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LIFELINE DISRUPTION IN TWO COMMUNITIES

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When communities are struck by disasters, their ability to respond effectively is related to two general factors: emergency preparedness and response planning; and the resource capacity available to put those plans into effect. A large body of literature and research exists that illustrate how these two factors are interrelated, especially at the local level, in determining the community's ability to deal with disaster situations, whether unexpected or anticipated. Much of this research has focused on the functioning of emergency response organization (such as the local emergency management agency, fire and police departments, the Red Cross, and emergency medical services) following a disaster.

Almost no attention, however, has been given to the emergency preparedness of lifeline organizations (such as power systems, communication systems, water and sewerage systems, transportation systems, and public works departments). The extent to which these systems are disrupted could prevent emergency response agencies from being able to adequately carry out their duties. The failure of lifeline systems could also continue to expose community residents to health and safety hazards generated by the disaster agent; for example, a lack of water to fight fires following an earthquake, or the interruption of power to hospitals and emergency dispatch centers. Clearly, the need for such systems to function effectively following the onset of a disaster will be related to the effected community's ability to respond and to begin to recover from the destruction caused by the disaster agent.

In an effort to understand how lifeline organizations and agencies prepare for disasters and what effects that planning has on their ability to respond to disaster events, the Disaster Research Center, with funding from the National Science Foundation, has begun a two-year project to study lifeline systems in disasters. To date, several case studies of disaster-affected communities have been conducted to assess the degree of disaster planning that lifeline organizations have undertaken, to identify the problems that these organizations have faced, and to determine the extent to which lifeline failures are related to a community's recovery process. These case studies have a variety of disaster agents: two tornado events; three communities effected by the Loma Prieta earthquake; and two communities effected by Hurricane Hugo.

This presentation will focus on the response of lifeline organizations in Charleston, South Carolina and Charlotte, North Carolina to the winds and rains generated by Hurricane Hugo in September, 1989. Figure 1 illustrates the location of the two communities with respect to the Atlantic Coast. Although much attention has been paid to Charleston and other the coastal and island communities that experienced Hurricane Hugo, few people are aware that inland cities such as Charlotte also experienced major problems due to the hurricane. Through a comparison of four lifeline systems in these two communities--power, telephone, and water and sewerage--preliminary conclusions will be drawn about the types of problems that can be anticipated and why these problems occur.

CHARLESTON, SOUTH CAROLINA

The City of Charleston,located in Charleston County, lies in a low

coastal area on the Atlantic seaboard. The population of the city is approximately 72,000 people, comprising about a quarter of the population in the County. Per capita income in 1986 in the city was $10,600, about $1,000 above the county average. During the past few years, the population in the area has been relatively stable but with a small net loss.

South Carolina Electric and Gas Company (SCE&G) serves approximately 420,000 customers in the Charleston area. This is a privately-owned company that provides not only electric power and natural gas, but also runs the metropolitan bus service for the Charleston area.

Southern Bell is the major provider of telephone service to the Charleston area.

In the city of Charleston, water is distributed by the city's Department of Public Works.

The Impact of the Hurricane

The eye of Hurricane Hugo passed over Charleston at 12:01 a.m. on September 22. Its combination of wind (the highest recorded winds were 121 miles per hour in the City and 179 miles per hour at Bull's Island) and tides (11.8 feet in the City and 19.8 feet at Bull's Island) made it the worst hurricane to hit Charleston since the so called "Great Hurricane of 1752," 237 years before. The magnitude of the storm surge makes Hurricane Hugo a 500 year event, which totally destroyed several small coastal and barrier island towns in Charleston County.

The Charleston County Emergency Operations Center (EOC) had been set up almost two days prior to the hurricane's landfall to track the storm and prepare for impact and response activities. When the winds began to hit the city, the EOC was extensively damaged, forcing people to quickly relocate to a

warehouse next door. However, the roof of the warehouse appeared unstable, causing EOC personnel to evacuate that building,as the eye of the storm passed their location, to a public works garage located about 100 yards away. Once the hurricane had passed and the warehouse roof was inspected and found to be sound, the EOC was relocated to the warehouse and began to function.

Effects on Power Systems

SCE&G was severely effected by the hurricane because of the loss of both transmission and distribution lines. Over 300,000 customers in the Charleston area immediately lost power. Over 400 transmission structures and 5,000 distribution poles were either downed by the winds or needed to be replaced due to damage. Over 625 miles of wire needed to be replaced and 14,000 wire connections (service drops) needed to be reattached in order to return power to structures. Over 13,000 distribution transformers, but only one power transformer, failed. In order to make these repairs, debris removal became a mandatory, and time consuming, first step.

In order to undertake these repairs, the company's workforce had to be augmented. Volunteer and contract crews from 15 states and 48 different utility and contract companies responded. About 4,700 personnel were then available to return the system to use.

Three types of problems resulted from expanding the workforce. Coordination became a major problem. The need to locate personnel, especially out-of-town crews, and to track the whereabouts was an ongoing problem. The need for such a widespread tracking system had not been envisioned. Partly, coordination became a problem because of the lack of an effective communication system. The company had very few radio-dispatched vehicles. Those that were available were not always equipped to communicate with the

base or with other vehicles in the field. The presence of so many additional relief personnel also began to overtax existing hotel space, making adequate sheltering a concern.

Prior to the hurricane, the company moved the buses to safer locations in preidentified vehicle staging areas. This precaution turned out to be fortuitous since the company's major bus garage in Charleston was totally destroyed.

Because of the company's unique situation of operating the local bus system, however, another problem of lack of transportation for out-of-town crews was solved. Once roads began to be cleared sufficiently for crews to be dispatched to specific sites, public buses were used to transport workers, their equipment, and some provisions (water and food) to field sites. In addition to providing transportation for repair crews, the company also provided free transportation to the general public for several days following the hurricane.

Although initial estimates ranged from 4-6 weeks to complete restoration of the electric system, power had been fully restored systemwide within 18 days to all customers who were able to receive it. However, as structures were repaired throughout the area during the ensuing weeks, heavy demands continued to be placed on SCE&G to return power quickly to individual customers.

Effects on the Phone Company

The telephone system serving the Charleston area was minimally disrupted by Hurricane Hugo. Because of their experiences in Hurricane David approximately 10 years before, the company hardened many of its existing facilities and placed other facilities underground. Although many of the

fiber optic cable connections need electric power, generators were available to provide backup power. Since these generators were propane fueled, however, personnel were required to resupply the propane tanks in order to keep them operational.

Effects on the Water and Sewerage Systems

Water distribution systems were minimally effected by the hurricane; however, a shortage of potable water did occur. Due to failure of the water and sewer treatment facilities, raw sewage was being dumped into Charleston Harbor and water could not be treated. Within days after the hurricane, Charleston County requested assistance from the State Department of Public Health to certify the quality of water at various distribution points. Until that time, people were advised to use water from temporary water trucks, to add chlorine bleach to the water, or to boil water before use.

CHARLOTTE, NORTH CAROLINA

Charlotte, North Carolina, an historically rich city which was incorporated in 1768, is approximately 200 miles inland from the Atlantic Ocean. It is a community of approximately 380,000 people in the midst of a rapidly growing, economically healthy part of Mecklenburg County. Since 1960, the population of the city has increased by almost 50%, making it the most rapidly expanding part of its greater metropolitan area (which has increased by only 37%).

Duke Power Company is the sole provider of electric power in Charlotte. The utility is the eighth largest investor-owned utility, in terms of kilowatt hour sales, in the country. It serves over 4 million people in both North and South Carolina. Of the company's four geographic divisions, the Charlotte

Division is Duke's largest service area in terms of the total number of customers served.

Southern Bell is the sole provider of telephone service in Charlotte. In North Carolina, Southern Bell is divided into five service divisions, the largest of which is Charlotte where forty percent of Southern Bell's workforce in North Carolina is located. These divisions are, however, neither internally continuous nor externally adjacent to each other. The divisions resemble pieces of swiss cheese with other phone companies being interspersed both within and between Southern Bell's divisions.

The city gets its water from Mountain Island Lake, a reservoir fed by year-round runoff into the Catawba River. The Charlotte-Mecklenburg Utilities Department distributes this water through 1700 miles of water mains. The same government agency provides sewerage service to Charlotte through 1800 miles of sewer mains.

The Impact of the Hurricane

Hurricane Hugo passed over Charlotte at 4:00 a.m. on Friday, September 22 at which time the 80-100 mile per hour winds caught the community largely unprepared.

After the eye of the hurricane passed over Charleston, the National Weather Service called the "warning point"--a communications center for severe weather warnings--in Mecklenburg County to warn them of the approaching hurricane. Because of the early hour, delays in mobilizing the county's emergency management personnel and in contacting representatives of the local utility companies occurred. The Emergency Operations Center (EOC) for the county was not set up until noon on the 22nd due to the wind, rain, and transit difficulties.

Effects on Power Systems

Although Duke Power tracked the hurricane as it approached the southeast coast, the company did not take preventative measures in the Charlotte Division to protect the electrical distribution system. Restoration activities began immediately after the hurricane had passed; however, wind-blown debris and downed trees hampered the repair crews' ability to both assess damage and undertake repairs.

Although transmission lines were not affected to any great extent, the distribution network was severely affected. Initially, 98% of Duke's 235,000 customers in the Charlotte Division lost service. The lucky customers who still had electricity were located in Charlotte's Central Business District and were largely commercial clients who were served by underground lines. The primary reason for the system's failure was due to wind damage at the company's central power station. Also, 98% of the system's circuit breakers were tripped, effectively shutting down the system.

Due to the extensive disruption of the system, Duke Power called for mutual-aid assistance. Since hurricane damage had effected two of Duke's other operational districts as well, personnel and equipment could not simply be borrowed from elsewhere in the company. Assistance came from 30 or so other power companies in 14 other states. Many of these companies even brought their outside contract employees who routinely supplemented normal time operations in their home states. A total of approximately 3000 additional workers came in to assist Duke's personnel in the recovery effort.

No emergency planning for a system failure of this magnitude had ever been undertaken by Duke. In the absence of such planning or any preparedness measures, several problems arose during the response and early recovery

period.

Ten emergent Operating Centers were set up to manage the convergence of these out-of-town workers and to coordinate the massive restoration efforts that were being undertaken. Each of these Centers was responsible for restoring power within a "logical electrical area." Volunteers were then assigned to a specific part of the power system to repair.

Communication became a major problem of the coordination effort. Georgia Power Company brought in a radio system that was used to communicate between these centers and the volunteer crews in the field. Also, 140 cellular phones were rented and distributed to the managers of the repair crews to assist them in talking with other similar repair crews outside of their own repair area. Once phone service began to be more regular, 125 additional operators were added to handle requests for assistance from the general public.

The presence of the repair volunteers also resulted in sheltering problems. Much effort was expended by Duke's regular employees in finding hotel accommodations for the out-of-town crews in facilities that had electricity.

The company was also under some pressure from public officials, as well as emergency management personnel, to provide priority restoration of service instead of following the post hoc system of areal repair that the company had devised. The three classes of businesses for whom priority was requested were: grocery stores (to avoid food spoilage and to make food available to people who could use it); drug stores (to provide essential medicines); and gas stations (because gas, especially that needed for the repair crew vehicles and emergency vehicles, could not be pumped without electricity).

Because of problems (many of which were exacerbated by the floods that

occurred one week after Hugo) in repairing the central power station and other significant part of the distribution system, some areas of Charlotte were without power for up to six weeks. This condition greatly effected the ability of other lifeline systems and the community in general to return to some sense of normalcy.

Southern Bell

Even though the storm had been tracked by the area office in Charlotte and some preparedness measures undertaken, the hurricane created widespread, but temporary, disruption of telephone communications throughout the Charlotte area. Over 107,000 trouble reports were received from customers, creating a backlog in the more than 1,000 "normal-time" service requests. Over 35,000 downed service wires had to be restored and 340 miles of cable restored.

Following the hurricane, emergency restoration centers for the Charlotte Division and for the North Carolina Area were set up in Charlotte. Southern Bell's emergency center for its northern operations was established in Atlanta.

The day that Hugo hit Charlotte, 24 of Charlotte's 34 central switching offices had to go to emergency power sources. Two of these centers stayed on emergency power for six days. The loss of electric power was the primary reason for disruption of the phone system in Charlotte and could not be fully restored until Duke was able to repair their central plant.

Emergency power sources--primarily, diesel generators--posed their own problems for phone company employees. Manually starting up the generators and servicing them delayed service resumption, especially in remoter areas where debris blocked roadways. The availability of diesel fuel became problematic since many of the stations had to stay on backup generators for several days

(unlike most "routine" emergencies which involve only one station for a few hours).

Besides emergency power needs at the switching centers, portable generators were also needed at various points along cable lines to power devices (e.g., multiplexers and signal amplifiers) that normally got their electricity from the central switching stations. Several reports of thefts of these portable generators, along with the fuel to power them, were reported by the phone company. These thefts, primarily in more rural areas, may have been related to the delay in restoring power to outlying areas where people were not only without power, but also without water since they had their own individual wells.

To support these activities, about 500 employees from other divisions and areas in Southern Bell were brought in, many from out of state. These employees increased the phone company's labor force in Charlotte by 40% within three days after Hugo hit the area. Crews were expected to continue with restoration efforts for up to three months which, like the power company's volunteers, overwhelmed local capacity for hotel accommodations.

Within one day of the hurricane's impact, service had been restored to 90% of the phones in Charlotte; however, there were intermittent interruptions over the next several days.

The Utility Department

Neither water nor sewerage systems were severely disrupted in Charlotte; however, some problems for waste water collection and treatment did result from the extended loss of power.

Thirty-one of the department's 38 pumps lost power following the hurricane. Of those 31, only seven had standby power capability. The

department found it difficult to obtain the diesel fuel for these generators given the power outages at gasoline pumping stations (both private as well as those maintained by the local government).

Without power, sewage backs up into holding tanks which, when they become full, spill over into adjacent ponds and streams. This sewer discharge problem, which lasted for several days following the hurricane, was made worse by the "full pond" phenomenon. When Hugo hit, it dropped enough rain on the Charlotte area to fill all of the area's lakes and reservoirs, and to bring streams and rivers to near-flood stage. So-called "clean" waste water was already overtaxing the disposal system when the sewerage system also began to be added to these same arteries due to loss of pumping and treatment capabilities.

The department was able to temporarily repair breaks to a dozen broken sewer lines that crossed open water sources and remove debris from pumping and treatment facilities. It could do nothing, however, to restore the waste water system until Duke restored power to them. Department spokespersons expressed some frustration over not being able to communicate their needs to the power company directly. Because they are a governmental unit, the decision was made by city and county officials that they had to make all requests through the EOC which would, in turn, pass the requests on to Duke Power.

CONCLUSIONS

Although analysis of data on these two case studies, as well as that from other lifeline studies, is still being conducted, some preliminary conclusions can be made.

1. The failure of the power system has direct effects on the ability of a community to begin the recovery process due to its centrality in the operations of other lifeline systems.

2. Even though most of the production, distribution, and transmission facilities of power systems are above ground, they can be successfully hardened to make them more resilient to wind damage.

3. Even though water and sewerage systems are able to withstand significant hurricane events with relatively little physical damage, the systems lose their functional capabilities due to power losses, resulting in possible public health emergencies.

4. Disparities between the ways private sector and public sector lifeline organizations function following a disaster (i.e., decentralized versus centralized decision making) may have consequences for the rate of both system and community recovery.

5. Non-coastal communities are much less likely to take preparedness measures following hurricane watches and warnings due to their misperceptions about safety.

6. Few lifeline companies or agencies prepare for the possibility of a regional catastrophic event that cause multiple systems to fail.

7. Few lifeline companies or agencies have adequate communication systems or equipment to coordinate the convergence of relief workers.

8. Although representatives from lifeline organizations are often included as EOC personnel following a disaster, very little attempt is made to integrate them into the emergency response planning process in an ongoing way.

9. Lifeline organizations often have little awareness of how other lifeline systems with which they may have to interact are organized, making it difficult to locate the proper point of contact in such organizations when non-traditional demands are presented and when such organizations span multiple communities and jurisdictions.

Metropolitan Statistical Areas, NC, SC