EARTHQUAKE HAZARDS INFORMATION DISSEMINATION:

A STUDY OF CHARLESTON, SOUTH CAROLINA

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Introduction

Background

Charleston, South Carolina, suffered a major destructive earthquake on August 31, 1886, which was felt throughout the Southeast. The earthquake, one of the largest historic earthquakes in eastern North America, resulted in about 60 deaths and extensive damage to the city of Charleston. More than 400 aftershocks occurred in the region within the next 30 years. (See Appendix 2 for an isoseismal map of the reported intensities of the 1886 earthquake, and a seismicity map of the state of South Carolina.) During the past decade scientists have attempted to understand the causes of that earthquake and of seismic activity in the southeastern United States.

Purpose

The U.S. Geological Survey (USGS) is interested in understanding information needs and dissemination channels so that more of the scientific information which is being collected can be tailored to users in the community. A major assumption of this study is that if the channels by which local officials and private sector representatives receive information concerning natural hazards are identified, it may be possible to use these same information channels to communicate earthquake information as it becomes available. A second major assumption is that users of hazards information differ widely in their requirements for information and their capacity to absorb information (Working Group on Earthquake Hazards Reduction, 1978). Recently the USGS (a source of much of the current scientific information on seismic activity and the earthquake hazard in the Southeast) has made an effort to determine how public officials and representatives of the private sector receive information regarding natural hazards and what type of information each user type finds most useful.

The purpose of this study is to identify how officials and representatives of the private sector in Charleston learn about hazards and how mitigation and response information gets incorporated in their job functions. This report documents why the officials in the Charleston area think they might need hazards information, what their job responsibilities are, and how they currently obtain information.

Procedures

This study identifies the public officials and selected representatives of the private sector who would have responsibilities for development of policy to mitigate the earthquake hazard or to respond to an actual disaster. A complete list of people we in-

terviewed is contained in Appendix 1. According to a report prepared by the National Science Foundation and the U.S. Department of the Interior (USGS) (1976, p. 16), there are several areas "where increased understanding provides substantial additional leverage for mitigation." We therefore interviewed people from these major areas, including the following: preparedness (includes such people as the disaster preparedness officials, fire chiefs, police chiefs, emergency medical services); land use (includes land use planners); building codes and standards (includes building inspectors, architects, engineers); and insurance (includes insurance agents, bankers). An interview guide that identified the major topical areas to be discussed was used in each interview.

Several scientists and academicians in Charleston and Columbia were interviewed because of their knowledge concerning the earthquake history and hazard of the Charleston area. Scientists at the USGS Headquarters in Reston, Virginia, familiar with the earthquake hazard in South Carolina, were also interviewed. The primary focus, however, was on interviewing local officials and representatives of the private sector in the Charleston area who either were or who might be involved in earthquake hazard mitigation and response.

The emphasis was on public officials and representatives of the private sector, rather than the public, because such officials have responsibilities and the authority to adopt hazard-mitigating policies. Also, the interviews provided an opportunity to communicate the increasing evidence that there are several major areas within which effective mitigation measures can be developed.

Related Studies

Studies that argue for the effectiveness of mitigation measures include the many that have urged the importance of preparedness for a major earthquake (National Governors' Association, 1979; Hays, 1979; Davenport and Waterstone, 1979; Scott, 1979; Association of Bay Area Governments, 1976; Federal Emergency Management Agency, 1980). Studies have been done on the effectiveness of land-use planning to mitigate the earthquake hazard (Nichols and Buchanan-Banks, 1974; Blair and Spangle, 1979; Brabb (ed.), 1979; Spangle and Associates et al, 1976; and Spangle and Associates et al, 1980). In addition, studies have been done on the incorporation of seismic safety into building codes and standards, particularly the reports by Kennett (1979) and the Applied Technology Council (1978). For a study of building design recommendations for natural hazards in the Eastern United States, in particular, see the report by Loss (1981). Also, the issue of insurance has been examined, particularly by Kunreuther et al (1978) and the Association of Bay Area Governments (1977). In addition, a recent study of California local officials identified three activities that local governments can take to reduce seismic risks--regulation of land use, enactment and enforcement of building codes, and emergency response planning (Wyner, 1981, p. 9).

Although the studies just cited do not extensively explore what local officials and private sector representatives currently know about the earthquake hazard, and how they get information, some of these issues have been addressed. Several years ago the USGS funded a series of studies as part of a San Francisco Bay Region Environment and Resource Planning Study, which had as its purpose "to identify and provide basic and interpreted earth science data needed in making land-use decisions for regional planning, to provide comprehensive array of data at a regional scale, and to test and evaluate the ways in which these data are most effectively used in the planning and decisionmaking processes" (Kockelman, 1975, p. 4). In addition to numerous other documents, reports were prepared that "interpreted" or "translated" technical geologic information into words and formats that land-use planners could more easily use. (For example, see Blair and Spangle, 1979; Laird et al, 1979; and Borcherdt, 1975.) Evaluations of this project were conducted by Kockelman (1975, 1976, 1979) and Arthur D. Little (1975).

This San Francisco Bay Area project was one of a very few that specifically attempted to link generators of earth sciences information to users of such information. Bates (1979) discusses other projects that attempt to link earth scientists and earth science information users. One recent project was the USGS/Federal Emergency Management Agency workshop, "Responding to a damaging earthquake in the eastern United States," in Knoxville, Tennessee, which was attended by local officials, scientists, and Federal and State officials (Hays, 1982).

Several efforts have been made to evaluate awareness of the hazard and willingness to undertake mitigation actions on the part of local officials. A study by the Seismic Safety Commission of California (1979) examined attitudes of public officials toward disaster preparedness in California. The study found that local leaders have little confidence in their ability to respond to a large catastrophe such as a major earthquake, and that they may be unaware of some program deficiencies, such as rescues involving heavy equipment. The study also found that local leaders generally had a fair understanding of the earthquake hazard in their community. (Also see Olson and Scott, 1980.) Other work in progress is examining local officials' attitudes and levels of awareness in other parts of the country, specifically the Northeast, Missouri, and Washington State (Dermengian et al, 1981; Mushkatel and Kilijanek, 1981; and Kilijanek and Mushkatel, 1981).

Acknowledgments

We would like to thank all the people who so graciously gave their time to provide us with information for this study. Their cooperation made it possible for us to complete this project. (See Appendix 1 for a complete listing of interviewees.)

The people we interviewed were selected because they have current responsibilities to mitigate the earthquake hazard or they have responsibilities for response functions if an earthquake were

to occur. Although we spoke with a majority of the department heads in the City of Charleston, it would not be appropriate to assume that our findings represent the view of all public officials and private sector leaders in the city and three-county area. Rather, our respondents reflect a selective sample of persons with hazards mitigation and response responsibilities.

The findings reported here are also shaped by several other factors which need to be acknowledged. We did not interview anyone "on the line"--the policeman on the street, the building inspector, the fire fighter. Rather, we spoke to their bosses. Thus, we cannot document that the information reported on and available at the administrative level filters down throughout the various departments to the person working "on the street." Also, we learned through our interviews that certain functions are not performed at the city or county level. In order to make a complete assessment of information needs in the area one should speak with several State and Federal officials including representatives of the South Carolina Department of Highways and Public Transportation (responsible for designing and maintaining the bridges and highways in the area), the South Carolina Emergency Services, the Federal Emergency Management Agency, Region IV, and the engineering staff at the South Carolina Electric and Gas Company in Columbia.

Finally, we would like to note that we were interviewing in Charleston during the time of tropical storm Dennis (August 1981). Many of the people we interviewed had their interest in natural hazards heightened because of the storm. Some spent at least one full day working out preparations for a storm or hurricane landfall in the Charleston area; these are people who, under normal circumstances, might spend only several hours per month coping with natural hazards. For others, responding to tropical storm Dennis was more routine. For us, it simplified our questioning since some respondents described their response to the storm when explaining their hazards-related job duties.

Background History of the Charleston Area

Metropolitan Charleston, South Carolina, is located in the coastal area called the "low country." It includes the cities of Charleston and North Charleston (68,800; 65,600 populations) and the three adjacent counties, Charleston, Berkeley, and Dorchester. This area of 6780.6 sq. km. (2,618 square miles) is called the Trident Area and encompasses the Charleston Standard Metropolitan Statistical Area (SMSA). The area, which has a warm, humid climate, is susceptible to hurricanes and tornadoes as well as seismic activity, and in the past several years it has also been hit by two severe ice storms.

The City of Charleston, founded and settled by English colonists in 1670, grew from a small seaport to become the wealthy economic, social, and political center of the low country region during the mid-1700's. The city has fluctuated between prosperity and decline, but today it is the legal, financial, medical, and professional center of the region. The area's economy is based on port facilities, government employment, tourism, and heavy industry producing chemicals, metal components, construction materials, heavy machinery and food products. Charleston Air Force Base, Charleston Naval Base, and numerous State medical and port facilities are located in the area. In 1980 the area's population was 430,000 and continues to expand.

The City of Charleston is centered on a peninsula bounded by the Atlantic Ocean and the Ashley and Cooper Rivers. The city occupies 70.9 sq. km. (27.4 square miles) and has a policy of annexing unincorporated areas of West Ashley and James Island. The area of the city has more than doubled in the last few years as a result of this policy. The Charleston area has only recently adopted land-use regulations.

The City of Charleston has used land-use planning for 6 years, although it has the oldest historic preservation ordinance in the country. The mayor, who has been in office for 6 years, is supportive of planning, but before his election the city administration was not interested. The city is revising its master plan which was prepared 5 years ago and is now judged as too general. The zoning ordinance has not been revised since 1966. It is difficult to apply the same ordinance to the older downtown area and the area west of the Ashley River, and variances are required for most projects. The city is also working with the National Trust for Historic Preservation to revise the historic area ordinance.

Charleston County is growing and expects to continue to grow for at least the next 10 years. The current population of the county is approximately 277,000 with 25 percent of the population in the downtown Charleston area. The greatest growth is occurring east of the Cooper River and west of the Ashley River, and there is tremendous growth in terms of increased property values on the islands along the low country coast--Kiawah, Seabrook, Isle of Palms, Folly Beach, and Sullivans Island. Charleston County has had zoning since 1971, but no master plan.

Dorchester County is the fastest growing county in the State with a 1980 population of 58,200. The Summerville area has experienced the most growth--from 18,700 in 1970 to 42,600 in 1980. The county has had a planning commission since January of 1980. Building permits are required by the county for tax purposes. There is no building code enforcement within the county, and the municipalities within the county have varying regulations on building permits and code enforcement. The county has a year 2000 land-use plan, and since they have entered the flood insurance program, they have been required to draft a new zoning ordinance and require permits to build in the floodplain.

Berkeley County is also growing, from 56,200 in 1970 to 94,700 in 1980. The area that is growing most rapidly is the Goose Creek/ Hanahan area were the population increased from 30,400 to 58,100 from 1970 to 1980. Last year the county had the largest industrial capital investment of any county in the State although most of their land is tied up by major landowners and national forest, and only a small percent currently is available for development. Several chemical firms have located in the county, and an aluminum reduction plant is now locating in the center of the county's growth area. Berkeley County has an 8-month-old planning commission, a subdivision ordinance, and a new land-use plan, completed in 1977.

Awareness of the Earthquake Hazard

All those with whom we spoke were familiar with the earthquake hazard in South Carolina in some way. Almost everyone was aware of the major earthquake in Charleston near the end of the 19th century, although many did not know the year (1886). This 1886 earthquake is an integral part of Charleston's history--some of its buildings, already damaged or burned in the destructive civil war, were further damaged or collapsed in the earthquake (Dutton, 1890). The earthquake damage is mentioned during many tours of the historic buildings and plantations of the Charleston area, and pictures of earthquake-damaged buildings, bent railroad tracks, etc., can be found in several local restaurants. The earthquake of 1886 is a separate chapter or discussion in many of the local historical books. On tours in historic Charleston, tourists are shown earthquake rods--bolts that were placed in the buildings after the 1886 earthquake to anchor the walls. Occasionally the local museums have shows about the 1886 earthquake. It is interesting to note, however, that few of the people with whom we spoke took seriously the possibility of an occurrence of a future earthquake of the magnitude of the 1886 earthquake.

The people of Charleston are history conscious; they are proud of the role their city has played in the founding and growth of the United States The adversity and difficult times that the city has survived are very much a part of its history and as such are of interest to both residents and tourists. The earthquake of 1886 falls into this category.

In addition to the historical perspective, several recent events have generated awareness of or curiosity about the current earthquake hazard. The U.S.G.S., Virginia Polytechnic Institute, and State University researchers came through the Charleston area in 1981 with large trucks equipped for seismic testing. The presence of these trucks generated curiosity, and various news media have carried stories on what the trucks are doing. Several of the people we interviewed had seen equipment from the trucks used to vibrate the ground and knew that scientists were attempting to locate possible faults in the area; others wanted to know what they did.

The news media also contribute to a general public awareness by running occasional stories on the geologists and seismologists conducting research in the area. The news media mention the 1886 Charleston earthquake when reporting about large earthquakes occurring elsewhere in the world. On anniversaries of the 1886 earthquake, the newspapers feature articles about the event which serve to remind residents and inform newcomers about the hazard.

The news media have also described the work of Professor Joyce Bagwell of Baptist College at Charleston in identifying all tremors in the area. Professor Bagwell, who operates the seismograph at Baptist College, has become a resource for the news media when reporting on local tremors and reported earthquakes. Almost everyone we spoke with knew of Professor Bagwell; some had seen

her on television; some had heard her speak at professional or civic meetings; and some had contacted her personally. When reporting on local tremors, the news media ask that people who feel the tremors contact Baptist College.

A number of unidentified large sonic booms causing shaking and loud noises in the area have also contributed to a general public awareness of the potential for earthquakes since earthquakes in this area can be associated with such large noises. People, when hearing these booms, have contacted Baptist College, the news media, or police, who in turn have contacted Baptist College. While many of these booms have turned out not to be earthquakes, some have been related to earthquakes and thus have served to maintain a general public awareness of the earthquake potential.

A certain amount of misinformation concerning the earthquake hazard in the area also is apparent. For example, many of the people we spoke with felt that the fault or faults in the area have been located. There seemed to be little awareness of the current uncertainty in the scientific community concerning what actually caused the earthquake of 1886 and where the causative and active faults lie. Some people also felt that the earthquake potential in the Charleston area is the same as the earthquake potential in seismically active California.

Users of Hazards Information

The people interviewed for this study represent a wide range of professions, responsibilities, and interests. Some, as discussed earlier, were aware of the earthquake hazard but did not perceive that their jobs caused them to have any direct responsibilities in an actual earthquake. Others dealt with disasters on a day-to-day basis, and had more specific ideas of the kinds of information regarding the earthquake hazard that would be useful to them.

The following sections summarize the varied job responsibilities of the people with whom we spoke. These types of differences would dictate different information needs.

Individuals Who Deal with Emergencies Routinely

We interviewed several individuals who are administrators of departments having responsibility for day-to-day response to emergencies (such as the Police Department, Fire Department, Emergency Medical Services) as well as several individuals who have primary planning and coordination responsibilities in a major disaster (for example, the county disaster preparedness officials, the disaster preparedness officer for the U.S. Navy, and the director of security for the school district). These individuals differ from individuals who administer departments less directly related to public safety, such as transportation, or who are county and city administrators, in terms of the specific response that would be expected of them in an emergency and of their information needs.

The county disaster preparedness officials, for example, generally have responsibility for preparing a basic disaster plan for the county. Thus, it is important that they have a good understanding of various types of emergencies and potential disasters so that they can suggest a response from the appropriate agencies. In some cases these officials are also responsible for the preparation of educational materials for the public; this involves preparing background information that explains the nature of the hazard and appropriate responses to the public. For example, during a disaster the Charleston County disaster preparedness official operates the Emergency Operations Center out of his office and receives calls from the public, local officials, and the media requesting information. He also has responsibility to prepare an evacuation plan for the county and prepares routes and instructions for the public which are camera-ready for the media if a disaster should appear imminent. The three county disaster preparedness officials also indicated a responsibility to continuously provide information to the public, either through pamphlets, films, speakers, etc. The day before tropical storm Dennis passed through the area, the disaster preparedness official for Berkeley County, for example, was asked to speak on a local radio talk show to explain how people could prepare for a hurricane.

The county disaster preparedness officials also have primary responsibility to contact the National Weather Service in the event of an impending disaster for which the service can give a forecast. Other county officials and administrators then rely on their disaster preparedness official to keep them advised of the situation and to provide them with information that they need in order to make decisions, such as recommendations for evacuation or the opening of shelters. Thus, the county disaster preparedness officials serve as focal points for information and coordination during a disaster. In Charleston County representatives of various departments and the military are sent to the Emergency Operations Center during an emergency, thereby reinforcing the notion that the county emergency preparedness office plays a central role in a major disaster.

It should also be pointed out that there are many less comprehensive plans and procedures developed by individual agencies which could significantly complicate coordination efforts. For example, in the Charleston area, there is a county plan for each of the three counties; a separate emergency plan for each school, prepared by the principal; an overall school emergency procedures planning guide; a storm manual for both gas and electricity services prepared by South Carolina Electric and Gas Company; planning procedures for the fire department; a police department emergency plan; a Charleston City post-disaster clean-up plan; a Charleston county post-disaster plan; an Emergency Medical Services disaster plan; and an emergency plan for each of the military facilities in the area. Not all these plans and procedures are referenced and coordinated to each other.

Responding to emergencies is part of the day-to-day activities for the police, fire, and emergency medical services departments. In a large disaster, officials in these departments assume that their duties would be approximately the same, just more intense. For a natural disaster, the City of Charleston's Fire Department, for example, has responsibility to make sure that all its generators are operating, that Fire Department vehicle batteries are charged, and that key personnel stay close to home or are easily reachable. A dispatcher would be assigned to the communications center of the police department. The county emergency preparedness official then has responsibility to contact the Fire Department's dispatcher. The separate fire departments in the Charleston area have mutual aid plans to exchange equipment and assistance.

The Fire Chief was aware of some of the specifics of how a serious earthquake might affect his operations. He realized that they would not know which buildings would be destroyed, that buildings could crumble, that gas and water mains might break, and that streets could be ruined. They keep only one or two pieces of equipment at each of their fire stations, which are scattered throughout the Charleston area, and he felt that if they lost one or two stations they could still survive. For the Fire Department then, it is important they they understand how their response ca-

pabilities could be affected by an earthquake or a range of earthquakes from minor to serious and, given the probabilities of certain earthquake events, any extra precautions that need to be taken at present.

The Fire Department has six people who work full-time in the Fire Prevention Bureau and speak to schools and civic groups about fires and natural hazards, such as hurricanes and tornadoes. Earthquakes are currently not discussed. The police department also has a public information program geared to the schools, but natural disasters are not discussed in their program.

The police department would be the city's primary coordinating agency during a disaster. They send a representative to the county Emergency Operations Center and also coordinate with South Carolina Electric and Gas Company. The police department communications center has a direct link with the county's Emergency Medical Services, Fire Department, Sanitation department and Housing Authority. The city also sets up a command post or emergency operating facility at City Hall, activated by the Mayor, and the police chief has primary coordination responsibilities within the emergency operating facility. Other radio networks and communication ties, such as with the National Guard, County Police Department, and Highway Patrol, might be brought in at that time. The police chief currently relies on the county's disaster preparedness official to inform him of an impending event, although at times he might phone the local National Weather Service directly. It is the responsibility of the police department to keep the roads open, and they might use city trucks to assist in an evacuation. The Police Department believes that it is the logical department for coordination because they feel they have the best equipment. They also provide 24 hour service. Unlike most other city departments, they can easily move into 12 hour shifts as part of their regular emergency plan. In large emergencies, the focus of the department is not on natural hazards but rather on civil disturbances.

Given the response duties assigned this department, it would be important for them to understand clearly how earthquakes of varying sizes and impacts could affect their response capabilities.

The Charleston County Emergency Medical Services representative would have primary responsibility for the transportation of injured citizens in a major disaster. They depend on the disaster preparedness office to give them warning that a disaster is impending. They would also call on informal mutual aid agreements with other Emergency Medical Services and fire departments within a radius of 80-250 km. (50-150 mi.). In addition to transportation responsibilities, Emergency Medical Services personnel are also involved in rescue and in coordinating the role that each hospital will play and in deciding which patients each hospital will take.

Coordination of rescue services could be a major problem in the Charleston area, particularly after tornadoes and earthquakes. The ability of Emergency Medical Services personnel to respond effectively could be seriously impaired, given that they

currently operate on a small budget and already are short on equipment. For example, there are only 15 ambulances in the county although in an emergency these personnel might also be able to use the National Guard. They might also have access to three or four four-wheel drive vehicles. The Navy Medical Regional Hospital would also be available to provide medical support. The County Hospital is currently designated to provide medical control in a disaster; personnel at County Hospital would then contact St. Francis and the Veterans Administration Hospitals by telephone and other area hospitals by radio to determine patient loads, etc. Information on which hospitals, bridges, and roads are susceptible, if any, to ground shaking would thus be useful to medical services providers.

Problems that might arise in a major earthquake, such as looking for people under rubble and performing mass search and rescue operations, also might need special expertise and practice. Coordination of the various groups that might provide search and rescue, such as the volunteer rescue squad, Emergency Medical Services, the sheriffs' and police departments, needs to be considered. Training in the use of special equipment and rescue techniques might also be required to better improve response capabilities in an earthquake. The Emergency Medical Services representative with whom we spoke also pointed out that Emergency Medical Services and rescue personnel in mining States might have more experience, possibly transferable to the Charleston situation, in the extraction of people from rubble.

In addition to the county disaster preparedness officials and the Emergency Medical Services representative, there are several quasi-public and private agencies that would be involved in first response, particularly the Red Cross and the Salvation Army. The Red Cross runs the public shelters that would be set up if an evacuation were necessary. The chapter office is the primary responder to a disaster, and local personnel coordinate the operation of emergency shelters with the school district and local law enforcement agencies. If a disaster is very large the Division Office (130 chapters and 2 States) would send in volunteers and coordinate resources, and the National Office might assume control if the event continued to grow. In addition to the shelters, the Red Cross operates emergency welfare services, which would also be necessary in the event of a major earthquake. The Salvation Army also provides food at some shelters, as well as providing food to emergency personnel.

We also spoke with the Navy's disaster preparedness officer. This is a civilian position within the staff of the Commander of the Charleston Naval Base. While a primary responsibility of this office is nuclear attack or sabotage, the disaster preparedness officer estimated that in the hurricane season he spends 80 percent of his time organizing response to natural disasters. The Commander of the Naval Base depends largely on weather data issued by Navy Weather Facilities located at Jackson, Florida, as well as a Naval Oceanographic detachment assigned to the Commander Naval Base, Charleston. They also have a teletype into the National

Weather Service. Thus, in a disaster such as a hurricane or tornado, the Navy has the capability to obtain necessary information independent of the county and react as they determine is appropriate. During tropical storm Dennis, for example, the Navy activated Hurricane Condition Two which meant that they sent their ships out to sea, while on Base they secured all materials which could become dangerous missiles during high wind conditions.

The Navy also has responsibility for the education and training of its personnel, about response in nuclear and natural disasters. Instructions concerning shelters and where to go in a hurricane or a tornado go out to everyone assigned to the Naval Base. A total of 15,000 "Disaster Preparedness Guide" pamphlets have been distributed to Navy personnel and their families. The pamphlet explains what to do in the event of a nuclear or natural disaster. Earthquakes are specifically mentioned in the guide.

The Southern Division of the Naval Facilities Engineering Command also has requested, over the past several years, that a consulting firm prepare an earthquake vulnerability analysis for the land and certain buildings at the Naval Base. This study has examined 54 buildings to date and has recommended further study for selected critical buildings.

The Navy is capable, therefore, of responding independently to a disaster, and although their disaster preparedness officer maintains communication with the county disaster preparedness officer, he is not dependent on the county for his information. Thus, background information about various hazards and appropriate responses would be useful, as well as details about what could happen at the Navy Base during an earthquake.

Administrators

People with administrative responsibilities for a department, city, or county have information needs that are different from those of people who are first-line responders. (In a few cases, we spoke with people who are administrative heads of first-line response agencies--e.g., the fire department, police, and Emergency Medical Services--and their responsibilities were noted in the preceding section.) All the administrators with whom we spoke had general oversight responsibilities for the functioning of their department (or county office). Emergency preparedness and hazard awareness or mitigation were a very small part of their overall responsibilities. If a disaster is or may be impending, however, such as tropical storm Dennis, these administrators spend almost all their time coordinating the disaster response.

The three county administrators with whom we spoke all mentioned that they rely on their disaster preparedness directors to keep them informed and to act as liaisons with the National Weather Service and other agencies that might provide information. They might attend an occasional briefing by the National Weather Service, but they would rely on their disaster preparedness officials to advise them in specific situations. Two of the three ad-

ministrators interviewed indicated that they would rely on their disaster preparedness official to make the decision as to whether or not to evacuate an area; this same disaster preparedness official, with officials of the county school system and the Red Cross, would then make the decision to open shelters.

The assistant administrator for Charleston County was particularly aware of the need to prepare for natural disasters because of a workshop he had attended. The workshop was put on for officials in the Southeast by the Academy for Contemporary Problems for the Federal Emergency Management Agency and focused on long-term recovery. Even though the workshop dealt primarily with a hypothetical midwestern community attempting to respond to a flood (and the Charleston official wished for an example more closely tied to his problems), he found it extremely useful in terms of helping him identify issues and problems that need to be considered in disaster response. For example, after his attendance there, the County revised its emergency plan to involve more directly the assessor's office and the buiding inspector in making damage assessments. Through the conference, he also learned of the Federal Emergency Management Agency and its functions.

In addition to the county administrators, we spoke with a mayor, a mayor's assistant, and several city department heads. Again, their responsibilities are much broader than hazard mitigation and disaster response, and for hazard-related information they rely primarily on the county disaster preparedness offices. This was the case with the mayor of Lincolnville, a small town near Summerville and the site of the epicenter of the 1886 earthquake.

In the city of Charleston the Mayor's Office has the responsibility for planning and coordination in the event of a natural disaster. They use the county plan to identify responsibilities, and they also have an internal city plan, developed with the police department. The city also has a post-disaster clean-up plan. In meetings with all the department heads to discuss the state of preparation for natural disasters, the subject of earthquakes has come up, but no specific plans have been made for the possible occurrence of one. During a disaster, the Mayor's Office relies on the Police Chief to be the liaison with other agencies. They are also in constant contact with the local office of the National Weather Service. After tropical storm Dennis, the mayor made a request to the local television and radio stations to help disseminate preparedness information as a public service. Thus, the Mayor's Office relies on other departments to deal with operational issues in disaster response, and they take responsibility for the larger coordination issues. General background information regarding a specific hazard appears to be the level of information needed.

City department heads, even though they personally may not use the information, need access to as much specific information as possible regarding hazards. This information can, if appropriate, be passed on to staff people with direct responsibility for mitigation or response. There are, of course, several departments

with no direct mitigation or response functions, and they would need less information. In Charleston, for example, the City Traffic and Transportation Department would have to insure the smooth flow of traffic in a disaster. The city's planning office also used little information regarding natural hazards although they would be interested in seeing more information, particularly on the earthquake hazard. Again, however, they have no direct or mitigation response functions. If the city decided to adopt some land-use techniques to mitigate the earthquake hazard, presumably they would be administered by the planning department, and at that time the department would require more specific information. The administrator of the Charleston Housing Authority also has general responsibilities that span much more than disaster or emergency preparedness. Because of the services they can provide--manpower (particularly maintenance crews), radio system, emergency generators, tree-cutting equipment, chains, and axes--they are part of a five-department response team coordinated by the Mayor's Office. Thus, they are directly involved in response and are also cognizant of natural hazards in the siting of their new facilities.

Examples of departments that can use very specific information include the office of the Commissioners of Public Works (water, sewer, and public transit). Personnel in that office pointed out that they would like to know the location of every small tremor because they are interested in a possible correlation between the tremors and damage to their underground pipes. They also have several tunnels that supply water to the Charleston area, and they need to know what the earthquake hazard means for those tunnels. The Department of Public Service is very interested in as much specific information as possible regarding the earthquake hazard in Charleston. The director has several overall responsibilities related to this hazard, including the administration and implementation of a clean-up plan to clean debris off of the street in the event of an earthquake and the administration of the seismic provisions of the Standard Building Code. Another administrator, with similar responsibilities and similar information needs, is the building inspector. In Charleston County, for example, all inspectors are on-call 24 hours a day; they take their vehicles home. The building inspectors would also have responsibility to assist in identifying and removing dangerous buildings and are responsible for assisting in an evacuation.

The school security chief for the county-wide school district has emergency preparedness as an additional responsibility in his office. He is responsible for making sure that principals submit their own emergency plans for each school and for designating particular schools as shelters. Since principals are designated as shelter managers, the school district becomes integrally involved in preparedness and response. Coordination is necessary with the county disaster office and the Red Cross.

Another administrator who has disaster response or hazard mitigation responsibilities as part of much broader administrative responsibilities and who needs fairly detailed and timely information is the administrator at the South Carolina Electric and Gas

Company. This utility has established written procedures for storm emergencies (covering both electric and natural gas services) and would be very involved in an earthquake in the Charleston area. The utility is responsible for identifying priority and essential customers and for operating crews in emergencies who can turn the power back on, turn gas off, etc. Details about what to expect in a major earthquake would thus be necessary.

Planning and Mitigation

Many of the people we interviewed had primarily planning and/or mitigation responsibilities for natural hazards in addition to their other job responsibilities. That is, they did not have administrative or coordination responsibilities, nor were they responsible for first-responder activities such as police and medical services, but as part of their jobs they could (and do) undertake actions that would mitigate the damaging effects of an earthquake in the Charleston area.

The public officials with these types of responsibilties are primarily planners, public works officials, and building inspectors, that is, officials who make decisions regarding uses of land and building construction. Currently, little geologic information is available for the Charleston area, and thus such information is not incorporated in many of the land-use decisions. For example, when the Ashley River Corridor Plan was developed for the area, only soils and topographic information was used. Several of the jurisdictions have only recently adopted some land-use regulations, and several have no building codes or code enforcement and thus would not yet have much need for detailed geologic information. Several of the jurisdictions, particularly the counties, mentioned that they use USGS topographic maps for some of their major planning projects (eg., the development of a master drainage plan). The Council of Governments for the area helped in a study of the depth to the top of the marl; the actual field work was done by a class in College of Charleston's geology department, with the cooperation of the State Geologist's office. However, the study is not used in any land-use decisionmaking process. The study has been used for site analysis by industrial representatives considering locating in the area, and by the State Department of Highways and Public Transportation.

Some geologic information is currently incorporated in the land-use planning process through the work of consultants. Several public officials indicated that they rely on consultants to major developers for earth sciences information and they incorporate such knowledge into their projects.

Actually precluding development on sites determined to be hazardous is difficult because the State has no powers of eminent domain. After an earthquake, for example, a local government would not be able to stop people from relocating in susceptible areas.

Building inspectors and public works officials also can undertake actions to mitigate the earthquake hazard. As mentioned earlier, in the Charleston area some jurisdictions have no building

codes, or if they have building codes, no one is designated with inspection and enforcement responsibilities. Thus, although the Standard Building Code, the code most commonly used in the southern United States, has a seismic provision in it (Section 1206), many jurisdictions have not adopted it. In some jurisdictions where the building code has been adopted, the jurisdiction may not have adopted the section relevant to the seismic hazard, or they may not have designated anyone to enforce the provision.

In the City of Charleston, the city council adopted a bulletin in June 1981 reaffirming the policy of the building inspector to enforce Section 1206. The city had adopted the building code in June of 1980. Since the wording of Section 1206 is vague about who is the appropriately designated official to implement the section, this action by the City of Charleston is noteworthy. In addition, the city council elaborated on how Section 1206 will be enforced for renovation work. This is an important question because of the large number of historic properties in the city. Basically, the property does not have to conform to the seismic provisions of the Standard Building Code, although the owner or developer is not allowed to do anything to the building that will reduce the ability of the building to withstand the earthquake risk. For new construction, the building inspectors require that the designers certify that it is built to withstand the seismic hazard. When enforcing Section 1206, the building inspector and public works officials use ANSI-A-58.1, "Building Code Requirements for Minimum Design Loads in Buildings and other Structures," a document prepared by the American National Standards Institute, which provides detailed standards for seismically resistant construction.

The Charleston County's building department also uses ANSI-A-58.1 and enforces Section 1206 of the Standard Building Code, which requires buildings over three stories or 5,000 square feet to meet seismic provisions. A permit is required of anyone who builds in the county, and since there is more new construction there than in the city, seismically resistant design may be incorporated into more and more of the new buildings.

In the private sector, we interviewed several individuals having different (potential) mitigation responsibilities, including: several engineers, architects, an insurance broker, and several bankers. The architects design buildings to meet the requirements set forth in the Standard Building Code and always use a structural engineer on their projects. The architects we interviewed pointed out that it usually costs more to design seismically resistant buildings unless the design is simplified. Such simplification may reduce the seismic risk non-structurally through architectural features such as placement of walls in relation to each other. The engineers also design to the specifications of ANSI-A-58.1 and Section 1206 of the Standard Building Code. One engineer pointed out that the seismic requirements of the building code set up an awareness of the seismic risk in the area for individuals in the different facets of the construction industry. He also pointed out that since his firm was primarily involved in

health care facilities they pay particular attention to seismic requirements. At one health care facility, although seismic reinforcement was not required by the building officials, the structural engineers argued for the additional reinforcing, and the client agreed to pay the additional costs. In their work then, engineers question all the local geotechnical experts to get their base information, and in cases where not much is known about the seismic risk, they choose to err on the side of conservatism. Thus, detailed information would be useful to architects and engineers, particularly structural engineers, in performing their jobs.

The bankers and insurance agents who we interviewed were not very familiar with the earthquake hazard. The banks do not require earthquake insurance although many of the insurance policies in the area automatically include it. One banker said that people call her asking if such insurance is required to obtain a bank loan because they are contacted by insurance agents wanting to sell them such a policy. Insurance rates for earthquake policies are uniform across the State, unlike wind storm rates. One respondent estimated that 5-10 percent of the policyholders in the State carry earthquake coverage as part of their property insurance package. The South Carolina Association of Independent Agents has discussed the earthquake risk in the State, but only lackluster interest has been demonstrated to date. General information on the nature of the risk would be useful for both bankers and the insurance industry.

Information Sources

Introduction

The officials interviewed for this study obtain information regarding a new subject or innovation from a variety of sources. Diffusion of information has been the subject of several studies, and our findings substantiate, in a limited way, much of what these earlier studies found (Rogers and Shumaker, 1971; Lambright, 1980; Bates, 1979; Bingham, et al, 1978; Bingham and McNaught, 1976; Roessner, 1978; Szanton, 1981; Cohn and Manning, 1977; Utech and Utech, 1974). These writers have identified major mechanisms involved in publicizing a new technology (or idea) and in making individuals in other sectors or disciplines aware of its availability. For example, Cohn and Manning (1977, p. 254) have a list of these mechanisms that includes: (1) scientific and technical journals; (2) computerized data banks and services; (3) professional, scientific, and technical society symposia; (4) intragovernmental committees; (5) national standards--and specifications committees; (6) technology liaison staffs; (7) informal personal contacts; (8) interagency sharing of Federal laboratories and test facilities; (9) personnel transfers; (10) technology transfers; (11) technology transfer agents (problem-resource counselors); (12) small business administration technology-utilization officers; and (13) State technical services programs.

Cohn and Manning discussed the transfer of technology among public works managers, and although not all of these mechanisms are relevant to the transfer of earthquake or other hazards information, many mechanisms are currently in use by officials and individuals in the Charleston area. The following discussion divides information sources for respondents in the study into these six categories: associations, government agencies, journals and magazines, colleges and universities, news media and personal exchanges, and although these categories are labeled differently from those used by Cohn and Manning, the overlaps are obvious.

The following discussion elaborates on the hazards information channels identified in the Charleston area. Because our sample is too small to determine if there are statistical differences between the public officials and private sector representatives or between various job functions, we will focus here on describing only the major sources of information.

Associations

Almost everyone we interviewed received information from a professional or civic association, and for many, the professional association was a primary source. For the county and city administrators, the Association of Counties, the Municipal Association of South Carolina, the National League of Cities, the U.S. Civil Defense Directors Association, and the South Carolina State Asso-

ciation of County Emergency Preparedness Directors were all sources of information. Such associations usually put out newsletters, and, in fact at the time we were in Charleston, the National League of Cities' newsletter had a one-paragraph article on the front page stating that Charleston, along with other eastern cities, had a significant risk of experiencing damage and loss of life and injuries in an earthquake.

Associations mentioned by the officials in public safety or first responder departments included: Low Country Regional Emergency Medical Services Council, State Association of Rescue Squads, the South Carolina Fire Academy, International Chiefs of Police, the State of South Carolina's Law Enforcement Association, the Police Executive Research Forum, the Police Executive Institute, the International Association of Fire Chiefs, the Tri-County Fire Chiefs Association, and the South Carolina State Fire Commission.

Associations mentioned by people responsible for planning and mitigation included: American Public Works Association, American Society of Civil Engineers, American National Standards Institute, Standard Building Code Congress, Low-Country Building Inspectors Association, Construction Specification Institute, American Institute of Architects, American Planning Association, American Waterworks Association, South Carolina Association of Independent Agents, South Carolina Power Exchange, and the Electric Edison Institute. Many of these associations sponsor seminars or workshops directly related to hazard mitigation or response, as well as putting out monthly newsletters. For example, at the spring 1981 meeting of the State Association of Emergency Preparedness Directors, the State Geologist spoke on the earthquake hazard in the State. The American Waterworks Association teaches an emergency preparedness course that is offered in cities around the country. The South Carolina Power Exchange and the Electric Edison Institute exchange information among members regarding how best to prepare for storms. The American Planning Association sponsored a conference several years ago on the earthquake hazard and invited planners from all cities with an earthquake risk. The Director of the Berkeley, Charleston, and Dorchester Council of Governments attended. The National Council Architectural Review Board sponsors a seminar on designing for the earthquake hazard. The seminar or course is required for architects who want to be licensed in California. It is currently offered at the University of Utah and occasionally at other schools on a one-time basis. One of the architects with whom we spoke contemplated taking this class. The Standard Building Code Congress also offers seminars on implementation of various aspects of the building code.

Several of the department heads in Charleston also hold leadership positions in their State professional organizations. For example, the fire chief is a member of the 18-person South Carolina State Fire Commission; the police chief is head of the South Carolina State Law Enforcement Association; the Charleston County building inspector is chairman of the Low-Country Inspectors Association; and the Navy disaster preparedness officer is on the

Southeastern Regional Emergency Management Committee of the Federal Emergency Management Agency. In these dual roles, if they felt a piece of information was important, they would be in a position to influence its dissemination.

In addition to professional associations, several people mentioned civic or church groups as a source of information on natural hazards or on the earthquake hazard specifically. At a recent meeting of a Civitan Club, a local civic group, a professor from the College of Charleston spoke on preparedness for a hurricane. Fortuitiously, he spoke 1 week before tropical storm Dennis came through the area. Professor Joyce Bagwell, from the Baptist College's seismograph operation, says she is a frequent speaker at churches and community clubs such as Kiwanis and Rotary.

Government Agencies

Many respondents also received information from various government agencies from the county to the Federal Government. Some city and county departments receive background information from the county offices of disaster preparedness. As mentioned earlier, these offices are primary sources of information when a disaster event is impending.

The State disaster preparedness office provides some information to the county offices of disaster preparedness, the Navy disaster preparedness officer, the county administrators, and the school district. As far as we could determine, no particular focus is given to the earthquake hazard.

Several officials also received information from the Federal Emergency Management Agency. The county disaster preparedness directors receive half their funding for their positions from the Federal Emergency Management Agency, as well as background materials that they can then distribute in their counties. One director offered the observation, however, that it is difficult to obtain some of the materials since they go out of print, and although he receives requests from the public for information, he does not have material he can distribute. One of the county disaster preparedness directors emphasized that he receives information from the Federal Emergency Management Agency's Region IV in Atlanta. The Navy receives information from the Federal Emergency Management Agency, particularly as their representative sits on the Federal Emergency Management Agency's Regional Emergency Management Committee. (Other members of the committee include the U.S. Departments of Agriculture and Commerce, Community Services Administration, 1st Army Headquarters, 14th Air Force Division, and the U.S. Army Corps of Engineers.) Evidently this committee has discussed the potential for a serious earthquake in the Southeast, but it has made no specific recommendations for response procedures.

The Federal Emergency Management Agency has also sponsored workshops put on by the Academy for Contemporary Problems on long-term disaster recovery. These workshops have been attended by

several officials in the Charleston area. As described earlier, one official in particular found the workshop very useful in stimulating his thinking about disaster preparedness in Charleston County. Revisions were made in the county response plan, on the basis of what he had learned at the workshop.

The fire chief was also familiar with the Federal Emergency Management Agency because they had sponsored the International Association of Fire Chiefs' publication Disaster Planning Guidelines for Fire Chiefs. He is adapting the guidelines for his fire department. Several public officials also received Emergency Management, a free publication distributed by the Federal Emergency Management Agency.

The National Oceanographic and Atmospheric Administration also has distributed information which some of our respondents mentioned. This agency is involved in some flooding and hurricane studies and also prepares information on weather-related hazards that public officials can then disseminate. It has also sponsored a conference which was attended by the Emergency Medical Services assistant director.

Almost every public official also had direct contact with the National Weather Service, which received consistently high marks for their seminars and interaction with local government. Many of the respondents had attended a seminar, many more than one, sponsored by the local National Weather Service office.

The South Carolina National Guard has provided training for some of our respondents, including the fire chief.

Information prepared by the USGS was used primarily by land-use planners. The county planning offices use survey topographic maps, and the Charleston city planning office uses both survey topographic maps and soils information prepared by the Soil Conservation Service. One county official also mentioned a survey study on floods and dams of the area.

A further government source for some of the public officials is the U.S. Government Printing Office catalog. One of the architects with whom we spoke mentioned that he learns of projects and studies by being on the mailing list of the National Science Foundation. He also participated in a National Science Foundation-funded project which taught architects how to incorporate seismic safety into their design process.

Journals and Magazines

As would be expected, a range of professional journals and magazines was used by the respondents. The list included, for the people in first-responder departments: Emergency Medical Services, Firehouse, Journal of Emergency Medical Services, Police Chief, International Civil Defense, Journal of Civil Defense, the newsletter from the State association of civil defense , and the Association of Counties newsletter.

For the administrators and people with planning and mitigation responsibilities, the list of journals included, in addition to

the newsletters of their professional organizations: Planning, Journal of Housing, Concrete, Public Works, and Contractors magazines.

A few respondents received information directly related to natural hazards from publications such as the Natural Hazards Observer and from newsletters from the United Nations and the U.S. Office of Foreign Disaster Assistance. One respondent also had obtained reports from bibliographies put out by the Disaster Research Center of Ohio State University.

Colleges and Universities

The local colleges and the University of South Carolina have provided information about hazard mitigation and response. As mentioned earlier, a professor from the College of Charleston spoke on hurricanes and how to prepare for one at the Civitan Club meeting the week before tropical storm Dennis came through the area. Dr. Pradeep Talwani, seismologist in the Department of Geology, University of South Carolina, Columbia, operates the seismograph network distributed throughout South Carolina. The program is a joint effort of the University of South Carolina and the USGS. The University of South Carolina, with several government agencies, sponsored a radiological monitoring class for firefighters. The earthquake hazard in the Charleston area was mentioned there. The University of Wisconsin sponsors continuing education classes for engineers, which at least one respondent found most useful. The College of Charleston's geology department performed for the Council of Governments, with the assistance of the State Geologist's office, a study of the depth to the top of the marl in the Charleston area. Several geologists at the University of South Carolina are working on identification of the faults and explanations for the seismic activity, and occasionally speak at various association meetings in the Charleston area. Dr. T. R. Visvanathan, University of South Carolina-Union, prepared a detailed listing of all earthquakes felt in South Carolina, along with some maps of selected events (Visvanathan, 1980). The Baptist College's seismic program, under the direction of Professor Joyce Bagwell, also provides information on seismic activity and the earthquake risk. Professor Bagwell speaks at various civic, church, and professional meetings as well as speaking to the news media, police, and sheriff whenever the public feels a tremor. She has become a readily identifiable spokesperson on the earthquake risk of the area. An additional way a local college can be a source of information is through direct contacts between students, faculty, and officials. A student from The Citadel in Charleston, for example, met with the building inspector for the city of Charleston and showed him the USGS report on studies related to the 1886 earthquake in Charleston which he was using to complete his senior paper (Lagasse, 1981). Thus, local colleges and universities appear to play a role as information specialists

(technical experts such as Professors Joyce Bagwell, Pradeep Talwani, and T. R. Visvanathan) and as sources of specialized services (the mapping of the marl, and the seismic network).

News Media

The news media are a major source of general, background information for most of the people with whom we spoke. Many people generally familiar with the earthquake hazard had learned all they knew from the news media, primarily television.

Both television and radio play important roles in the dissemination of information before an impending disaster. As tropical storm Dennis approached the area, television and especially radio broadcast periodic updates on the weather condition. (An interesting observation: we heard over commercial radio that the storm was moving towards Myrtle Beach north of Charleston before officials of one of the counties received information over their "special" radio. At the time we heard of the change in direction, the county officials were still operating on the assumption that the storm would strike the Charleston area.)

One of our respondents pointed out that a local television station had recently run a two-part series on the earthquake hazard in the area: most respondents indicated that more commonly media coverage of the earthquake was in an historical context.

Personal Exchanges

A further source of information used by many of our respondents is the personal exchange of information. Several rely on their colleagues and others working in related fields for information, and use personal contact as the means to collect the information. For example, the city public service department phoned the Los Angeles building inspectors office to obtain a copy of the stringent building and engineering code that was just implemented. When the planning director wants some information on how other cities deal with a particular problem, he is more likely to phone people he knows in various cities than to read publications. Officials at the South Carolina Electric and Gas Company are likely to talk to people they know in various other southern utilities for suggestions on how they deal with particular problems.

Two important questions when looking at information sources are: (1) what type of information is conveyed by the sources and (2) how much information does the user retain. We did not attempt to answer these questions systematically although our respondents offered some informal observations. Obviously, journals such as the Journal of Housing and Concrete have a much broader emphasis than hazards, generally, or earthquakes, particularly. No journal or magazine was devoted entirely to earthquake mitigation or response, although there are several publications, primarily used by

the county disaster preparedness officials that look at hazard mitigation and response. Thus the amount of hazards information--and specifically earthquake-related information--received by most respondents is small.

In summary, information directly related to the earthquake hazard, as identified by several respondents, included: the USGS Professional Paper 1028 (Rankin, 1977); the USGS History of the 1886 Charleston earthquake (Dutton, 1890); the Applied Technology Council report ATC3-06 (Applied Technology Council, 1978); the National Science Foundation-funded project on architects and seismic-resistant design (Britz, 1981); the course at the University of Utah for architects; the report by a senior engineering student at The Citadel (Lagasse, 1981); the Southern California engineering code; the Los Angeles building code; the Standard Building Code and its Congress; the American Institute of Planners (now the American Planning Association) conference in San Francisco on earthquake hazard; the discussion in the Disaster Preparedness Guide for the Naval Base (Commander Naval Base, 1981); the discussion in Disaster Planning Guidelines for Fire Chiefs (Hildebrand, 1980); the discussion in school emergency preparedness plans (Crews, undated); the report on the earthquake vulnerability of buildings prepared by Blume and Associates; and the recent earthquake engineering conference in Knoxville, Tennessee (Beavers, 1981) and the workshop on "Preparing for and responding to a damaging earthquake in the Eastern United States" (Hays, 1982).

Summary of Findings

Awareness of the Earthquake Hazard

- No one we interviewed was unaware of the fact that earthquakes have occurred in South Carolina. The earthquake of 1886 is an integral part of Charleston history.

- The level of awareness of the current earthquake hazard for many of our respondents is only at the level of curiosity. With the exception of building inspectors and structural engineers, few of the respondents currently incorporate awareness of an earthquake hazard into their decisions.

- In addition to the historical factor, general awareness of the current earthquake hazard is maintained by: the occasional appearance in the area of large trucks used by the USGS and Virginia Polytechnic Institute and State University to test for seismic activity; the occasional news media story on geologists and seismologists in the area conducting research; the Baptist College seismograph run by Joyce Bagwell, who has become a local resource person for the media and officials interested in local tremors and reported earthquakes; the occasional unidentified large sonic boom in the area since many people think these booms and the accompanying shaking are earthquakes; and small tremors that occur frequently in the Charleston/Summerville area.

- There appears to be a certain amount of misinformation concerning the earthquake hazard in the area. Many of the people we spoke with were under the impression that the fault or faults in the area causing the 1886 earthquake have been located. Also some respondents felt that the earthquake potential in the Charleston area is the same as the earthquake potential in seismically active California.

Users of Hazards Information

- Officials generally approach hazard mitigation and disaster response from a multi-hazard perspective. They realize that entirely separate plans do not have to be made for each hazard and that responses to earthquakes, hurricanes, tornadoes, ice storms, etc., will have many similarities. This is important in attempting to ensure an effective, coordinated response at all levels of government. If separate plans and responsibilities are required for each disaster, the probability that everyone will be able to remember his or her duties and perform them effectively is low.

- For all types of users, accurate, timely information before and during a disaster appear to be most important. Communication and coordination lines are fragile, and to ensure their smooth functioning, complete, pertinent, and understandable information is very important.

- Some people, particularly those with land-use planning responsibilities, who could (and perhaps should) utilize more of the existing information on earthquake hazards are not aware that such information exists, the extent that it is useful, or its relevance to what they do.

- Certain types of information users (such as the Commissioners of Public Works, South Carolina Electric and Gas Company, and the building inspectors) can use and need very detailed information concerning the location of the fault(s) and the history of seismic activity.

- Some of the public officials and private sector representatives whom we interviewed have placed a significant level of trust in the seismic provisions of the building code to protect them from serious damage in the event of a major earthquake. Other officials are aware that even if a seismic provision exists in the code, there are major problems of code implementation and enforcement. It appears that considerable effort is needed to get the seismic provision of the building code adopted throughout the area, to establish a local authority to implement the provisions should they be adopted, and to designate sufficient personnel to enforce the code.

- The county disaster preparedness officials play a major role in keeping other administrative officials informed before and during most disasters. Within the City of Charleston the first responder agencies are police, fire, emergency medical services, the Red Cross, and Salvation Army.

Information Sources

- Basic scientific information pertaining to the earthquake hazard is lacking in the Charleston area. Although many of the respondents are generally aware of the earthquake hazard, most are not familiar with the few information sources that provide any detail on seismic hazards and risk, nor are many aware of how they can obtain further information.

- Many of the respondents with whom we spoke obtain information on hazards generally through professional and trade societies, newsletters, journals, and personal exchanges with other professionals.

- General information on hazards is also obtained from the news media and community groups. In some cases a professional person may hear an interesting talk on a hazard at a community or civic function and then arrange for a similar talk to be given at a professional function.

- Workshops appear to be a particularly effective catalyst for stimulating thinking and activity in a particular area. Certainly many of our respondents obtained much useful information concerning hurricanes from workshops sponsored by the National Weather Service.

- The public, as well as some officials, professional people, and private industry people, receives information on what to do in an emergency from the radio and television. Thus the media play a powerful role in communication of emergency information.

Table 1: Summary

- Table 1 summarizes the sources and users of hazards information in the Charleston area.

TABLE 1: SOURCES AND USERS OF HAZARDS INFORMATION IN THE CHARLESTON, SOUTH CAROLINA AREA

INFORMATION USERS**	SOURCES OF HAZARDS INFORMATION, BY CATEGORY*							
	TECHNICAL (re: Earthquake only)		MITIGATION		GENERAL PREPAREDNESS		RESPONSE	
	Personal Contacts	Written Materials	Personal Contacts	Written Materials	Personal Contacts	Written Materials	Personal Contacts	Written Materials
ACADEMICIANS	academic peers, USGS scientists, professional geologists.	academic journals, USGS professional papers and maps.						
ADMINISTRATORS (CITY)				USGS topo maps Occasional article in Contractors magazine, Public Works magazine	County Disaster Preparedness National Weather Service Other administrators, city officials	From county "Civil Defense". Newsletters from Municipal Association of S.C., National League of Cities	Other city officials--Police, Fire.	
ADMINISTRATORS (COUNTY)	Observed USGS/VPI & SU trucks.			USGS floods and dam study. USGS topo maps.	State Disaster Preparedness Office. Academy for Contemporary Problems Workshop. National Weather Service, Red Cross, School District	 FEMA and NOAA booklets. U.S. Government Printing Office catelog. Newsletters from Association of Counties.	Academy for Contemporary Problems Workshop	

*The focus of this study is on how officials obtain information regarding the earthquake hazard; however, because so little information exists currently regarding that particular hazard, this table reflects sources of information more generally. The Technical information column, however, does refer only to earthquake hazard information.

**It should be noted that while information sources are reported for categories of information users, there can be variation within categories. For example, not all the county administrators with whom we spoke received information from all the sources listed here. The information in this table represents a summary of our findings.

INFORMATION USERS**	SOURCES OF HAZARDS INFORMATION, BY CATEGORY*							
	TECHNICAL (re: Earthquake only)		MITIGATION		GENERAL PREPAREDNESS		RESPONSE	
	Personal Contacts	Written Materials	Personal Contacts	Written Materials	Personal Contacts	Written Materials	Personal Contacts	Written Materials
ARCHITECTS (Private)	National Science Foundation project Seminar put on by NCARB-course for architects who practice in California.	National Science Foundation reports. ATC3-06 report (Applied Technology Council) So. Calif. Engineers Code.						
BANKING	Homeowners and Developers				Homeowners, Developers, Federal regulators			
BUILDING INSPECTOR (CITY)	Other inspectors (e.g. Los Angeles) Conferences (e.g. Knoxville conference on Earthquake Engineering) Local engineering community, including local colleges.	American National Standards Institute Report #51 Engineering Periodicals		American Public Works Ordinances (Model) Engineering Periodicals. Emergency Management (FEMA publication)				

INFORMATION USERS**	SOURCES OF HAZARDS INFORMATION, BY CATEGORY*							
	TECHNICAL (re: Earthquake only)		MITIGATION		GENERAL PREPAREDNESS		RESPONSE	
	Personal Contacts	Written Materials	Personal Contacts	Written Materials	Personal Contacts	Written Materials	Personal Contacts	Written Materials
BUILDING INSPECTOR (COUNTY)	Standard Building Code Congress (educational programs and seminars) Low Country Inspectors Association.	USGS Bulletins Earthquake manuals Scientific Literature Mass Media	Low Country Inspectors Association.	Engineering Periodicals.				
COUNCIL OF GOVERNMENTS	American Institute of Planners Earthquake conference. U.S. Dept. of Interior	Geological information "Ecological Character of Sea Island Coastal Region. S.C. & GA."		Planning Magazine SCS maps USGS topo maps	National Weather Service Workshop on hurricanes once a year.			
DISASTER PREPAREDNESS (COUNTY)					Local weather bureau, National Weather Service FEMA, Region IV. Other county directors, 2 or 3 meetings per year.	Journal of Civil Defense Publications from FEMA, NWS. Newsletters from state and U.S. Civil Defense Directors.		
EMERGENCY MEDICAL SERVICES (COUNTY)					NWS/NOAA conferences (re: hurricane threat)		Low Country Regional EMS Council Clearinghouses such as ACT Foundation	Journals: Emergency Medical Services; Firehouse.

INFORMATION USERS**	SOURCES OF HAZARDS INFORMATION, BY CATEGORY*							
	TECHNICAL (re: Earthquake only)		MITIGATION		GENERAL PREPAREDNESS		RESPONSE	
	Personal Contacts	Written Materials	Personal Contacts	Written Materials	Personal Contacts	Written Materials	Personal Contacts	Written Materials
							State Association of Rescue Squads South Carolina Fire Academy	
ENGINEERS (PRIVATE)	Local geotechnical people seminars put on for engineers (such as those put on by Univ. of Wisconsin). ASCE seminars Annual conventions.	Trade and professional magazines.	Engineering seminars and conventions.	Trade and professional magazines.				
FIRE (CITY)					County Disaster Preparedness Office.		County Disaster Preparedness Office Weather Service FEMA News media, civic meetings. South Carolina National Guard.	FEMA publications International Association of Fire Chiefs monthly newsletter and magazine.

INFORMATION USERS**	SOURCES OF HAZARDS INFORMATION, BY CATEGORY*							
	TECHNICAL (re: Earthquake only)		MITIGATION		GENERAL PREPAREDNESS		RESPONSE	
	Personal Contacts	Written Materials	Personal Contacts	Written Materials	Personal Contacts	Written Materials	Personal Contacts	Written Materials
							Radiological Monitoring Class Tri-County Fire-Chiefs Association International Association of Fire Chiefs (conferences) South Carolina Fire Academy South Carolina State Fire Commission	
SOUTH CAROLINA ELECTRIC AND GAS COMPANY					Electric Edison Institute South Carolina Power Exchange	Civil Defense manuals	Electric Edison Institute South Carolina Power Exchange other utilities	
HOUSING AUTHORITY			U.S. Department of Housing and Urban Development.	Journal of Housing	Other city departments.		Other City departments.	
INSURANCE			South Carolina Association of Independent Agents State Insurance Commission					

INFORMATION USERS**	SOURCES OF HAZARDS INFORMATION, BY CATEGORY*							
	TECHNICAL (re: Earthquake only)		MITIGATION		GENERAL PREPAREDNESS		RESPONSE	
	Personal Contacts	Written Materials	Personal Contacts	Written Materials	Personal Contacts	Written Materials	Personal Contacts	Written Materials
NAVY		Consultant Reports			FEMA-Southeastern Regional Emergency Management Committee Seminars-National Weather Service, State Disaster Preparedness Agency.	Navy Base Paper-"Bow Hook" Newsletter from International Civil Defense		
PLANNING (CITY)	consultants		contacts with other cities' officials	USGS maps, soils information Planning Magazine.				
PLANNING (COUNTY)			Other county officials	USGS topo maps				
POLICE (CITY)		General background reading					International Chiefs of Police (seminars, etc.) State of South Carolina Law Enforcement Association Police Executive Institute Police Executive Research Forum	Police Chief

INFORMATION USERS**	SOURCES OF HAZARDS INFORMATION, BY CATEGORY*							
	TECHNICAL (re: Earthquake only)		MITIGATION		GENERAL PREPAREDNESS		RESPONSE	
	Personal Contacts	Written Materials	Personal Contacts	Written Materials	Personal Contacts	Written Materials	Personal Contacts	Written Materials
PUBLIC SERVICE	Conferences (e.g. Knoxville conferences on Earthquake Engineering) Local engineering community	American National Standards Institute Report #51 Engineering Periodicals	Other cities' officials (e.g. Los Angeles)	Model Ameri-Public Works ordinances Engineering Periodicals				
PUBLIC WORKS (CITY AND COUNTY)		General texts			American Waterworks Association course on emergency preparedness National Weather Service			
SCHOOL DISTRICT					State Department of Education State and County Disaster Preparedness Offices			
TRANSPORTATION			ASCE Meetings	Engineering journals.				

Discussion

In interpreting our findings, it is important also to reflect on recommendations that have been made previously by other researchers. The basic question we used is, "Do our findings represent a departure from earlier thinking in this area, or are our findings consistent with other research in the earthquake hazard mitigation area and, more broadly, the area of information transfer?" In a 1978 document, Earthquake Hazards Reduction: Issues for an Implementation Plan, (Working Group on Earthquake Hazards Reduction, 1978) prepared by many of the leading Federal policymakers in the area of earthquake hazard mitigation, several recommendations are made on ways to identify user requirements for information and to facilitate the utilization of such information. The authors point out that users of earthquake hazard information differ widely in their requirements for information and their capacity to absorb information, a point borne out entirely in our study of Charleston. There, the building inspectors, engineers, and water works officials require information as specific as possible, whereas most of the other public officials and private sector representatives wanted a more generalized overview of the hazard, particularly about what would be expected of them if an earthquake did occur. Unlike the recommendations in the 1978 Implementation Plan (p. 63) which stated that engineers, architects, and planners needed the most in-depth information, we found in Charleston that some architects and planners are not themselves aware that they can use detailed information in their jobs. Rather, they rely on the building departments and the structural engineering community to incorporate any detailed seismic safety information into the design process.

The Issues for an Implementation Plan also made recommendations regarding how information can be disseminated. They were:

1. Two-way communication must be established between producers and users. Here, the authors of the Implementation Plan made the point that users and researchers tend to have different motivations and it "may be necessary to use intermediaries to interpret research results and to create products that clearly will be helpful to the users". The Charleston study findings second this point; there we found that users were for the most part unaware of existing research on the earthquake hazard and unaware of the channels through which that information would normally be communicated.

2. Research planning should be done in close cooperation with users in order to improve the likelihood of useful and practical application. Again the Charleston study findings support this point, since if users are unaware of any of the details of the existing research and unaware of how to find out about the research, it is not likely that it will be used.

3. Adequate training should be provided to users. The point made in the Implementation Plan is that users must be taught the necessary skills to utilize technological information. The Charleston study suggests that this is true. Technological information must not only be translated; users also need the skills to interpret and use correctly the information given them.

4. Multiple inputs of knowledge to the user should be encouraged. The Implementation Plan states that "repeated exposures in different formats and through several channels may be required. This technique is particularly successful when new information is provided by persons to whom the users customarily look for guidance, such as members of their own professional or disciplinary groups" (p.63). In the Charleston study it was found that users of hazards information receive multiple inputs of knowledge concerning the hurricane threat, and most receive information through personal channels. Since this appears to work successfully for hurricane-related information, it would likely also be a successful strategy for earthquake hazard information.

Even if information is successfully transmitted to users, however, still other factors can opetate as impediments to action regarding seismic safety. It is beyond the scope of this paper to elaborate on or to detail such impediments; however, we will briefly mention several major barriers to the effective use of seismic hazard information and the implementation of seismic safety policies that have been identified by others. Atkisson and Petak (1982) in a discussion of the politics of community seismic safety identified major impediments that include:

1. Other contemporary problems appear to be more important. In the Charleston area this will certainly be a factor since there are many more immediate issues that arise on a daily basis for political leaders and public officials. Even in California and Utah, States with a serious seismic risk, a recent survey of the problem perceptions held by policy-makers and political influentials did not identify earthquakes (or any natural hazard) among the top five problems.

2. The absence of earthquake-oriented political constituencies. In order for a particular issue to be perceived as important by policy-makers, "some substantial segment of the community must become convinced that the problem exists" (Atkisson and Petak, 1982, p. 96). In the Charleston area at this time, it is likely that the public officials are more informed and aware than most citizens. The technical information has not been communicated, and in some cases is just not available to the public, so at this point it would be very unlikely to have citizens' groups or organized constituencies exert any pressure on officials.

3. The absence of "inside" advocates. Atkisson and Petak (1982, p. 97) make the point that ". . . issues, problems and policy proposals which are not 'owned' by responsible and attentive parties swiftly become undernourished and have a way of disappearing into the night". In Charleston the building inspectors for both the city and the county will likely be the "inside" advocates who will, because of the nature of their jobs, keep a certain amount of attention focused on the issue of seismic safety. Also, since the interviews were conducted in Charleston, an ad hoc seismic safety consortium for the Southeast has been formed, consisting primarily of advocates from the Charleston area. Individuals on this committee will undoubtedly develop more active roles as advocates. However, the nucleus of individuals who become advocates in the Charleston area may remain quite small until the issue takes on more importance.

4. The debilitating problems of complexity and uncertainty. Seismic safety is a particularly complex issue that does not lend itself to a simple remedy. Atkisson and Petak (1982, p. 98) feel that those problems that can be readily simplified are, in this political system, the problems most likely to be solved. Another facet of this impediment to action is how local officials perceive the risk and uncertainty surrounding the issue of seismic safety.

5. The cost of problem-solving policies. According to Atkisson and Petak (1982, p. 98), a further impediment to action in the arena of seismic safety is:

> "the perceived cost of framing a problem-solving policy and implementing a problem-solving solution . . . In short, policy-makers properly ask whether or not the development of a solution to any specified problem is worth the mix of costs associated with the design and implementation of a solution" (p. 98).

Certainly in Charleston this fact can loom as a significant impediment to action. Officials, and private sector representatives, will rightfully ask (and are asking) if the costs involved in the development of seismic safety programs are worth it, given that the risk to residents in their city is still somewhat undefined. Public officials particularly have set revenues from which they can develop programs; given that resources are limited and demands on them great, officials must ask if seismic safety programs represent the wisest use of these limited resources.

6. Issues of fact and value. Atkisson and Petak (1982, p. 99) point out that factual uncertainty in the area of seismic safety can be a great hindrance to action.

> "If the technical community cannot resolve these basically scientific and technical issues, asks the legislator, how can I be expected to dispose of the problem at this time?" (p. 99)

In Charleston the problem of factual uncertainty has particular importance since the geoscience community has not yet been able to pinpoint the cause(s) of seismic activity in the Southeast. Thus, scientists cannot say with certainty if future earthquakes in the Southeast and along the eastern coast would be centered near the epicenters of earlier earthquakes. Scientists are asking,

> ". . . how good is the historic record for predicting future seismicity? Perhaps other favorably oriented zones of weakness that have not experienced historic seismic activity should be considered as places of potential earthquakes, particularly if they currently are sites of low-level seismicity?" (Hamilton, 1981, p. 10)

This level of uncertainty in the scientific community, while important for officials to understand, also leaves them in a bit of a quandary. What actions can they realistically be expected to take, given the existing level of scientific knowledge?

The need for better technical information relates to the earlier point that perception of risk is important to understanding both impediments and incentives to action. In a study of local government officials in California, Wyner attempted to define acceptable seismic risk for those officials. He argues that since risk analysis is not an explicit, visible undertaking in the decisionmaking process, local officials exhibit little knowledge of existing risk. And, that by default, the status quo becomes the acceptable risk at any point in time (Wyner, 1981, p. 2). Thus there is little incentive to undertaking further seismic safety measures. In the Charleston area the question that Wyner asks in California, "how safe is safe enough?" has not entered the arena of public policymaking (except for military construction) in a formalized manner. There, by default as well, the status quo is judged by most people to be safe enough.

A further study of problems in the implementation of seismic safety practices, specifically implementation of the seismic provisions of the building code, is currently being conducted by Nilson and Olsen (1981). They are attempting to account for variation in the effectiveness of seismic building regulations across a number of California jurisdictions. They identified a set of technologically induced problems as well as political and economic problems that contribute to uneven enforcement. Thus, if this

pattern were to be found in other areas of the country, and the relevant literature suggests that it would, the implementation of effective earthquake hazard mitigation measures in the Charleston area can be a long, difficult process.

We do not want to imply that our study of how basic earthquake hazards information is being used currently by officials and private business in the Charleston area is a basis for making recommendations for the implementation of sophisticated mitigation measures in the area. Rather, we want to convey through this discussion of implementation problems the thought that adequate information alone will not be sufficient to mitigate the hazard. Mitigation of the hazard will come only as solutions are found to the many reasons, cited in this report, why appropriate mitigation measures are not being effectively implemented now.

Recommendations

Two sets of recommendations were generated by this study. One set concerns the Charleston area; the other concerns the process of information dissemination more generally. The Charleston area recommendations are divided into the three categories--risk definition, mitigation activities, and preparedness activities.

Charleston Area Recommendations

Risk Definition

- Recommendations for policy concerning the earthquake hazard in the Charleston area should take into account scientific uncertainty about the locations of the faults and the mechanisms causing seismic activity in the area.

- Local response agencies need to have information about their vulnerability--what would happen to Charleston in the event of an earthquake--in order to understand what their responsibilities and duties should be and to devise an effective preparedness plan that can be implemented at all levels of government.

- Charleston officials need to know what areas would receive damage from an earthquake and what kinds and relative severity of damage to expect. The USGS, South Carolina Geological Survey, and academicians should begin to compile basic data necessary to answer these questions.

- Maps need to be compiled showing locations of the 1886 earthquake damage distribution and current hazards potential. The preparers of these maps need to translate and interpret the maps for local officials.

- A structures inventory needs to be completed, identifying those structures that are likely, due to age, construction, etc., to incur extensive damage in a major earthquake.

Mitigation Activities

- Because the Charleston area is prone to hurricanes and other natural hazards which occur more frequently than damaging earthquakes, efforts should be made to tie mitigation and response planning, education, and awareness efforts together for all natural hazards.

- Various jurisdictions in the Charleston area are in the very early stages of beginning to use the tools and information available to them to regulate land use. Planning commissions, zoning and subdivision ordinances, and building codes are be-

ing increasingly used to guide land development. Earth-science information is a necessary factor in this process. While Charleston expands its base of earth-science information to meet the land planning and regulating needs of the area, it should include those factors peculiar to earthquake-prone areas, such as maps showing areas prone to liquefaction. Since the majority of respondents in this study indicated substantial interest in attending a workshop that would explain the earthquake hazard, mitigation, and response, USGS and others should consider coordinating such a local workshop.

Preparedness Activities

- Until more definite technical information is available to be incorporated into a mitigation policy, Charleston should concentrate on improving its capability of responding to a damaging earthquake.

- Local response agencies need to know what kinds of services would be necessary to respond to an earthquake. They need to make this information need known to Federal and State agencies..

- Local response agencies need to inventory their emergency facilities and vehicles to see if they would withstand an earthquake. Facilities to be inventoried include: schools, police stations, hospitals, fire stations, and emergency vehicles (storage).

- The news media play an important role in Charleston. They educate the entire public including officials and professional people. They have been doing an excellent job keeping people informed and tying what happens elsewhere to what could happen in Charleston. However, the media need more information about the earthquake hazard in Charleston to continue to perform their job. USGS and other geologists engineers and social scientists should provide briefings and maintain ongoing contact with media representatives.

Recommendations to disseminate earth-science information:

- Professional and trade society newsletters, and journals are widely trusted and read by officials, professionals, and private industry. They should be used to educate and inform. USGS staff and others should prepare short, nontechnical articles for journals and newsletters that explain, among other subjects, the earthquake hazard and potential mitigation actions.

- Local and regional workshops can serve as important educational catalysts; new information should be presented to a region through intensive workshops.

- The local media, especially television and radio, should be kept aware of testing, research, and new findings.

Bibliography

Applied Technology Council, 1978, Tentative provisions for the development of seismic regulations for buildings, ATC Publication ATC 3-06, NBS Special Publication 510, NSF Publication 78-8. Washington, DC: U.S. Government Printing Office.

Arthur D. Little, Inc., 1975, "An evaluation of the San Francisco Bay region environment and resources planning study." Washington, DC: Office of Policy Development and Research, U.S. Department of Housing and Urban Development. 93 p.

Atkisson, A. A. and Petak, W. J., 1982, "The Politics of community seismic safety," in Hays, W. W. (editor). Preparing for and Responding to a Damaging Earthquake in the eastern United States: Proceedings of Conference XIV, September 16-18, 1981, Knoxville, Tennessee. U.S. Geological Survey Open File Report 82-220, p. 92-105.

Association of Bay Area Governments, 1977, Earthquake insurance issues. Berkeley, California: Association of Bay Area Governments. 14 p.

Association of Bay Area Governments, 1976, Earthquake preparedness: Ideas for action. Berkeley, California: Association of Bay Area Governments. 13 p.

Bates, F., 1979, Transferring earth science information to decisionmakers. Problems and opportunities as experienced by the U.S. Geological Survey. Geological Survey Circular 813. Arlington, VA: U.S. Geological Survey. 30 p.

Beavers, J. E. (Editor), 1981, Earthquakes and Earthquake Engineering-Eastern United States, Volumes I and II. Ann Arbor, Michigan: Ann Arbor Science. 1189 p.

Bingham, R. D., Hawkins, B., Frendreis, J. P., and LeBlanc, M. P., 1978, Professional associations as intermediaries in transferring technology to city governments. Milwaukee: The University of Wisconsin. (Prepared under a grant from the National Science Foundation.)

Bingham, R. (assisted by McNaught, T. P.), 1976, The adoption of innovation by local government. Lexington, Massachusetts: Lexington Books. 271 p.

Blair, M. L. and Spangle, W. E., 1979, Seismic safety and land-use planning-selected examples from California. Geological Survey Professional Paper 941-B. Washington, DC: U.S. Government Printing Office. 82 p.

Borcherdt, R. D. (ed.), 1975, Studies for seismic zonation of the San Francisco Bay region. U.S. Geological Survey Professional Paper 941-A. Washington, DC: U.S. Government Printing Office. 102 p.

Brabb, E. E. (ed.), 1979, Progress on seismic zonation in the San Francisco Bay region. Geological Survey Circular 807. Arlington, VA: U.S. Geological Survey. 91 p.

Britz, K. I., 1981, "The integration of seismic design principles into preliminary architectural design." Prepared for National Science Foundation. Pittsburgh: Carnegie Mellon Institute. 84 p.

Cohn, M. M. and Manning, M. J., 1977, "Dynamic technology transfer and utilization: The key to progressive public-works management" in Technological Innovation: The Experimental R & D Incentives Program. Edited by D. E. Cunningham, J. R. Craig and T. W. Schlie. Boulder, Colorado: Westview Press. p. 248-264.

Commander Naval Base, 1981, "Disaster prepardness guide." Charleston, S.C.: Naval Base. 19 p.

Crews, A. C., n.d., Charleston County Schools Emergency Plan. Charleston: Charleston County School District. 32 p.

Davenport, S. S. and Waterstone, P., 1979, Hazard awareness guidebook: Planning for what comes naturally. Austin, Texas: Texas Coastal and Marine Council. 41 p.

Dermengian, J. M., Christen, R. F., Paulin, G. B., Von Seggern, D. H., Cybriwsky, Z., 1981, "A preliminary analysis of the state of awareness of seismic hazards in the northeastern United States in response to an earthquake hazard and risk analysis survey." University Park, PA: Geophysics Program, The Pennsylvania State University. 6 p.

Drabek, T. E. and Mushkatel, A. E., 1980. Earthquake Mitigation Policy Formulation Processes: A Comparative Case Study. Denver, Colorado: Department of Sociology, University of Denver. 52 p.

Dutton, Capt. C. E., 1890, The Charleston earthquake of August 31, 1886. Washington, DC: Government Printing Office. (Reprinted 1979; available from Branch of Distribution, U.S. Geological Survey, Arlington, VA.). 528 p.

Federal Emergency Management Agency, 1980, An assessment of the consequences and preparations for a catastrophic California earthquake: findings and actions taken. Washington, DC: FEMA. 59 p.

Hamilton, R. M., 1981, "Geologic Origin of Eastern U.S. Seismicity" in Earthquakes and earthquake engineering-eastern United States, Volume I. Edited by James E. Beavers. Ann Arbor, Michigan: Ann Arbor Science, p. 3-24.

Hays, W. W. (ed.), 1982. Preparing for and Responding to a Damaging Earthquake in the Eastern United States: Proceedings of Conference XIV, September 16-18, 1981, Knoxville, Tennessee. U.S. Geological Survey Open File Report 82-220. 197 p.

Hays, W. W., 1979, Program and plans of the U.S. Geological Survey for producing information needed in national seismic hazards and risk assessment, fiscal years 1980-1984. Geological Survey Circular 816. Arlington, VA: U.S. Geological Survey. 40 p.

Hildebrand, M. S., 1980, Disaster planning guidelines for fire chiefs. Final Report. Washington, DC: Federal Emergency Management Agency. 70 p.

Kennett, E. W., 1979, Designing for earthquakes: Proceedings from the 1978 summer seismic institutes for architectural faculty. Washington, DC: American Institute of Architects Research Corporation, for the National Science Foundation. 316 p.

Kilijanek, T. S. and Mushkatel, A. E., 1981. Earthquake Mitigation Policy in Washington and Missouri: A Comparative Analysis. Paper presented at the annual meeting of the Western Social Science Association, April 23-24, San Diego, California. 24 p.

Kockelman, W. J., 1975, "Use of USGS earth science products by city planning agencies in the San Francisco Bay region. Menlo Park, California: U.S. Geological Survey Open-File Report 75-276. 110 p.

Kockelman, W. J., 1976, "Use of USGS earth science products by county planning agencies in the San Francisco Bay region." Menlo Park, California: U.S. Geological Survey Open-File Report 76-547. 186 p.

Kockelman, W. J., 1979, "Use of U.S. Geological Survey earth related products by selected regional agencies in the San Francisco Bay region." Menlo Park, California: U.S. Geological Survey Open-File Report 79-221.

Kunreuther, H., Ginsberg, R., Miller, L., Sagi, P., Slovic, P., Borkan, B., and Katz, N., 1978, Disaster Insurance Protection: Public Policy Lessons. New York: John Wiley and Sons.

Laird, R. T., Perkins, J. B., Bainbridge, D. A., Baker, J. B., Boyd, R. T., Huntsman, D., Staub, P. E., Zucker, M. B., 1979, Quantitative land-capability analysis. U.S. Geological Survey Professional Paper 945. Washington, DC: U.S. Government Printing Office. 115 p.

Lagasse, S. M., 1981, "The Earthquake hazard of the South Carolina low country region and the civil engineering implications." Unpublished Senior Research Paper. Charleston, SC: The Citadel. 83 p.

Lambright, W. H., 1979, Technology transfer to cities: Processes of choice at the local level. Boulder, Colorado: Westview Press. 188 p.

Loss, John, 1981. Building Design for Natural Hazards in Eastern United States. College Park, Maryland: College of Architecture, University of Maryland. 168 p.

Mushkatel, A. H. and Kilijanek, T. S., 1981, "Local resistance to seismic mitigation policy: St. Louis vs. HUD-Round 1." Paper presented at the Earthquake and Earthquake Engineering Meeting, September 13-16, Knoxville, Tennessee. 27 p.

National Governors' Association, 1979, Comprehensive emergency management: A governor's guide. Washington, DC: National Governors' Association, Center for Policy Research. 65 p.

National Science Foundation and Department of the Interior (USGS), 1976, Earthquake prediction and hazard mitigation options for USGS and NSF Programs. Washington, DC: U.S. Government Printing Office. 76 p.

Nichols, D. R. and Buchanan-Banks, J. M., 1974. Seismic Hazards and Land-Use Planning. U.S. Geological Survey Circular 690. Washington D.C.: U.S. Government Printing Office. 33 p.

Nigg, J., 1981, "Societal response to earthquake threat in the eastern United States: Issues, problems and suggestions," in Hays, W. W. (editor) Preparing for and Responding to a Damaging Earthquake in the Eastern United States: Proceedings of Conference XIV, September 16-18, Knoxville, Tennessee. U.S. Geological Survey Open File Report 82-220. p. 77-91.

Nilson, D. C. and Olsen, R. S., 1981, "Policies and implementation: Enforcing the seismic provisions of building regulations." Redlands, California: Policy Research Center, University of Redlands. 17 p.

Olson, R. A. and Scott, S., 1980, "Preparing for earthquakes: Where does California stand?" California Data Brief 4 (October):3-6.

Rankin, D. W., 1977, Studies related to the Charleston, South Carolina earthquake of 1886--A preliminary report. U.S. Geological Survey Professional Paper 1028. Washington DC: U.S. Government Printing Office. 204 p.

Reagor, B. G., Stover, C. W., and Algermissen, S. T., 1980. Seismicity Map of the State of South Carolina. U.S. Geological Survey Miscellaneous Field Studies, Map MF-1225.

Roessner, J. D., 1978, "Federal policy and the application of technology to state and local government problems," September 1977, in Hearings on Local Distress, State Surpluses, Proposition 13: Prelude to Fiscal Crisis or New Opportunities? before the Subcommittee on Banking, Finance, and Urban Affairs, House of Representatives, July 25. Ninety-fifth Congress, Second Session. 38 p.

Rogers, E. M. and Shoemaker, F. F., 1971, Communication of innovations. New York: The Free Press. 476 p.

Saarinen, T. F. and McPherson, H. J., 1981, Notices, Watches and Warnings: An Appraisal of the U.S.G.S.'s Warning System with a Case Study from Kodiak, Alaska. Natural Hazard Research Working Paper #42. Boulder, Colorado: Institute of Behavioral Science #6, University of Colorado. 91 p.

Scott, S. (ed), 1979, What decision-makers need to know: Policy and social science research on seismic safety. Berkeley, California: Institute of Governmental Studies, University of California, Berkeley. 38 p.

Seismic Safety Commission, 1979, Public official attitudes toward disaster preparedness in California. Sacramento, California: Disaster Preparedness Committee, Seismic Safety Commission. 59 p.

Spangle and Assoc., Inc. with Degenkolbs and Assoc., Earth Sciences Assoc., 1980, Land use planning after earthquakes. Portola Valley, California: William Spangle and Associates. 24 p. plus appendices.

Spangle and Assoc., Inc., F. Beach Leighton and Assoc., Baxter, McDonald and Company, 1976, Earth science information in land use planning-guidelines for earth scientists and planners. Geological Survey Circular 721. Arlington, VA: U.S. Geological Survey. 28 p.

Szanton, P., 1981, Not well advised. New York: Russell Sage Foundation and the Ford Foundation. 173 p.

U.S. Department of Commerce, 1981. 1980 Census of Population and Housing: South Carolina. PHC80-V-42. Washington D.C.: U.S. Government Printing Office. 16 p.

Utech, H. P. and Utech, I., 1974, "The Communication of innovations between local government departments." Pilot Study for the National Science Foundation, Office of National Research and Development Association. Washington DC: National Science Foundation.

Visvanathan, T. R., 1980, Earthquakes in South Carolina 1698-1975. Bulletin 40. Columbia, South Carolina: South Carolina Geological Survey. 61 p.

Wissel, P., O'Connor, R., Cigler, B., 1976, The use of geological information in the greater Pittsburgh area. University Park, Pennsylvania: The Pennsylvania State University, Center for the Study of Environmental Policy. 143 p.

Working Group on Earthquake Hazards Reduction, 1978, Earthquake hazards reduction: Issues for an implementation plan. Washington, DC: Office of Science and Technology Policy. Executive Office of the President. 231 p.

Wyner, A. J., 1981, "Seismic safety planning in California: How safe is safe enough?" Paper presented at the annual meeting of the Western Social Science Association, April 23-24, San Diego, California. 28 p.

Zupan, A.-J. (compilor), 1980-81, Catalog of geologic publications, Circular 1. Columbia, South Carolina: South Carolina Geological Survey. 27 p.

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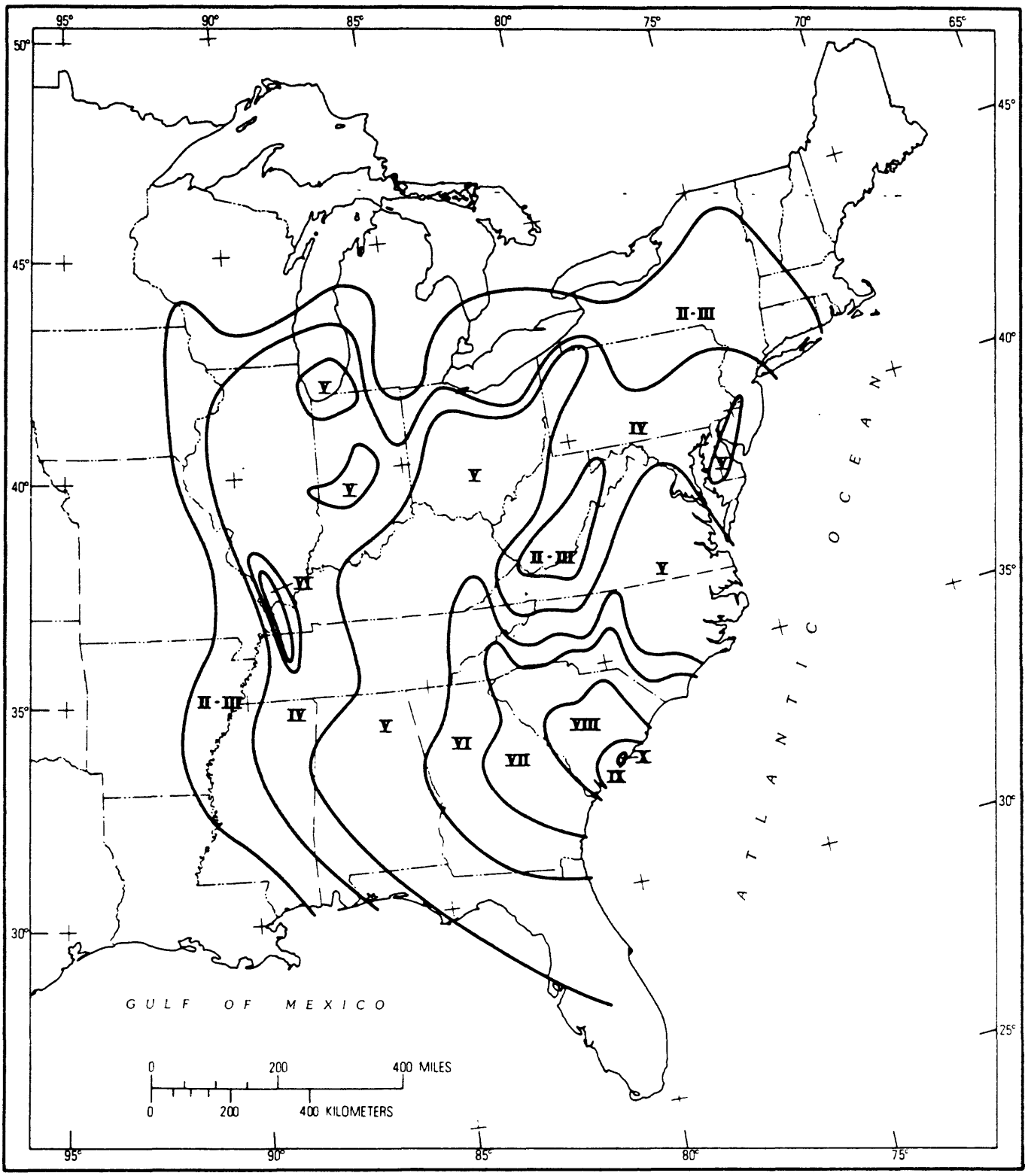
APPENDIX 2

MAPS DEPICTING SEISMIC RISK IN SOUTH CAROLINA

Figure 2.1: Isoseismal Map of the Eastern United States contoured to show the broad regional patterns of the reported intensities for the 1886 Charleston earthquake. (Rankin, 1977).

Figure 2.2: Seismicity Map of the State of South Carolina (Adapted from Reagor, Stover, and Algermissen, 1980).



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MODIFIED MERCALI INTENSITY SCALE OF 1931

I. Not felt--or, except rarely under especially favorable circumstances. Under certain conditions, at and outside the boundary of the area in which a great shock is felt: sometimes birds, animals, reported uneasy or disturbed; sometimes dizziness or nausea experienced; sometimes trees, structures, liquids, bodies of water, may sway--doors may swing, very slowly.

II. Felt indoors by few, especially on upper floors, or by sensitive, or nervous persons. Also, as in grade I, but often more noticeably: sometimes hanging objects may swing, especially when delicately suspended; sometimes trees, structures, liquids, bodies of water, may sway, doors may swing, very slowly; sometimes birds, animals, reported uneasy or disturbed; sometimes dizziness or nausea experienced.

III. Felt indoors by several, motion usually rapid vibration. Sometimes not recognized to be an earthquake at first. Duration estimated in some cases. Vibration like that due to passing of light, or lightly loaded trucks, or heavy trucks some distance away. Hanging objects may swing slightly. Movements may be appreciable on upper levels of tall structures. Rocked standing motor cars slightly.

IV. Felt indoors by many, outdoors by few. Awakened few, especially light sleepers. Frightened no one, unless apprehensive from previous experience. Vibration like that due to passing of heavy or heavily loaded trucks. Sensation like heavy body striking building or falling of heavy objects inside. Rattling of dishes, windows, doors; glassware and crockery clink and clash. Creaking of walls, frame, especially in the upper range of this grade. Hanging objects swung, in numerous instances. Disturbed liquids in open vessels slightly. Rocked standing motor cars noticeably.

V. Felt indoors by practically all, outdoors by many or most: outdoors direction estimated. Awakened many, or most. Frightened few--slight excitement, a few ran outdoors. Buildings trembled throughout. Broke dishes, glassware, to some extent. Cracked windows--in some cases, but not generally. Overturned bases, small or unstable objects, in many instances, with occasional fall. Hanging objects, doors, swing generally or considerably. Knocked pictures against walls, or swung them out of place. Opened, or closed, doors, shutters, abruptly. Pendulum clocks stopped, started or ran fast, or slow. Moved small objects, furnishings, the latter to slight extent. Spilled liquids in small amounts from well-filled open containers. Trees, bushes, shaken slightly.

VI. Felt by all, indoors and outdoors. Frightened many, excitement general, some alarm, many ran outdoors. Awakened all. Persons made to move unsteadily. Trees, bushes, shaken slightly to moderately. Liquid set in strong motion. Small bells rang--church, chapel, school, etc. Damage slight in poorly built buildings. Fall of plaster in small amount. Cracked plaster somewhat, especially fine cracks chimneys in some instances. Broke dishes, glassware, in considerable quantity, also some windows. Fall of knick-knacks, books, pictures. Overturned furniture in many instances. Moved furnishings of moderately heavy kind.

VII. Frightened all--general alarm, all ran outdoors. Some, or many, found it difficult to stand. Noticed by persons driving motor cars. Trees and bushes shaken moderately to strongly. Waves on ponds, lakes, and running water. Water turbid from mud stirred up. Incaving to some extent of sand or gravel stream banks. Rang large church bells, etc. Suspended objects made to quiver. Damage negligible in buildings of good design and construction, slight to moderate in well-built ordinery buildings, considerable in poorly built or badly designed buildings, adobe houses, old walls (especially where laid up without mortor), spire, etc. Cracked chimneys to considerable extent, walls to some extent. Fall of plaster in considerable to large amount, also some stucco. Broke numerous windows, furniture to some extent. Shook down loosened brickwork and tiles. Broke weak chimneys at the roof-line (sometimes damaging roofs). Fall of cornices from towers and high buildings. Dislodged bricks and stones. Overturned heavy furniture, with damage from breaking. Damage considerable to concrete irrigation ditches.

VIII. Fright general--alarm approaches panic. Disturbed persons driving motor cars. Trees shaken strongly--branches, trunks, broken off, especially palm trees. Ejected sand and mud in small amounts. Changes: temporary, permanent; in flow of springs and wells; dry wells renewed flow; in temperature of spring and well waters. Damage slight in structures (brick) built especially to withstand earthquakes. Considerable in ordinary substantial buildings, partial collapse: racked, tumbled down, wooden houses in some cases; threw out panel walls in frame structures, broke off decayed piling. Fall of walls. Cracked, broke, solid stone walls seriously. Wet ground to some extent, also ground on steep slopes. Twisting, fall, of chimneys, columns, monuments, also factory stacks, towers. Moved conspicuously, overturned, very heavy furniture.

IX. Panic general. Cracked ground conspicuously. Damage considerable in (masonry) structures built especially to withstand earthquakes: threw out of plumb some wood-frame houses built especially to withstand earthquakes; great in substantial (masonry) buildings, some collapse in large part; or wholly shifted frame buildings off foundations, racked frames; serious to reservoirs; underground pipes sometimes broken.

X. Cracked ground, especially when loose and wet, up to widths of several inches; fissures up to a yard in width ran parallel to canal and stream banks. Landslides considerable from river banks and steep coasts. Shifted sand and mud horizontally on beaches and flat land. Changed level of water in wells. Threw water on banks of canals, lakes, rivers, etc. Damage serious to dams, dikes, embankments. Severe to well-built wooden structures and bridges, some destroyed. Developed dangerous cracks in excellent brick walls. Destroyed most masonry and frame structures, also their foundations. Bent railroad rails slightly. Tore apart, or crushed endwise, pipe lines buried in earth. Open cracks and broad wavy folds in cement pavements and asphalt road surfaces.

XI. Disturbances in ground many and widespread, varying with ground material. Broad fissures, earth slumps, and land slips in soft, wet ground. Ejected water in large amounts charged with sand and mud. Caused sea-waves ("tidal" waves) of significant magnitude. Damage severe to wood-frame structures, especially near shock centers. Great to dams, dikes, embankments often for long distances. Few, if any (masonry) structures remained standing. Destroyed large well-built bridges by the wrecking of supporting piers, or pillars. Affected yielding wooden bridges less. Bent railroad rails greatly, and thrust them endwise. Put pipe lines buried in earth completely out of service.

XII. Damage total--practically all works of construction damaged greatly or destroyed. Disturbances in ground great and varied, numerous shearing cracks. Landslides, falls of rock of significant character, slumping of river banks, etc., numerous and extensive. Wrenched loose, tore off, large rock masses. Fault slips in firm rock, with notable horizontal and vertical offset displacements. Water channels, surface and underground, disturbed and modified greatly. Dammed lakes, produced waterfalls, deflected rivers, etc. Waves seen on ground surfaces (actually seen, probably, in some cases). Distorted lines of slight and level. Threw objects upward into the air.

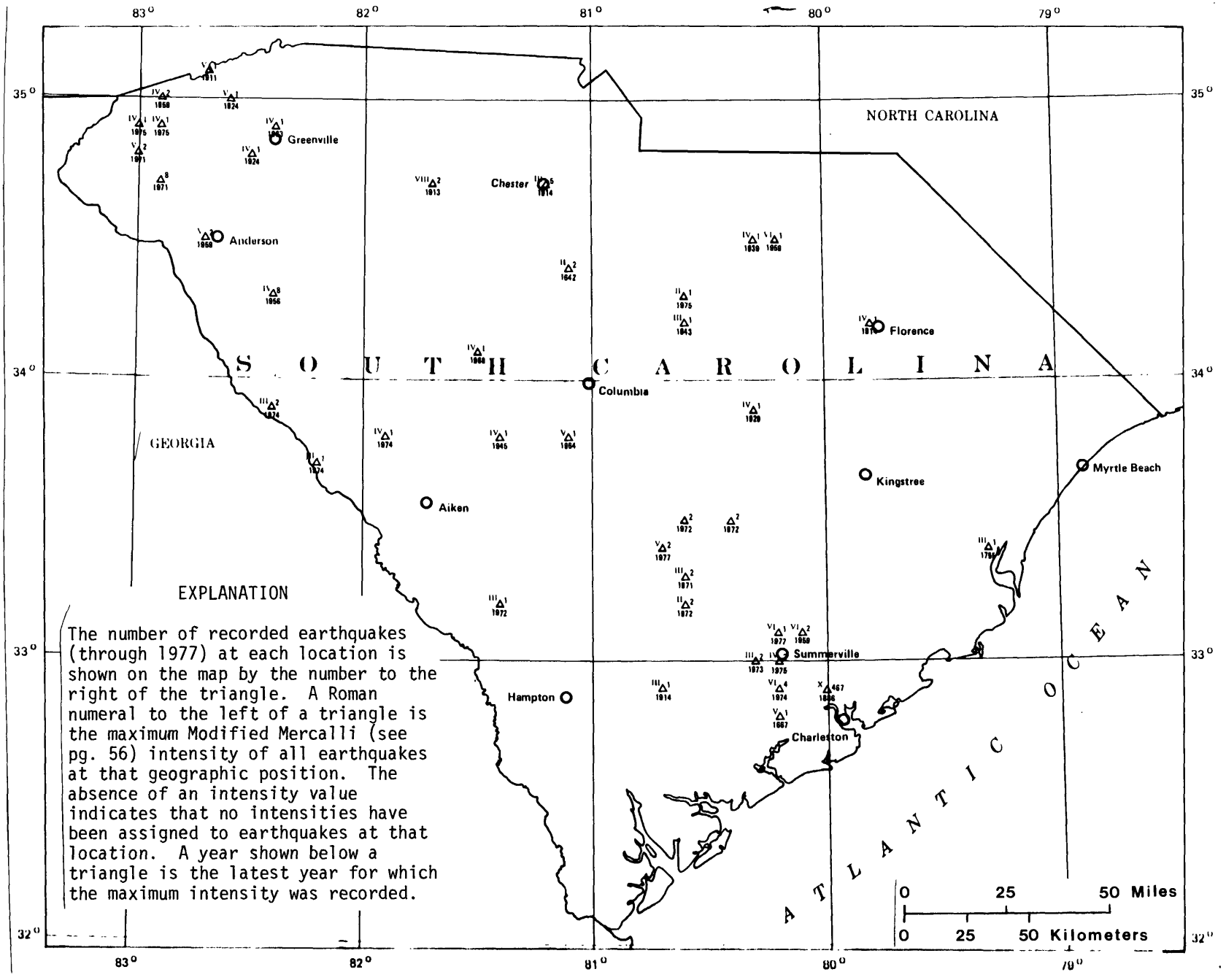
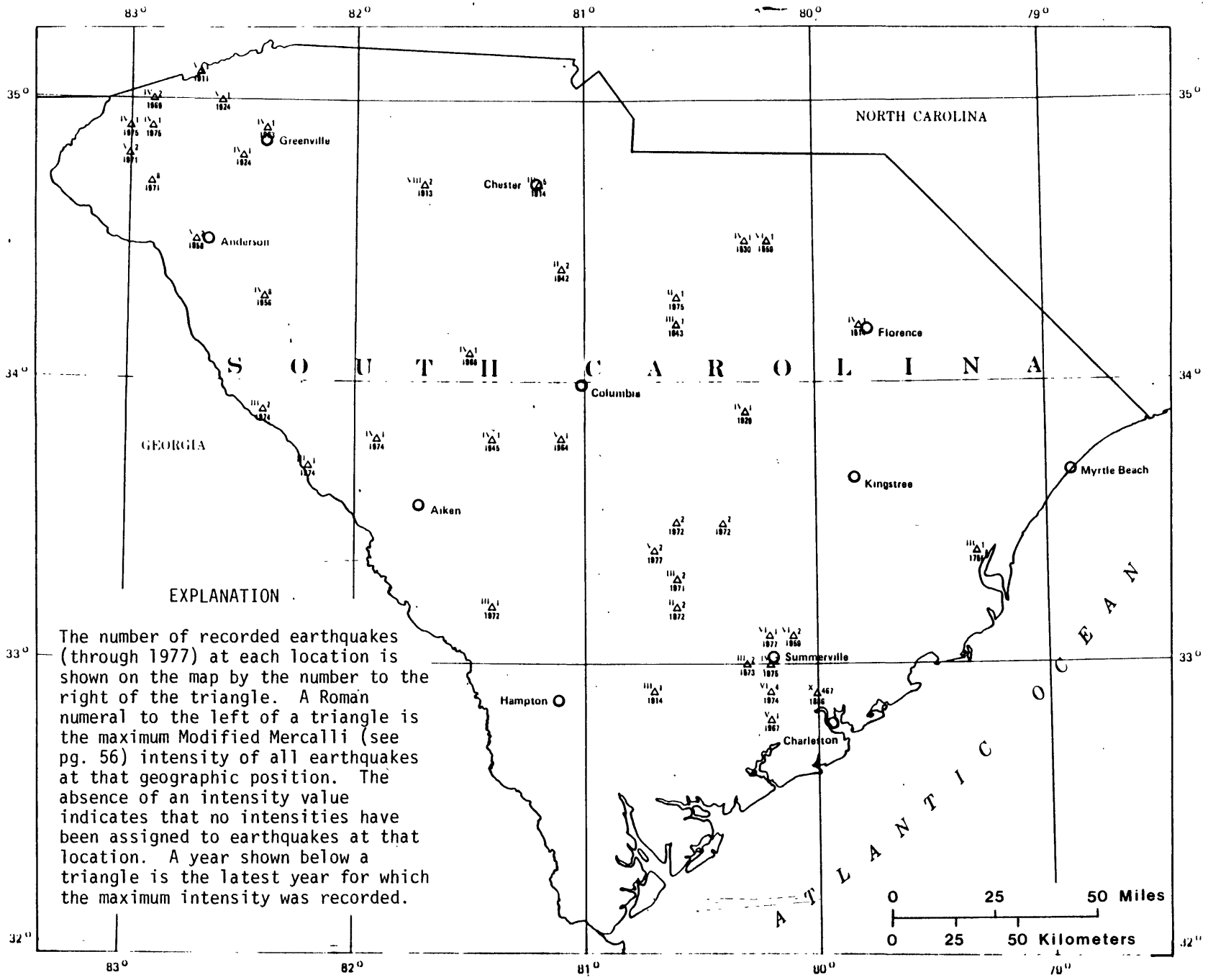


Figure 2.2--Seismicity Map of the State of South Carolina (adapted from Reagor, Stover, and Algermissen, 1980).



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