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# BUSINESS VULNERABILITY AND DISRUPTION: DATA FROM THE 1993 MIDWEST FLOODS

Kathleen J. Tierney
Disaster Research Center
Department of Sociology and Criminal Justice
University of Delaware
Newark, DE USA 19716

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## ABSTRACT

Understanding business vulnerability to disasters is important for loss estimation, hazard mitigation, disaster preparedness, and recovery planning. However, only a very small number of studies have focused systematically on that topic. This paper presents preliminary findings from a study of a random sample of 1079 businesses in Des Moines/Polk County, Iowa, a community that experienced extensive damage and disruption as a result of the Midwest floods of 1993. The study focused on a range of topics, including business dependence on lifeline services, the physical flood damage businesses experienced, lifeline service disruption, and the impacts that disruption had on businesses. This paper reports findings on the importance of different lifeline services for businesses in different economic sectors and on flood-related lifeline service interruptions and their impact on business operations.

## Introduction

The Great Midwest Flood of 1993 was one of the most damaging disaster events in U. S. history. The flooding, which was the result of an anomalous and long-lasting pattern of excessive rainfall in the Upper Mississippi River Valley and the Great Plains during the spring and summer of that year, affected the Missouri and Mississippi rivers and their numerous tributaries. The intensity and duration of the rainfall and subsequent flooding were unprecedented; at their peak, floodwaters covered approximately 20 million acres of land in nine states. According to a report recently compiled by the National Oceanic and Atmospheric Administration, the "[r]ecord river stages, areal extent of flooding, persons displaced, crop and property damage, and flood

duration surpassed all floods in the United States in modern times" (NOAA, 1994:ix).

Forty-eight deaths were attributed to the floods. Estimates of the losses resulting from the flooding range between $12 and 20 billion; about half these losses were agriculturally-related, including damage to crops, fields, and equipment. A total of 525 counties in nine states, including all 99 counties in Iowa, were covered by Federal disaster declarations. Approximately 50,000 homes were destroyed or severely damaged, and more than 1,100 levees were breached or severely damaged. Damage to utilities, particularly water, waste water treatment, and storm water systems, is currently estimated to be in excess $85 million. The closure of the Mississippi River to barge traffic and the loss of bridges, interstate highways, and rail lines due to flooding produced major losses for the transport industry (NOAA, 1994; Interagency Floodplain Management Review Committee, 1994). Entire communities were inundated by flood waters, and the federal government is currently undertaking a program to relocate a number of highly vulnerable communities.

Des Moines, Iowa's state capital, was chosen as the site for this study because it was extensively damaged and disrupted by the flooding. The state of Iowa had experienced heavy and persistent rainfall throughout the spring and early summer of 1993, setting the stage for the catastrophic flooding that came later. In agricultural areas, the intense spring rains slowed soybean planting and made it impossible to plant corn. Heavy rainfall on

July 4 and 5, followed by a series of severe thunderstorm on July 8 and 9, caused major flooding along the Raccoon and Des Moines Rivers. The floodwaters subsequently inundated the Des Moines Water Works, leaving 300,000 residents without potable water and necessitating massive organized efforts to provide water for drinking and other purposes. Electrical power stations were flooded, resulting in power outages that affected 35,000 households and the entire downtown business district. Business losses in the Des Moines area alone have been estimated at $200-500 million. According to the New York Times (July 18, 1993), Des Moines was "perhaps the hardest hit city in the flood zone," because of the extent and duration of the flooding and the degree to which lifeline services and community activities were disrupted.

In the late spring and early summer of 1994, approximately nine months after the floods, the Disaster Research Center conducted a mail survey of businesses in Des Moines and Polk County, Iowa, to obtain information on how the flooding and resulting lifeline outages affected business operations, how businesses coped with the disruption, and what measures businesses had undertaken to deal with the impacts of floods and other disasters. The sections that follow describe the project in more detail and present preliminary survey findings on the importance of different lifeline services for business activities and on flood-related lifeline service interruptions and their impact on business operations.

## Disasters and Businesses

Disaster-related damage and disruption produce a range of impacts, not only on individual businesses but also on communities. Businesses that depend on a steady cash flow and that are forced to close down for even short periods may have difficulty remaining viable. Those that must relocate because of disaster damage may not do as well in their new locations, and marginal businesses may sink into insolvency as a result of disaster losses. Owners of commercial buildings that are destroyed or damaged typically encounter financial and other problems during the reconstruction process. Because loans constitute the main source of recovery funding for disaster-stricken businesses, owners who suffer losses are typically forced to take on additional debt. Business closures can contribute to short- and long-term unemployment and can inconvenience residents of disaster-stricken communities, who must go elsewhere to obtain needed goods and services.

It is not uncommon for disasters to severely damage major commercial districts in the communities they strike. This occurred, for example, in Xenia, Ohio, which suffered extensive damage from a massive tornado in 1974; in Coalinga, California, which experienced a damaging earthquake in 1983; and in Santa Cruz and Watsonville, California, which were hard-hit by the Loma Prieta earthquake in 1989. When their business districts are damaged by disasters, communities can face a host of problems, including the loss of property and sales tax revenues, threats to long-term business district viability, the potential loss of important

Existing studies on businesses in disasters have been relatively narrow in scope. For example, Durkin (1984) focused on small businesses that were affected by the 1983 Coalinga earthquake in an effort to determine the factors that facilitated or impeded business recovery. He found that the businesses that had the most difficulty recovering were those that were marginal or already in financial difficulty at the time of the earthquake, businesses that lost expensive inventories, that leased rather than owned their business properties, and that were heavily dependent on foot traffic but were forced to relocate due to earthquake damage.

Other studies have focused more specifically on the Small Business Administration's disaster loan program, the principal source of Federal assistance for disaster-stricken businesses. French, et al. (1984), in their study of the first few months of the community recovery process following the Coalinga earthquake, found that the slow pace of loan approvals, the bureaucratic "red tape" that accompanied the application process, and the interest rates charged on loans created dissatisfaction with the SBA business loan program. Dahlhamer (1992), in a study of 309 Southern California businesses that applied for SBA loans to cover losses they suffered in the 1987 Whittier Narrows earthquake, found that proprietor characteristics, business characteristics, and community characteristics were associated with the ability to obtain SBA assistance. Dahlhamer's research indicates that the SBA uses standards similar to those of commercial lenders in making decisions on disaster loans. Although one of the goals of the loan

program is to assist victimized businesses that commercial lenders might consider too "risky," the businesses and owners that experience the best outcomes in the government disaster loan application process would also find it relatively easy to qualify for loans in the commercial sector. Conversely, the applicants that tend to be unsuccessful in the loan application process are those who would also find it difficult to receive loan assistance from other sources. Studies like these provide some information on the experiences of one group of businesses--those that apply to the SBA--but their findings cannot be generalized beyond that population.

The Disaster Research Center has recently begun carrying out studies that are designed to shed light on more general topics, such as business vulnerability to disasters, how disaster-related damage and disruption affect business operations, and business mitigation and preparedness practices. In 1993, DRC conducted a mail survey on earthquake hazard awareness, perceived vulnerability to earthquake-related damage and disruption, and business emergency preparedness, using a random sample of businesses in Memphis/Shelby County Tennessee, a community that is affected by the earthquake hazard associated with the New Madrid Fault Zone. The Des Moines study used a similar survey approach to obtain data on how the floods and the resulting physical and lifeline damage affected business operations.

## The Des Moines Flood Survey

A two-stage stratified sampling method was used to select businesses for the Des Moines/Polk County survey; the stratifying variables were business type and business size. This ensured that an adequate number of large and small businesses as well as businesses from all industrial sectors were selected for the survey. (Since most small businesses are in the service sector and since overall most businesses are small, a non-stratified random sample would contain much larger numbers of those types of businesses, making it difficult to draw conclusions about others, such as large firms and those in the manufacturing sector.)

In the first stage of the sampling design, the 14,193 businesses in Polk County were aggregated by Standard Industrial Codes (SIC) into five business sectors: wholesale and retail sales; manufacturing, construction, and contracting; business and professional services; finance, insurance, and real estate; and other businesses (including agriculture, forestry and fishing, mining, transportation, communication, and public utilities). The second stage of the sampling design entailed the random selection of both small (fewer than 20 employees) and large (twenty or more employees) businesses within each of the five business sectors[1]. As a result, the original proportional stratified sample was

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[1] Twenty was used as the cut-off point delineating "small" and "large" businesses, since a larger number would result in too few "large" businesses being selected for the study. The majority of businesses in Des Moines-Polk County are very small (less than 10 employees).

partitioned into 10 smaller subsamples, based on size and business type.

The data collection strategy employed was a modified version Dillman's (1978) "total design method," an approach that is widely used in mail survey research and that usually consists of a series of mailings and phone calls. However, given DRC's previous experience with business surveys, the initial mailing of questionnaires was followed up by telephone calls to business owners after a reasonable amount of time for questionnaire completion had passed, and postcards and second reminder mailings were eliminated.[2] On March 14, 1994, each of the 2,164 businesses selected to participate in the study received a self-completion survey by mail. Approximately two weeks after the initial mailing, businesses that had not returned a completed survey were followed up with one or more phone calls encouraging proprietors to respond; phone calls continued until July 1, 1994[3]. As of November 8, 1994, a total of 1,079 questionnaires had been received and coded. The response rate for the study is 50 per cent, well above the DRC's target goal of 40%.

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[2] Additional mailings were not eliminated entirely, however. When contacted, a number of business owners said that they had not received the initial mailing, or that it had been discarded, so another copy of the questionnaire was sent to them.

[3] During the mailing process, if it was determined that a business was outside the Des Moines-Polk County limits, or that it had closed, it was processed as a non-sample case and replaced by another business from the same zip code within the same subsample. A total of 426 businesses were processed as non-sample cases and replaced by other businesses.

The survey instrument contained questions on the following topics: (1) the flooding and physical damage businesses experienced, including information on dollar losses and insurance coverage; (2) use of lifeline services in business activities and their importance during normal times; (3) flood-related lifeline service interruptions and their impact on business operations; (4) the duration and causes of business closure; (5) types of assistance (e.g., SBA loans) businesses used to recover from flood-related damage and disruption, as well as owners' assessments of the adequacy of the aid they received; (6) owners' evaluations of the extent to which the business had recovered; (7) preparedness measures businesses had undertaken, both before and since the flood; (8) previous disaster experience; and (9) general information on each business, such as how long it had been in operation and whether the space the business occupied was owned or leased.

Although parts of Des Moines and Polk County were inundated by flood waters, the flooding affected businesses in the community primarily through its impact on the provision of lifeline services. While only some sections of the community suffered direct flood damage, the entire community was affected by the damage that was done to water treatment and sewage facilities, and flood-related electrical service interruptions were extensive. Thus, this initial analysis focuses mainly on how lifeline outages affected business operations.

## Importance of Lifeline Services for Business Operations

As a way of gauging how vulnerable businesses are to lifeline service interruptions, we first attempted to determine how critical these services are to businesses in different economic sectors. We initially asked a series of questions about how businesses use lifeline services in their activities--for example, whether they use electricity for operating lights and office equipment, heavy equipment, and computers, whether they use water for drinking, sanitation, cooling, or industrial processes, and so on. Next, we asked about the importance of these different types of lifeline use for business operations. Based on these responses, we developed an overall importance score for each lifeline service. Tables 1 and 2 contain information on assessments of the importance of different lifeline services by small and large businesses, disaggregated by economic sector. Overall, electricity was rated as the most critical lifeline service by both large and small businesses, with the former considering electric service more important than the latter. Large manufacturing and construction firms and both large and small companies in the finance, insurance, and real estate sectors were more likely than other businesses to rate electricity as critical to their operations. While small businesses generally considered telephone service to be the second most critical lifeline, large businesses appeared to view telephones, water, sewer service, and natural gas as equally critical. These data provide some indication of how much business owners believe they rely on different lifeline services and of the extent to which

business activities would be disrupted or curtailed by lifeline failures.

## Lifeline Service Interruption in the Midwest Floods

Extent and Duration of Lifeline Service Interruptions. The data discussed above relate to owners' assessments of the criticality of different lifeline services. Considered next are survey findings on how the flooding affected the provision of lifeline services to businesses and how service interruptions affected their activities. The data indicate that lifeline service interruptions of various kinds were widespread during the flood period. As shown in Table 3, approximately 80% of the businesses surveyed reported being without water as a result of the flooding. Nearly 40% lost sewer services, and about 35% reported being without electricity as a result of the flooding. Twenty-three per cent of the businesses lost telephone services, and a relatively small proportion, about 6%, reported that natural gas service was curtailed as a result of the flooding.

With respect to sectoral differences in flood-related lifeline service interruption, businesses in the manufacturing and construction sector were more likely than other businesses to report that they lost electricity, telephone service, and natural gas as a result of the flooding. Loss of water service was so widespread that rates of service interruption did not vary significantly by sector.

Some lifeline services were lost for a longer period of time than others. As Table 4 shows, the median length of time

businesses were without water, sewer, and natural gas service was 288 hours, or about 12 days. In contrast, the median period of time electricity and phone services were lost was about two days. Few sectoral distinctions were evident in the data on duration of lifeline loss; it does appear, however, that compared with other types of businesses, those in the service sector experienced longer interruptions in water service. The number of businesses that reported losing natural gas service was small; within that group, businesses engaged in wholesale and retail trade experienced the shortest service interruptions, and those in manufacturing and construction went the longest time without service.

Disruptiveness of Lifeline Outages. Businesses that reported lifeline service interruptions were asked to assess how disruptive those outages were to their business operations. On the whole, as shown in Table 5, the loss of service placed severe constraints on business operations; a very high proportion of those surveyed rated lifeline service loss as "disruptive" or "very disruptive." On average, the loss of telephone service was seen as most problematic by business proprietors, with about 67% indicating that they found service interruption "very disruptive," followed by electricity (65%), sewer (43.5%), and water (41.9%). Telephone loss was seen as particularly disruptive by businesses in the finance, insurance, and real estate, and wholesale and retail trade sectors. Businesses in the finance, insurance, and real estate and manufacturing and construction sectors were more likely than other businesses to rate loss of electricity as "very disruptive." It

appears that, even though businesses were without water and sewage services for longer periods of time, the loss of phones and electricity were still judged to be most disruptive of ongoing business operations. This is generally consistent with what business owners reported on the questions discussed above, regarding the extent to which they rely on those lifelines during their normal operations.

Business Closure. Of the total sample of 1,079 businesses, 448, or about 41%, were forced to close for some period of time during the flooding. Table 6 contains data on the proportion of small and large businesses in each sector that were forced to close and on the median length of time they were closed. Rates of business closure were highest for large manufacturing and construction firms, large companies offering business and professional services, and small manufacturing and construction firms. More than half of all businesses in these categories were forced to close for at least some period of time. Large businesses in the finance, insurance, and real estate sector also closed frequently. Businesses outside the four major categories, classified as "Other," were least likely to close as a result of the flooding, but those that did were shut down for longer periods of time. Large manufacturing and construction firms and both small and large service sector businesses also tended to close for longer periods than other businesses.

As shown in Table 7, when asked to indicate why their businesses had to close, proprietors most frequently cited loss of

water (mentioned by approximately 64% of respondents whose businesses closed), loss of electricity (about 42%), loss of sewer or waste water services (39%), and loss of customers. Other common reasons for closure included the loss of telephone service (28%), the fact that employees could not get to work (26%), and inability of the business to deliver its products or services because of the floods (26%). Actual flooding of the building was reported as a reason for closure by about 20% of the businesses.

After indicating the various reasons why their businesses were forced to close, proprietors were asked which were the three most important reasons for closing. The causes most frequently rated as important were loss of water, flooding of the business property, and loss of electricity. Other reasons owners considered important included the need to evacuate because of the threat of flooding, loss of customers, an official proclamation that was issued ordering businesses in the downtown area to vacate, and the inability of employees to get to work. These data indicate that actual flooding was a comparatively rare source of business disruption in this event, and that the loss of critical lifeline services was a much more important cause of business closure, affecting a significantly larger number of businesses.

One implication of these data is that business proprietors tend to underrate the importance of water service for their operations. While generally assigning greater importance to lifeline services such as phones and electricity, these business owners also acknowledge that interruption of water service was the

most important factor causing their businesses to shut down.

## Discussion and Conclusions

In order to estimate the direct and indirect economic losses that can result from floods, earthquakes, hurricanes, and other disasters, several types of data are needed. First, it is necessary to determine what is at risk. This is accomplished through identifying the elements in the human, built, and natural environment that can be affected should a disaster occur. Second, the various direct effects the disaster agent is likely to produce, such as deaths, damage to different types of structures, lifelines, and the natural environment need to be well understood. Third, more detailed research is needed to determine how the physical damage engendered by disasters creates secondary and indirect losses and disrupts social and economic activity.

An important part of this effort involves clarifying how different types of disaster damage affect ongoing economic activity. For example, in the earthquake area, considerable emphasis is placed on increasing the seismic performance of buildings through the development and application of building codes. Protecting the life safety of building occupants is the main objective of the building codes, but their use is also predicated on the assumption that reducing the potential for building damage will also keep businesses in operation, thus reducing direct and indirect economic losses. However, codes may accomplish little in the way of loss reduction if economic disruption stems instead from causes other than building damage,

such as damage to nonstructural building components and lifelines. For this reason, those interested in earthquake loss reduction are increasingly emphasizing the importance of maintaining the functionality of structures and systems--an effort that involves broader concerns than those addressed by the codes.

Studies like the Des Moines survey attempt to make a contribution to this effort by disaggregating the effects of different types of disaster-related damage on business operations. The analyses reported here are preliminary and descriptive. They do suggest, however, that in the 1993 floods, damage to lifelines and resultant service interruptions were a more important cause of business disruption than was the physical flooding itself. Only 15% of the businesses sustained direct flood damage, yet a very high proportion were affected by the loss of one or more critical lifeline services. Businesses found themselves without telephone service, without electricity, and perhaps most importantly, without water for drinking and sanitation. During the time lifeline services were unavailable, a large proportion were out of business. Because so many more businesses were affected by lifeline outages than were directly affected by flooding, the latter likely contributed less than the former to the overall economic losses resulting from the event. Additionally, while many of the businesses that were flooded suffered direct physical damage and may have had more problems getting back into operations, some owners at least had flood insurance that would cover some of those

losses.[4] Businesses that were forced to close due to lifeline outages were less likely to have their losses covered; in our survey, approximately 90% of the businesses that closed indicated they had no business interruption insurance. More extensive analyses will be needed to explore questions such as how physical flood damage and the loss of lifeline service were related to economic losses, how business proprietors coped with these types of disruption, and how lifeline disruption, physical damage, insurance, and other factors affected business recovery.

Efforts to increase levels of disaster mitigation and preparedness tend to focus on the micro-level, giving individual homeowners and business owners information on how they can secure their property against damage. Underlying such programs is the assumption that mitigating damage to the structure and contents of a building and obtaining insurance protection to cover physical damage will have the greatest payoff as loss-reduction strategies. However, as this research indicates, a home or business may escape direct damage and yet suffer extensive disruption as a result of lifeline service interruption. One implication of this work is that, in order to reduce disaster losses, individually-focused preparedness efforts must be balanced by broader, macro-level approaches that focus on maintaining the functionality of businesses, communities and local economies. Clearly, ensuring the

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[4] Insurance coverage for businesses in this event was not widespread, however. In our sample, only 25% of the businesses that experienced flooding indicated their losses were covered by flood insurance.

continuing provision of lifeline services would be a critical element in that strategy.

The Des Moines survey focused on a representative sample of businesses to determine how those businesses fared in a major disaster and to identify the causes, extent, and consequences of business disruption. The study constitutes a major improvement over earlier research, in that it produced findings that are generalizable to the entire population of businesses that were affected by a disaster. However, the study only focused on a single case, and its findings obviously cannot be generalized to other communities and other disaster situations. Nevertheless, it can be argued the general pattern observed in Des Moines might also be characteristic of other types of disasters, such as earthquakes; that is, in a large earthquake, many businesses will experience direct physical damage, but it is likely that an even larger number will suffer disruption and losses due to lifeline failures. DRC is currently preparing to undertake a survey of businesses affected by the Northridge earthquake to further explore the issues discussed here and to compare and contrast the two disaster events.

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Table 1. Importance of Lifeline, by Sector for Small Businesses - 19 or Fewer Employees

| Type of Business | NIAA[a] | NVI | I | VI | C |
|---|---|---|---|---|---|
| Wholesale and Retail Trade: | | | | | |
| Electric (N=157) | .6% | 1.9% | 11.5% | 40.1% | 45.9% |
| Water (N=157) | 1.3 | 14.0 | 29.9 | 31.8 | 22.9 |
| Phone (N=120) | 6.7 | 5.8 | 15.8 | 27.5 | 44.2 |
| Sewer (N=153) | 1.3 | 10.5 | 24.8 | 30.7 | 32.7 |
| Gas (N=140) | 3.6 | 11.4 | 22.9 | 21.4 | 40.7 |
| Manufacturing and Construction: | | | | | |
| Electric (N=90) | 1.1 | 2.2 | 11.1 | 35.6 | 50.0 |
| Water (N=92) | 1.1 | 10.9 | 32.6 | 33.7 | 21.7 |
| Phone (N=58) | 5.2 | 13.8 | 13.8 | 27.6 | 39.7 |
| Sewer (N=87) | 2.3 | 12.6 | 36.8 | 24.1 | 24.1 |
| Gas (N=76) | 1.3 | 10.5 | 30.3 | 18.4 | 39.5 |
| Business and Professional Services: | | | | | |
| Electric (N=256) | .8 | 3.1 | 13.7 | 33.2 | 49.2 |
| Water (N=258) | 0 | 9.3 | 28.3 | 32.9 | 29.5 |
| Phone (N=188) | 4.8 | 9.0 | 12.2 | 34.0 | 39.9 |
| Sewer (N=252) | .8 | 7.5 | 26.6 | 30.2 | 34.9 |
| Gas (N=232) | 1.7 | 6.9 | 25.4 | 33.2 | 32.8 |
| Finance, Insurance, and Real Estate: | | | | | |
| Electric (N=108) | 0 | 1.9 | 6.5 | 25.0 | 66.7 |
| Water (N=107) | 0 | 13.1 | 27.1 | 34.6 | 25.2 |
| Phone (N=74) | 4.1 | 5.4 | 16.2 | 32.4 | 41.9 |
| Sewer (N=105) | 0 | 5.7 | 29.5 | 34.3 | 30.5 |
| Gas (N=88) | 2.3 | 4.5 | 29.5 | 27.3 | 36.4 |
| Other:[b] | | | | | |
| Electric (N=68) | 1.5 | 2.9 | 14.7 | 39.7 | 41.2 |
| Water (N=70) | 1.4 | 12.9 | 38.6 | 30.3 | 17.1 |
| Phone (N=56) | 1.8 | 8.9 | 19.6 | 28.6 | 41.1 |
| Sewer (N=68) | 2.9 | 13.2 | 36.8 | 26.5 | 20.6 |
| Gas (N=56) | 1.8 | 16.1 | 37.5 | 23.2 | 21.4 |
| All Businesses | | | | | |
| Electric (N=679) | .7 | 2.5 | 11.8 | 34.5 | 50.5 |
| Water (N=684) | .6 | 11.5 | 30.1 | 32.7 | 25.0 |
| Phone (N=496) | 4.8 | 8.3 | 14.7 | 30.8 | 41.3 |
| Sewer (N=665) | 1.2 | 9.2 | 29.0 | 29.8 | 30.8 |
| Gas (N=592) | 2.2 | 9.0 | 27.2 | 26.7 | 35.0 |

[a] NIAA= Not Important At All, NVI= Not Very Important, I= Important, VI= Very Important, C=Critical

[b] "Other" consists of agricultural, fishing, forestry, mining, transportaion, and public communications firms.

Table 2. Importance of Lifeline, by Sector for Large Businesses - 20 or More Employees

| Type of Business | NIAA[a] | NVI | I | VI | C |
|---|---|---|---|---|---|
| Wholesale and Retail Trade: | | | | | |
| Electric (N=56) | 0 % | 1.8% | 1.8% | 39.3% | 57.1% |
| Water (N=56) | 0 | 5.4 | 30.4 | 28.6 | 35.7 |
| Phone (N=42) | 14.3 | 2.4 | 7.1 | 45.2 | 31.0 |
| Sewer (N=55) | 0 | 9.1 | 23.6 | 21.8 | 45.5 |
| Gas (N=47) | 4.3 | 8.5 | 21.3 | 25.5 | 40.4 |
| Manufacturing and Construction: | | | | | |
| Electric (N=73) | 0 | 1.4 | 2.7 | 17.8 | 78.1 |
| Water (N=73) | 0 | 4.1 | 27.4 | 31.5 | 37.0 |
| Phone (N=57) | 3.5 | 3.5 | 14.0 | 52.6 | 26.3 |
| Sewer (N=73) | 1.4 | 5.5 | 39.7 | 26.0 | 27.4 |
| Gas (N=69) | 0 | 10.1 | 24.6 | 23.2 | 42.0 |
| Business and Professional Services: | | | | | |
| Electric (N=86) | 0 | 0 | 9.3 | 36.0 | 54.7 |
| Water (N=86) | 1.2 | 1.2 | 15.1 | 40.7 | 41.9 |
| Phone (N=62) | 1.6 | 11.3 | 24.2 | 25.8 | 37.1 |
| Sewer (N=83) | 1.2 | 1.2 | 24.1 | 24.1 | 49.4 |
| Gas (N=84) | 2.4 | 7.1 | 23.8 | 23.8 | 42.9 |
| Finance, Insurance, and Real Estate: | | | | | |
| Electric (N=65) | 0 | 0 | 6.2 | 30.8 | 63.1 |
| Water (N=65) | 0 | 1.5 | 29.2 | 38.5 | 30.8 |
| Phone (N=44) | 4.5 | 6.8 | 18.2 | 43.2 | 27.3 |
| Sewer (N=65) | 0 | 3.1 | 20.0 | 38.5 | 38.5 |
| Gas (N=53) | 0 | 5.7 | 20.8 | 30.2 | 43.4 |
| Other:[b] | | | | | |
| Electric (N=58) | 0 | 0 | 3.4 | 55.2 | 41.4 |
| Water (N=58) | 1.7 | 13.8 | 31.0 | 32.8 | 20.7 |
| Phone (N=43) | 4.7 | 9.3 | 14.0 | 41.9 | 30.2 |
| Sewer (N=56) | 1.8 | 12.5 | 28.6 | 35.7 | 21.4 |
| Gas (N=50) | 4.0 | 4.0 | 30.0 | 36.0 | 26.0 |
| All Businesses | | | | | |
| Electric (N=338) | 0 | .6 | 5.0 | 34.9 | 59.5 |
| Water (N=338) | .6 | 4.7 | 25.7 | 34.9 | 34.0 |
| Phone (N=248) | 5.2 | 6.9 | 16.1 | 41.1 | 30.6 |
| Sewer (N=332) | .9 | 5.7 | 27.4 | 28.9 | 37.0 |
| Gas (N=303) | 2.0 | 7.3 | 24.1 | 27.1 | 39.6 |

[a] NIAA= Not Important at All, NVI= Not Very Important, I= Important, VI= Very Important, C= Critical

[b] "Other" consists of agricultural, fishing, forestry, mining,transportation, and public communications firms.

Table 3. Percent of Businesses Reporting Lifeline Service Interruption, by Business Sector

| Business Sector | Electric Percent (N) | Water | Phone | Sewer | Gas |
|---|---|---|---|---|---|
| Wholesale and Retail Trade | 29.8% (228) | 79.7% (227) | 21.0% (224) | 39.2% (227) | 3.0% (167) |
| Manufacturing and Construction | 41.1 (175) | 82.4 (176) | 32.2 (174) | 34.5 (174) | 12.4 (113) |
| Business and Professional Services | 36.7 (357) | 79.7 (359) | 23.1 (355) | 43.0 (358) | 7.5 (241) |
| Finance, Insurance, and Real Estate | 36.9 (176) | 78.0 (173) | 24.6 (175) | 44.2 (172) | 3.0 (101) |
| Other[a] | 25.2 (131) | 82.3 (130) | 13.0 (131) | 33.8 (130) | 6.2 (81) |
| All Businesses | 34.6 (1067) | 80.2 (1065) | 23.1 (1059) | 39.9 (1061) | 6.4 (703) |

[a] "Other" consists of agricultural, fishing, forestry, mining, transportation, and public communications firms.

Table 4. Median Duration of Service Interruption, by Business Sector (in hours)

| Business Sector | Electric | Water | Phone | Sewer | Gas |
|---|---|---|---|---|---|
| Wholesale and Retail Trade | 48 | 288 | 48 | 288 | 108 |
| (N) | (59) | (169) | (43) | (83) | (4) |
| Manufacturing and Construction | 48 | 288 | 72 | 288 | 480 |
| | (72) | (137) | (52) | (56) | (12) |
| Business and Professional Services | 48 | 312 | 48 | 288 | 240 |
| | (124) | (262) | (72) | (138) | (13) |
| Finance, Insurance, and Real Estate | 48 | 288 | 48 | 288 | 228 |
| | (59) | (127) | (38) | (72) | (2) |
| Other[a] | 36.5 | 288 | 48 | 288 | 240 |
| | (32) | (104) | (16) | (44) | (4) |
| All Businesses | 48 | 288 | 48 | 288 | 288 |
| | (346) | (799) | (221) | (393) | (35) |

[a] "Other" consists of agricultural, fishing, forestry, mining, transportation, and public communications firms.

Table 5. Disruptiveness of Service Interruption, by Sector

| Type of Business | ND[a] | NVD | D | VD |
|---|---|---|---|---|
| Wholesale and Retail Trade: | | | | |
| Electric (N=68) | 1.5% | 10.3% | 20.6% | 67.6% |
| Water (N=181) | 6.1 | 11.0 | 41.4 | 41.4 |
| Phone (N=46) | 0 | 6.5 | 21.7 | 71.7 |
| Sewer (N=89) | 2.2 | 12.4 | 42.7 | 42.7 |
| Gas (N=4) | 30.0 | 25.0 | 0 | 25.0 |
| Manufacturing and Construction: | | | | |
| Electric (N=72) | 4.2 | 11.1 | 13.9 | 70.8 |
| Water (N=143) | 2.8 | 18.2 | 45.5 | 33.6 |
| Phone (N=54) | 5.6 | 5.6 | 20.4 | 68.5 |
| Sewer (N=60) | 5.0 | 16.7 | 53.3 | 25.0 |
| Gas (N=15) | 40.0 | 20.0 | 20.0 | 20.0 |
| Business and Professional Services: | | | | |
| Electric (N=128) | 4.7 | 7.8 | 25.8 | 61.7 |
| Water (N=282) | 3.9 | 11.3 | 34.4 | 50.4 |
| Phone (N=80) | 2.5 | 5.0 | 30.0 | 65.5 |
| Sewer (N=148) | .7 | 8.8 | 39.9 | 50.7 |
| Gas (N=17) | 35.3 | 23.5 | 17.6 | 23.5 |
| Finance, Insurance, and Real Estate: | | | | |
| Electric (N=64) | 4.7 | 6.3 | 17.2 | 71.9 |
| Water (N=136) | 2.9 | 11.8 | 41.2 | 44.1 |
| Phone (N=41) | 0 | 4.9 | 22.0 | 73.2 |
| Sewer (N=76) | 5.3 | 5.3 | 34.2 | 55.3 |
| Gas (N=3) | 33.3 | 33.3 | 33.3 | 0 |
| Other:[b] | | | | |
| Electric (N=33) | 3.0 | 12.1 | 36.4 | 48.5 |
| Water (N=107) | 7.5 | 18.7 | 44.9 | 29.0 |
| Phone (N=17) | 0 | 11.8 | 29.4 | 58.8 |
| Sewer (N=45) | 4.4 | 22.2 | 46.7 | 26.7 |
| Gas (N=5) | 0 | 20.0 | 40.0 | 40.0 |
| All Businesses | | | | |
| Electric (N=365) | 3.8 | 9.0 | 21.9 | 65.2 |
| Water (N=849) | 4.5 | 13.4 | 40.2 | 41.9 |
| Phone (N=238) | 2.1 | 5.9 | 24.8 | 67.2 |
| Sewer (N=418) | 2.9 | 11.5 | 42.1 | 43.5 |
| Gas (N=44) | 34.1 | 22.7 | 20.5 | 22.7 |

[a] ND= Not Disruptive at all, NVD= Not Very Disruptive, D=Disruptive, VD=Very Disruptive

[b] "Other" consists of agricltural, fishing, forestry, mining, transportation, and public communications firms.

Table 6. Median Number of Hours Businesses Closed by Type and Size of Business

| Type and Size of Business | Percent Closed | Median Number of Hours |
|---|---|---|
| Wholesale and Retail Trade: | | |
| Small[a] (N=67) | 42.1 | 72.0 |
| Large[b] (N=23) | 44.6 | 72.0 |
| Manufacturing and Construction: | | |
| Small (N=43) | 51.6 | 48.0 |
| Large (N=35) | 54.2 | 96.0 |
| Business and Professional Services: | | |
| Small (N=98) | 42.3 | 96.0 |
| Large (N=40) | 52.9 | 108.0 |
| Finance, Insurance, and Real Estate: | | |
| Small (N=32) | 35.2 | 72.0 |
| Large (N=28) | 48.4 | 56.0 |
| Other:[c] | | |
| Small (N=15) | 26.4 | 336.0 |
| Large (N=11) | 22.4 | 96.0 |
| All Businesses | | |
| Small (N=255) | 40.8 | 72.0 |
| Large (N=137) | 45.7 | 96.0 |

[a] Small businesses are those with 19 or fewer employees.
[b] Large businesses are those with 20 or more employees.
[c] "Other" consists of agricultural, fishing, forestry, mining, transportation, and public communications firms.

Table 7. Reasons for Business Closures

| | Valid Percentage |
|---|---|
| Evacuated due to threat or warning of flooding | 21.4% |
| Building was flooded | 19.9 |
| Building was declared unsafe | 6.9 |
| Need to have building structurally assessed | 4.0 |
| Need to repair building | 12.5 |
| Loss of inventory | 11.9 |
| Loss of machinery/office equipment | 15.4 |
| Employees unable to get to work | 26.3 |
| Damage to owners' own residence or other properties | 6.9 |
| Few or no customers | 34.4 |
| Could not get supplies/materials needed to run business | 16.3 |
| Could not deliver products/services | 25.7 |
| Could not afford to pay employees | 6.7 |
| Loss of electricity | 41.7 |
| Loss of telephone service | 28.3 |
| Loss of natural gas | 6.9 |
| Loss of sewer or waste water service | 34.8 |
| Loss of water | 63.6 |
| Other | 21.6 |

Number of Businesses that closed (N=448)