HANDBOOK FOR CONDUCTING A GIS-BASED HAZARDS ASSESSMENT AT THE COUNTY LEVEL

by

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Introduction

This handbook has been created under the auspices of the South Carolina Emergency Preparedness Division (SCEPD) to provide county emergency managers with a method for identifying those areas most vulnerable to hazards within their counties. Throughout the document, the text is accompanied by numerous tables, figures, and flow diagrams to facilitate a successful completion of a hazards assessment for your county. Primary tasks include the identification of those hazards with the potential to affect your county and the geographic areas (hazard zones) most likely to suffer when the hazards occur. Recognizing the importance of the social aspect of hazards, you are to also identify those social groups who may be differentially vulnerable due to disabilities or other constraining characteristics. The integration of these two vulnerabilities, social and physical, results in the identification of the most vulnerable places in your county. As such, the hazards assessment becomes a valuable instrument for pre-impact planning, post event response, and mitigation.

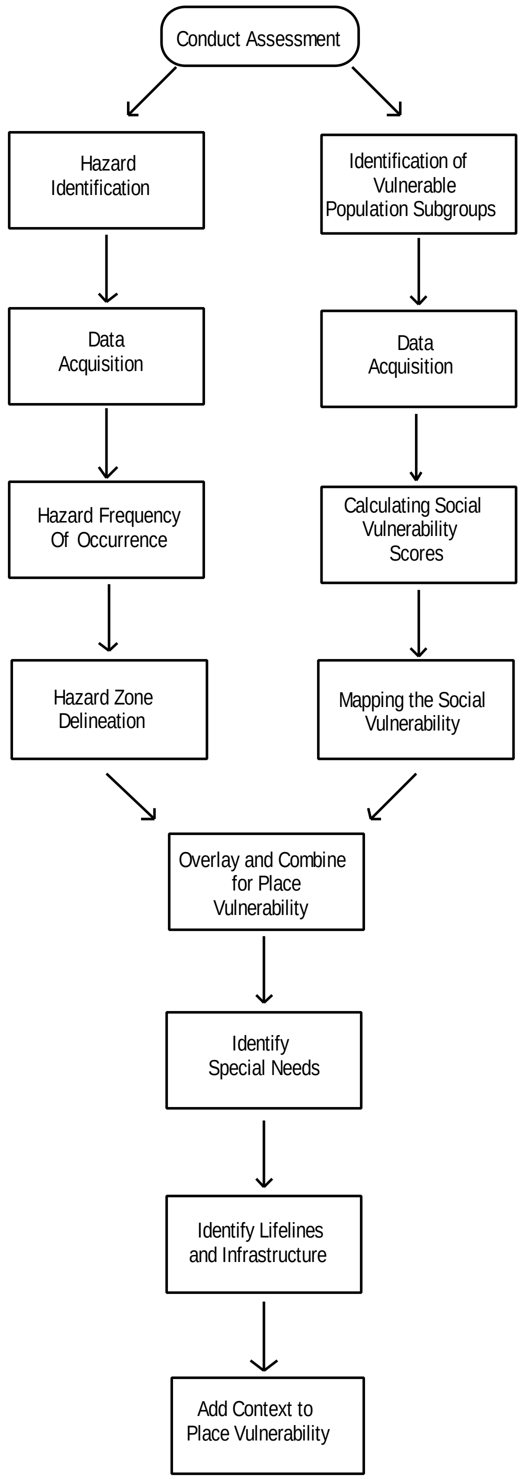
Purpose of Assessment

In June 1997, the Federal Emergency Management Agency and the National Emergency Management Association unveiled a State Capability Assessment for Readiness, which was developed to give states an objective way to judge disaster mitigation and preparedness. In order to evaluate the success of mitigation and preparedness programs an assessment of existing or baseline conditions is required. As the state of South Carolina progresses toward the development of a statewide hazard mitigation plan, it is clear there is little systematic baseline data that inventories and catalogs hazardous areas and vulnerable populations, especially at the local level. This handbook provides guidelines and a method for conducting this baseline all-hazards assessment at the county level. While providing a generic model, much of the methodology was tested using Georgetown County, hence the reference in many of our specific examples.

The end product of this assessment is a detailed series of data that integrates the social vulnerability of the population with the geographic distribution of potential hazards. These data can be mapped to increase your understanding of where the most vulnerable areas of your county are located. Additionally, the collection of this data will enable you to make queries of those vulnerable areas. For example, areas with high concentrations of the elderly, a population often needing additional assistance, could be displayed with their proximity to healthcare facilities or shelters. Bridges or evacuation routes could be mapped with storm surge data to estimate what category of storm intensity would make the path unusable. These examples point to the usefulness of this project as a planning tool when creating ‘what if’ hazard scenarios. The theoretically-based methodology presented here for the generation of this baseline hazards information may also be helpful when submitting grants for mitigation funds.

Eventually, the data you collect could also be used to provide a statewide analysis of hazard vulnerability. The extensive data requirements listed in this handbook are the minimum ones necessary to produce the all-hazards assessment. Where possible, counties are encouraged to include additional hazard and social indicators and more detail than presented here. The checklist that follows outlines the steps that are required in producing the hazards assessment. Figure 1 also provides a schematic representation of these steps.

Figure 1 Hazard Assessment Procedures



Checklist for Hazard Assessment

Getting Started

- ❑ Computer Hardware/Software
- ❑ GIS Technician/Center
- ❑ Time
- ❑ Technical Support

Procedures for Hazard Potential Determination

- ❑ Hazard Identification
- ❑ Data Acquisition
- ❑ Hazard Frequency of Occurrence

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- ❑ Identification of Vulnerable Population Subgroups
- ❑ Calculating Social Vulnerability Scores

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- ❑ Hazard Zone Delineation
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- ❑ Identification of Special Needs Populations
- ❑ Identification of Key Infrastructure and Lifelines

Creating the Final Report

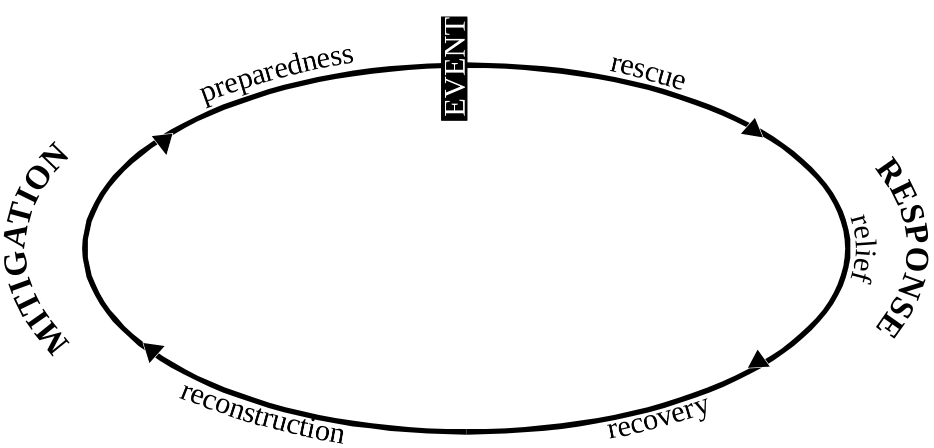
- ❑ Report Contents
- ❑ Caveats and Potential Difficulties

Hazards Background

This handbook details a methodology for conducting a hazards assessment using an all-hazards approach. Hazards, simply, are threats to people and the things they value. This methodology was created to identify the risk posed by multiple hazards for the purpose of promoting mitigation. Mitigation refers to the measures or actions that lessen the harmful affects of hazards. These measures may be structural or non-structural, such as hurricane roof straps or zoning restrictions, respectively. Mitigation is one component of the Emergency Management Cycle (Figure 2). Considering the threat from all hazards provides an opportunity to mitigate for several hazards simultaneously. Utilizing a geographic information system (GIS) allows for the analysis of multi-hazard information for better mitigation planning.

Vulnerability, broadly defined, is the potential for loss of property or life from natural or technological hazards. In this hazards assessment, you will consider both physical and social vulnerability. Assessments of physical vulnerability usually involve the determination of the occurrence probability of a given hazard event and the delineation of areas likely to be adversely affected. Social vulnerability refers to those groups of people who may be differentially vulnerable due to disabilities, income, or other constraining characteristics. Assessing social vulnerability requires you to identify those groups and the spaces they occupy. As a result of this all-hazards assessment, you will be able to advocate various mitigation measures that shrink the size of these vulnerable areas and thus reduce the population and property at risk.

Figure 2 The Emergency Management Cycle



Data Support

The data required to conduct this hazards assessment has been derived from multiple sources (see Appendix 1). The most current data can be collected from federal government sources. See Appendix 1 for a source list. Some data may be available on South Carolina Emergency Preparedness Division's World Wide Web site:

South Carolina Emergency Preparedness Division, Office of the Adjutant General
1429 Senate St. Columbia, SC 29201
803-734-8020
World Wide Web: http://www.state.sc.us/epd/

Some additional data resources, specifically the hurricane wind model and several datasets of hazardous materials facilities, must be obtained by contacting the Hazards Research Lab at the University of South Carolina:

Hazards Research Laboratory, Department of Geography, University of South Carolina
Callcott Building, University of South Carolina, Columbia, SC 29208
803-777-1699
World Wide Web: http://www.cla.sc.edu/geog/hrl/
Email: uschrl@ecotopia.geog.sc.edu

Some additional "base" data, such as road infrastructure, county boundaries, or major water bodies, may be available locally. Contact your local Council of Government (COG) as indicated in Appendix 2 or your county GIS administrator. All South Carolina COGs use *ARC/INFO* and *ArcView* GIS.

Intended User of this Document

A hazards assessment contains four primary elements: 1) hazards identification and occurrence; 2) identification of vulnerable populations; 3) the integration of these two elements in some geographic or spatial context; 4) and the identification of the social and infrastructure context. The construction of elements one, two, and four can be time-consuming, but is relatively uncomplicated. Element three requires the use of geographic information systems (GIS). GIS requires some technical sophistication in both computers and geography, including knowledge about database design, scale and mapping. A GIS is a set of tools and procedures used to collect, manage, analyze, and display spatially-referenced information. Although many GIS products are available, this document makes reference to *ARC/INFO* and *ArcView*, both ESRI products. Most of the procedures in this assessment can be conducted in *ArcView*, however, more complicated operations, such as polygon overlay and map projection transformation, will require using *ARC/INFO*.

GIS can assist in pre-impact planning, post event response, and mitigation. However, as with any technology, there are many misconceptions about what GIS can and cannot accomplish. GIS is not ready to go right off the shelf. It requires quality data input and verification if it is to be effective. GIS software also requires some fundamental understanding of how phenomena relate to each other in space and over time. As such, much of this assessment will likely require assistance beyond the emergency management office in your county and require contact with your county GIS administrator or the GIS personnel at your local Council of Government (COG).

Getting Started

The following resources are needed if the assessment is to be conducted ‘in house’.

Computer hardware/software

There are many geographic information system software packages available on the market. The most widely-used are the ESRI products *ArcView* and *ARC/INFO*. *ArcView* is a good package for display purposes but is not adequate for the actual construction of your database. Access to *ARC/INFO* is required in order to handle polygon overlay operations. A higher-level computer system with enough power and memory capable of running GIS software (approximately 32 MB RAM) and disk space large enough to store the acquired data is required.

GIS technician/center

You should identify the geographic information systems (GIS) technician or center in your county capable of handling this project. Emergency management agencies frequently do not have this capability, but it can be found in city or county government. It may be necessary to work cooperatively with your local Council of Government (COG) to get access to the GIS and technical support.

Time

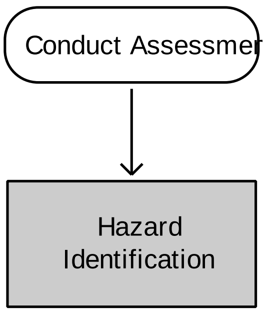
The assessment will take between 9-12 months to complete. This will vary depending on data availability, data compatibility, and the degree of technical sophistication of the individuals involved. Most of the time demand will be spent on data acquisition, verification, and entry. The actual development of the geographic coverages is the least time consumptive portion of the GIS.

Technical support

A contact sheet follows at the end of this document. Some technical aspects of this assessment will vary depending on whether the assessment is conducted in house or contracted out.

Procedures for Hazard Potential Determination

In general, there are three main steps in the individual hazard potential determination: hazard identification, data acquisition, and calculation of hazard frequency of occurrence.



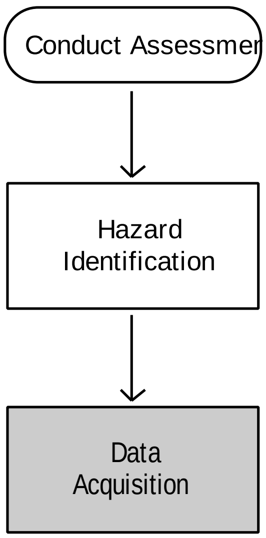
Step 1 Hazard Identification and Past Experiences

The first step is to develop the hazard history for your county in order to determine the range of hazards that have affected you in the past. Every county will have a slightly different profile depending on what hazards affect the county. Table 1 provides a guideline for hazards that may affect your county. There will be some hazards not in this list that your county may need to consider.

Table 1 Checklist for Hazards Identification

Hazard	Occurrences (Yes or No)
Hurricane/Tropical storms	
Tornado	
Flood	
Thunderstorm wind	
Hail	
Drought	
Winter storms/ice	
Temperature extremes	
Earthquake	
Wildfire	
Hazardous materials--transportation	
Hazardous materials--fixed	
Radiological incident--transportation	
Radiological incident-- fixed facility	
Dam failures	
Biohazards	

Using your local knowledge, count those hazard sources that your county has experiences. Some events are reported to a national registry or to a state agency. You may find inconsistencies in the data sets which will require you to consult the archives of your local or state newspaper. This search may take several hours but it is a necessary step to an accurate identification. Failure to adequately document past experience with a hazard will result in an inaccurate assessment of probabilities of occurrence.



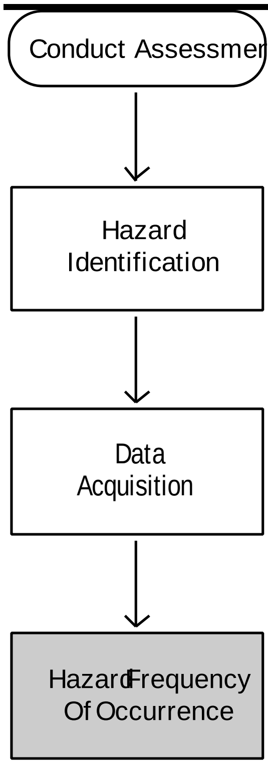
Step 2 Data Acquisition

Many of these databases are derived from federal sources and may need additional verification at the local level, especially those that contain locational data such as street addresses. Where possible, gather data at the most detailed level available such as specific address, parcel, etc. It is extremely important to understand the limitations of the data sets that you are using as you conduct your hazards assessment and to document these limitations.

Table 2 provides a matrix for core hazards data that most counties will need including some of the specific attributes or variables and sources. More detailed listings by individual hazard are found in Appendix 1.

Table 2 Data Acquisition Matrix for Hazards

Category	**Theme**	**Attributes**	**Sources**
Hurricane	events	maximum wind, minimum pressure, date and time	National Hurricane Center
	storm surge	storm category	SLOSH model output
	wind		USC-Hazards Research Lab
Floods	Q3 flood data	zone	FEMA
Earthquakes	epicenters	magnitude, intensity	South Carolina Seismic Network
	felt intensities	area	South Carolina Seismic Network
Tornadoes	events	damage, injuries, deaths	National Severe Storms Lab
Wind	events	damage, injuries, deaths	National Severe Storms Lab
Hail	events	damage, injuries, deaths	National Severe Storms Lab
Lightning	damage events	damage, injuries, deaths	National Climatic Data Center
Drought	events	severity	Palmer Drought Severity Index
Wildfire	events	acres burned	SC Statistical Abstract
Toxic Releases	stationary	cause, source, chemical, amount, evacuation area	TRI, Tier2, ERNS, DOT
	transportation	cause, source, chemical	ERNS, DOT



Step 3 Hazard Frequency of Occurrence

The estimated occurrence of the hazard is a useful element in the hazards assessment so one can distinguish between infrequent hazards like earthquakes from frequent hazards such as hazardous materials spills. This calculation provides a useful indicator of the relative importance of each of these hazards as they affect your county. Unfortunately, the magnitude of the potential impact of hazards, while important, is beyond the scope of this assessment.

The frequency of occurrence is a straight-forward calculation from the historical data and the length of that record in years. The number of hazard occurrences divided by the number of years in the record yields the probability of the event occurring in any given year. For instance, if a hypothetical hazard “A” occurred 17 times in your county over the past 23 years, the probability of occurrence for that hazard “A” in any given year is 17/23 or .739 or less than once per year. Since some hazards are geographically specific, such as flooding, this probability of occurrence may be assigned to a specific area or hazard zone (see section IV). Likewise, chemical spills from train accidents will be confined to those areas surrounding the rail lines, not the entire county. In this way portions of your counties can be differentiated based on these varying levels of hazard occurrence. For those hazards that are not locationally specific and thus have no clearly defined geography, such as tornadoes, the frequency of occurrence should be assigned to the entire county area.

The following methods should be used in determining the frequency of occurrence for each hazard. You may find that data are not available for your county for each hazard. Should that occur, you will need to find a surrogate data source or leave that hazard for a future assessment once the data become available.

Flood

The most useful flood frequency indicators are the Q3 Flood data. These are not available, however, for all counties. Once Q3 flood data have been obtained, you will be able to reselect the flood hazard zone using the designated 100-year and 500-year flood zones. These indicate the probability of a flood occurrence of 1% and 0.25% respectively. If Q3 data are not available for your county, you may choose to digitize the existing analog maps. This will be very costly, however, and you might want to consider alternative indicators (see Appendix 1).

Wildfire
The probability of occurrence is calculated as the number of reported wildfires divided by the total number of recorded years worth of data.

Thunderstorm wind events
The probability is calculated as the number of recorded wind events divided by the total number of recorded years.

Hail
The probability is calculated as the number of recorded hail events divided by the total number of recorded years.

Tornadoes
The probability is calculated as the number of recorded tornado events divided by the total number of recorded years.

Droughts
The probability is calculated as the number of recorded drought years, based on the Palmer Drought Severity Index (PDSI) divided by the number of recorded years.

Hazardous Materials Spills (fixed site and transportation)
The probability of occurrence is simply the number of reported accidents (differentiated by transportation versus fixed facility) divided by the number of recorded years of data.

Hurricane
In order to identify the hurricanes that were a potential threat to your county, you will need to reselect those hurricanes from the *Tropical Cyclones of the North Atlantic Basin 1886-1996* data set that were within 150 miles of your county boundary. The approximate average diameter of hurricanes is 150 miles. This will require you to create a buffer of 150 miles surrounding your county and intersect that area with the tropical cyclone wind observations. Once a subset of those observations is obtained, you must reselect those observations with a maximum sustained wind speed of greater than or equal to 64 knots. If your county is on the Atlantic coast of South Carolina, you then categorize these observations by their Saffir-Simpson rating. After summing the number of events for each category, the probability of occurrence may be determined. Regardless of your county's relative position to the shore, it is necessary to determine the probability of occurrence from hurricane winds. Researchers at the Hazards Research Lab (see Appendix 2) have developed a model which calculates this probability for each county. Please contact them and they will provide this data for your assessment.

Earthquakes

The earthquake probability of occurrence was calculated by dividing the number of felt earthquakes by the total number of years in the record.

Table 3 provides an example of hazard frequency occurrences from Georgetown County. Note that in Georgetown, wildfires occur more than two hundred times per year, the highest frequency hazard event. The '*' symbol indicates that there is no record of events per year.

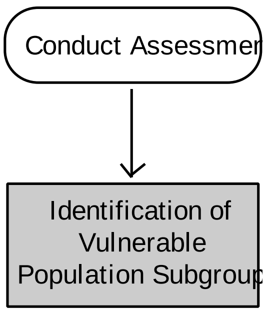
Table 3 Hazard Frequencies for Georgetown County, South Carolina

Hazard	Number of Events	Years in Record	Recurrence Interval (years)	Hazard Frequency % chance/year
Hurricane Surge-Cat 1	19	111	5.84	17.12
Hurricane Surge-Cat 2	18	111	6.17	16.22
Hurricane Surge-Cat 3	3	111	37.0	2.70
Hurricane Surge-Cat 4	4	111	27.75	3.60
Hurricane Surge-Cat 5	0	111	112 +	0.01
Hurricane Wind	1-4	111	111.0-27.75	0.9-3.6
Floods	*	*	100/500	1.0/0.2
Earthquake	12	298	24.83	4.03
Tornado	5	46	9.20	8.70
Thunderstorm Wind	48	41	0.85	117.07
Hail	10	41	4.10	24.39
Drought	25	101	4.04	24.75
Wildfire	3213	15	0.005	21,420.0
Chemical Release-Trans.	10	10	1.0	100.0
Chemical Release- Fixed	41	10	0.24	410.0

This table of hazard occurrence is a necessary step in determining the overall hazards vulnerability. It will also help to define more clearly what types of events are more frequent and their potential impact on the community.

Procedures for Determining Social Vulnerability

Based on the social science research on vulnerability to hazards the following social descriptors are the most indicative of the population characteristics that may place people at greater risk: age, gender, race, and income. Additionally, some risk is posed by the type of housing and where the people reside within the county. In general, there are three main steps in the social vulnerability determination: vulnerable subgroup identification; data acquisition; and the calculation of social vulnerability scores.



Step 1 Identification of Vulnerable Population Subgroups

The following variables were selected from the U.S. Census (1990) to measure social vulnerability. These specific variables were chosen based on a review of the scholarly literature (see References at end of document). These variables represent the minimum threshold of data that are necessary to produce the population vulnerability estimate. For the most accurate representation, these data should be gathered for the smallest geographic unit available, the census block. Each variable is available, however, at the census block, block group, and tract levels.

<u>Number of people less than 18 years of age</u>
This variable is useful as an indicator of the location of dependent populations. Particularly the youngest members of this population group will need assistance during a hazard event and are more prone to respiratory distress from certain inhaled toxins. This population may also have less ability to recover quickly after a disaster.

<u>Number of people over 65 years of age</u>
This variable is useful as an indicator of the location of dependent populations. Particularly the oldest members of this population group will need assistance during a hazard event and are more prone to respiratory distress from certain inhaled toxins. This population may also have less ability to recover quickly after a disaster.

<u>Number of females</u>
This variable has been shown in the social science literature to be correlated with a lack of resources and influence, limiting the range of adjustments available to them during an emergency. Certain toxins are also threats to women’s reproductive health. This population may also have less ability to recover quickly after a disaster.

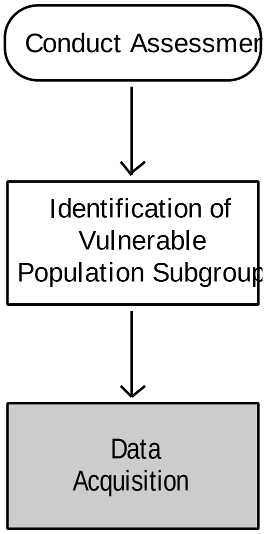
Number of non-whites
Often correlated with a lack of resources, race has also been shown by some research to exist alongside less desired land uses that include industry and transportation networks. This population group may be more vulnerable to certain technological hazards such as toxic releases or chemical spills. This population may also have less ability to recover quickly after a disaster.

Number of housing units
Determining the intersection of hazard zones and areas occupied by humans drives the hazards assessment. The number of housing units serves as an indicator of where the greatest number of people reside, an important consideration when combined with known areas of hazard occurrence.

Total population
Like housing units, the total population variable is an important consideration when combined with known areas of hazard occurrence. While these data could also be used to determine population density, raw population numbers are used since there is the potential to mask important information. Two census blocks may have the same population density, or the same percentage of elderly, but one may have a vastly greater number of people, an important consideration from an evacuation standpoint.

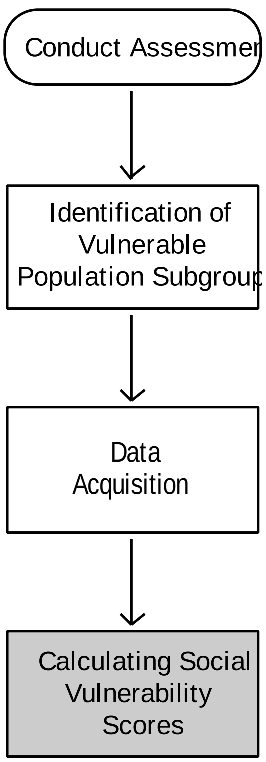
Number of mobile homes
This variable is an indicator of housing stock that is of a lower structural quality than standard housing. Hazards with high wind speeds are particularly troublesome for this type of housing construction.

Mean house value
This variable is used as a surrogate measure of income. Income data is not made available by the U.S. Census at the block level. Mean house value can, however, indicate the economic status of individuals. Lower house values may indicate a more vulnerable population due to a lack of resources for mitigation and recovery or housing that is of a lower structural quality.



Step 2 Data Acquisition

Once the vulnerable population subgroups have been identified, the data must be acquired. Most of this data can be obtained via the US Census which is available from the SC Budget and Control Board. Additionally, some US Census data may be procured from a number of different sources including the World Wide Web (http://www.census.gov/). For the Georgetown County pilot assessment, census block level data was used.



Step 3 Calculating Social Vulnerability Scores

The method for calculating the socially vulnerable areas is the same for each variable except mean housing value. For the number of females, non-whites, age less than 18, age over 65, housing units, mobile homes, and the total population, the percentage for each was determined by dividing the number of each variable in the block by the total number of that variable for the entire county and then scaled for final vulnerability summation.

The following steps and example explain the process.

Step 1 Calculate **X**.

$$\mathbf{X} = \frac{\textbf{\# of Mobile Homes in Census Block}}{\textbf{\# of Mobile Homes in County}}$$

Why: Determine percent of county's mobile homes in each block.

Step 2 Calculate **Mobile Home Score** by dividing **X** by maximum **X**

$$\textbf{Mobile Home Score} = \frac{\mathbf{X}}{\textbf{maximum X}}$$

Why: Places values in same scale as other social variables.

	# of Mobile Homes in Census Block	# of Mobile Homes in the County	X	Mobile Home Score
Block A	125	3,500	0.036	1.00
Block B	76	3,500	0.022	0.55
Block C	4	3,500	0.001	0.03
Block D	21	3,500	0.006	0.17

Thus, in this example Block A is most vulnerable followed by Block B, Block D and finally Block C.

The vulnerability measure for Mean Housing Value is determined by the following steps. The variable calculated represents the lowest mean house value and is used as an indicator of poverty.

Step 1 Calculate **X.**

X = County Average Mean House Value - Mean House Value for Census Block

Why: Determine how different each block is from the county mean

Step 2 Calculate **Y.**

Y = X + Absolute Value of Maximum X

Why: Removes all negative values

Step 3 Calculate **Mean House Value Score.**

$$\textbf{Mean House Value Score} = \frac{\textbf{Y}}{\textbf{maximum Y}}$$

Why: Places values in same scale as other social variables

	Mean House Value in Census Block	County Average Mean House Value	X	Y	Mean House Value Score
Block A	41,286	75,000	33,714	69,364	1.00
Block B	110,650	75,000	-35,650	0	0.00
Block C	76,776	75,000	-1,776	33,874	0.49
Block D	64,900	75,000	5,100	40,750	0.58

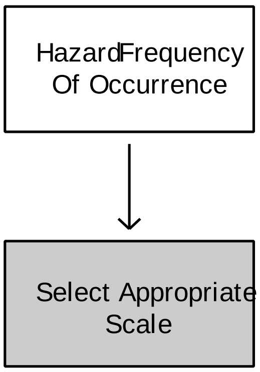
Thus, in this example, Block A is most vulnerable followed by Block D, Block C and finally Block B.

The social vulnerability scores are summed for each block. The following table illustrates this process with the **Mobile Home** and **Mean House Value** scores already presented. The **Vulnerability Score** is the final social score and should be assigned to the block as its overall social vulnerability score. Of course, in your county analysis there will be several other social variables besides the two presented here.

	Mobile Home Score	Mean House Value Score	Vulnerability Score
Block A	1.00	1.00	2.00
Block B	0.55	0.00	0.55
Block C	0.03	0.49	0.52
Block D	0.17	0.58	0.75

Determining Hazard Zones and Social Vulnerability

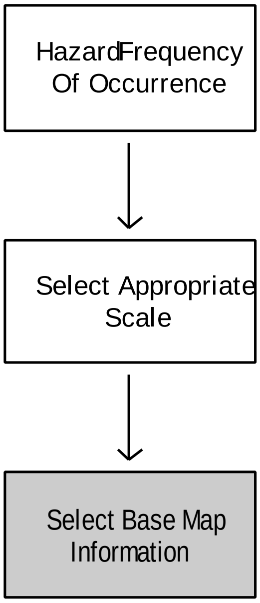
The procedures for the mapping and display of the hazards and social information are outlined below.



Step 1 Select Appropriate Scale

Scale is an important issue in this analysis. Since it is necessary to simplify the world in order for it to be represented on a map, features must be generalized. The degree of this generalization depends on the scale of the map, or the ratio of distance on the map to distance on the ground. Maps with large scales (1 inch on the map equals 100 inches on the ground or parcel-level maps) can depict much more detail than maps with small scales (1 inch on the map equals 1,000,000 inches on the ground or country-level maps). Inherent in this capture of detail is often the movement of point, line, and area features from their “true” position in order to include all pertinent information clearly. Due to this combination of simplification and generalization, it is important to recognize the limitations of given map scales for certain types of analysis.

An example of how the scale issue is important in this hazards assessment involves the intersection of hazard zone maps and parcel maps. It would be inappropriate and inaccurate to overlay parcel maps with flood zone maps in order to determine which parcels lay in the 100-year flood zone. The scale of the flood zone maps is much smaller (1:24,000) than parcel maps (i.e. 1:100) meaning that, “in reality,” the boundary of the flood zone may be somewhere quite different in relation to the parcels than the digital version would lead you to believe. For example, if the flood zone boundary accuracy is plus or minus 250 feet, the flood zone boundary could “actually” be anywhere within 250 feet of the displayed boundary. In this case, determining whether or not a particular parcel is within the flood zone is not possible. Thus, it is important to establish a reasonable scale of analysis and a corresponding scale of display. For a county-level analysis, many data are available at 1:24,000 scale, such as roads, block groups, and county boundaries, making this a reasonable scale for analysis. However, when one moves to display that data, 1:100,000 scale may be more appropriate in order to display all of the county on one sheet of paper. One should always be cognizant of the scale of each data layer and question the validity of each GIS operation before it is attempted so as not to derive false conclusions from the data simply because the scales are mixed.

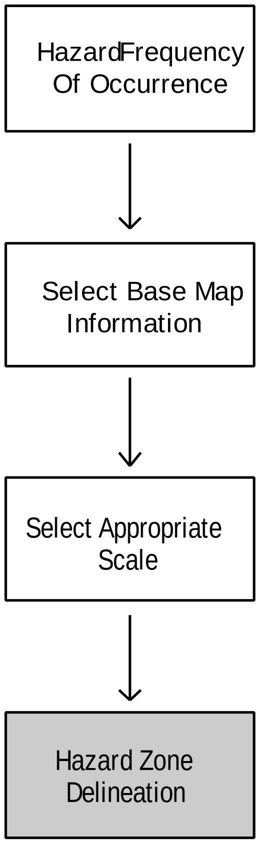


Step 2 Select Base Map Information

The next phase involves the delineation of hazards zones. You have already calculated the probability of occurrence for each hazard. This probability of occurrence now needs to be assigned to the appropriate potential impact areas for each specific hazard. Before you can begin to visualize the results of the hazard zone delineation and the distribution of the social vulnerability of the county, you will need several pieces of base information. These include layers such as your county boundary, water bodies, city boundaries, and important town locations.

If your county has GIS capability, these layers should already be available to you. If your county does not have GIS capability, you may have to contact your local COG which may have these data layers as well.

Often, the assessment of base map information raises issues of appropriate scale. Many different sources of base map information are available ranging from features extracted from Digital Orthophoto Quads (DOQ) to TIGER features to Digital Chart of the World, among others. Each has positive and negative aspects. For instance, the DOQ data delivers a high level of detail (building footprints) yet the attributes of each feature (number of people living in each house) is not known since DOQ has no polygon features. TIGER data, while containing the boundary files for the US Census divisions which can be related to many types of social data, is sometimes inaccurate. Since we were interested in a county-wide analysis of vulnerability, the use of TIGER files for our base map seemed appropriate. This selection of scale also permits us to utilize US Census information at the block level in our assessment of social vulnerability.



Step 3 Hazard Zone Delineation

For many of the hazards, their occurrence is somewhat random (such as tornadoes or thunderstorm wind) and there is no well-defined geometry to their hazard zone. In addition, many of the existing databases only record the number of events per county and do not give specific information on location such as longitude/latitude. For others, there is a clearly identifiable zone of impact. The determination of specific hazard zones is detailed below. Once the hazard zones are determined, the probability of occurrence calculated should be assigned. Map 1 provides an example of the hazard zone delineation for hazardous materials accidents.

Floods
The 100-year and 500-year designated flood zones delineate the geographic extent of the flood hazard. Working from the Q3 flood data, you will be able to reselect the flood hazard zone using the designated 100-year and 500-year flood zones. The 100-year flood zone is designated by the zone code ‘A’ and its derivations, signifying those areas of 100-year flood. Zone code ‘V’ and its derivations similarly signify areas of 100-year flood combined with wave action. Zone ‘B’ represents the 500-year flood zone.

Wildfires
While wildfires happen in a specific place and at a specific time, they have the potential to occur nearly anywhere. Therefore, the hazard zone encompasses your entire county.

Thunderstorm wind
While thunderstorm wind events happen in a specific place and at a specific time, they have the potential to occur anywhere. Thus, the hazard zone encompasses your entire county.

Hail
While hail events happen in a specific place and at a specific time, they have the potential to occur anywhere. Therefore, the hazards zone encompasses your entire county.

Hurricane
This hazard has two main components: storm surge and wind. For those counties on the coast, the NOAA National Hurricane Center has calculated the areas that will potentially be inundated in each Saffir-Simpson scale category. These hazard zones, derived from output from the National Hurricane Center's SLOSH model, represent the worst-case scenario for each hurricane category. Assign the probabilities of occurrence that you have calculated to the appropriate zone. For all counties, the hazard zones for hurricane wind occurrence are output from a model at the Hazards Research Lab. See Contact List for the GIS layers that correspond to your county.

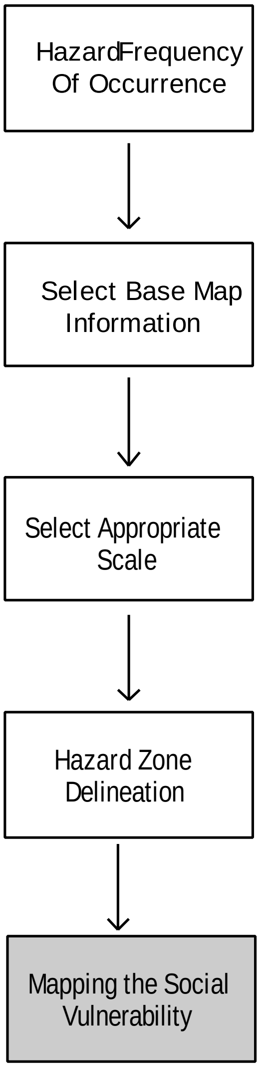
Earthquake
First, the epicenter latitude and longitude is entered into the GIS for each felt earthquake. The South Carolina Seismic Network indicates the total area (number of square miles) that felt the earthquake. Second, a circular buffer is created around each epicenter which approximated the felt area (square miles) of that earthquake. In other words, if the earthquake had a recorded felt area of 30,000 square miles, then a circular buffer equal to 30,000 square miles would be drawn around the epicenter. Third, each of these twenty-three buffers are overlayed with each other. This operation results in the number of earthquakes felt at every point in South Carolina. Fourth, this felt earthquake layer is clipped with the county boundary, resulting in the number of felt earthquakes at every point within the given county.

Tornado
While tornadoes happen in a specific place and at a specific time, they have the potential to occur anywhere. Therefore, the hazards zone encompasses your entire county.

Drought
The drought hazard zone includes your entire county, except for Oconee, Pickens, and Greenville Counties which are bisected by climate divisions.

Hazardous Materials Releases--Transportation
To delineate the hazard zones, a buffer of one-half mile was created around each railroad and arterial highway segment. This distance of one-half mile was chosen because it was recommended by the U.S. Department of Transportation as the default isolation distance if there is a fire involving hazardous chemicals.

Hazardous Materials Releases--Fixed Sites
To determine the hazard zones, a buffer was created equal to the radius of the largest protective action distance (PAD) for all chemicals at a given facility. This distance ranges from 0.2 to 5.0 miles.



Step 4 Mapping the Social Vulnerability

Once you have calculated the social vulnerability scores within the GIS, they are now ready to be displayed. An important issue to take into account when mapping this data is class interval determination.

People have difficulty recognizing more than six colors on a map at once. Thus, when mapping continuous information, such as social vulnerability scores, it is necessary to divide that information into classes. The purpose of classification is twofold: to make the process of reading and understanding a map easier; and to show something about the area you're mapping that is not self-evident. There are several ways to construct class intervals, each with advantages and disadvantages.

The use of natural breaks is one method. This method identifies breakpoints between classes using a statistical formula. This method is rather complex, but basically the method minimizes the sum of the variance within each of the classes. The natural breaks method finds groupings and patterns inherent in your data.

In the quantile classification method, each class contains the same number of features. Quantile classes are perhaps the easiest to understand, but they can be misleading. Population counts (as opposed to density or percentage), for example, are usually not suitable for quantile classification because only a few places are highly populated. You can often overcome this distortion by increasing the number of classes.

The equal area method classifies polygon features by finding breakpoints so that the total area of the polygons in each class is approximately the same. Classes determined with the equal area method are typically very similar to quantile classes when the sizes of all the features are roughly the same. The equal area classification scheme will differ from quantile if the features are of vastly different areas.

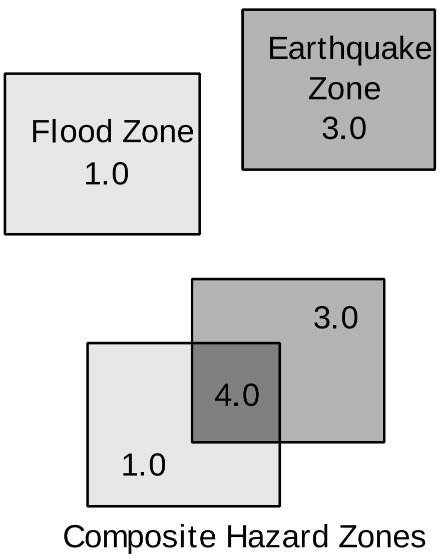
All of the social vulnerability maps are produced at the block level. Map 2 provides an example of a vulnerability variable, percent of total elderly population, and is based on the natural break method of classification.

While a composite index of social vulnerability is computed, each of the specific indicators represents a layer within the GIS so that emergency managers could examine the distributions of certain characteristics (e.g. mobile homes) and their proximity to hazardous zones.

Intersection of Hazard Zones and Social Vulnerability Areas

The determination of both the composite hazard zones and composite social vulnerability areas requires several steps which are outlined below. First, each hazard zone layer will need to be overlayed with all other hazard zone layers creating a composite hazard zone coverage. The new resultant polygons will have a hazard zone score equal to a summation of the probability for each hazard within that polygon (Figure 3). This component of the hazards assessment requires you to use *ARC/INFO*.

Figure 3 Simplified GIS Polygon Overlay



Step 1 Combine all hazard layers to create a single layer of intersected polygons (this step sums the probability of occurrence for each hazard, giving each polygon a final hazard vulnerability score)

Step 2 If desired, this composite hazard layer may be displayed, creating the overall hazard vulnerability map (each polygon will be identified by its overall hazard score; you may choose to class the scores into high, medium, or low categories)

Map 3 is an example of mapped composite hazard zones for Georgetown County.

Second, the percentages of each social variable for every block will need to be summed to arrive at a composite social vulnerability score for each block.

Step 1 Combine all social layers (this step sums the social scores for each variable for each block)

Step 2 If desired, this layer may be displayed, creating the overall social vulnerability map (each block will be identified by its overall social score; you may choose to class the scores into high, medium, or low categories)

Map 4 is an example of mapped composite social vulnerability for Georgetown County.

The final step in the procedure is to combine the hazards map and social vulnerability map to produce the overall hazards assessment. This is accomplished by multiplying the score from each layer together to arrive at a final place vulnerability score.

- Step 1 Create the final place vulnerability layer by multiplying the hazard score for each polygon by the social score for each block (this will result in a single layer of intersected polygons, each with its final overall vulnerability score)

- Step 2 If desired, this layer may be displayed, creating the overall place vulnerability map (each polygon will be identified by its overall place vulnerability score; you may choose to class the scores into high, medium, or low categories)

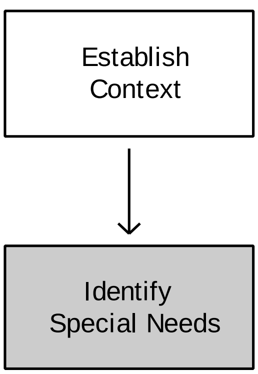
Map 5 illustrates what that composite map looks like for Georgetown County.

In addition to a spatial representation of place vulnerability, the GIS allows us to calculate the true number of vulnerable people and their residences in each hazard zone. To calculate the number of vulnerable persons and structures in each hazard zone, areal interpolation employing proportionate areas (assuming uniform densities of phenomena) is utilized. Interpolation is the process for estimating the value for missing points or areas. These are not necessarily the 'true' values, but rather a mathematical best estimate. In areal interpolation, this procedure finds the area of a new polygon resulting from the union operation. The attributes of the social vulnerability layer are allocated proportionally to the percentage area occupied by the resulting polygon. It is important to remember that the calculation of these missing values from neighboring areas is only an approximation. We assume, for instance, that population is uniformly distributed across a census block when in reality there may be a clustering of the phenomena in one or more parts of the block.

The data collected for special needs populations and infrastructure will be added as contextual elements for the assessment. For instance, an area of medium overall vulnerability may be given more attention if it is found to also contain a daycare center and a hospital.

Establishing the Social and Infrastructure Context

The intersection of hazard and social vulnerability is not sufficient to completely portray the hazard scenario for your county. You must also establish the social and infrastructure context. There are certain elements of each that can contribute to the attenuation or amplification of the vulnerable areas. For instance, vulnerable groups that are distant from evacuation routes or downstream from a dam subject to failure will be at greater risk. Overlaying the infrastructure over the place vulnerability may yield valuable information for mitigation planning. For example, an area ranking high in place vulnerability may be found to also contain two daycare centers and be near a known ‘choke’ point on an evacuation route. This information would alert emergency managers that a vulnerable population, children, may need to be evacuated and special steps taken to avert the congestion associated with that particular evacuation route. Two steps are involved in establishing context: 1) the identification and collection of special needs population data; 2) the determination of key infrastructure and lifelines.



Step 1 Identification of Special Needs Populations

There exist special needs locations that require careful consideration for hazard and emergency response because of advanced evacuation lead time and difficulty in relocation. These include day care centers, nursing homes, health centers, hospitals, schools, prisons, military bases, and homeless shelters.

Daycare facilities
While this group of children is likely to be with their families at the time of a forecasted evacuation, such as for a hurricane, knowledge of their location remains essential due to hazards with a sudden rate of onset, such as a chemical spill or an earthquake. These facilities may be identified using a digital phone book (many versions are available and can be procured through office supply stores), a conventional phonebook, by contacting the local U.S. post office, or through local knowledge.

Adult care facilities
This population is more vulnerable because of medical and mobility constraints. These facilities may be identified using a digital phonebook, a conventional phonebook, or by contacting the local U.S. post office.

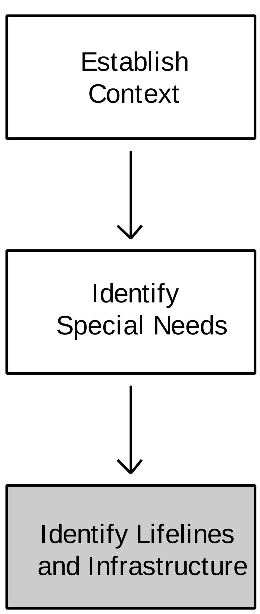
Hospitals
This population is more vulnerable because of medical and mobility constraints. These facilities may be identified using a digital phonebook, a conventional phonebook, or by contacting the local U.S. post office. Primary care facility locations should also be collected taking care to not overlook other clinics that may provide important services such as dialysis.

Schools
Similar to day care facilities, this group of children is likely to be with their families at the time of a forecasted evacuation, such as for a hurricane, but knowledge of their location remains essential due to hazards with a sudden rate of onset, such as a chemical spill or an earthquake.
These facilities may be identified using a digital phone book, a conventional phone book, or by contacting the local U.S. post office. The local public school boards should also be able to provide the data quickly, but an effort should be made to make sure the private schools are not overlooked.

Prisons
This population is more vulnerable because of mobility constraints. These facilities may be identified using a digital phonebook, a conventional phonebook, or the local police.

Military Bases
This population is more vulnerable because of mobility constraints. These facilities may be identified using a digital phonebook or a conventional phonebook.

Homeless Shelters
This population is more vulnerable because of medical and mobility constraints. These facilities may be identified using a digital phonebook or a conventional phonebook.



Step 2 Identification of Key Infrastructure and Lifelines

Infrastructure includes roads, structures, utilities, railroads, bridges, dams, airfields, ports, and emergency response facilities. Many of these fall under the definition of a lifeline, the networks that provide for the circulation of people, goods, services, and information upon which health, safety, comfort, and economic activity depend. All of the lifeline data are represented as either point or line coverages in the GIS.

The crucial infrastructure variables necessary are roads, railroads, airports, bridges, and waterways. This data should be available within your local government or through your Council of Government (COG). These variables are not only infrastructure, but also lifelines. If any one or more is to fail during an emergency, serious complications could arise. It is very important, therefore, to understand these variables and how they might collapse under different stresses. A subset of transportation lifelines is the emergency evacuation routes. These usually consist of the major arterial highways leading out of the county toward shelters and safer areas. Consequently, the location of evacuation shelters must be determined as well. Both shelter and evacuation route information should be available from the county emergency manager. An example of lifelines for Georgetown County is provided in Map 6.

Where possible, it would be helpful to identify the location of dams, power lines, power substations, water treatment facilities, fire/police stations, and other community service facilities. Be aware that some variables fall into more than one category. For example, hospitals not only represent a special needs population, but are also crucial lifeline nodes during an emergency. Dam data may be obtained by contacting DHEC. Fire/police stations can be garnered by contacting those agencies. Other information will be a bit more problematic. You might try contacting the local utilities for positional information on these crucial lifelines. Table 4 summarizes the data sources for lifelines and infrastructure.

Table 4 Data Sources for Lifelines and Infrastructure

Category	Theme	Attribute	Sources
Special Needs	daycare centers	name, address, phone number	digital phonebook, U.S. post office
	nursing homes	name, address, phone number	digital phonebook, U.S. post office
	health centers	name, address, phone number	digital phonebook, U.S. post office
	hospitals	name, address, phone number	digital phonebook, U.S. post office
	schools	name, address, phone number	digital phonebook, U.S. post office, school district
	military bases		Phonebook
	jails/prisons		Police Department
	homeless shelters		Phonebook
Roads	interstates	ID number	COG
	evacuation routes		local EPD
	major roads		COG
	minor roads		COG
Railroads	lines		COG
Bridges	bridges		SCDOT
Dams	dams	failure potential, ownership	South Carolina DHEC
Airfields	airfields		COG
Response Facilities	fire stations		Fire Department
	police stations		Police Department
	emergency shelters		Local EPD

Creating the Final Report

Report Contents

Your final report should include the following information for a complete hazards assessment:

- Introduction
    - Boundaries of Study Area
    - Characteristics of Physical Environment
    - Hazard History of Study Area
    - Selecting the Appropriate Scale and Base Map

- Hazard Potential Determination
    - Identification of hazards, hazard zones, and frequency of occurrence (including maps)

- Determining Social Vulnerability
    - Characteristics of Socioeconomic System
    - Identification of vulnerable populations (including maps)
    - Calculating Social Vulnerability Scores

- The Intersection of Hazard Zones and Social Vulnerability
    - Determination of Composite Hazard, Social, and Place Vulnerabilities (including maps)

- Establishing the Social and Infrastructure Context
    - Identification of Special Needs groups and Infrastructure (including maps)

- Description of Data Sources

- Discussion of Limitations, Data Discrepancies, or Hazards Omitted

Caveats and Potential Difficulties

Previously, emergency managers in South Carolina have been unable to systematically analyze areas vulnerable to multiple hazards. Multiple hazard and social vulnerability data now exist in a digital, geographically-referenced format. This allows for the easy retrieval and analysis of “what if” hazard scenarios leading to better pre-event mitigation and post-event response/recovery. Additionally, mitigation funding may be more appropriately distributed according to the location of vulnerable people and locations. However, this vulnerability assessment contains three major caveats.

First, the all-hazards approach requires the assembly of extremely disparate datasets of differing measure and quality, which requires more than a passing knowledge of the physical and social processes involved. The task is data intensive, requires sophisticated computer support, and a substantial time commitment on the part of emergency planners or their consultants. Second, there are inherent difficulties in deciding where a line should be drawn in delineating hazard zones and their subsequent classification into categories of a particular degree of vulnerability. What constitutes a highly vulnerable census block? Does an earthquake-prone area with a high elderly population demand more attention than a mobile home park in the flood zone? A familiarity with the local context is key. This assessment should be used as a complementary tool to assist the local emergency personnel in planning for and responding to disasters. Third, GIS overlay analysis is sensitive to issues of scale and representation. For example, the analysis assumes uniform population distribution within a census block. Often this is far from true. Additionally, the hazard and social variable layers do not coincide perfectly, thus creating sliver polygons from the overlay operation.

Unfortunately, you will have difficulty in collecting all data desired for your hazards assessment. For instance, you may not have the time to accurately locate all point data due to the necessity of intensive fieldwork. A second example, the determination of the wildfire hazard could be enhanced by extracting forest land cover from satellite imagery. This will, however, incur significant additional expenses. Finally, some data is simply not available for most areas, such as the location of subsurface earthquake faults. This data set would enhance hazard identification greatly, yet is impossible to obtain currently.

These difficulties aside, this methodology can lead to better hazard mitigation. Determining the biophysical and the social vulnerability provides the opportunity to identify those areas in greatest peril. It is this type of discovery that make this approach worthy of implementation in each county of South Carolina.

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Appendix 1: Data Sources

Individual Hazards Zone Data Specifics

Floods

Data Sources

The area at risk from flooding is provided by the Federal Emergency Management Agency's (FEMA) Flood Insurance Rate Maps (FIRMs). These may be obtained by contacting FEMA's Map Service Center, 6730 Santa Barbara Court A-G, Baltimore, Maryland 21227. To conduct a GIS analysis, these FIRMs must be in digital format. At present, Q3 Flood data are available for some areas through FEMA, specifically Beaufort, Berkeley, Charleston, Colleton, Georgetown, Greenville, Horry, Lexington, Richland, Saluda, and Sumter counties. Other counties must obtain the analog maps and have them digitized. This is a very costly procedure and should be avoided where possible.

Limitations of Data

It is important to recognize the limitations of the digital flood data. FEMA suggests that no individual parcel flooding determination should be inferred from these maps. Additionally, the terminology referring to the 100-year and 500-year flood zones should not be misunderstood. The 100-year flood recurrence interval refers to a probability of at least 1 percent that an area will be flooded in any given year. This corresponds to the flood levels expected on the long-term average of once every one hundred years, hence the often misinterpreted term '100-year flood'. It is important to note that only the outermost edges of the 100-year flood zone have a risk as low as 1 percent per year. As one moves closer to the stream channel or tide line, the risk increases progressively. Because of flood zone development (leading to water displacement) and other factors, flooding is often more frequent than the 100 or 500-year flood zone line would indicate.

Potential Surrogates

Systematic data on flood events is available from the stream gauge records kept by the U.S. Geological Survey. Unfortunately, these physically-based parameters do not include data on losses or casualties associated with each flood event. FEMA collects data on participation in the NFIP program and on disaster declarations including loss estimates, but these data are not correlated with specific streams/rivers. Instead they are aggregated and reported by counties or states. In the absence of a good correlation between event and loss data, the NFIP data can be used as the surrogate for the flood hazard, but would only provide an aggregate measure for the community or county.

Wildfire

Data Sources

Data on the number of fires on forested land is freely available in the *South Carolina Statistical Abstract* produced yearly by the SC Budget and Control Board. This information is provided by the SC Forestry Commission and reports only those fires responded to by the forest service. Information is available for each SC county beginning with the 1981 *Abstract*. This data is available for all SC counties.

Potential Surrogates

There is currently no alternate source for this information.

Data Limitations

While data on the number of fires and their average size is given, the specific location is not provided. This dataset is limited because only fires that occur on protected forested land are reported, the fires are reported by fiscal year not calendar year, and only fires responded to by the forest service are listed. It should be cautioned that there is often a large number of fires, but these fires do not necessarily occur near residential populations and vulnerable structures. This fact makes this dataset suspect in determining the true level of risk from wildfire. It is the best available source, however, at present.

Thunderstorm Wind

Data Sources

Data on thunderstorm wind events for South Carolina is available from 1955 to 1995. This data was retrieved from the National Severe Storms Laboratory, Storm Prediction Center, University of Oklahoma. The determining criteria for inclusion in this dataset are windgusts greater than 50 knots. The data include location (latitude and longitude), date and time, fatalities and injuries, and an index of damage. This data is available for all SC counties and may be obtained at the Storm Prediction Center WWW site:
http://www.nssl.noaa.gov/spc/archive/index.html

Potential Surrogates

There are no satisfactory substitutes for this database.

Data Limitations

This dataset is limited because only damaging events and those witnessed by people are listed. The true frequency of the risk, therefore, is understated.

Hail

Data Sources

Data on hail events for South Carolina is available from 1955 to 1995. These data were retrieved from the U.S. Hail Data Archive at the National Severe Storms Laboratory, Storm Prediction Center, University of Oklahoma. The determining criteria for inclusion in this dataset are hailstones 1.75 inches in diameter or greater. The data include location (latitude and longitude), date and time, fatalities and injuries, and an index of damage. This data is available for all SC counties and may be obtained by contacting the Storm Prediction Center WWW site: http://www.nssl.noaa.gov/spc/archive/index.html

Potential Surrogates

There are no satisfactory substitutes for these data.

Data Limitations

This dataset is limited because smaller hail events are missing and only damaging events and those witnessed by people are listed. The true scope of the risk, therefore, is likely understated.

Hurricane

Data Sources

Hurricanes are complex hazards with both a water and wind component. Jasper, Beaufort, Colleton, Charleston, Berkeley, Georgetown, and Horry counties all need to be aware of the storm surge threat in addition to the wind danger. All other SC counties must be concerned only with the wind hazard.

All Counties: A complete listing of all hurricane tracks and wind observations is available in the dataset *Tropical Cyclones of the North Atlantic Basin 1886-1996* and may be obtained from the University of South Carolina Hazards Research Lab (USCHRL). These data are originally from the *Atlantic Basin Best Tracks* dataset created and distributed by the National Hurricane Center, Miami, Florida. This data is used as the input to a probabalistic model developed by Dr. Michael Hodgson at USCHRL. This model calculated the number of hurricane wind events occurring at each point in the state. This data is available for all SC counties and may be obtained by contacting the USCHRL.

Coastal Counties Only: Storm surge is an elevation of the ocean surface resulting from the compound effects of water being pushed shoreward by wind across decreasing depths on a continental shelf, low pressure at the sea surface, tides raising the water level, and winds raising the ocean surface. The SLOSH model (**S**ea, **L**ake, **O**verland **S**urges from **H**urricanes) is a computer simulation developed by the National Weather Service used to predict the height of hurricane storm surge. The U.S. Army Corps of Engineers and U.S. FEMA contracted with the NOAA National Hurricane Center to calculate the worst case inundation zones for coastal South Carolina using SLOSH model output. These zones are based upon the Saffir-Simpson hurricane magnitude and intensity categories that range from 1 (winds greater than 64 knots/74 mph) to 5 (winds greater than 135 knots/155 mph). These digital inundation zones are available from the SC Emergency Preparedness Division. As of September 1997, the SLOSH model output has been run for all of the coastal counties Horry, Georgetown, Charleston, Colleton, Jasper, and Beaufort.

Potential Surrogates

There are no substitutes for these data.

Data Limitations

The SLOSH model output is still model-based and represents an approximation of what might occur given a particular hurricane. The SLOSH model is run multiple times and its output is combined into the Maximum of Maximum Envelope of High Water (MOMs) for all storms from various directions of the same Saffir/Simpson scale. Depending on the specifications or parameters used in developing the “idealized” storm, there may be subtle changes in the inundation contours. The MOMs used in the Georgetown study were for a fast moving storm (>25 mph). MOMs maps have been designed for use in planning operations for those areas affected by the high water produced by a hurricane. The USCHRL wind probability model is also based on standard hurricane parameters with each storm potentially having a larger or smaller wind field than predicted.

Earthquake

Data Sources

Data on the number of felt earthquakes and their felt area in South Carolina can be obtained from the report *South Carolina Earthquakes 1698-1995* by the South Carolina Seismic Network, University of South Carolina. Copies of this report are available by contacting the Earthquake Program Coordinator of the South Carolina Emergency Preparedness Division. A map of the liquefaction and soil hazards from earthquakes has also been devised by SCEPD and USGS, but it is inadequate for determining your earthquake potential. The earthquake hazard zones have been established by the Hazards Research Lab (USCHRL) in the Department of Geography at the University of South Carolina. This data is available for all SC counties and may be obtained by contacting the SCEPD.

Potential Surrogates

For South Carolina counties that have epicenters within them, you may also use the report *South Carolina Earthquakes 1698-1995* by the South Carolina Seismic Network, University of South Carolina. Those counties without epicenters should follow the described procedure for felt earthquakes.

Data Limitations

Very few earthquakes in the SCSN report have felt areas, so many other earthquakes are excluded from this probability calculation. A felt earthquake also does not mean any loss occurred, however, no systematic measure of earthquake loss has been recorded for the state. Additionally, the liquefaction and landslide potentials are unknown at a county scale of analysis, and thus cannot be included in the probability calculation. Furthermore, the shape of the felt areas is likely not circular given varied geologic structures. Lastly, the depiction of felt areas as finite circles infers a greater degree of accuracy than is warranted.

Tornado

Data Sources

Tornado strikes in South Carolina are available from 1950 to 1995. This data was obtained from the National Severe Storms Laboratory, Storm Prediction Center, University of Oklahoma. The attributes in this data source include location (latitude and longitude), date and time of event, the number of deaths and injuries, and an index of damage. The data is available for all SC counties and may be obtained by contacting the Storm Prediction Center WWW site: http://www.nssl.noaa.gov/spc/archive/index.html

Potential Surrogates

There are no known substitutes for this dataset.

Data Limitations

This dataset is limited because only damaging events and those witnessed by people are listed. The true scope of the risk, therefore, is likely understated.

Drought

Data Sources

Data on the occurrence of drought for your county is available from the Southeast Regional Climate Center. This data is provided by climate division in South Carolina, so you must first determine in which division your county is located. There are 7 climate divisions in South Carolina. The data is provided in the form of the Palmer Drought Severity Index (PDSI). The PDSI is derived from the weighted differences between actual precipitation and evapotranspiration. The PDSI index runs from 4.0 and above (extreme moist spell) to zero (near

normal) to -4.0 and below (extreme drought). For this assessment, a drought is considered to have occurred in any year with three or more consecutive months of a rating -2.0 or below (moderate drought). You will need to calculate this from the data as it is not specifically set off. This data is available for all SC counties and may be obtained by contacting Hope Mizzell, Drought Coordinator, South Carolina Drought Information Center, 803-737-0800. Other drought information is available on their website:
http://water.dnr.state.sc.us/climate/sco/drought.html

Potential Surrogates

There are no known substitutes for this dataset.

Data Limitations

The counties of Oconee, Pickens, and Greenville are divided into two climate divisions so the data from the entire climate division is applied to each county. This represents a generalized view of drought conditions for the entire county. You should recognize that drought can be increased or decreased by human activity. Thus the drought hazard is often a function of water use and conservation practices as much as a lack of precipitation versus the rate of evapotranspiration.

Accidental Chemical Release from Transportation Sources

Data Sources

These hazards involve the accidental release of hazardous chemicals during transportation via trucks and trains. These accidental releases are cataloged in the Emergency Response Notification System (ERNS) maintained by the National Response Center, the U.S. Environmental Protection Agency, and the U.S. Coast Guard. This data is available for the years 1987 to 1996 and may be obtained by contacting the ERNS WWW site:
http://www.epa.gov/ERNS/docs/region4.html
The database includes the following parameters: chemical spilled, amount of spill, cause, and source. The only location data is by county.

The second data component for identifying these hazard zones is an accurate railroad and arterial highway network coverage. This data is available for all SC counties. Contact your local COG.

Potential Surrogates

There are no satisfactory alternatives to this dataset.

Data Limitations

This dataset has a few limitations that are based on the following factors: 1) the hazard zone is not necessarily a worst case scenario given that some chemicals may disperse further; 2) the ERNS dataset does not always accurately portray the risk of chemical accidents since all emergency response calls are logged regardless of magnitude; 3) there are often duplicate records, false reports, and hazardous materials spills with no determined cause; and 4) many ERNS reports involve minor petroleum product spills which should not be included in the hazardous materials probability determination.

Accidental Chemical Release from Fixed Sources

Data Sources

This data for this hazard was drawn from the U.S. Environmental Protection Agency's Toxic Release Inventory and South Carolina DHEC's Tier2 Hazardous Materials Storage Inventory. This includes facility locations, such as wastewater treatment and industrial plants, that release or store hazardous chemicals. Facilities report their emissions under TRI if they have Standard Industrial Classification (SIC) codes 20-39 and ten or more employees. Facilities report under Tier2 if they have more than the reportable quantity (RQ) of a given set of chemical substances. More specific details pertaining to the requirements of TRI and Tier2 may be found in the report *South Carolina EPCRA Reporting* by SCEPD and SCDHEC (1995).

Also needed is the Emergency Response Notification System (ERNS) maintained by the National Response Center, the U.S. Environmental Protection Agency, and the U.S. Coast Guard. This data is available for the years 1987 to 1996 and may be obtained by contacting the ERNS WWW site:
http://www.epa.gov/ERNS/docs/region4.html
This is needed to determine the probability of accident occurrence.

The final data component needed for this hazard is the Protective Action Distance (PAD) for each reported chemical as reported by the U.S. Department of Transportation in the *1993 Emergency Response Guidebook*. PADs are suggested distances for isolating unprotected people from spill areas involving the listed hazardous materials. These PADs will be used to delineate vulnerability zones.

Potential Surrogates

There are no other systematic datasets that provide this level of detailed information.

Data Limitations

This dataset is limited since only vaporous chemicals with the potential to produce poisonous effects have been assigned PADs by the U.S. DOT. Hence, not all TRI or Tier2 chemicals have PADs. Additionally, TRI is limited because it is self-reported, only includes a subset of industrial facilities, only requires companies to estimate their releases on a quarterly or yearly basis not monitor emissions, and covers a limited number of chemicals. Lastly, the ERNS dataset does not always accurately portray the risk of chemical accidents since all emergency response calls are logged regardless of magnitude and many ERNS reports involve minor petroleum product spills which should not be included in the hazard probability determination.

Appendix 2: Contact List for Technical Support

South Carolina Emergency Preparedness Division, Office of the Adjutant General
1429 Senate St. Columbia, SC 29201
803-734-8020
World Wide Web: http://www.state.sc.us/epd/

Hazards Research Laboratory, Department of Geography, University of South Carolina
Callcott Building, University of South Carolina, Columbia, SC 29208
803-777-1699
World Wide Web: http://www.cla.sc.edu/geog/hrl/
Email: uschrl@ecotopia.geog.sc.edu

Appalachian Council of Governments
P.O. Drawer 6668 Greenville, SC 29606
864-242-9733
Fax: 864-242-6957
World Wide Web: http://home.scaog.org
Email: info@scacog.org
Counties: Anderson, Cherokee, Greenville, Oconee, Pickens, Spartanburg

Berkeley-Charleston-Dorchester Council of Governments
5290 Rivers Avenue, Suite 400 North Charleston, SC 29418
Counties: Berkeley, Charleston, Dorchester

Catawba Regional Planning Council
215 Hampton Street P.O. Box 450 Rock Hill, SC 29731
803-327-9041
Fax: 803-327-1912
World Wide Web: http://www.state.sc.us/cogs/catwaba/crpc2.htm
Email: crpc@infoave.net
Counties: Chester, Lancaster, Union, York

Central Midlands Council of Governments
236 Stoneridge Drive Columbia, SC 29210
803-376-5390
Fax: 803-376-5394
World Wide Web: http://www.cmcog.state.us
Counties: Fairfield, Lexington, Newberry, Richland

Lowcountry Council of Governments
P.O. Box 98
Yemassee, SC 29945
Counties: Beaufort, Colleton, Hampton, Jasper

Lower Savannah Council of Governments
803-649-7981
World Wide Web: http://scescape.net/~lscog/default.htm
Email: lsadmin@scescape.net
Counties: Aiken, Allendale, Bamberg, Barnwell, Calhoun, Orangeburg

Pee Dee Regional Council of Governments
P.O. Box 5719 Florence, SC 29502
Counties: Chesterfield, Darlington, Dillon, Florence, Marion, Marlboro

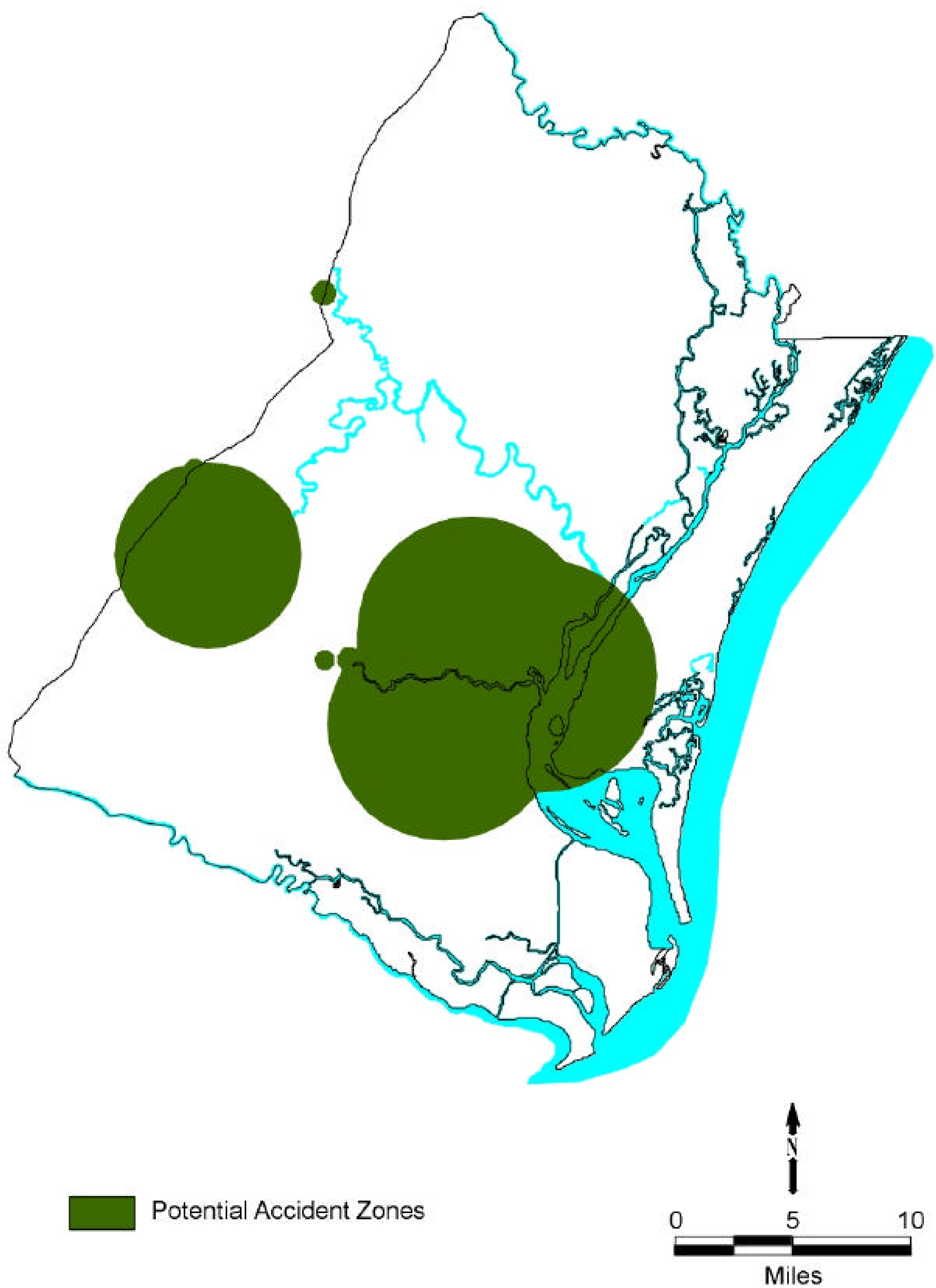
Santee-Lynches Council of Governments
P.O. Box 1837 Sumter, SC 29150
Counties: Clarendon, Kershaw, Lee, Sumter

Upper Savannah Council of Governments
P.O. Box 1366 Greenwood, SC 29648
864-941-8050
Fax: 864-941-8090
World Wide Web: http://www.state.sc.us/cogs/usav/cont.htm
Counties: Abbeville, Edgefield, Greenwood, Laurens, McCormick, Saluda

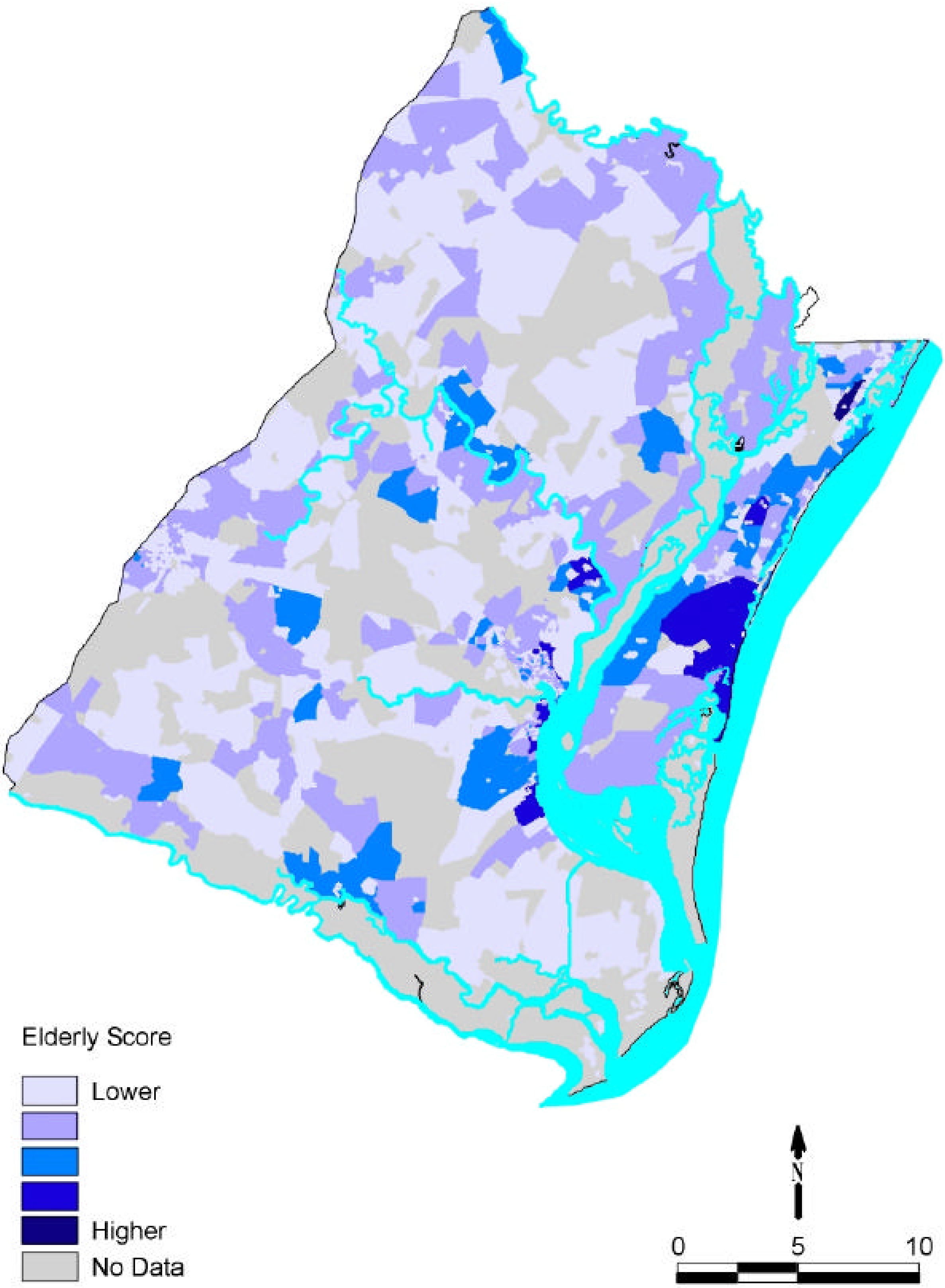
Waccamaw Regional Planning and Development Council
P.O. Box 419 Georgetown, SC 29440
Counties: Georgetown, Horry, Williamsburg

Appendix 3: Handbook Sample Maps

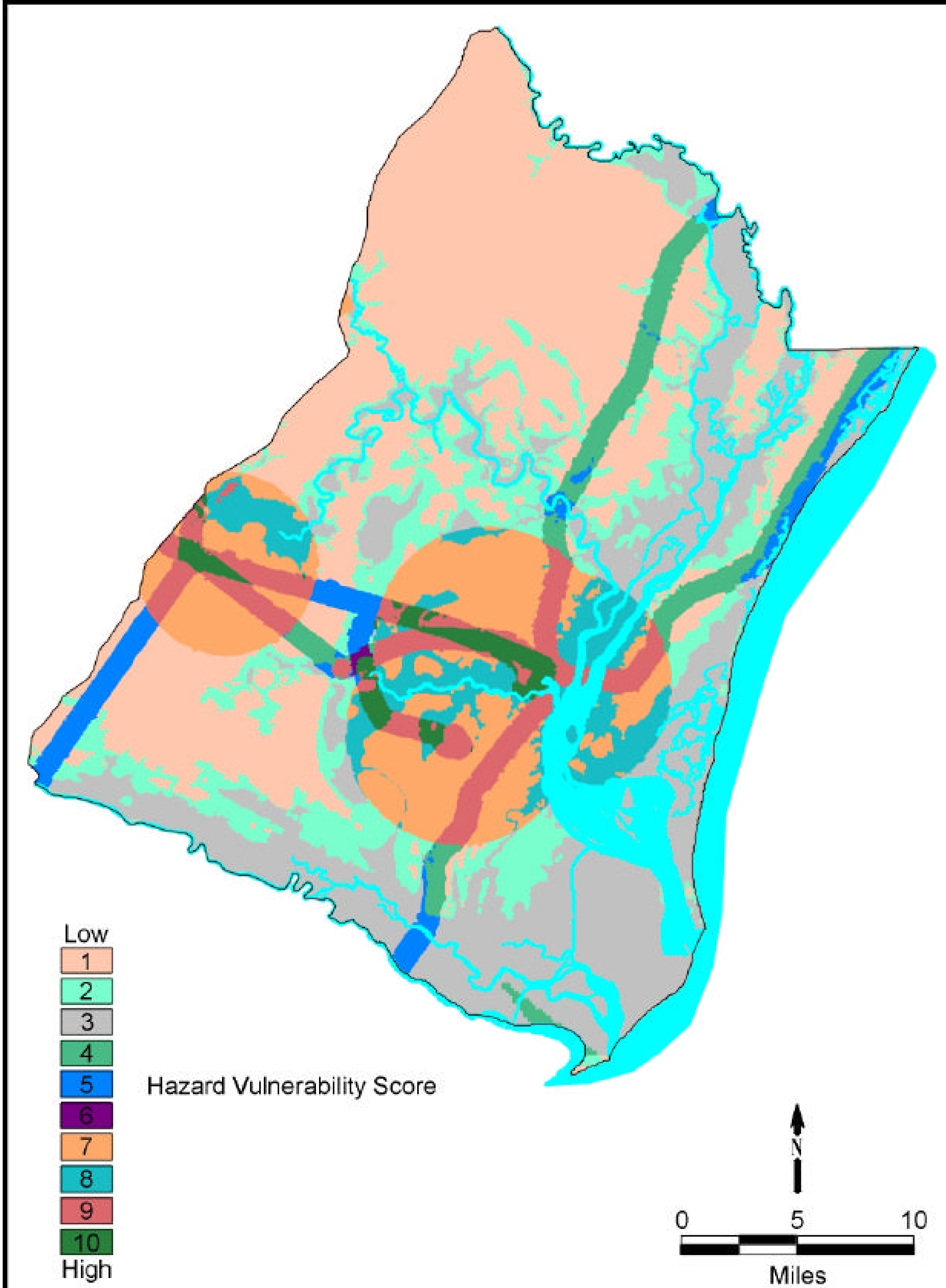
Map 1
Fixed Facility Evacuation Zones



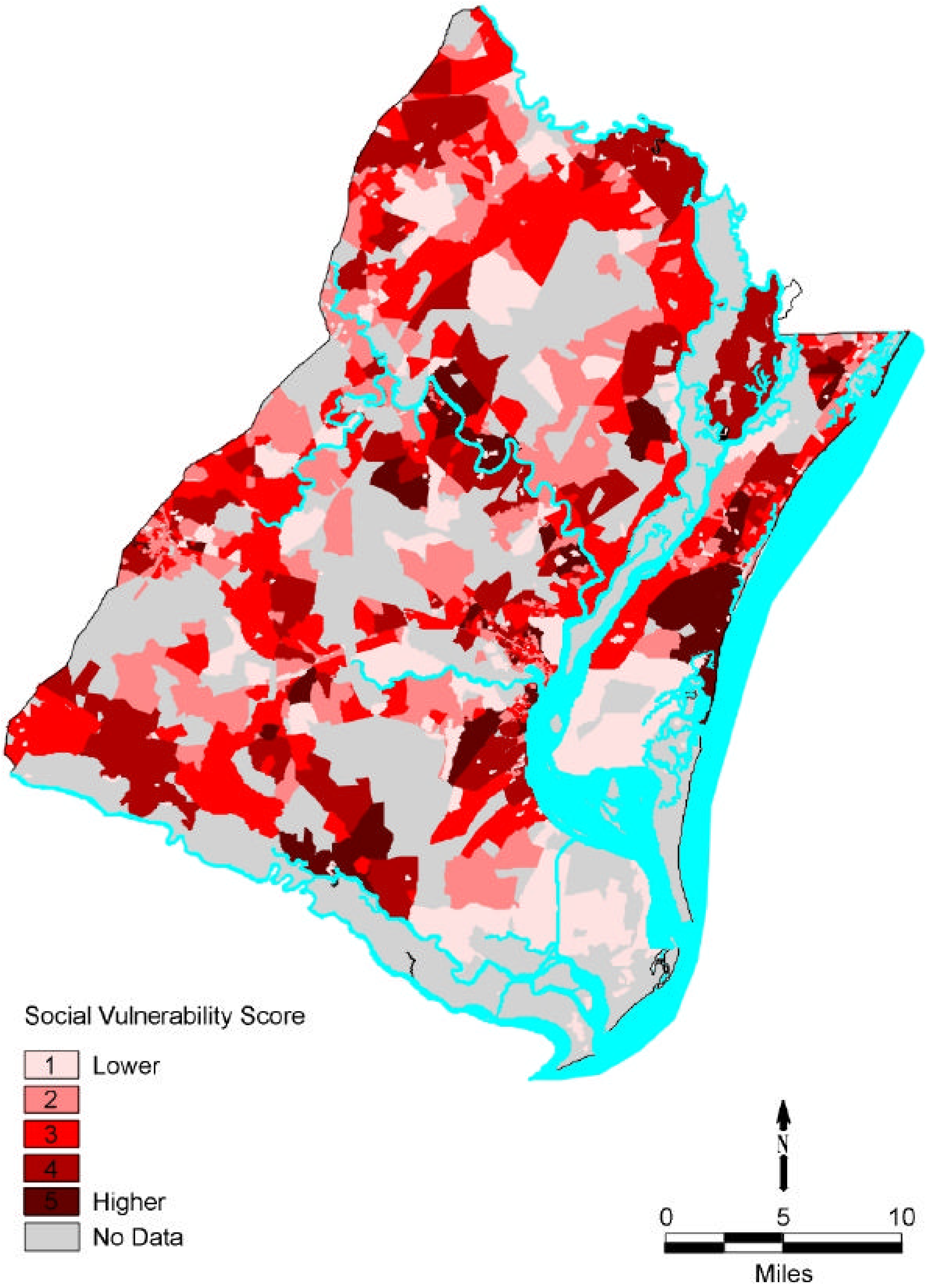
Map 2
Social Vulnerability of Elderly People



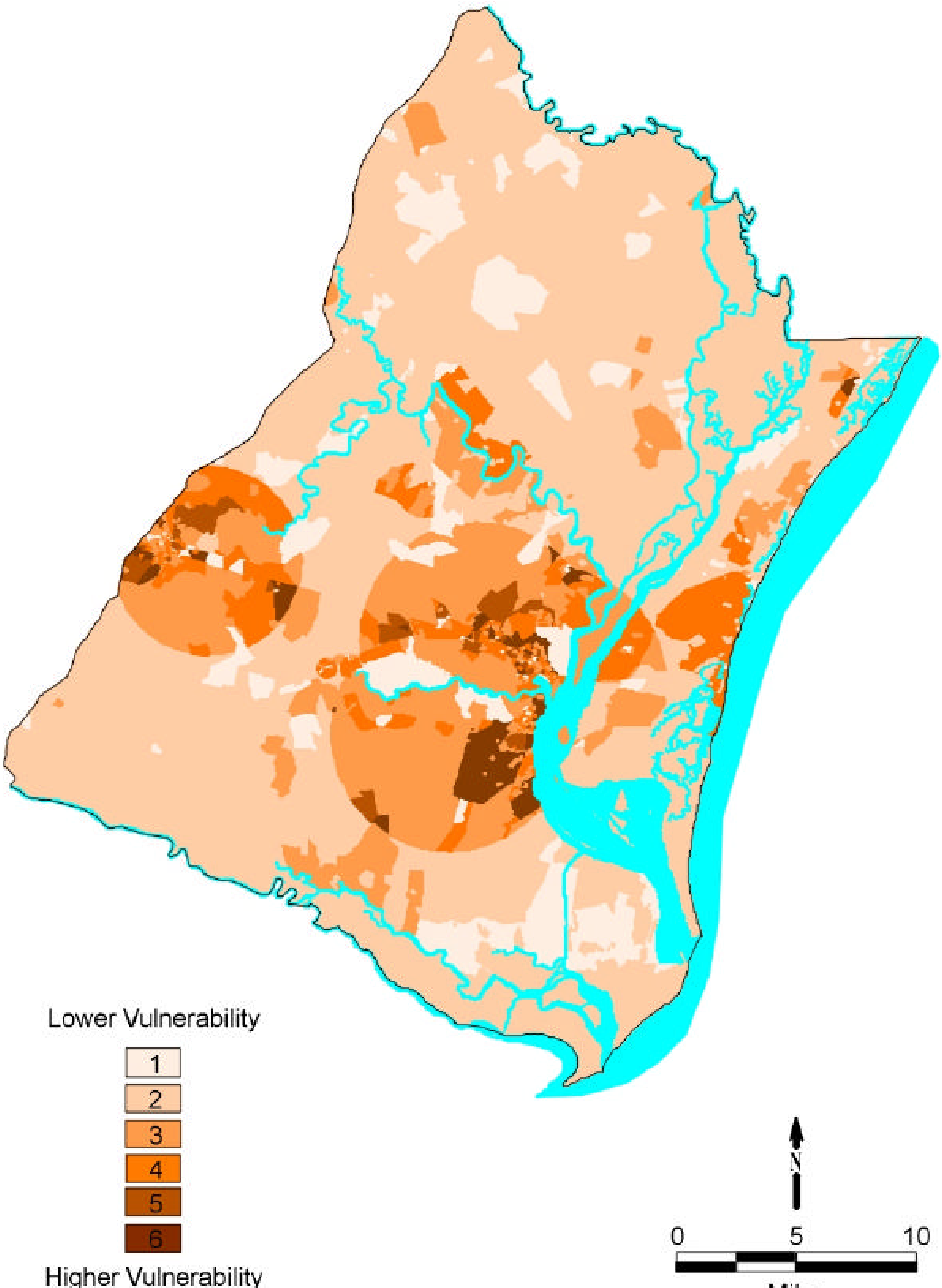
Map 3
Mapped Composite Hazard Zones



Map 4
Mapped Composite Social Vulnerability



Map 5
Overall Place Vulnerability



Map 6
Lifelines for Georgetown County