needs, programs, and activities of the Utah Council.

INTRODUCTION

A beginning premise of this paper is that information transfer occurs for a reason. The reason may be that we seek to bring about an action by others; it may be that we wish to engender support for our own actions or planned actions; we may wish simply to make others aware of information we may have or know; we may wish to circulate our ideas or views about a subject; or we may seek to provide information summaries covering the work, ideas, and activities of others. Probably, there are many more reasons we communicate, but the factor common to all is that the communication has a purpose.

It is accepted generally among those familiar with information transfer processes that the objective or purpose of the communication must be decided before the medium or method of the communication is selected. Clearly, there are many forms of communications and, among these forms, many organizational differences. Given particular situations, some forms permit better communications than others. By better, I mean more effective.

Effectiveness, in the end, must be measured in terms of success in having achieved the purpose (which, by the way, usually is not just to prepare an articulate, or even significant, message).

This points out an additional element of the communications process -- namely, the receiver or user of the information. Successful communications are said to have been achieved when the receiver understands. Assuredly, information transfer is achieved only when this happens.

As there are many forms and methods of communications, so are there many classes of receivers. Technical competencies vary among us, interest levels in each subject are quite different, and the time that each of us may choose to allocate to a particular issue will be different. These differences cannot be ignored when communications are structured.

Most of us, I believe, already know all of this. At least, we think we do. And, I expect that these aspects are considered to some degree in most of our communications. Still, there probably are very few among us who believe that we are as effective as we would prefer in our information transfer programs.

The comments above are intended only to establish the basis of the views presented in this paper which has the principal objective of describing the Utah Seismic Safety Advisory Council's information transfer objectives and programs. By its statutory mission, the Utah Council must communicate its findings and recommendations for seismic risk reduction actions to the people of the State which, through their elected representatives, provide authority for program implementation. This challenge reduces to communicating technical information mostly to the non-technical public. The Council's objective in this communications process is to be persuasive with its information in order to bring about public support for legislative and administrative actions for seismic risk reduction.

In this paper the Utah Seismic Safety Advisory Council, including its formative legislation and legislative charge, will be described. A brief overview of the Council's work programs and directions will be furnished. These organizational aspects of the Council then will be correlated with our views and plans for communicating to the people of Utah the Council's recommendations for actions and programs to achieve seismic risk reduction.

It should be noted at the outset that seismic safety information transfer activities of the Council have just begun. This paper therefore will focus as much upon future plans and constraining influences in the State as it will upon actual experiences in this endeavor.

Also to be noted at the outset is that future plans we have in Utah for information dissemination on seismic topics are acknowledged to be influenced by other staff experiences with technology transfer and communications which are not necessarily seismic-related. Hence, prior experience has shaped and will continue to shape our work, even though it is not of the specific seismic-related experience that we wish we had. Nonetheless, helpful correlations can be made between previous information transfer involvements by staff and the anticipated communications needs of the Utah Seismic Safety Advisory Council.

DESCRIPTION OF THE UTAH SEISMIC SAFETY ADVISORY COUNCIL

What is the purpose of the Utah Seismic Safety Advisory Council? The Council was established by legislative authority (HB 46) in 1977 for the purpose of advising the Governor and the Legislature on earthquake safety matters and recommending programs and actions--by the State, local governments, and the private sector--for seismic risk reduction. Simply stated, the Council is a policy-recommending body. Its charge is policy formulation, not policy implementation.

Legislative Charge. What is the Council charged to do? Within the broad general purpose stated above, the formative legislation establishing the Council included specific charges and responsibilities. As paraphrased from the legislation, the Council is to:

- Recommend a consistent policy framework for seismic safety in Utah.
- Suggest goals and priorities for earthquake hazards reduction.
- Recommend Statewide and local programs to reduce earthquake hazards.
- Assist with the coordination of seismic safety activities of government at all levels and of the private sector which may be involved in practices important to seismic safety.
- Request that State agencies devise criteria to provide seismic safety.
- Recommend methods for --
  - -- improving building standards and construction compliance with the standards.
  - -- siting and design of critical facilities, hospitals, and schools.
  - -- delineating fault zones which require special investigation, regulation, and reporting procedures.
- Educate the public and private sectors on earthquake safety.

- Recommend training for specialized enforcement and technical personnel which may have responsibilities relating to earthquake hazards.

- Advise the Governor and Utah Legislature on matters relating to seismic safety.

- Review proposed earthquake-related legislation and propose needed legislation.

- Recommend the addition, deletion, or changing of State and federal standards as deemed desirable to promote seismic safety.

The reader should note that all charges and responsibilities in the list above involve either policy formulation or advisory activities. Acceptance and implementation of suggestions which the Council may make are expected to occur through normal processes--involving both government and the private sector. The extent to which acceptance and implementation of recommendations take place will be decided in large part by the persuasiveness of justification arguments which are made regarding the various issues. It is this aspect of communications which is of paramount importance to the Council.

Council Organization. The organizational structure established by the 1977 Utah Legislature for carrying out the above-named statutory charges consists of an 11-member Council appointed by the Governor. As prescribed in the formative legislation, members are appointed from the following areas: architecture, planning, structural engineering, geotechnical engineering, geology, seismology, utilities, Utah League of Cities and Towns, Utah Association of Counties, and the public-at-large.

The Council is charged to complete its work by June 30, 1981 (a four-year period), at which time the Council is to be disbanded, unless new legislative authority is given. The four-year life and the policy-formulating role for the Council create a need to differentiate clearly between seismic hazards reduction policy formulation and implementation. We are concerned that the expectation levels of those whom we serve are consistent with this differentiation.

The Council believes that comprehensive seismic safety policy recommendations can be suitably developed during the four-year period. Implementation of some policies possibly can be initiated during this time but certainly are not expected to be concluded. Nor should the State's funding assistance for particular seismic safety programs be expected to conclude in 1981. Implementation programs will need to carry on long after the Council is disbanded. The Council faces a major challenge in communicating this situation to the State's policy makers.

Organizationally, the Council reports directly to both the Governor and the Utah Legislature. Administratively, the Council is in the State's Department of Natural Resources, where it has been accommodated with equal status among ten other divisions. However, by Legislative intent, the Council is somewhat autonomous from the Department of Natural Resources. The executive director of that Department serves as the Council's advocate in matters related to fiscal budgeting, and in accepting the unique status which the Legislature established for the Council, the Department has assisted considerably in getting the Council, office, and staff established.

The Council's autonomy is reflected in several ways. The Council elects its own chairman yearly from among its members. The executive director of the Council is appointed by the Council. And, work programs and budget requirements are established by the Council, with the budget requests subject to acceptance by the Governor and the Legislature. Given this absence of direct supervision of the Council, the extent of cooperation and support from the Department of Natural Resources and its staff to the Council is both noteworthy and commendable.

Organization relationships of the Council within State Government are indicated in Figure 1.

WORK PROGRAMS AND DIRECTIONS

The Council recognizes that seismic safety issues and related programs for risk reduction are many and varied. Moreover, their implementation will involve or affect numerous public agencies and private organizations. Some issues needing review are not necessarily related except in the ultimate goal of seismic risk reduction. To cope with this diversity, the Council anticipates divided support for particular recommendations which may impact upon special interest groups.

Work Program. As a method of analyzing these diverse and sometimes unrelated seismic safety issues, one of the initial activities of the Council was to identify as comprehensively as possible the various topical areas and to classify them in a work program. A logical basis for their classification was established in the general categories of mitigation, preparedness, and recovery. Although there is some overlap of issues between mitigation and preparedness, the three noted categories have provided a reasonable basis for the Council to proceed with development of a work schedule and prioritization of its effort. Scheduling and prioritization have taken into account two principal considerations -- first, initial assumptions as to the relative risk-reduction importance of the issues, and, second, availability of resources (manpower and funding) for the four-year overall time frame.

Individual issues to be addressed by the Council and for which risk-reduction actions or programs will be recommended are indicated in Figure 2. The issues are grouped in the three classifications noted above and are placed in time sequence during the four-year period consistent with the prioritization basis described above.

One observation regarding the issues listed in Figure 2 is noteworthy. Early investigations suggest that Utah is well along in development of recovery plans for natural disasters. These plans place emphasis upon recovery from earthquake events. Progress also has been made in the State with respect to preparedness planning. For example, at the State level, departments have prepared or are preparing operational plans describing their roles, responsibilities, and activities in any disaster recovery program. At this time, about two-thirds of the State's agencies have completed their plans. Local communities are working on similar plans, with encouragement and guidance from the State's Office of Emergency Services. The adequacy and comprehensiveness of these plans with respect to seismic hazards has yet to be reviewed. However, the main point here is that some seismic hazard reduction issues already have been addressed in Utah. Hence, the Council's work program has been focussed upon those issues where little has been done -- namely, seismic hazards mitigation.

Personnel and Budgets. The Utah Seismic Safety Advisory Council expects to carry out its Legislative charges, addressing the risk-reduction issues indicated in Figure 2, utilizing the following manpower resources.

- Council members. Makeup of the Council, by Legislative design, comprises considerable earthquake-related expertise. Three-fourths of the Council members are specialists in some aspect of earthquakes -- either geological aspects or planning and construction aspects. With this capability, the Council functions as a working group as well as a policy-recommending body. Task committees for analyzing various issues have been set up within the Council, with members participating in analyses of issues which fall within their areas of interest and expertise. Utilization of the Council in this manner adds significantly to our manpower resources and, at the same time, provides expert personnel to the State at almost no cost.

- Council Full-Time Staff. A small staff -- consisting of an executive director, a seismic planning specialist, and a secretary -- is employed by the Council to coordinate, initiate, and direct various program activities. Among its functions, the staff assists the Council task committees by arranging meetings, preparing written documents, and taking care of needed correspondence.

- Other State Agencies. State government includes other agencies which have capabilities sometimes needed in order for the Council to carry out its work. For example, the Utah Geological and Mineral Survey engages in several seismic-related projects, and specialized personnel of that agency have much to contribute to the Council's work. Also, the State Attorney General's Office has furnished considerable assistance to the Council in statutory and legal matters. And, the Utah Office of Emergency Services, State Planning Coordinator's Office, and the State Science Advisor have been of assistance. To the extent feasible and acceptable, the Council expects to continue utilizing existing State resources and capabilities for particular studies where those agencies have the necessary capability and willingness.

- Contract Services. For studies requiring special expertise or expedient completion, the Council has set aside funds to purchase professional services through contract agreements. We expect to utilize these funds for obtaining information and recommendations relating to seismic policy planning rather than for research or program implementation.

The initial appropriation to the Council for the 1977-1978 budget year was $80,000. The budget has been split almost evenly between personnel (full-time staff) and program activities, including office start-up costs and contract services. The Legislative appropriation for 1978-1979 is $120,000, which is the amount requested by the Council. This will be allocated with a split of about 60 percent to personnel and 40 percent to program activities, with an increase in funds for contract services to about $30,000. Our budget requests for the third and fourth years are expected to be in the range of $120,000 and $100,000, respectively. The lower amount expected to be requested in the fourth (last) year reflects our expectation that contract services can be reduced as we move into final phases of preparing policy recommendations. Note that these fiscal-year budgets say nothing about implementation programs and their associated costs.

The detailed description of the Council organization, program directions, and budgeting plans given above may help to illustrate our efforts to carry out Legislative intent in an organized fashion. We may have overlooked some important considerations due to our newness in such an endeavor, and we undoubtedly will find some program modifications are needed as we progress. But, we believe an orderly program approach is essential for the broad spectrum of issues to be addressed.

The methodical work program by which the Council will be guided may be placed in perspective by a brief anecdote. Our approach may be likened to the response given to the question, "How do you eat an elephant?" The answer, "One bite at a time!," is how we shall deal with the rather large undertaking which the Utah Legislature has charged to the Council.

COMMUNICATING TECHNICAL INFORMATION

This portion of the paper discusses technical information transfer and other forms of communications within the context of goals and program activities of the Utah Seismic Safety Advisory Council. Kinds of information to be communicated, characteristics of user groups, and barriers to be overcome are among the considerations discussed. As well, comments are made regarding conceptual methods which the Utah Seismic Safety Advisory Council will attempt to apply in achieving successful communications.

The beginning point is a reminder that the Council is a recommending and advisory body regarding seismic risk reduction. Although the Council expects to suggest procedures and responsibilities for carrying out the various recommendations it will make, new authorities--statutory or executive--for implementation actions will be needed in some cases. Dedicated cooperation among organizations and government will be necessary in almost all cases if the implementation actions are to succeed. Therefore, another burden upon Council, additional to its charge to develop and recommend seismic safety policy, is a responsibility for successful communication of seismic safety issues and related risk-reduction recommendations to those who will implement and those who will need to comply with accepted recommendations or programs. Successful communication will entail both technical information transfer and effective public relations work.

<u>Communicating To Special-Interest Groups</u>. How can the Utah Council best accomplish the needed communications? It seems to me that no single communications method will be adequate. This is because a number of different public interests are involved or affected, and also because the diversity of seismic safety issues require individual treatment. For example, land planning and building construction involve different problems and different institutionalized organizations. Introduction of seismic safety considerations into their professional activities will not alter the rather well-defined boundaries or "turf" of each profession. We therefore must assure that the interests of each group are considered and accommodated when seismic safety principles are suggested to be added to their work.

Planning and construction are but two special-interest groups which might be affected by various seismic risk-reduction public policy programs. The special-interest groups span both the public and private sectors--e.g., school administrations, emergency services, realtors and land developers--each group having its own array of activities to be guarded. These and other groups can be expected to respond to earthquake risk reduction recommendations according to their special interests.

In my view, communications from the Council regarding earthquake safety, if they are to be pursuasive, will need to be sensitive to the various special interests. Sometimes these special interests are manifested simply in an expressed desire to participate in the policy-formulating activities. In other cases, the special interests are aroused by particular content of the policies. Each of these manifestations is to be recognized; both must be accommodated. I do not believe that any single, all-encompassing communications method can accomplish this requirement, given the diversity of interests and groups.

Another factor affecting communications is the degree of detail wanted, or even needed, by the different interest groups to permit their understanding and assessment of the merits of particular seismic safety policy recommendations or programs. Groups such as legislators and city officials usually will not want rigorous technical material. What they really want, I believe, is comprehensive, distilled information which conveys that all aspects of an issue or program have been assessed, that implications for various agencies, organizations, and political pressure groups have been summarized, and that the recommended programs fit the reality of their local situations. For the most part, these groups are reliant upon others--engineering consultants, planning specialists, and their line agency directors--for assessments of the technical merits of particular programs. Hence, raw technical material typically is wasted upon such groups.

An implication of the preceding paragraph is that there is another group of technical and quasi-technical people having considerable influence upon those who make or adopt seismic safety policy, or for that matter any public policy. These people can "make" or "break" programs that the Council may recommend, and this can be done simply in informal meetings and discussions with those decision-makers whom they advise. It therefore seems essential to communicate with this group. Such communications typically can be more technical and more protracted, because detailed understanding is sought.

The Communications Form. A commonly accepted format of information transfer which is responsive to the two different groups identified above is a detailed statement of the issue accompanied by an executive summary and a separate set of succinct action recommendations. I subscribe to this format as an effective means to accommodate the various degrees of interest, available time, and technical levels of the users.

Another consideration relating to communicating seismic information is the medium to be used. On this matter, I have a bias which unquestionably will affect the Utah Seismic Safety Advisory Council's communications. My definite preference is for written material -- brief, well written, and well organized. That preference is implied in the preceding paragraph about the format of information transfer items.

Although a preference of medium for communicating earthquake information may exist, it must be realized that the most suitable medium may be different for some situations. There are other factors to consider besides preference--e.g., size of the user group and content of the information. One contrasting user group is the general public, which certainly should be kept informed about earthquake hazards and feasible mitigation actions. In my view, these communications can be best accomplished with attractive brochures and public dialog via the newspapers, radio, and TV. In general, I do not favor lectures, slide shows, or briefings to small public groups upon request or by schedule, except in a few specific situations. My reason for disfavor upon lectures and slide shows relates to the inefficiency of such efforts to reach large numbers of

Tailoring Communications In Utah. Based upon the above-stated communica philosophy, how has the Utah Seismic Safety Advisory Council proceded to it? This question must be answered in several parts, again due to the d of the situations.

As a means of setting the context of communications by the Utah Seismic Advisory Council, it is helpful to comment once again on the general nat the Council's work and the types of information to be transferred.

First, the Council basically is not a generator of new technical informa about earthquakes. It does not engage in applied research. It does, ho make use of the research produced by other agencies and organizations.

Second, it is becoming more evident to us daily that the Council's princ work is in tailoring seismic safety programs for the unique conditions o Utah. The issues of school safety, dam safety, hazardous buildings, sei risk mapping, building code provisions for earthquake safety, and others to be universal in earthquake hazards reduction programs. In Utah, we seem to be examining the same basic issues as have been or are being examined in California and by others working on problems of earthquake safety. Moreover, the basic solutions for these seismic safety issues seem to be quite universal. The distinction among programs appears, therefore, to lie in statutes, ordinances, executive orders, and procedures for carrying out specific programs. Utah has its own established institutions and processes into which recommended programs must fit. The Council's principle role, then, is in suggesting seismic safety policies, organizational structures, and needed authorities--legislation, ordinances, and executive orders--which fit Utah's institutions and procedures.

Third, the Council's "clientelle" is the people of the State of Utah--the policy makers, the line agencies of government, the designers and developers, and the general, lay public. Not only must the Utah Council know the impact upon and the ramifications of recommended seismic safety policies upon this "clientelle," it also must explain the benefits of the recommended policies and be persuasive as to the merits of the policies.

Given this context, the scope and purposes of the Council's communications are clarified. And, a basis is furnished for reviewing the communications activities of the past and future.

One of the first communications activities undertaken by the Council was widespread distribution of a brochure describing the purposes and activities of the newly formed agency. We believed that it was essential to our future work to develop a general Statewide awareness of the Council's existence and legislative charge. The brochure was distributed to all governmental units in Utah, to all known policy-makers, to line agency personnel whose responsibilities might involve some aspect of seismic safety, and on a more limited basis to elements of the private sector having some work relationship with seismic safety issues. One additional consideration when the brochure distribution was conceived was that it might facilitate our future contacts with particular individuals whose assistance or participation we might seek. Another consideration was that the brochure would serve as notification that the Council will be developing recommendations which could affect State and local government programs as well as activities in the private sector, such as building design and construction, land development, and real estate.

The Council also has commenced circulation of proposed policy recommendations. The intent of these materials is to elicit comment and reaction in order to determine the acceptability of the recommendations at the user levels.

The Council staff currently is developing detailed evaluations of several seismic safety issues indicated in the work program (Figure 2). These evaluations include assessment of the particular seismic-related hazards in Utah, the current practices in the State which may or may not address the issue, and possible alternatives for reducing the particular risks resulting from the hazard. We have not yet completed any of these issue evaluations. One by one, they will be done over the next three years.

An example of the procedures being followed in the detailed evaluations of particular issues is seismic safety of school buildings. There are two aspects of this issue -- new school construction and existing school buildings. With respect to new school construction, our inquiries and investigations to date have revealed some serious shortcomings in the design-construction process if new schools are to have some degree of earthquake resistance beyond ordinary construction practices.

Authority for school construction in Utah is vested jointly between the local school district and the State Board of Education. Local communities are precluded by law from exercising any control over construction standards. The current Utah Code gives the State Board of Education authority to review and approve plans for new schools, and further prescribes that such reviews show compliance with construction standards as established by the State Building Board. The State Building Board subscribes to the Uniform Building Code, but there is no State building code. The Utah Code is garbled with respect to inspection of construction which is underway. Code language states only that educational functions need be inspected, and poor wording in that section of the Code assigns no responsibility for inspection of the construction.

In actual practice, the construction plan review process by the State Board of Education focusses principally upon educational functions and space requirements--the "educational specification" aspects. The State Building Board staff states that construction plan review is provided only for those school buildings which involve State construction funds--and in Utah that is not a very large portion of the new schools. Of course, the local school districts rely most heavily upon their architects and engineers for construction standards. School district review of construction plans for new buildings is carried out only by the few larger districts which can afford to employ qualified staff.

The conclusion at which the Council is arriving is that the construction process for new schools in Utah lacks sufficient organization to assure that seismic safety is achieved. Moreover, current statutes are sufficiently vague on seismic safety that the issue can be avoided by the local school district. It appears that permissive statutory authority is inadequate for a successful seismic safety program.

What will the Utah Seismic Safety Advisory Council do with this particular issue? First of all, we need to make known the findings as described above. We do not believe the current procedures and practices for school construction are well known or understood throughout the State. A careful documentation of current procedures seems needed. After that, a well-written summary of findings must be prepared and circulated. Finally, we also must suggest remedial actions in the form of policies and programs. We hope the process will be pursuasive and that improved seismic safety can be assured for new school construction--but that is a decision that the policy-makers of the State must make.

The Utah Council has not yet explored the use of public dialog in newspapers, radio, and TV for informing the public about our work, findings, and policy recommendations. In Utah we currently have a press interested in earthquake safety, and we therefore have taken opportunities to furnish feature stories. These have not been prepared or released in any organized way to date, however. It is evident to us that more needs to be done to utilize this medium of communication. Our strategies for doing so have yet to be mapped.

Getting The Information To Users. Finally, one aspect of the communications process merits a few comments. During its brief period of operation, the

Council has identified numerous technical papers and reports on earthquakes, several of which focus on conditions in Utah. We therefore are a bit surprised to find the lack of awareness among governmental and other institutional organizations in the State that these studies exist. Many of the documents can be of great help in matters of seismic safety. This deficiency has caused us to reflect upon why this lack of awareness exists. Three possible reasons are suggested: (1) there may be a prevalent disinterest in seismicity among those who might use the information; (2) the technical documents may not have been circulated widely enough; or (3) the technical documents may be written in a way that non-technical and quasi-technical users simply cannot comprehend them, whereupon the documents are set aside, unused, and eventually lost in piles of other papers.

Of the three possible reasons suggested above, it is my view that the second and third are the cause of the noted lack of awareness. The question then arises: What can be done about this? I suggest two things for us in Utah. First, we must develop a Statewide earthquake information system and procedures to circulate earthquake-related information to potential users. Since most reports and documents are somewhat specialized, these can be directed to those people, organizations, and governmental units whose work and activities may relate to the particular document. Second, we must find a way to distill technical reports into briefer, more-readable, better-illustrated booklets. I suggest that this is an appropriate activity for the organization which generates the technical report or the agency which sponsors the report. Much is to be gained by supplementing the research effort with the additional resources necessary to prepare the kind of summary final documents that have been described.

SUMMARY

Information transfer has a purpose, and this purpose must be a fundamental determinant of the medium and method of the communication if the communication is to be effective.

The purposes of the Utah Seismic Safety Advisory Council in communicating earthquake information is to broaden and deepen public understanding of earthquake hazards and alternatives for reducing the risks associated with these hazards. Although the focal user group of earthquake hazards information from the Utah Council comprises policy-makers at the State and local government levels, advisors to the policy-makers, and special-interest groups having influence among the policy-makers also must be informed of the seismic hazards and alternatives for correcting particular risk situations.

The Utah Seismic Safety Advisory Council, which was established by legislative action in 1977, is charged to recommend a seismic safety policy for Utah, to recommend programs for earthquake hazards reduction, and to advise the Governor and Legislature on seismic safety matters. Implementation of recommendations made by the Council is not included in its statutory charter. Implementation of seismic safety programs will require legislative or executive acceptance, and this, in turn, requires that the Council state its recommendations concisely, accurately, and persuasively so as to achieve the needed public support.

With strong legislative and administrative support, the Utah Council has been provided the needed resources to carry out its charge. However, Council success in its work ultimately will be measured in terms of hazards reduction programs which are implemented. The Council therefore is challenged to engender the public support needed to assure program implementation, and this will be achieved largely through successful communication of its hazards assessments and risk-reduction recommendations.

Information transfer to achieve these goals will need to be tailored to several interest and technical competencies among the user groups. As well, the habits of various users regarding information assimilation must be recognized so that the communications are received and understood. Policy-makers need concise, easily read,summary documents; whereas their advisors and special-interest groups more often are concerned with technical content. The Utah Council must be sensitive to these differences among users and must prepare its communications accordingly.

Finally, the Utah Council has an additional important role. It must take actions to assure that available earthquake-related information is, in fact, communicated to the people of the State. Much information developed in past years which would be helpful in decision-making processes both in government and the private sector has not been utilized. Whatever the reasons may be for this underutilization of the information, the Council must work to identify and overcome the problems.

Public policy aspects of earthquake hazards reduction offer a challenging work arena, at times fascinating and at other times frustrating. The challenges are found in combining technical knowledge with practical applications. The frustrations occur in blending diverse views and special interests into programs which are politically acceptable, since compromises from ideal solutions inevitably must be made. It is this aspect of seismic safety planning which is so dependent upon communications and which therefore creates a need for including communications as an integral part of earthquake hazards reduction public policy development. It should be most enlightening to review the Utah Seismic Safety Advisory Council's work, successes, and failures from this perspective at the end of its four-year period.

Figure 1

ORGANIZATIONAL RELATIONSHIPS OF THE

UTAH SEISMIC SAFETY ADVISORY COUNCIL IN STATE GOVERNMENT

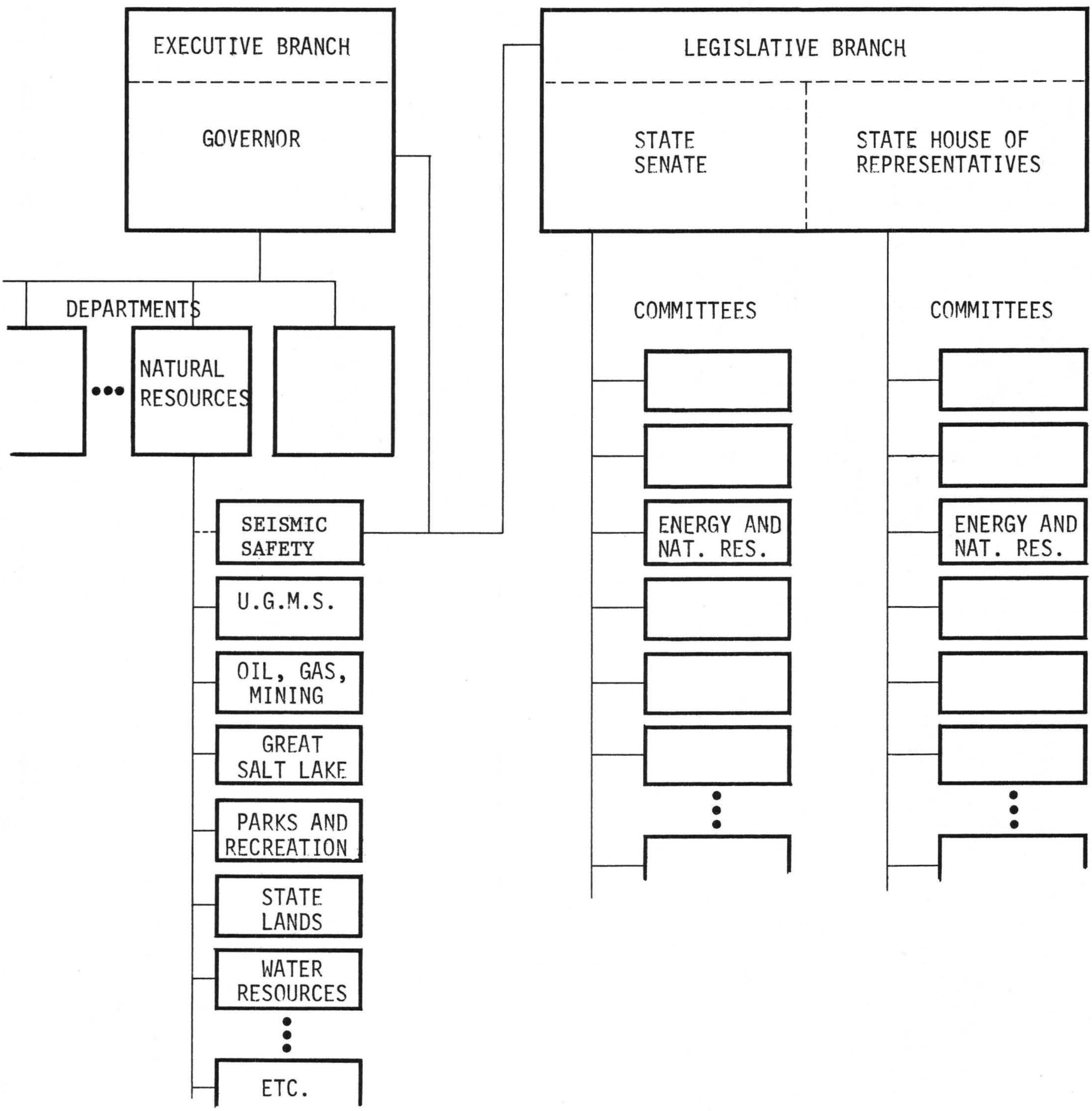
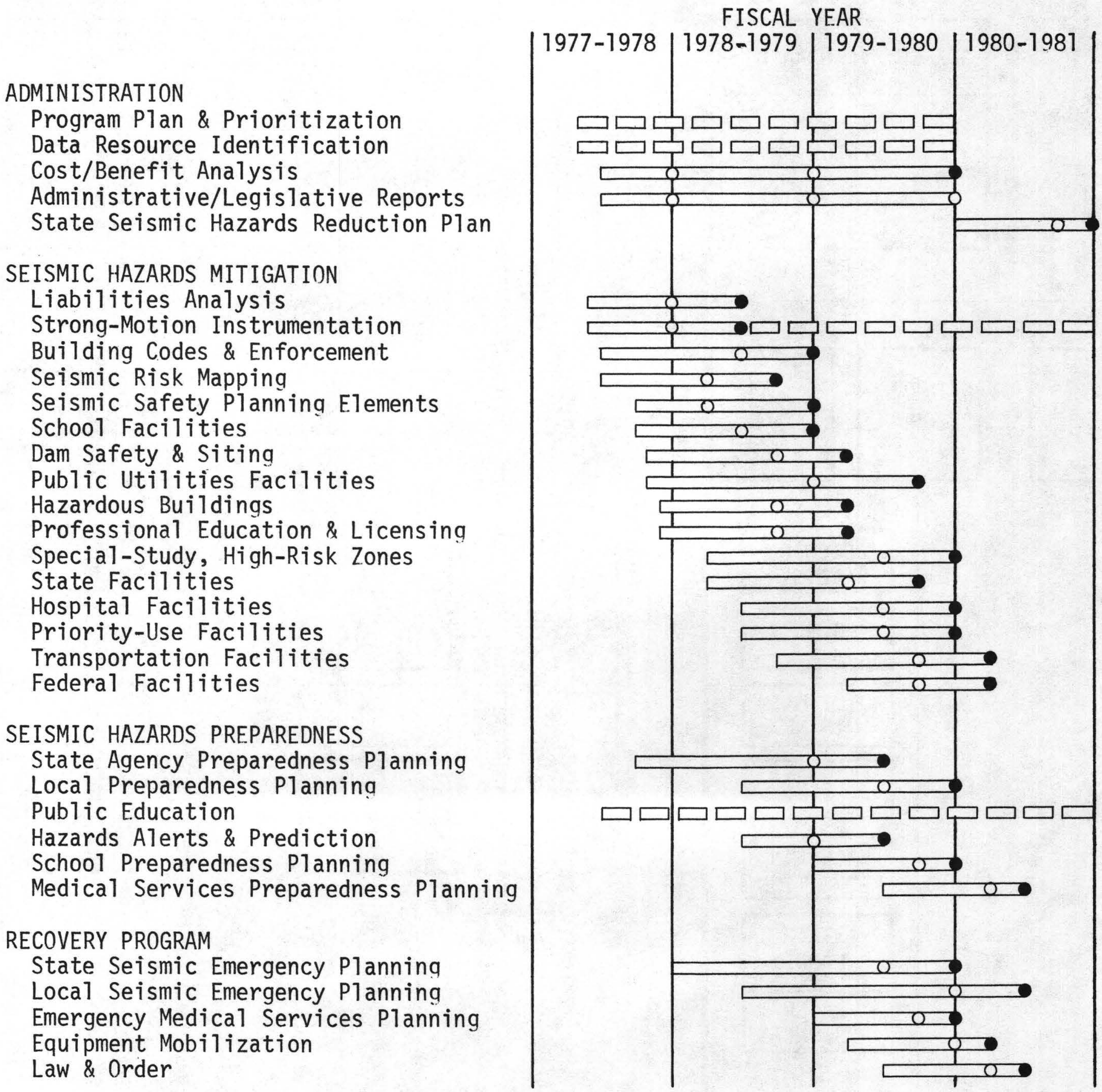


Figure 2

UTAH SEISMIC SAFETY ADVISORY COUNCIL

SEISMIC SAFETY ISSUES AND FOUR-YEAR WORK PLAN



○ Denotes study report.
● Denotes recommendations.
▭▭ Denotes continuing effort.

LEGIS - an example of a computerized method for communicating information.

By John K. Swearingen*

SUMMARY

The Congressional Legislative Information and Status System (LEGIS) is an automated information system presently being developed by the staff of the Senate, the House of Representatives and the Library of Congress. As a new source of information services it represents the joint development of a legislative information and tracking system which will provide status content summary and cross reference information on all official activities of the Congress.

The need for LEGIS was established during a series of interviews with Senators, Congressman and their office and committee staffs. These interviews occurred within the last two years and provided the data necessary for formulating specific user information requirements.

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* Technical Services Committee, U.S. Senate

Thousands of bills and resolutions are introduced in Congress each year but only several hundred bills complete the legislative process and are signed into law by the President. For those concerned with legislation it is necessary to identify all bills that bear on an area of interest and to know their present status and content. Status in this context includes committee and subcommittee actions such as scheduling hearings, markup sessions and final consideration. Content of the original measures can be changed by amendment of one word, whole paragraphs or substitution of the entire wording by another measure. After completion of committee action the measure is then subject to similar status actions and content modifications by the entire Senate.

A significant feature of the development phase of LEGIS is the sharing of programming effort among the staff of the Senate, the House of Representatives and the Library of Congress. This reduces the technical resources required of each of the three organizations. Sharing of data is another important aspect of LEGIS. Officials and staff of the House and Senate will fully validate their respective information for all categories of transactions; whereupon each House will transmit this data to the other house for use in maintaining its own LEGIS data base of both Senate and House actions. Similarly the Library of Congress will transmit subject and other indexing terms together with official titles of measures for updating the Senate and House LEGIS files. Data required by the Library of Congress files which is keyboarded by Senate sources will be transmitted to the library of Congress. Timeliness and the elimination of duplication of data preparation will be two added benefits to this sharing of data.

Legis was designed as a user-oriented system which demanded provision of a wide variety of outputs depending on the users' need. The dissemination process provides a mechanism for making meaningful output data readily available to the user. From the beginning it was planned that the information would be accessible through a network of user terminals installed in all senate offices.

Development of LEGIS was planned in an incremental fashion. Two versions of LEGIS were planned. Version I includes detailed status information on the major provisions of bills and resolutions and their amendments. It is accessible on Senate terminals under a Library of Congress' data retrieval program called SCORPIO.

In the final version, the LEGIS data base will contain status, content and cross referenced information on the major provisions of all legislation. It will also record comparable information on floor amendments and to a lesser degree, committee and conference amendments.

Other categories of official Congressional activity will also be recorded in Version II of LEGIS. These include treaties, nominations, petitions, memorials, Presidential messages, Executive messages and communications, Legislative Review, Committee investigations, and oversight hearings.

LEGIS data is entered on a timely basis at entry points located off the floor of the Senate and in all Senate Committees. All data for the Legis system is entered by official clerks of the Senate during the normal course of the work day. As the knowledgable Legislative experts, their responsibility for the accuracy and completeness of this information will ensure the quality of the LEGIS data base. Errors, omissions, and misleading information are corrected for the system through a revision of the status steps, reprogramming of edit criteria and systematic review by Senate staff.

The LEGIS programming effort is shared between the House and Senate. Both staffs were required to dedicate up to 10 individuals for peak periods during the development effort. The development and implementation of procedures, selection and procurement of hardware, design modification of facilities and conversion of data for manual files, was planned jointly, but was carried out by each individual organization. To achieve economies the primary responsibility for design, programming, testing and integrating software modules that would be used jointly, was assigned either to the House or to the Senate. Unique capabilities required either by the House or Senate were developed independently by the respective house.

LEGIS is being implemented in two major versions. Version I, operational in 1977 included the development of data entry and data base maintenance subsystems, and the conversion of the status data on bills and resolutions. Terminals were installed and user training began for information retrieval of bills and resolutions. User training and data entry and other system functions was also conducted in 1977. User training in 1977 was limited to a pilot group consisting of 10 Senators' offices and two committee offices. When the Version I data base was determined to be complete and accurate and the Scorpio retrieval program fully de-bugged by the pilot test the system was opened to all Senate users and is now being installed in additional offices.

Version II is near completion and will be installed with an enhanced version of the Scorpio retrieval program during 1978.

Comments

The following comments are in response to specific points in the outline for the workshop.

I.A. People, Activity and Strategies

1. The motivation for the activity was the need to provide Senate staff with comprehensive and up to date information on the status of all legislation.

2. The development which is still underway has occurred over a two year period. The first version is complete and in use - the expanded system is in the programming stage.

3. The objectives can be stated in several terms. In terms of quality it was to be of such high quality that it could become the official record. In terms of timeliness, all files were to be completely updated as of the beginning of each work day and some updates were to take place during the day in which they occurred. In terms of distribution the data was to be distributed on the widest basis to the most users possible.

4. The strategy for accomplishing the objective was to engage in a joint effort with the House of Representatives' computer staff and with support in certain areas by the Library of Congress' computer staff to minimize development effort and to assure compatible data from the House.

5. In the Senate, 20 Committees and the Secretary of the Senate are the suppliers of information. It is the responsibility of each to report on a timely basis the actions affecting legislation that took place in their committee or responsibility area.

6. Among the issues to be resolved were some acceptability factors. The computer processes had to be adapted to existing Senate procedures. Senate rules and procedures have evolved over the two hundred year history of the Senate, drastic change to ease the programming effort would not be accepted.

7. Critical issues were resolved by placing project management in the Rules and Administration Committee which is responsible for the rules of the Senate and for administration of services of the Senate. An active dialogue was maintained during the entire process between the project manager and all key data suppliers.

II.A. Relationships of People and Activity

1. Requirements for information were specified for three classes of users. The first class was the Secretary of the Senate who is responsible for the official records of the Senate and who supplies more data than any other. The second class of users were the committees who were responsible for reporting information as it developed in their committees and who were counted as prospective heavy users of all other information. And finally the third class were the 100 Senators' offices who had a need for all of the information in the system but who supply no information.

2. Two way communication with users was accomplished by several general indoctrination meetings open to all prospective users and project review sessions limited to those persons who were crucial to the success of the program.

3. The focal point during development was the project manager from the Rules Committee. In actual use the computer becomes the focal point for the terminals in user offices.

4. The public media was not used.

5. The existing channels for communicating information were used but with some modification. The sources of information remain the same, however, reporting procedure was changed to use a computer terminal to input the information into the computer data base.

6. There was an intermediary or translator between producers and users. During the development stage the Rules Committee project manager filled that role. In actual use a training staff instructs users in the computer access methods. Because the users are very familiar with the information, training covers only the manipulation of the computer terminal.

II.B. Performance Evaluation

1. Information is supplied to the data base in a timely manner, when the actual user retrieves it is a matter of when the user decides there is a need to access the information. The information is of high quality because it is supplied by the persons who are responsible for it. Furthermore it is continually reviewed and critiqued by users who are familiar with some part of the data and are capable of spotting errors or omissions and will promptly report them to the supplier of the data who is responsible for making the correction. During the pilot test the training staff circulated to all pilot users, critique and error forms on which users were to note any errors or omissions. These were collected on a daily basis and forwarded to the data suppliers for correction of files.

2. The communication was monitored for the aforementioned pilot offices who were kept in close contact with the training staff during the pilot period. The strengths and weaknesses of the information process were determined by survey of the pilot user offices. The critique and error sheets contained space for comments and the training staff continually evaluated the critiques.

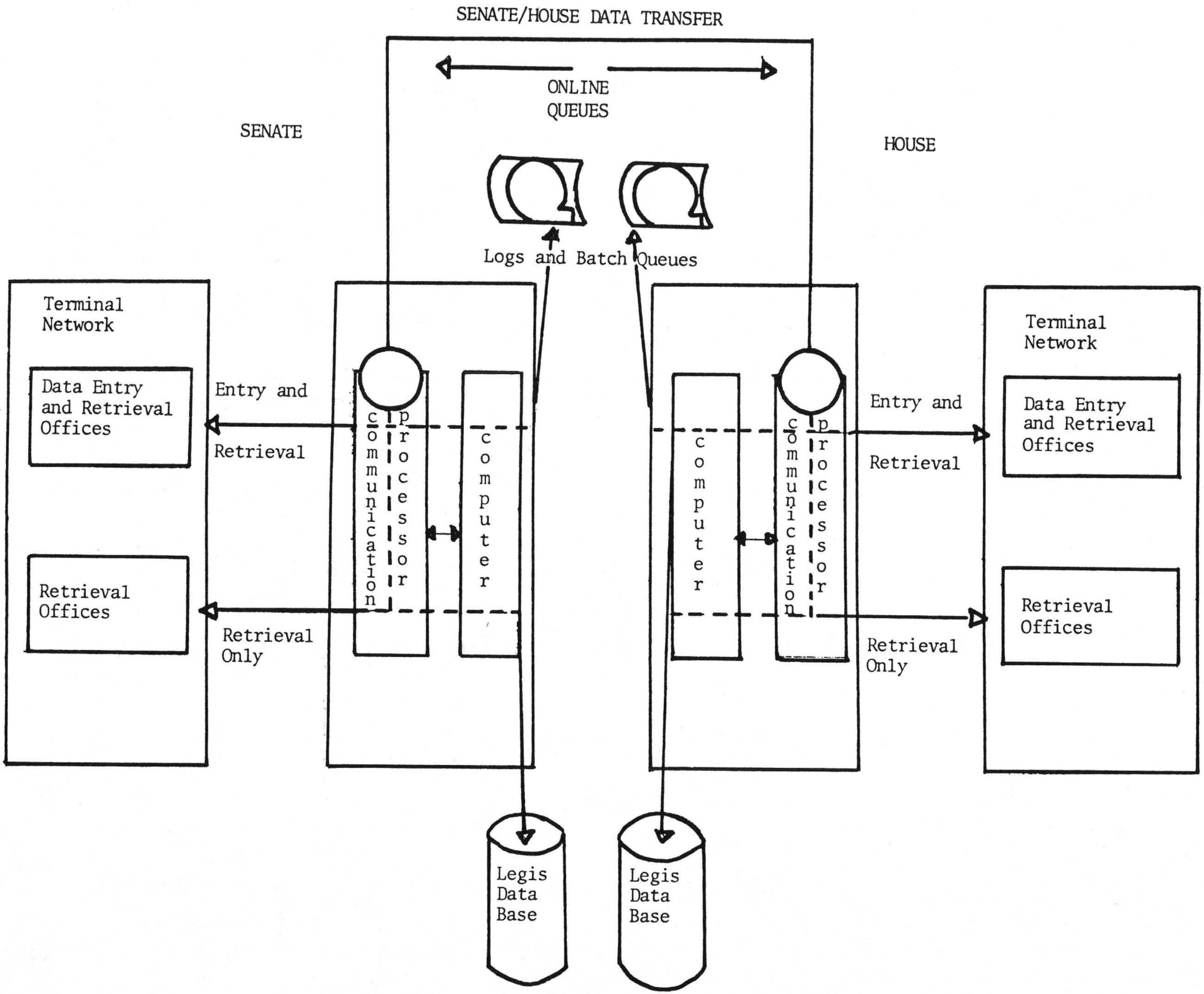
3. Strength: the data base gathers in a single location information that previously was scattered. Consolidation revealed some missing elements that were easily added making the new data base richer in content. Weakness: It is dependent on a number of sources for input, some of these sources can be delinquent in reporting without any notice, therefore it cannot be assumed that all status reported is truly the most current status.

4. The first version of LEGIS was made available to a limited number of users as a pilot to qualify the data and to test the data access system. As soon as the data base was complete and accurate and the access method fully debugged, users were added with the intention of accessibility of all Senate offices by the end of 1978.

5. We are continuing to learn from this experience in a number of areas. First, unless data is subjected to continuous scrutiny, errors will creep in to erode the quality and possibly cause errors in related data. Secondly, training for all levels of suppliers and users must be a continual process.

6. Senators are continually faced with the need to decide how to vote on minor amendments to legislation, amendments that are not always clear in their purpose and impact on the major issue and that are introduced with little advance notice. LEGIS provides all Senators with the same information at the time it is announced by the proposer so that Senators have more time and more information on which to make their decisions.

7. It is hard to say whether legislation resulted since the whole function is legislation. Legislation is being produced by people who have a better understanding of it and therefore it should be more thoughtful and better aimed legislation.


SENATE/HOUSE DATA TRANSFER
ONLINE QUEUES
SENATE
HOUSE
Logs and Batch Queues
Terminal Network
Data Entry and Retrieval Offices
Retrieval Offices
Entry and Retrieval
Retrieval Only
communication processor
computer
Terminal Network
Data Entry and Retrieval Offices
Retrieval Offices
Entry and Retrieval
Retrieval Only
computer
communication processor
Legis Data Base
Legis Data Base

SUMMARY OF LESSONS LEARNED

THE SENDER MUST NOT ASSUME THAT THE RECEIVER UNDERSTANDS THE MESSAGE.

THE RECEIVER MUST NOT ASSUME THAT HE KNOWS WHAT THE SENDER IS SAYING IF RELEVANT ITEMS ARE NOT COVERED.

THINGS ARE PERCEIVED DIFFERENTLY BY PEOPLE WITH DIFFERENT VIEWPOINTS.

THE MEANING OF A PARTICULAR WORD IS NOT THE SAME FOR EVERYBODY.

GOOD COMMUNICATIONS REQUIRE A CONTINUING EFFORT.

EFFECTIVE COMMUNICATIONS REQUIRE FEEDBACK.

BE HUMAN IN DEALING WITH HUMANS.

THE EARTHQUAKE ENGINEERING RESEARCH INSTITUTE PROGRAM ON INFORMATION DISSEMINATION

by M. S. Agbabian*

INTRODUCTION

The Earthquake Engineering Research Institute (EERI) has successfully completed the preparation and presentation of three regional seminars on the subject "Earthquake Design Criteria, Structural Performance and Strong Motion Records." More than 600 professional engineers and scientists attended these seminars in Washington, D.C., Chicago, and Seattle. The National Science Foundation provided partial financial support.

The principal accomplishment of these seminars was to present the state of the art to practicing engineers and building officials at a practical and usable level. Emphasis was placed on the needs of the region where the seminar was held. The regional geology and seismicity was defined, and the requirements for designing earthquake resistant structures were explained.

Dissemination of information at the practical level is one of EERI's principal missions. These seminars accomplished this goal.

It is now planned to continue these seminars and to expand the scope of the technology utilization plan. The expanded scope includes the preparation of monographs and videotapes that will reach engineers and scientists who may not have the opportunity to attend the seminars. Three interrelated activities are now in the planning stages:

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*Chairman, Continuing Education Committee, EERI

Presentation of Seminars

Preparation of Monographs

Videotaping of Lectures

The seminars, monographs, and videotaped lectures are being designed for practicing engineers and government officials who wish to enhance their ability to evaluate and resolve earthquake engineering problems. They will provide in capsule form the important areas of recent progress and the procedures for utilization of earthquake engineering technology.

<u>SEMINARS</u>

The seminars will consist of a series of lectures by engineers and scientists distinguished by their contributions in various areas of seismology, geophysics, and earthquake engineering. Attention will be focused on engineering rather than seismological aspects of strong motion data acquisition and utilization in design. Regional problems of earthquake design criteria and performance of structures will be emphasized.

EERI considers the entire United States and its territories as the scope of its outreach. Seminars are being planned for St. Louis, Missouri; Houston, Texas (with emphasis on offshore facilities in seismic areas); and Puerto Rico. Additional seminars are also being considered for Boston, Memphis, and a return presentation in California where the idea of these seminars was first tried out successfully.

Seminar topics include the following:

1. Experience with Earthquakes
2. Regional Geology and Seismicity

3. Introduction to Structural Dynamics
4. Seismic Design Procedures and Criteria
5. Correlation of Ground Motion with Damage
6. Strong Motion Instruments, Stations, and Networks
7. Reading of Records and Data Processing
8. Understanding and Predicting Soil Behavior
9. Soil-Structure Interaction for Buildings
10. Understanding and Predicting Structural Behavior
11. Behavior of New and Old Existing Buildings
12. Learning from Earthquakes

MONOGRAPHS

It became clear from our experience with the previous seminars that the attendees should have a more permanent and usable reference than just the copies of the slides that the lecturers had used. It is now proposed that a series of monographs be prepared in advance of these seminars. These monographs will have educational material that is not available in the published literature. (The published literature consists of a few textbooks, numerous technical reports, and journal papers.) These proposed monographs will be utilization-oriented and will provide the reader with state-of-the-art information, in usable form, on the principal topics covered by the seminars. The monographs will also reach a much larger readership through the general resources of EERI.

It is planned that when the complete set of monographs is issued, the practicing engineer and building official will have for reference a comprehensive treatment of earthquake hazard mitigation technology. Monograph topics are not identical with seminar lecture topics, because in their total coverage they will be more comprehensive than the seminar lectures.

Individual topics representative of the monograph series are:

1. Regional Geology and Seismicity of the United States
2. Introduction to Structural Dynamics
3. Reading of Records and Data Processing
4. Understanding and Predicting Soil Behavior
5. Effects of Soil-Structure Interaction
6. Seismic Design Spectra for Buildings, Based on Inelastic Behavior
7. Earthquake Design Criteria for Structures
8. Seismic Design Procedures.

VIDEOTAPING OF LECTURES

Small groups of engineers at consulting engineering firms and architect-engineer firms, and graduate students and faculty at universities can benefit from the lectures presented at the Regional Seminars. These small groups will be able to make arrangements with EERI to receive the videotaped lectures for use at a time and place of their choosing. In order to accomplish this, it is planned to organize another seminar in a California institution where lecture rooms are equipped with videotaping facilities. Some of these institutions broadcast the lecture through a closed-circuit TV system to classrooms outside the campus. Thus, a live audience of engineers and graduate students will have the opportunity to attend, while the lectures are being videotaped.

SCHEDULE

Discussions with regional groups have set tentatively the period October 1978 to February 1979 as the time for the next series of seminars. Some of the monographs are already under preparation.

IMPLEMENTATION PLAN

Regional coordinators will be appointed for each region where the seminars are scheduled. These coordinators will be EERI members who are well informed about seismic hazards and risks of their region. They will participate in the planning of the seminars.

An advisory committee consisting of members of the Continuing Education Committee of EERI will review the program from time to time and advise the coordinators. The Committee members consist of representatives from the East Coast, the Midwest, the Pacific Northwest and California.

The lecturers and authors of monographs are all distinguished in their fields and enjoy an international reputation for their contributions to earthquake hazard mitigation technology. They have a thorough knowledge of the methods for dissemination of information on the state of the art in earthquake engineering technology.

THE CONNECTICUT DEPARTMENT OF ENVIRONMENTAL PROTECTION, NATURAL RESOURCES CENTER'S EXPERIENCES IN COMMUNICATING NATURAL RESOURCE INFORMATION TO THE LAND USE DECISION MAKERS OF THE STATE

by
Richard C. Hyde*

The Natural Resources Center of the Connecticut Department of Environmental Protection is charged with producing and collating the natural resource baseline data needed to make better air, water, and land use decisions. It is designed to serve the environmental needs of units within the Department, as well as other state and local agencies, by centralizing natural resource information collected in the past, coordinating existing data collection programs; and developing understandable data formats, usable decision making systems, and educational outreach programs.

After much trial and error, an informational communication system and educational process has evolved which utilizes several approaches that appears to work well in Connecticut although we still strive for improvement. This system utilizes the use of a multidisciplinary technical staff capable of gathering, interpreting, integrating, and disseminating data. Connecticut is fortunate in that resource inventory programs have had strong state support during the past twenty years leaving us with a great deal of information to assist, when used, to make better land use decisions.

The principle aim of our program is to provide the natural resource information and decision approaches to state and local agency people in order for them to make more informed decisions pertaining to land use. The foundation of this program sits on the wide range of completed or nearly completed systematic inventories which include topography, surficial geology, bedrock geology, water resources, soils along with some less systematic biological and miscellaneous natural resource data inventories.

To function in an orderly manner, the Natural Resources Center is divided into three distinct units, although an interchange of activities between units by the multidisciplinary staff occurs by design.

(1) The Geological and Natural History Survey is responsible for the aspects of basic data collection, collation, and scientific interpretation. These inventories include, as previously stated, studies in earth material (including topography,

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bedrock geology, surficial geology, and soil), hydrology, biology, and atmospherics. Presently, all data and map information is stored manually but we are experimenting with its storage, retrieval, and manipulation through two computer digitation techniques.

(2) The Long-Range Water Resources Management Planning Unit provides the lead effort for the Connecticut Department of Environmental Protection in the Connecticut Long-Range Water Resources Planning Process. The prime objective is to integrate all water resources oriented programs into this planning process and to develop a comprehensive water and related land use resource management program.

Comprehensive water resources management planning involves natural hydrologic systems and the socio-economic demands placed upon these natural systems. For water resources planning purposes, the natural hydrologic system can best be expressed in terms of the elements of the hydrologic cycle within each of Connecticut's drainage basins. Presently each ± 20 square mile third-order drainage basin is being inventoried and the information computerized for resource base, location of sanitary landfills, permitted point water pollution sources, known incidents of ground water contamination, salt piles, septage lagoons, sewage treatment plants, monitoring stations; including (stream gages, water quality sites, precipitation stations, ground water level wells, crest stage recorders, seismic stations), potential ground water aquifers, water supply wells, etc.

(3) The Resource Assistance and Data Dissemination Unit is responsible for developing programs which respond to the user's needs of natural resource information and to promote its use in long-range planning and land use decision making. The principle objective of this effort is to disseminate to environmental and land use decision makers technical information on natural resources distribution, processes, functional roles, and management alternatives in formats most suited to the needs and understanding of the specific decision making group.

To accomplish this job and to meet the needs of a wide variety of users of differing degrees of sophistication, it has become necessary to formulate and undertake numerous activities aimed at the public and private sectors. These activities are designed to raise the general awareness of the services and subject matter available on natural resources in Connecticut and to train and educate such persons on the proper use of resource information in the decision making process.

(a) In terms of increasing general awareness of resource information availability, the Center publishes annually three documents which have become very popular with land use decision makers. Distribution is geared to specific target groups but this may vary with the individual's needs.

(1) The annual Natural Resources Information Directory is prepared for each municipality and distributed to all 169 chief administrative officers, conservation, planning, zoning, and wetlands commissions in Connecticut. This summary is intended to keep the town agencies abreast of the various types of natural resources data that are available for their town and to identify the sources responsible for collecting the data or have expertise concerning the data. The regional planning agencies, soil and water conservation districts, regional Department of Environmental Protection offices, and similar agencies also receive copies of these directories.

(2) The Natural Resources Information Directory, Connecticut is aimed at state agencies, regional groups, private consulting firms and businesses needing ready access to the availability of data on a statewide basis. It is similar to the town directory in that it lists the type of published and open-filed data, the sources responsible for the data collection, along with a brief description and its use.

(3) The List of Publications is prepared periodically for the academic community and certain consulting and regional agencies interested in the scientific literature of the Connecticut Geological and Natural History Survey. All three documents have become very popular with groups and individuals concerned with land use decision making and essentially they have become the initial reference for most of the work in the field.

As backup for the reference lists, the Center maintains a working reference library in our central office which is open to the public. The library mainly attracts state and regional agency people and private consultants but we also periodically deal with town commissions or local planning staff who utilize the maps, reports, and aerial photos to work on town master plan revisions.

(b) A strong technical assistance program has been developed to compliment the data dissemination and library aspects. The nature of the multidisciplinary expertise and skills of the Center staff provide an opportunity to promote the use of the data and to respond to specific requests for special assistance beyond that which may be available by the permanent staff of the regulatory or management units in the Department. Such special assistance is supportive of the unit staff effort for resource data acquisition and interpretation, while the regulatory or management process itself is conducted by the staff of the requesting unit. When appropriate, special technical assistance is given to other state agencies and municipalities for the formulation of project study designs and preliminary environmental appraisals dealing with the natural resource systems.

Another form of technical assistance offered to the communities is the concept of a multidisciplinary review of site proposals for a given land use. This approach is well established as a workable technique for improved land use decision making. The Environmental Review Team provides a unique and innovative cost-free service to local municipalities and private developers. By utilizing a team of professionals in the fields of natural resources, engineering, and planning, a proposed development is objectively reviewed with respect to its natural resource base, the probable effects of the natural resources on the project, and the potential impact of the project on the environment. Recommendations for utilizing opportunities on the site and avoiding or minimizing any negative impacts are given. This information is then provided to the town and the land owner or developer, in a format which can be used in producing better development plans as well as providing more complete information to aid in the local decision making process.

In the past, land use decisions were often based primarily on social, economic and political considerations, with little thought as to the land's capacity for accepting specific uses. A site review of the proposed property by the team and local officials allows for an active interchange of ideas, discussions and visual observations to occur. The results provide the town with an impartial view of the site conditions from expertise it is not able to obtain locally or from its existing staff as well as exposing the local decision maker to new ideas and methodologies. This process increases the efficiency within the overall framework of local decision making. Long-term benefits are also accrued through this process to public and private sectors in the form of fewer regulatory actions being required and the reduction in costs for corrective measures.

In our experience we have found when any of these technical assistance services are offered and the user feels he has gained from the experience repeat requests follow, allowing additional opportunities to educate the users on the benefits of including environmental information into the planning and decision making process. On the state level and recently on the local level, this approach has resulted in user agencies developing their own technical staff to meet daily needs for determining resource carrying capacities in land use decisions.

(c) Since most land use decisions are made on the local level of government, an on-going user training program has been established in the form of workshops and seminars for municipal agents. One such workshop series, conducted in conjunction with the University of Connecticut Cooperative Extension Service, offered four two-and-a-half hour sessions spaced one month apart to each municipality. During a three-year period, 142 of the 169 towns participated in these workshops. The municipal workshop series, entitled <u>Use of Natural Resource Data By Municipal Land Use Decision Makers</u>, exposed the local agents to the resource data available for their community, to the techniques of making selected single-topic derivative maps, and to the process of making first-cut site decisions and community master plans based on resource conditions. Other special topic workshops are conducted as interest warrents on such areas as septic system installations, wetlands, land conservation, watershed management, and flood control. Manuals and videotape presentations have been prepared in conjunction with the training programs. The workshop format and content has been extensively evaluated at the municipal level, and another major series is now being offered which reflects user response to their needs and level of informational understanding. The new series is a course consisting of five evening sessions and three all-day Saturday field trips. The course stresses the need for understanding the natural processes we live within and that man's activities should take into consideration natural processes in order to minimize costly, long-term negative impacts. The idea that the natural land surface drainage basin is the smallest, completely self-contained resource system capable of management is promoted and that development impact considerations cannot end at political and site boundaries. The Department is currently completing state-wide coverage of drainage area maps at 1:24,000 scale and developing drainage management systems for local use. Other topics covered in the course include: methodologies for evaluating land use proposals, legalities of land use decisions, the study of specific case examples and communication procedures between community agencies and adjacent towns.

In conclusion, any program that attempts to develop a constituency, whether it be for the incorporation of natural resource data in making land use decisions or for making use of earthquake hazard reduction information, must exercise every available avenue and reasonable communication technique to get the word out. Only through a persistent long-term informational and educational outreach approach can the user's general awareness and knowledge be expected to rise to an implementation level incorporating the concept into the routine decision making pattern.

How to Improve Communication on Earthquake Hazard Reduction

by

Howard Kaplan[1]

First, remember that you are trying to send information to people who usually do not have extensive scientific background or understanding. You must make a serious, sustained effort at presenting your information in clear, concise and simple language which can be passed along through intermediaries in our two major forms of media: (A) electronic, meaning both radio and television and (B) print, meaning daily, weekly and semi-weekly newspapers; weekly or monthly magazines and other time-oriented publications.

Second, you must be completely honest--even at the risk of upsetting bureaucratic levels above you in the ladder of GS numbers. If you do NOT know the answer to a reporter's question, say so. There's no stigma attached to not knowing everything. Above all, DON'T FAKE IT. Misrepresentation is the quickest road to losing your credibility because reporters talk to other reporters.

Third, if an error is found, OWN UP TO IT as quickly as possible and re-contact your media representatives to correct the misinformation. Again, there is no reflection on your INTEGRITY if you make a quick, sincere effort to replace incorrect information or data with accurate information. The rule of thumb of the Associated Press was "Get if first--but FIRST get it RIGHT!" Incorrect information, although it may be disseminated inadvertently, can lead to outright panic in some situations. And when the subject is earthquake hazard reduction, everyone must try to get it right the first time. That means you are obligated to make certain you have not been misunderstood by your media contacts.

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Establish lines of communication before any emergency and keep all your sources fully informed even with the most routine data. You should determine whether (a) your facility is covered on a regular basis by both print and electronic newspersons and (b) who they are. You should acquaint yourselves with your local city editors, news editors and assignments editors (usually in the electronic media). If there are specialists, such as reporters who cover ONLY government agencies or scientific achievements, familiarize yourself with them. Know how to reach them in both an emergency and non-emergency situation.

Determine your most reliable sources in urban and suburban areas. Ascertain which is the most efficient, most effective and most informative method of communicating. Is it a press conference, where reporters can participate in a give-and-take? A film which can be utilized by television stations as a public service help? An informal chat or interview which can serve a radio audience? (Sometimes the audio interview portion from a TV appearance can be used on radio as well).

Try to learn what the public wants to know. In this subject area, of course, we will want to know "Will an earthquake happen here?" If so how? Why? When? Where? What can be done to prevent it? To blunt its destructive force? To recover quickly form its effects? Take a few moments to consider some of the questions you want to answer in your scientific evaluation, and you can rest assured they probably will match, in great measure, those of reporters and the public.

The difficult part of communicating information on hazardous events such as earthquakes is "What should the public know?" Your primary chore here is to dispel myths and legends! Remember that newsmen (and women!) have been reared in United States homes and educated in United States schools so they learn and believe the same myths and legends as does everyone else in our society. Maybe ALL of them don't, but a good number do. Act accordingly.

It takes courage to be different, in the United States as elsewhere. It is a lot easier and more natural to conform. It is also pleasant to back a winner and an unhappy experience to be persecuted as a member of an unpopular minority. But it is nearly "fatal" for a news source to happen to be too superior to those whom you wish to (a) lead or (b) whose favor and/or support you wish to obtain.

Remember: Theorists and "braintrusters" are viewed with suspicion by the lesser educated. A newspaper must seek the level of its readers and a radio or TV station must seek the same level of its listeners. Be careful. Don't create hysteria. Many prejudices are learned and most people harbor a suspicion of scientists and the scientific community.

Given this situation, how do you win?

1) Be truthful. Give your best estimate of the situation based on the most current, most reliable data you have access to. Do not duck a question and don't be afraid to answer "I don't know" if that's the case.

2) Be explicit. Don't resort to technical jargon or argot. Speak in plain English and, if possible, give simple-to-understand examples. Remember, people resent change and resist progress.

3) Be understanding of your reporters. Don't consider them adversaries. They are not out to trick you or "get" you. If they ask certain questions you consider off-base, point it out. Usually, they have to take along some of the questions of their management or their bosses. In any event, the questions asked are a means of getting a story.

The question of what to do when you are confronted with an unquestionably hostile or antagonistic reporter was raised. One scientist said it appeared that certain reporters try to cast the interviewee in one of three roles (1) hero, (2) villain or (3) clown. Everyone prefers to be a hero but, in the event of telling truths that the public--including the media--may not like, you can be cast in the villain role.

The worst classification, however is three and avoid it at all costs.

Should you be interviewed, however, by one reporter who is determined to produce material inimical to the goal of providing accurate earthquake hazard reduction, immediately contact all the other media to dilute that person's sting. It also would help if you were to write to the reporter's immediate supervisor as soon as possible and point out specifically where the reporter (a) ignored facts or (b) distorted them or (c) put them in improper balance or sequence with other data, etc.

If you find your comments or information improperly presented, don't hesitate to ask for the opportunity to correct the situation--either with a printed correction or retraction or by a letter of your own clearly stating the facts or by an opportunity to appear on broadcast time matching that when the original problem was aired.

4) Beware the "invisible censor." Some newspapers and radios or TV stations in smaller communities are prone to adopt a "neutral" position on controversial matters--such as earthquake preparedness, development of adequate building codes, etc.--because of pressure from certain groups. Don't antagonize potential sources but don't hesitate to speak out clearly on the risks of community, area, regional or governmental inaction with respect to the public's health and safety in potential earthquake zones.

5) Be cognizant. Most newspapers, magazines, radio and television stations these days are fairly departmentalized. There are "specialists" who favor certain segments of the news--such as aviation, medicine, social efforts. KNOW WHO THEY ARE. Help them at every opportunity. TRUST them and it becomes a MUTUAL trust. (Offer to double check any material for scientific accuracy, but DON'T REWRITE MERELY FOR THE SAKE OF REWRITING.) Make it clear you are NOT acting as a censor but merely as an "additional" editor to assure an accurate story.

6) Don't use labels if you can possibly avoid them. Don't fall back on glittering generalities, either. Play the straight scientist, even if it sometimes appears that you are teaching 9th grade physics. Be prepared to overcome local hostility. The way of the reformer is difficult.

7) Be active and available, especially in an emergency situation. If YOU cannot be around, make sure there are good substitutes that can speak to reporters clearly, authoritatively, responsibly and quickly. Nothing arouses suspicion or distrust from a reporter quicker than to stall him. If you must check something first, make certain the reporter understands you are doing it for his/her benefit.